The Hong Kong Polytechnic University

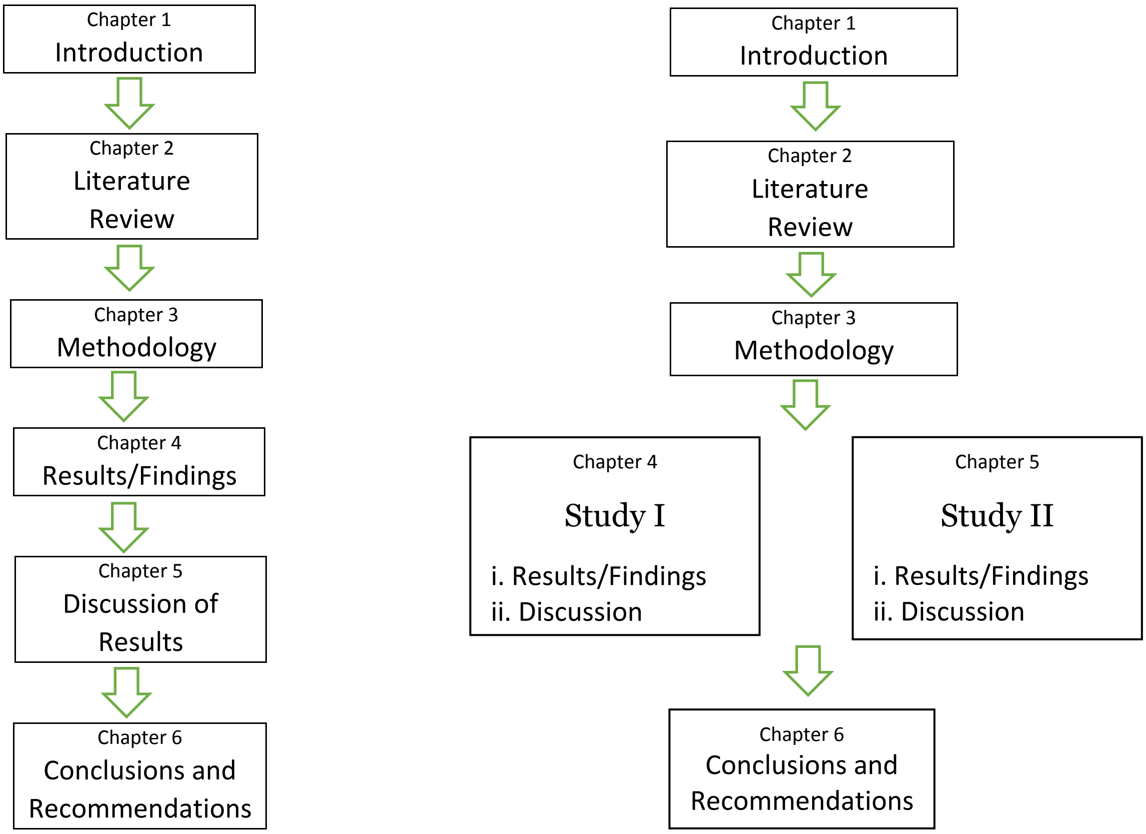
Department of Building and Real Estate

Risk Allocation Model for Public-Private Partnership Water Supply Projects in Ghana

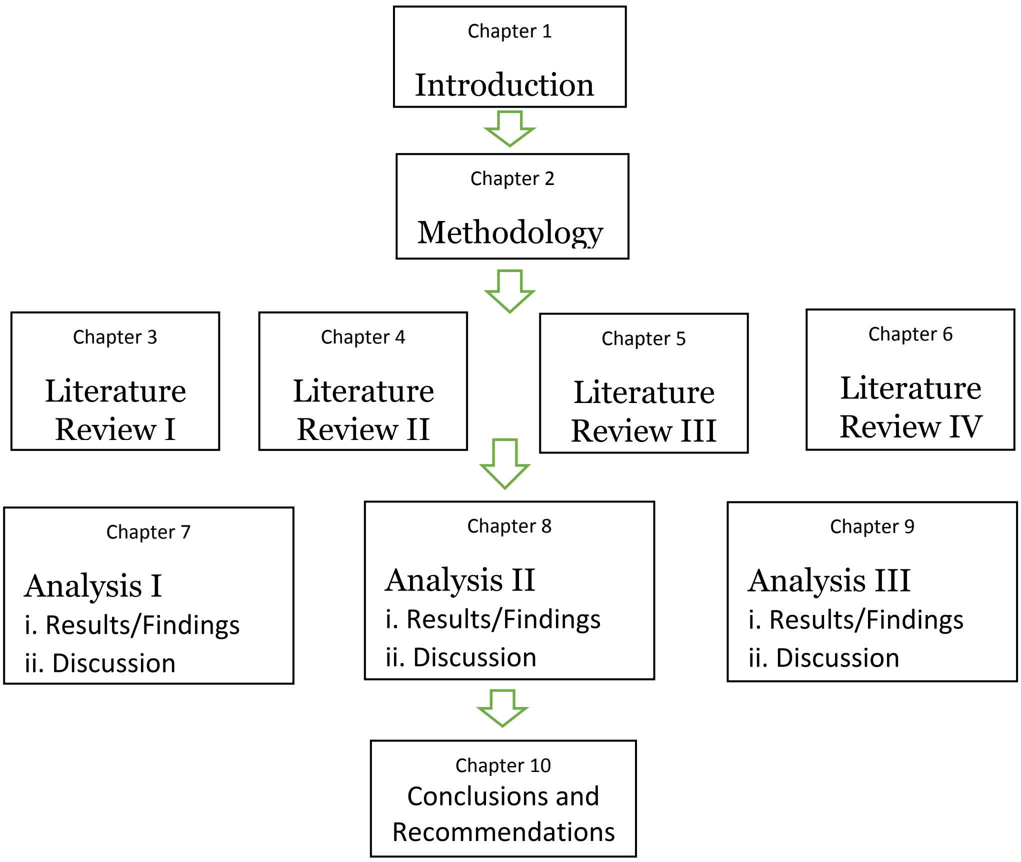
A thesis submitted in partial fulfillment of the requirements of the Degree of Doctor of Philosophy

2015

Theses are usually organised in the following ways:



The organisation of the thesis presented here is as follows:



- Uses past simple tense and passive voice to describe methodology and findings, e.g. *respondents were selected* ~~*was found*~~ (e.g. paragraph 3, sentence 2)
- Avoids unnecessary linking words
- Paragraphs the abstract clearly

<u>To consider</u>

In general, this abstract is effective. However, it could be improved in the following aspects.

Reduce length of abstract by avoiding unnecessary details (e.g. paragraph 8).

Highlight how the findings can be used in further research.

Explain the limitations of the research.

Use vocabulary to show the importance of the work, e.g. *poor water management has serious negative consequences on human health and clean water would potentially improve millions of people's lives*.

Use vocabulary to show the success of the research conducted, e.g. *the results clearly demonstrate that…*

Abstract

The abstract is the first part of a thesis and should be a short summary of the entire thesis. Its purpose is to attract people to read your thesis. Abstracts normally include: the background, the importance of topic, the purpose of the research, the methodology used in the study, the key findings and the implications the findings will have. The abstract should be very short and precise.

This abstract is very effective partly because the writer includes the following:

Structure

Background	Paragraph 1
Aims	Paragraph 2, sentence 2
Methods	Paragraph 3-5
Results	Paragraph 6-7
Implications	Paragraph 9

Content

- Uses and defines key terms (e.g. paragraph 1 sentence 1)
- Introduces abbreviations of key terms that appear in the thesis (e.g. paragraph 1 sentence 1)
- Gives the scope of the research (e.g. paragraph 2, sentence 2)
- Highlights key data from the findings (e.g. paragraph 6 sentence 1)
- Explains how the findings will aid the wider community (e.g. paragraph 8)
- Includes key words. If there is no requirement for a key word list, the most important words should appear in the text
- Organises information in a logical manner (background, focus of research, methods adopted, results obtained, significance and contribution of the research)

Language

- Uses present perfect tense when describing the background to highlight the topic is current (e.g. paragraph 1, sentence 1)

ABSTRACT

The last two decades have witnessed a growing trend by governments around the world using the skills and expertise and financial resources of the private sector through public-private partnership (PPP) procurement in delivering public water supply services and infrastructure. Like other countries, the Government of Ghana is turning to the private sector to develop the country‘s water supply infrastructure, and PPP in the water sector is emerging. Key reasons for adopting this policy are inadequate public funding, the need for improved management and efficiency, growing water demand, and poor asset condition and lack of maintenance. PPPs have diverse modalities including service and management contracts, affermage-leases, concessions, joint ventures and build-operate-transfer (BOT-type) arrangements. In the water industry of low- and middle-income countries, water concessions and BOT contracts are the most popular modalities.

PPP water supply projects are a plethora of risk, and the contractual agreements for these projects allocate the risks between the public water utility (government) and the private sector entity. The overall aim of this thesis is to develop a model for successfully allocating risks in PPP water supply projects in Ghana, so that decision-makers can arrive at a fair risk allocation decision. However, the outcome of the study is applicable to other developing countries that share similar characteristics with Ghana.

The primary data acquisition tool for this research study is a three-round Delphi questionnaire survey of industry experts from both public and private sectors, with relevant experience in the local water industry and PPP procurement. The expert respondents were selected through purposive sampling and semi-snowballing approaches. Thirty-seven to forty-one PPP experts provided valid responses to various parts of the questionnaire. The

panel sizes are justified, given that PPP is at its budding stage in Ghana. Various statistical methods such as arithmetic mean, Cronbach's alpha reliability analysis and factor analysis were used to analyse the obtained data, and the fuzzy synthetic evaluation (FSE) method was subsequently applied for success and risk assessment and risk allocation modelling.

Mean score ranking method ranked and prioritized the risk allocation criteria (RAC), critical success factors (CSFs) and critical risk factors (CRFs) associated with PPP water supply projects. This approach established seven important RAC, 14 CSFs and 22 CRFs.

Factor analysis generated principal factors for the CSFs. The five critical success factor groups (CSFGs) that ensure successful implementation of water supply projects are Factor 1: Commitment of the partners; Factor 2: Strength of the consortium; Factor 3: Asset quality and social support; Factor 4: Political environment; and Factor 5: National PPP Unit. The CRFs were theoretically categorised into three principal risk factors (PRFs), namely PRF1 – Financial and commercial risk, PRF2 – Legal and socio-political risk, and PRF3 – Technical risk.

The proposed model showed that the overall success index (OSI) of the five CSFGs for PPP water projects in Ghana is 6.10, implying that, collectively, the factors are *'very important'* and if provided sustained and unremitting attention, would improve the likelihood of successful implementation of PPP water supply projects. Political environment (index = 6.20) is the most critical factor group affecting project success, followed by Asset quality and social support (index = 6.18); National PPP Unit (index = 6.17); Strength of the consortium (index = 6.07); and Commitment of the partners (index = 5.94). The model would aid decision-makers to select the important factors that contribute most significantly to successful implementation of PPP water supply projects, rather than purely relying on qualitative selection of CSFs.

On risk modelling, the fuzzy model showed that the overall risk level of PPP water supply projects is _high', with an index of 4.78, implying that these projects are risky to the public and private sectors. It, overall, confirmed that PRF1 – Financial and commercial risk (index = 4.91) most significantly contributes to the overall risk of PPP water projects, followed by PRF2 – Legal and socio-political risk (index = 4.72), and PRF3 – Technical risk (index = 4.67). This approach not only aid implementers to determine a project's risk level and high-risk areas in order to develop appropriate countermeasures but also assists private participants (or investors) to select the least risky project.

The proposed prototypic fuzzy quantitative risk allocation decision model (FQRADM) for PPP (water supply) infrastructure projects deals with the imprecise and subjective nature of risk allocation decision-making, and handles the simultaneous consideration of the multiple risk allocation criteria and multiple decision-makers. Thus, the model is an eight-tier system, in which outputs of preceding steps are fed into following steps to handle the problems of subjectivity and multi-criteria. The steps include: (i) establish critical risk factors and critical risk allocation criteria (RAC); (ii) define the RAC as input variables (IVs); (iii) compute weighting functions of the IVs; and (iv) evaluate the risk factors against the RAC; (v) establish membership functions of the IVs; (vi) compute the risk carrying capacity indices of the public and private partners; (vii) quantify risk allocation proportions to the public and private partners; and (viii) model output. The output variable of the model is the risk allocation proportions between the government and private partner according to their capabilities to control and manage evaluated risk factors. This risk allocation strategy ensures that both parties have an incentive to manage the risks.

Overall, this study could trigger policy development toward PPP practice in Ghana and other developing countries, because these findings have wider implications for legal and regulatory systems, public capacity, financing, public procurement, and politics.

Keywords: Ghana; Public-private partnership; water supply projects; private sector; public sector; risk factors; risk assessment; risk allocation; critical success factors, fuzzy synthetic evaluation, factor analysis.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AfDB	African Development Bank
AVRL	Aqua Vitens Rand Limited
BOOT	Build-own-operate-transfer
BOT	Build-operate-transfer
BPD	Building Partnership for Development
CE	Cause-and-effect diagram
CM	Construction management
CSFs	Critical success factors
CSFGs	Critical success factor groups
CRFs	Critical risk factors
CWSA	Community Water and Sanitation Agency
DEA	Data development analysis
FA	Factor analysis
FSE	Fuzzy Synthetic Evaluation
FX	Foreign exchange
GWCL	Ghana Water Company Limited
HIPC	Heavily Indebted Poor Country
IMF	International Monetary Fund
ISODEC	Integrated Social Development Centre
IV	Input variable
KMO	Kaiser-Meyer-Olken
MF	Membership function
MS	Mean score
NGT	Nominal group technique
OCED	Organisation Co-operation of Economic Development
ORI	Overall risk index
OSI	Overall success index
PPP	Public-private partnership
PPA	Public Procurement Authority
PAU	PPP Advisory Unit
PC	Project company
PCFA	Principal component factor analysis
PRFs	Principal risk factors
PURC	Public Utilities Procurement Commission
QRADM	(Fuzzy) Quantitative risk allocation decision model

RA	Risk allocation
RAC	Risk allocation criteria
RAM	Risk assessment model
RCCI	Risk carrying capacity index
RL	Risk level
RMC	Risk management capability
RMP	Risk management process
SI	Success index
SWRO	Seawater reverse osmosis
UWP	Urban water project
UWS	Urban water systems
VfM	Value-for-money
WBS	Work breakdown structure

The Introduction

The Introduction is usually organised in the following way:

1.1 INTRODUCTION

1.2 BACKGROUND

a. Identify the research topic.

b) Provide the background to the study

c). Define key terms.

↓

1.3 MOTIVATION FOR STUDY

a. Describe the general background to topic, then narrow the focus of the study to the limited area of your topic.
b. Highlight the research gap.
c. Explain how the gap will be filled.

↓

1.4 OBJECTIVES

Give a comprehensive list of the objectives of the study.

↓

1.5 METHODS USED IN THE THESIS

Outline the methods used in the study. (This is optional)

↓

1.6 OUTLINE THE CONTENTS OF THE THESIS

1.7 SUMMARY

Chapter 1: Introduction

The introduction chapter is designed to help the reader better understand the technical sections of the thesis by giving an overview. It normally includes the following: the rationale for the research, the scope, the scientific importance of the research, the introduction, explanation and definition of key terms, a review of recent research relevant to your research topic, an overview of the methodology used and an overview of the way the thesis is organized with a short summary of each chapter.

This introduction is very effective partly because the writer includes the following:

Structure

Introduction	Section 1.1
Definitions	Section 1.2
Background	Section 1.3
Focus of Study and research gap	Section 1.4
Objectives	Section 1.5
Methodology	Section 1.6-1.7
Outline of the Thesis	Section 1.8
(Conclusion/summary)	Not included

Content

- Highlights the importance of the topic (e.g. Section 1.1, paragraph 1, sentence 3)
- Introduces key terms and their abbreviations (e.g. Section 1.1, paragraph 2, sentence 4, paragraph 3, sentence 1)
- Defines key terms in a separate subheading (e.g. Section 1.2)
- Highlights the need for the study (e.g. Section 1.1, paragraph 3, final sentence)
- Suggests possible benefits of the research (e.g. Section 2.1, paragraph 4, sentence 2)
- Groups and cites key studies that will be reported in the literature later (e.g. Section 1.2.2 paragraph 1, sentence 3)
- Quotes key definitions (e.g. Section 1.2.2 paragraph 2)

- Develops the background section chronologically from the general background to the specific situation in Africa (e.g. Section 1.3.2 paragraph 1-paragraph 6) then sums up (e.g. Section 1.3.2 paragraph 1-paragraph 7)
- Refers forward to later chapters in the thesis (e.g. Section 1.3.3 paragraph 2 final sentence)
- States the scope of the research (e.g. Section 1.7, paragraph 1, sentence 1)

<u>Language</u>

- Uses correct language to quantify, e.g. *a large number* (e.g. Section 1.3.3 paragraph 1 sentence 1)
- Uses the same grammatical structure for the first word when listing the specific aims of the thesis
- Uses one paragraph for each chapter when outlining the structure of the thesis (e.g. Section 1.8 paragraph 4)
- Links the following chapter with a final paragraph (e.g. Section 1.8 final paragraph)

<u>To consider</u>

In general, this chapter is effective. However, it could be improved in the following aspects.

Avoid using subtitle headings as part of the text. It is better to include a short introductory sentence for longer subsections, e.g. Section 1.8 could begin with *The thesis is organized in the following way*. This is better than starting by discussing the first chapter.

Avoid using *etc.* with lists. It is better to use *e.g. schools and hospitals* (Section 1.2.1 paragraph 1, sentence 1).

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

The relationship between quality infrastructure and country competitiveness is well-established (Vives et al., 2006). Network utilities, including water, provide essential services for both commerce and manufacturing sectors, thereby contributing to high factor productivity of a country (Newbery, 2000; Guasch, 2009; World Bank, 1994). Economic and social development significantly depends on efficient water supply infrastructure and failure to develop the sector threatens quality of life and public health, and stifles economic growth (Kessides, 2004).

History suggests that water supply infrastructure services have been provided by both public and private sectors. While much of this infrastructure services have traditionally been delivered by the public sector, the past two decades have seen increasing private participation in public water services, in developed and developing economies. Given its responsibility for water infrastructure provision, the public sector is at liberty to choose the most appropriate procurement route. Adopting public-private partnerships (PPPs) means that governments assume contractual and regulatory roles, ensuring that public benefits are maiximised while the private participant achieves a reasonable return on its investment (Arndt, 2000; Beato and Vives, 1996; Rivera, 1996).

Negative experiences regarding PPP in water supply infrastructure suggest that too much risk is left to, the private participants without providing a proportionate return (Wells and Gleason, 1995; Gavin, 2010; Vives et al., 2006; Irwin et al., 1997), or the public agency without realising the maximum possible value-for-money (VfM) for the public

(Blanc-Brude et al., 2006; Johnston and Gudergan, 2007; Nickson and Vargas, 2002; Marques and Berg, 2011). Governments and private participants must understand risks specific to a country and sector, and how to structure a risk allocation between the public and private sectors for a PPP (water supply) project.

This thesis develops analytical models that look at three areas that are key to the success of water supply projects: (i) critical success factors, (ii) risk factors with high impacts on such projects, and (iii) risk allocations between the public and private sectors. The models offer useful guidance and insight into achieving successful water supply projects. On water based PPP, these important areas have not been adequately addressed in the literature.

1.2 DEFINITIONS

1.2.1 Water Supply System

A water supply system is an infrastructure for abstracting, transmitting, treating and distributing water to households, commercial and industrial establishments, public institutions (schools, hospitals, etc), and for public needs such as fire-fighting and street cleaning (Alegre, 2006). A typical water supply system has two broad parts: the water plant (for abstraction, treatment and storage) and the distribution network (for delivering water to consumers). A drinking water supply system supplies potable water to consumers in required quality and quantity (Ameyaw et al., 2013; Alegre, 2006). Therefore, public water supply is a vital service for communities, towns and cities regarding general welfare, protection of public health and collective security, economic activities and environmental protection (Alegre, 2006). The value chain and unique characteristics of the water supply sector are explained in Chapter 4.

1.2.2 Public-Private Partnership (PPP)

In the literature, the term *Public-private partnership (PPP)* has several definitions with no standard definition. The definitions of PPP seem to depend mainly upon the countries and international organisations concerned. Many authors also proposed definitions to suit their studies. In the water management literature, several authors and international institutions (e.g., Walker, 1993; Rivera, 1996; Idelovitch and Klas, 1995; Ballance and Trémolet, 2005; World Bank, 2006) have used the term *"private sector participation (PSP)"* to mean PPPs.

A PPP can cover a range of contractual arrangements which can be grouped into two main categories, irrespective of sector or geographical location: a) financed-based approach that taps private-capital for new developments to meet government's infrastructure needs; and b) service-based approach that exploits the private sector's innovations, technical know-how, skills and management expertise to optimise cost and operational efficiencies in service provision, often for existing projects. In essence, PPPs fall between full privitisation (asset sale) and traditional public procurement. This thesis recognizes both approaches to PPP, and for the purpose of consistency, adopts the term ‗PPP'. In the context of this study, a PPP in the water sector

> *"involves transferring some or all of the 'assets' [and]/or 'operations' of public water systems into private hands"* (Palaniappan et al., 2006, pg.10).

This definition implies the basic characteristics of a PPP, such as ultimate public sector ownership of and responsibility for water assets, allocation of risk and sharing of responsibilities between private and public participants, existence of a partnership and a contractual agreement, and contribution of needed resources (financial, human, technology, etc) by both sectors (World Bank, 2003; Guasch, 2004; HM Treasury, 1997; Kwak et al, 2009).

1.3 BACKGROUND

1.3.1 A brief History of PPP in the Water Sector

The involvement of the private sector in the water sector is not new, but has deep historical roots in many countries. Private sector initiatives contributed immensely to the development of modern urban water systems (UWS), which resulted in privately managed and operated or owned water systems (Prasad, 2007). Driven by urban growth and development, urban water systems in several cities in North America and Europe (including colonies) were financed, constructed, owned, managed and operated by private sector firms in the 19th and early 20th centuries (Marin, 2009; Prasad, 2007).

England is the forerunner of water systems and its first PPP was probably a water concession that was awarded in 1602 to a local entrepreneur to provide water supply services to London while paying a fee to the British crown (May, 1996). A concept of partnership for engaging the private sector in water services has existed in Spain and France for over a century. In France, the *affermage* model emerged, in which a private firm runs a publicly-owned water system with the public sector remaining the asset owner and investor, and in Spain, mixed-ownership arrangements (popularly called *empresas mixtas*) also emerged. An early example of water PPP in Australia can be traced back to 1858 during which the Bendigo Waterworks Company was awarded a concession to supply water to Bendigo (Arndt, 2000).

However, following gross abuse of monopoly powers in the mid-19th century, governments nationalised most of these systems to municipal authorities. The main reasons include failure by the private firms to improve water quality which created public health concerns; unwillingness to expand access to the poor; public mistrust for private firms providing water services; excessive prices; and corruption (Prasad, 2007). In the first half of 1900s, a similar re-municipalisation occurred in the developing world during which the public sector assumed control of water utilities. However, after years of public sector struggles with service provision, the trend changed in the early 1990s.

1.3.2 The Water Sector Context since the 1990s

> *"High costs, low efficiency and unreliability ... are the characteristics of many public utilities in developing countries"* (Khan, 1997, pg. 7).

By the end of the 1980s, public water systems in most cities across the world were beset with access, quality and reliability problems, and moreover, undue political interferences and clientelism had resulted in overstaffing and low labour productivity (Nickson, 1996; Mustafa, 1993; Marin, 2009). For political expediency, governments kept tariffs below cost recovery levels while public water utilities exhibited failures to cope with the grave deficiencies in water supply for the poor (Cheema, 1988). The financing of publicly-owned and -operated water and wastewater utilities overwhelmed the capabilities of the public sector, giving rise to lower-than-expected performance and low productivity by a number of public water utilities in many countries (Coyaud, 1988; Idelovitch and Klas, 1995).

In response, governments around the world turned to the private sector in the form of PPPs to address public water utilities‘ operational failures, infrastructural backlogs, and funding gaps in the provision of water supply and sanitation services, since the early 1990s (Nickson, 1996; Braadbaart, 2001; Haarmeyer and Mody, 1998). The government of Ghana, overwhelmed with similar financial, managerial, and technical challenges of meeting national water needs, is turning to both domestic and international private water operators for some relief (Ameyaw and Chan, 2013b).

Chong et al. (2006) and Zhong et al. (2008) stated that the United Kingdom‘s water privatisation in the late 1980s triggered the spread of various PPP options in the developing world, particularly following its promotion by the World Bank and other international financial institutions. Advocates of the PPP policy argued that the private sector would inject experience and operational efficiencies, extend water supply services, provide the much needed capital for water-related infrastructure development without public subsidies, generate income for governments, and relieve poor governments of budget constraints (Ranasinghe, 1999; Liddle, 1997; Idelovitch and Klas, 1995). In effect, the aim was to transfer design, construction, finance, commercial, operation and maintenance, and other risks to the private sector depending on the contractual arrangements, and to ensure VfM through leveraging the management and technical skills of competent private sector firms (Tahir, 2007; Hall, 1998; OECD, 2009a). In the case of the United Kingdom‘s water privatisation, the fundamental motive was to limit the role of the state and to reduce government borrowing to the minimum, allowing the private sector to finance the huge water investments (Lobina and Hall, 2001).

Compared with other sectors such as telecommunications, energy/power plants and road transportation, private investment in the water sector has been modest, yet private activity continues to increase in various dimensions (Haarmeyer and Mody, 1998).

Since PPP is not new to the water sector, as indicated earlier, what is new is the belief that the private sector alone can resolve several years of chronic inefficiencies in the sector (Rodriguez, 2004). While literature comparing public and private sector efficiency in developing countries remains limited, vast documentation exists on the prominent role of private involvement in several cross-country studies on developed countries (Shendy et al., 2011). In the United States and United Kingdom water industries, Hassanein and Khalifa (2007) drew on 234 project cases and observed better performance by the private sector than its public counterpart regarding labour productivity (staff per 1,000 connections), tariffs imposed, and return on equity. Estache and Rossi (1999), based on 50 utilities from Asian Development Bank‘s (ADB) 1995 survey, found that the private sector is more efficient in water services delivery in the Asia Pacific region. Through nine water utilities case studies, Haarmeyer and Mody (1998) observed that private sector capital has relieved governments of budgetary pressures while improving operational efficiency.

Some evidence exists for better performance in private utilities in Africa and other developing countries. A comparative study, private versus public sector water provision in Africa, by Kirkpatrick et al. (2004) revealed better performance in private utilities than publicly-managed utilities. Their study was based on statistical and data development analysis (DEA) performance measures. However, based on stochastic cost frontier analysis, the authors found no statistically significant cost differences between public and private utilities. Clarke and Wallsten (2002) also studied water supply in Africa and reported greater service coverage with private sector ownership, particularly among low-income households, than where there is heavy reliance on pure public utilities. A World Bank study in the 1990s observed that private participation had yielded substantial public benefits in terms of expanded access, quality of services and considerable improvements in productive efficiency (Rivera, 1996). The study, however argued that sustainability of these gains requires continuous commitment from governments and financial institutions in implementing economic water pricing, financing and regulatory reforms.

Overall, PPP in water services, based on case studies and statistical or econometrical analysis, have produced mixed outcomes: some improvements in quality and reliability of water services and improved coverage are reported, but cases of high unaccounted-for-water, high water tariffs, low water quality and lower-than-expected private sector performance attracting public opposition and subsequent contracts cancellation are commonplace (Marin, 2009; Kirkpatrick et al., 2004).

Despite their instrumental role in some countries, PPPs in urban water supply present a new set of challenges, collectively termed risks, for the parties involved. Therefore, drawing favourable conclusions on the sound performances of PPPs in the water sector without examining actual and potential risks is misleading.

1.3.3 Risks

PPPs in water supply have been very controversial (Prasad, 2006, 2007), with a large number falling short of original targets. For example, the anticipated surge in private sector investments only partially materialised (Hall and Lobina, 2006). Vives et al. (2006) explained that efforts at expanding private investment and attracting more private participation have often met with significant risks. The difficulties and controversies encountered by the PPP projects initiated over the past twenty years have resulted from a poor understanding of the risks involved by private sector participation in the unique and complex water sector (Orr et al., 2005; OECD, 2009a). Risk is defined in Chapter 5 and Chapter 6 explains various risks affecting PPPs in the water sector.

Typically, water supply projects are characterised by significant initial investments, low rates of return, regulatory hurdle rates, arbitrary political interference, risk of asset-stranding as conditions change, diverse users of service and institutions, long lead times for upgrading, high sunk costs, high asset condition and consumer base uncertainties, and externalities not reflected in tariffs (Clough et al., 2004; Ameyaw and Chan, 2013a; Ouyahia, 2006). Thus, the sector is risk-prone and differs from other sectors because it accumulates most of the risks that apply to infrastructure (OECD, 2009a). Moreover, the interaction of state and non-state actors, coupled with diverse institutional arrangements for delivering water supply services has given birth to a complex sector (ADB, 2009). The public and private sectors must be mindful of the risks and uncertainties associated with the water sector (Wibowo and Mohamed, 2010; Haarmeyer and Mody, 1998). Chapter 4 explores this complexity in more detail.

1.3.4 Risk Allocation

Risks to a project must be allocated to the direct public and private participants. To allocate risk is to determine which party bears its negative consequences (in this case) if the risk eventuates in future. Risk is allocated entirely to one party or shared among them. Appropriate allocation of risk constitutes a key success to PPP, and is driven by a party‘s risk management capability and resources to handle assigned risk(s) (HKIS, 2009; OECD, 2009a; Chang, 2012). This implies the party which is best able to foresee and assess the risks, and avoid, minimise or control the risk occurrence and its loss on the project. It also implies the party that is least risk-averse, best able to absorb or diversify the consequences of the risk and able to sustain the risk at the lowest price. Risk allocation and risk allocation criteria (RAC) are explored in Chapter 5.

One major challenge that flawed most water PPPs is misallocation of major risks, such as commercial and currency risks (Haarmeyer and Mody, 1997; Ballance and Trémolet, 2005; Bayliss, 2002; Lobina, 2005; Gavin, 2010). Most of the 1990s water partnerships secured government guarantees and a number of contracts were renegotiated soon after private takeover. Thus, as noted previously, the public sector agency or private entity is overloaded with risk. Chung et al. (2010) asserted that an intrinsic risk in PPP procurement is the risk allocation decision-making process. Risk allocation remains a daunting task in the sector (Ballance and Trémolet, 2005; Haarmeyer and Mody, 1997). This thesis demonstrates that it is possible to allocate risks based on established RAC that reflect the risk management capabilities of the public and private partners. This allocation strategy ensures that both parties have incentives to manage assigned risks.

1.4 FOCUS OF THE STUDY

The research study primarily focuses on analysis of risks and risk allocation in Ghanaian PPP water supply projects. As discussed in Chapter 4, PPP is different from traditional public provision of water supply services/infrastructure in many ways, and there are diverse models, each of which has a varying influence on risks and their allocation in a project.

1.4.1 Why Water Supply Sector, and Ghana?

Water supply projects exhibit some unique characteristics which render risk allocation complex and challenging, and expose water based PPPs to serious risks. For instance, the concepts of water as a social and an economic good makes its pricing a complex issue, because of the interactions of political and market (economic) forces (Bohman, 2010). This is explained to mean that water pricing attracts some level of government control or regulation which influences the project‘s risk level and the private sector‘s willingness to participate. This, and other characteristics of the water sector which expose projects to high-risks are less conspicuous for other infrastructure sectors. Hence, PPP water supply projects require a well thought-out risk allocation process than other PPP infrastructure projects.

The decision to adopt PPP in the water sector began in the early through the mid-1990s, under the National Democratic Congress (NDC) government. But the process has been slow, and not much progress has been made after almost 15 years. Some commentators stated that there are a number of areas that require further research to inform the government‘s policy (Fuest and Haffner, 2007; Ameyaw and Chan, 2013b). These areas include drivers for success, risk analysis, risk allocation, etc.

In a developing and inexperienced country like Ghana there are major risk issues that the private sector is more concerned with (Ameyaw and Chan, 2013a). These issues include future demand for water services, local currency instability, macroeconomic issues, local regulatory and legal systems, social and political issues, and public policy. A review of local projects, however revealed that risk allocation has not been widely adopted, is less developed and is not yet been given attention by practitioners and researchers (Ameyaw and Chan, 2013b, 2014). As PPP is generating momentum, a study of risks and risk allocation is therefore expected to be crucial in seeking to develop a PPP program and to enhance project success and VfM, because project performance is dependent on whether the applied risk allocation strategy can result in effective risk management (Jin, 2011).

The outcome of this study is applicable to other jurisdictions, especially for water projects in developing countries which share similar characteristics with Ghana. For example, chapters 4, 5 and 6 are general without been restricted to Ghana. It is essential to develop effective risk allocation approaches that reflect local conditions in order to enable developing countries to attract increased private participation and to ensure successful outcomes.

1.5 RESEARCH AIM AND OBJECTIVES

The study aims to advance understanding of risks, and to develop a reliable and practical risk allocation model to guide risk allocation decision-making in PPP water supply projects in Ghana. The following objectives are developed to achieve the overall aim of the study:

1. To investigate the water sector‘s characteristics and risk environment, and PPP models and trends within the water industry;
2. To investigate PPP evolution and experience and drivers in the water industry of Ghana;
3. To identify and evaluate critical success factors (CSFs) for PPP water projects, and to model the impact of the CSFs on successful implementation of PPP projects in Ghana;
4. To identify and evaluate PPP water supply project risk factors and to develop a risk assessment model (RAM) for PPP water supply projects;
5. To determine the most important risk allocation criteria (RAC) in PPP; and
6. To develop a quantitative risk allocation decision-making model (QRADM) for PPP water supply projects.

1.6 RESEARCH METHODOLOGY

1.6.1 Overall Research Procedure

The research procedure has four main stages (see Fig. 1.1). Stage 1 consisted of initial literature review and discussions with my Supervisor and some water practitioners and academics in Ghana on the potential of this research area. This approach aided the establishment of the research aim and objectives, approach and methodology.

Stage 2 involved extensive literature review, analysis of project cases within and beyond Ghana, and discussion with some academics/practitioners. The literature survey covered general PPP literature with emphasis on water supply based PPPs, the risk management process with a focus on risk-factor and risk allocation literatures and the water sector and its risk environment. The review on risk and risk allocation focused on construction project management and general project management literatures. Moreover, a large number of the case studies were sourced from the water management PPP literature. Data sources include

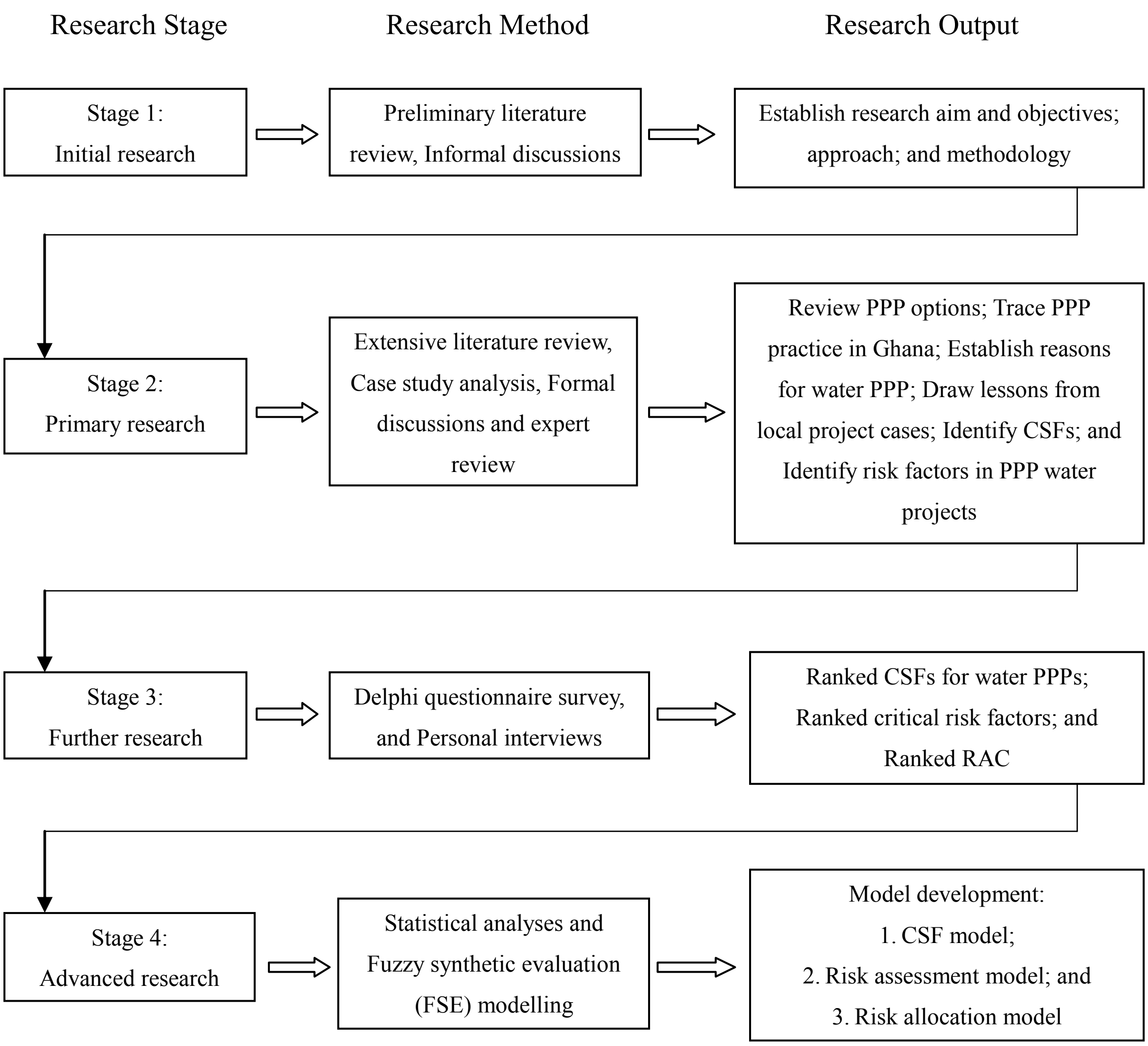

Fig. 1.1 Overall research procedure

books, journal papers, conference papers, internet sources (e.g., PhD theses, World Bank's published reports/papers on water, reports from Ghanaian water companies and other research orgainsations), etc. In Stage 2, objectives 1 and 2 were achieved whereas objectives 3 through 5 were partly achieved.

Stage 3 focused on primary data collection through a three-round Delphi questionnaire survey and personal interviews with industry experts in Ghana. By this, objectives 3 and 4 were partly achieved and objective 5 was achieved. The data acquisition techniques for this stage are explained in detail in Chapter 2.

Stage 4 covered quantitative data analysis and model development, which helped to fully achieve objectives 3, 4 and 6. This stage primarily depended on the outcome of Stage 3. Statistical analysis techniques included mean scoring, factors analysis, and fuzzy synthetic evaluation, as explained in Chapter 2.

1.7 APPROACH OF THE RESEARCH STUDY

This research study is restricted to an analysis of risk factors (including risk allocation) both public and private sectors encounter in developing and implementing PPP water supply projects rather than presenting risks that arise from particular models. The discussion therefore covers different types of models – from management contracts through ‗greenfield' projects. The rationale for this approach (adopted from World Bank, 2006) is as follows. First, multiple risk factors arise in the development and implementation of each PPP model. For instance, demand and non-payment risk factors arise in every water supply project. Repetition is thus eliminated when structuring the discussion by risks and their allocations.

Second, the approach avoids the danger of an unproductive argument about the exact meaning of different PPP models, but rather focuses on issues of concern – risk identification and risk allocation between the public and private sectors. Third, it is recognised that a number of recent PPP models are hybrids (e.g., rehabilitate-operate-transfer, refurbish-operate-transfer, transfer-operate-transfer, etc), which are associated with various risk factors.

Finally, this thesis is based on the assumption that, to a large extent, water PPPs would be successful if the direct participants understand the risk issues of the sector on their own merit. The established risk register (Tables 6.1 and 8.1) therefore serves as a useful guide for governments and private operators in, or planning to enter into, water partnerships.

While the thesis is primarily organised around risk factors rather than models for engaging the private sector, it admits that more risks are associated with certain models than others and that some risk factors may not apply to certain models. For example, design and construction risks are irrelevant to a typical management contract.

1.8 STRUCTURE OF THESIS

Chapter 1 introduces the overall research study and explains the key terms used in the thesis. The chapter outlines the aim and objectives of the study, and defines the scope of the research and specifies its approach and methodology.

Chapter 2 explains the methodology and research methods adopted in this research. These methods are grouped into data acquisition, statistical analysis and modelling methods, with each method explained in detail.

Chapter 3 is mainly restricted to Ghana. The chapter explores Ghana‘s PPP evolution and experience in applying PPP to water supply projects. Specifically, the chapter presents a brief general data of Ghana, reviews the key drivers for adopting PPP and emerging trends in PPP practice, and identifies success factors for project implementation, by investigating project cases.

Chapter 4 explains the key characteristics of the water sector, its risk environment and PPP models in the water industry which is helpful in understanding risk factors and risk allocation in the context of water supply projects. It describes the value chain of the water sector and explains why it is unique and differs from other service and infrastructure sectors of any economy. It also discusses trends of water PPPs in both developing and developed worlds.

Chapter 5 explains the risk management process (RMP) in the context of PPPs. It explains risk and risk allocation, significance, principles and limitations of risk allocation, how to achieve risk allocation and defines risk allocation in the context of this study. It also reviews empirical studies on risk assessment and risk allocation modelling to establish knowledge gaps in existing literature.

Chapter 6 presents a framework for identifying and categorising PPP water supply project risks, beginning with a comprehensive extant literature review. Forty risk factors under 10 categories are summarised and defined in detail. This is necessary to understand risks and tackle their appropriate assessment and allocation.

Chapters 7, 8 and 9 present primary research from Delphi questionnaire survey analysis and modelling. Chapter 7 presents ranked CSFs using mean score ranking and a CSF model based on factor analysis and fuzzy set approach.

Chapter 8 presents ranked critical risk factors in PPP water supply projects and a fuzzy risk assessment model, according to the industry experts‘ professional knowledge and experience, and fuzzy set approach.

Chapter 9 introduces a fuzzy risk allocation decision model. The model is based on the top-ranked risk factors from Chapter 8, risk allocation criteria and fuzzy set approach. The high risk factors are allocated between the government and the private sector. Validation of this research study is also presented in this chapter.

Chapter 10 concludes the thesis. It presents a review of the research objectives and conclusions, value and significance of the thesis, limitations, and recommendations for future research.

Following on this Introduction, the next chapter explains the research methodology for the study.

Chapter 2: Research Methodology

The methodology section is a description of the methodological approach(es) taken and an explanation of why this was chosen. It often includes: a general introduction restating the central aims, the details of any part of the methodology that may be unfamiliar to the readers, an explanation of how the results will be analysed, and an explanation of any limitations with the methodology

This chapter, which reviews relevant literature when describing research methodology, is very effective partly because the writer includes the following:

Structure

Introduction	Section 2.1
Data acquisition	Section 2.3
Survey design	Section 2.4
Statistical analysis	Section 2.5
Modelling method	Section 2.6
Summary	Section 2.8

Content

- Begins by linking to the previous chapter and highlighting the aims and scope (e.g. Section 2.1, paragraph 1, sentence 1)
- Gives an outline of the chapter (e.g. Section 2.1, paragraph 1, sentence 2-3)
- Gives general background to methodologies used in the field (e.g. Section 2.1, paragraph 2)
- Outlines the important criteria for selecting the case study (e.g. Section 2.3.2 paragraph 2)
- Justifies the selection of survey method (e.g. Section 2.3.4, paragraph 1 and 2)
- Describes the limitations of the method (e.g. Section 2.3.4 paragraph 5)
- Highlights the important criteria when developing the survey method (e.g. Section 2.3.4 paragraph 3)

- Cites research to give credibility to the methodological choices taken (e.g. Section 2.3.4.3, paragraph 5, point 6 and Section 2.3.4.4, paragraph 1, sentence 1).)
- Presents and numbers equations in the correct format (e.g. Section 2.5.1, Eq. 2.1)
- Cites research relevant to the methodological choices and rationalizes them, (e.g. 2.3.4 Delphi survey, 2.4.2 Questionnaire research, 2.5 statistical methods etc)
- Justifies the choice of the modelling method (e.g. Section 2.6, paragraph 2).
- Clearly outlines the relevance of and the rationale for each of the selected research methods
- Provides a succinct yet comprehensive chapter summary (e.g. Section 2.8)

<u>Language</u>

- Uses past simple tense and passive voice when describing methodology e.g. *was identified through,* Section 2.3.3 paragraph 1, sentence 1)
- Uses the same grammatical structure for the first word when listing (e.g. Section 2.3.4.1, paragraph 3)
- Uses a summary sentence with longer paragraphs to sum up the main idea of the paragraph (e.g. Section 2.3.4.1, paragraph 5, final sentence)
- Uses clear topic sentences for longer paragraphs (e.g. Section 2.6, paragraph 2, sentence 1)
  Leads to the next chapter with a final linking sentence (e.g. Section 2.8, final sentence)

<u>To consider</u>

In general, this chapter is effective. However, it could be improved in the following aspects.

Avoid too many numbered subsections, e.g. *2.3.4.1* is too detailed to help the reader navigate the thesis, many writers limit subsection numbering to three digits.

Avoid starting sentences with *obviously* because it is too strong. It is better to write 'It seems that' or, 'It appears that', or, write nothing (Section 2.3.4.3, paragraph 1, final sentence).

Avoid using colloquial expressions, e.g. 'hotly contested' (Section 2.3.2, Paragraph 3, sentence 4).

CHAPTER 2 RESEARCH METHODOLOGY

2.1 INTRODUCTION

Chapter 1 introduces the research study and outlines its aim, objectives and scope. This chapter deals with the methodology and consists of two parts. The first part describes the research methodology adopted for this study by expanding on Fig. 1.1. This part is subdivided into data acquisition methods, statistical analysis methods and modelling method. The second part presents the expert respondents' background information from the Delphi questionnaire survey. For meaningful outcomes and contribution to knowledge and practice, a construction research must apply rigorous and appropriate research methodologies and methods (Walker, 1997), and where appropriate, draw on professional and expert knowledge of practitioners (Abowitz and Toole, 2010).

In construction project risk management research, many researchers have utilised different kinds of research methods to investigate risks in PPP projects. These methods include: (a) literature review, (b) case study, (c) questionnaire survey, (d) interviews, and (e) Delphi questionnaire survey (Ameyaw and Chan, 2013a; Ke et al., 2010b; Ng and Loosemore, 2007; Cheung and Chan, 2011; Zeng et al., 2007; Choi et al., 2010; Xu et al., 2011; Shen et al., 2006).

Delphi questionnaire survey is adopted as the primary data acquisition tool for this study, and supported by other research methods. Together, the adopted tools are used to investigate the success factors, risk factors and risk allocation in PPP projects. Details of the Delphi questionnaire are described in section 2.4. The obtained data is analysed by the Statistical Package for Social Science (SPSS 21.0), where the results are expressed in mean value ranking, and critical success factors and risk factors are grouped into a few meaningful principal factors using factor analysis model and theory, respectively. Development of the success evaluation, risk assessment and risk allocation decision models is performed by fuzzy synthetic evaluation method.

2.2 RESEARCH METHODS FOR THIS STUDY

Table 2.1 shows the objectives of the study with the corresponding methods for achieving them. These methods are divided into two: data acquisition methods (literature review, case study, questionnaire survey; interview, and Delphi survey); and data analysis methods (factor analysis, mean score ranking, and fuzzy synthetic evaluation).

2.3 DATA ACQUISITION METHODS

The choice of research methods is influenced by consideration of desired scope and depth (Fellows and Liu, 2005). Case study is a deep study, questionnaire survey is a broad study, and interview lies between case study and questionnaire survey with respect to depth and breadth. And literature survey also gives insights into existing knowledge and practices, and points to gaps. Because this research explores PPP risk management practice in water projects, the combination of these research methods are deemed suitable.

2.3.1 Comprehensive Literature Review

Literature review consolidates related previous studies by other researchers/authors (Chow, 2005). The study began with a comprehensive review of pertinent materials from professional journals, conference papers, text books, refereed publications, published and unpublished research reports, doctoral theses and internet information to capture current,

Table 2.1 Methods to achieve research objectives

Research Objectives	Research Methods						
	Data acquisition				Data analysis		
	Comprehensive literature review	Case study	Questionnaire survey	Delphi survey technique	MS* ranking technique	Factor analysis	Fuzzy synthetic evaluation
1 To investigate the water sector‘s characteristics and risk environment, and PPP models and trends within the water industry	✓						
2 To investigate PPP drivers, practice and experience in the water industry of Ghana	✓	✓					
3 To identify and evaluate critical success factors (CSFs) for PPP water projects, and to model the impact of the CSFs on successful implementation of PPP project success in Ghana	✓	✓	✓	✓	✓	✓	✓
4 To identify and evaluate PPP water supply project risk factors, and to develop a risk assessment model (RAM) for PPP water projects	✓	✓	✓	✓	✓		✓
5 To determine the most important risk allocation criteria (RAC) in PPP	✓			✓	✓		
6 To develop a quantitative risk allocation decision-making model (QRADM) for PPP water supply projects					✓		✓

* MS = Mean score

relevant background knowledge about water PPPs and inherent risk factors. It is worth noting that apart from academic literature, the review also focused on institutional literature, because PPP promotion in the water sector at the global level has been seen by development institutions (such as the World Bank group, OECD, ADB, AfDB, BPD, etc) as a means to ensure successful projects implementation by presenting best practices and sector reform strategies.

The objective of the review of extant literature is to: develop a framework for the study; investigate PPP models within the water industry; trace the evolution, experience and trends of PPPs in the Ghanaian water sector; identify critical success factors for water PPPs in Ghana; identify relevant risk factors associated with PPP water supply projects; and to prepare for the Delphi questionnaire survey.

Broadly, the literature review has three parts. Part one (Chapter 3) reflected country context and PPP experience in Ghana, and provided an in-depth understanding of PPP application and status in the local water industry. The material comprised past studies of the urban water sector (e.g., Whitfield, 2006; Nyarko, 2007; Fuest and Haffner, 2007; Bohman, 2010; AVRL, 2010; Ameyaw and Chan, 2012; Hirvi, 2012; etc) and policy documents such as the National Water Policy. Part two (Chapter 4) explores the water sector and PPP practice with the objective to providing a shared understanding of the water sector, its value chain and unique characteristics and current PPP status at the global level. Parts one and two set the foundation for the overall study. Part three (Chapters 5 and 6) reviewed risk management and allocation issues in PPP with emphasis on water supply projects. Both chapters provide an understanding of risk factors affecting water supply projects.

2.3.2 Case Study

PPP experience, success factors and risk-induced factors in PPP projects could be context- and sector-specific in nature, heavily influenced by country conditions and sector characteristics. Case study is a well-established research approach where the focus is on a live case (Tahir, 2007; Baxter and Jack, 2008; Yin, 2003), and it is also an effective approach to study PPP applications to capture relevant project features (Gomm et al., 2000). Case studies are carried out in this study to:

i. identify risk factors associated with PPP projects in Ghana (reported in Ameyaw and Chan, 2013a).
ii. trace emerging PPP trends in the local water sector (section 3.5, and reported in Ameyaw and Chan, 2013b; Ameyaw and Chan, 2014).
iii. explore local PPP practice/experience and to draw out lessons (section 3.6).
iv. subjectively identify perceived critical success factors for Ghana's PPP water supply projects (section 3.7.2).

A summary of these cases is provided in Table 3.2. The project cases are a mix of both failed and successful, and urban and small-town water supply projects. These projects, to a large extent, represent the practice of PPP in the water sector of Ghana, as they are selected from different geographical regions of the country. The choice of a case study is based on at least one of the following criteria:

1. It had to be a water supply PPP project of any model or contractual arrangement;
2. It must have been attempted, or implemented and operational for a year or more. It is possible to filter the relevant risks based on this criterion; and
3. Information regarding the project's nature and contractual structure is readily available.

Each of the six case studies satisfied at least one or all of the above-mentioned selection criteria. Collection of evidence for the six case studies was achieved by reviewing the reports and documentation (Baxter and Jack, 2008) obtained from the urban water company, the sector ministry, the domestic private operators of the small-town water systems and general projects‗ literature (Akabang, 2010; Public Private Infrastructure Advisory Facility, 2011; Tuffour, 2010; Adinyira, 2008). Cases 1, 3, 5 and 6 have been reported in detail elsewhere as part of the overall study. Case 1 (see section 3.6.1), been hotly contested from 1999 to 2002, was cancelled. Case 2 (see section 3.6.2) was implemented from 2006 to 2011 under the management of Aqua Vitens Rand Ltd.

The case study research method described above contributed partly or fully to achieving some of the study objectives, as illustrated in Table 2.1. Findings from the selected case projects will enable the verification of findings from other sources of data adopted for this study (Cheung, 2009).

2.3.3 Questionnaire Survey and Personal Interviews

A preliminary list of over 50 risk factors was identified through literature review and case study methods. The factor list was further reviewed, filtered and refined through email-based questionnaire survey with two selected international industry practitioners and academics with experience in PPP procurement. Selection of these ‗experts‗ was based on their knowledge and experience, evidenced by recent research and publications (e.g., Wibowo and Mohammed, 2010; Wibowo et al., 2012; Wibowo and Bernd, 2005; Xenidis and Angelides, 2005a, b) in this subject area, and availability and willingness to respond to the survey. Against this background, two industry and academic respondents were enough to vet the comprehensiveness and relevance of the initial risk-factor list. The approach facilitates the addition of, if any, unidentified relevant factor(s). Following this, one of the experts suggested *"refinancing and land acquisition risks"*. This led to a final list of 40 risk factors which was formulated into questionnaire for the Delphi survey. Email is a ―push" technology that permits a researcher to directly communicate with target respondents (Andrew et al., 2003), irrespective of geographical location. Thus, it is convenient and ensures anonymity of respondents.

On the CSFs, the initial factor list following case study analysis and literature review was further screened by an international water PPP expert working in Ghana through a personal interview. Again, the selection of this expert respondent was informed by his direct involvement in both international and local PPP water infrastructure projects. He is currently the project manager for a 25-year BOOT water supply project in Ghana. The expert suggested *"strong and competent public partner"*, giving a list of 14 CSFs for water PPPs that were used in the Delphi questionnaire survey.

2.3.4 Delphi Survey Method

The Delphi survey is one of the most frequently used methods of empirical data collection in exploratory and evaluation construction management research (Hallowell and Gambatese, 2010; Hon et al., 2011). It is widely adopted in many complex areas where consensus building or convergence of opinion on a practical subject is required (Chan et al., 2001), by using a series of questionnaires delivered by means of multiple iterations to gather data from a panel of selected experts without any biases (Young and Jamieson, 2001; Hsu and Sandford, 2007; Chan et al., 2001; Yeung et al., 2007).

At PhD level, many objectives have been achieved through Delphi questionnaire survey, including: construction safety and health risk management (Hallowell, 2008); partnering performance index for construction projects (Yeung, 2007); etc. It has been successfully applied in several journal papers to explore topics across disciplines, including construction management: selection of procurement systems (Chan et al., 2001); sustainable construction (Manoliadis et al., 2006); PPP project risk allocation (Ke et al., 2010b; Xu et al., 2010); PPP project risk assessment (Yeung et al., 2010); and vulnerability assessment of water services (Moglia et al., 2009).

Therefore, Delphi method is adopted as the main data acquisition tool for obtaining unbiased views of industry experts on success factors, risk assessment and risk allocation in PPP water supply projects, through a number of rounds interspersed with group opinion and controlled feedback – in the form of statistical data – and with results of previous rounds being fed into the next round (Linstone and Turoff, 1975).

Delphi has several advantages over alternative methods, such as staticised groups, interacting (focus) groups, and nominal group technique (NGT, or estimate-talk-estimate or brainstorming NGT). The Delphi process can be continuously iterated till consensus is reached, and is best suited in the subject areas where adequate historical data for the application of other methods is lacking (Martino, 1973). In the context of this study, there is lack of quality, sufficient data because PPP in water development practice in Ghana is infant (Fuest and Haffner, 2007), hence, the suitability of this tool. In addition, the features of Delphi method ensure reduced biasing effects of dominant individuals, irrelevant communications and group pressure towards conformity (Yeung et al., 2010), and confidentiality (i.e., anonymity of participants) is aided by geographic distribution of the participants and the use of e-mails to solicit and exchange information amongst panelists. Following multiple iterations, Delphi panelists become more problem-solving oriented, thereby offering their views more insightfully (Hsu and Sandford, 2007). The method is also chosen due to the flexibility of using a variety of statistical analysis techniques to analyse and interpret the collected data objectively and without bias (Dickey and Watts, 1978; Hsu and Sandford, 2007; Ludwig, 1994). These merits make Delphi an appropriate empirical data collection tool for the current study.

However, Delphi method has limitations. The most significant are the difficulties of (i) identifying a sizeable number of industry experts and (ii) achieving and maintaining a high level of response, and in reaching a consensus (Robinson, 1991; Hsu and Sandford, 2007). These challenges were encountered and dealt with through strategic approaches (section 2.3.4.3).

Underlying issues in conducting a Delphi survey include: (1) expert panelists and their requirements; (2) number of Delphi panelists; (3) iterative process (desired number and format of rounds, and response and attrition rates); and (4) controlled and anonymous feedback and measures of consensus (Manoliadis et al., 2006; Ameyaw et al., forthcoming).

2.3.4.1 Expert panelists and their requirements

Delphi panelists must be carefully and objectively identified and selected, because the validity of the study (Hsu and Sandford, 2007; Yeung et al., 2010) and the quality of the results produced are directly related to the selection process (Judd, 1972; Jacobs, 1996). The selection of Delphi panel of experts is generally determined by the disciplinary areas of expertise required by the particular topic under study. Individuals qualify as Delphi panelists if they have related backgrounds and experience concerning the target subject, and are prepared to review their preceding decisions in order to achieve consensus (Hsu and Sandford, 2007).

The expert selection criteria for this study reflected the fact that PPP is new and emerging in Ghana, and therefore, identifying experts with adequate expertise and knowledge to respond to the survey was challenging. Two approaches were adopted. A purposive sampling was adopted to generate a list of industry experts. Official invitation letters requesting industry support were sent beforehand to targeted public and private institutions with interests and involvement in water supply projects (indicated below). They were asked to nominate qualified practitioners (within and outside their organisations) based on predefined criteria emphasized in the letter. This approach produced an initial list of senior practitioners.

The second step entailed a semi-snowballing approach by opportunistically asking identified practitioners to suggest potential participants (Moglia et al., 2009). Potential participants suggested by their fellow participants willingly accepted to contribute to the research. The identified experts were further qualified as ―experts” fit for the study, according to their roles in their respective institutions and based on predefined criteria:

1. Having extensive working experience from the local water industry, with a good knowledge of water sector risks;
2. Having recent hands-on experience in at least one PPP water supply project; and
3. Having expertise and in-depth knowledge of the concepts of PPP risks.

Thus, the final list of participants was based on access and willingness to participate. To solicit valuable experts‘ opinions, only personnel meeting above criteria were invited to participate in the survey. The expert panel was formed by recruiting practitioners with many years (a minimum of five years) of relevant industry experience. Senior industry advisors, top management decision-makers and professional staff who are either familiar with PPP procurement process or the direction for the PPP agenda being pursued by the government were targeted.

There was a deliberate effort to ensure an appropriate representation (Robinson, 1991; Powell, 2003) from private and state institutions from different backgrounds and levels of expertise. As shown in Table 2.4, the experts were mainly drawn from Ghana Water Company Limited (GWCL) – water supply services provider for urban Ghana; Public Utilities Regulatory Commission (PURC) – economic regulator for water and electricity; Ghana Urban Water Limited (GUWL) – manager of GWCL; PPP Advisory Unit (PAU); Public Procurement Authority (PPA) – responsible for public procurement; and private sector (private water developers and consulting firms; e.g., Hydrocol Ghana Ltd., Denys B.V., WaterTech (Ghana) Ltd., Maple Consult, WaterAid-Ghana, Safewater Network, etc). For detailed information on these institutions, readers are referred to the inventory of sector institutions by Fuest et al. (2010). These institutions are a mix of public, private and international sectors from which diverse experts were selected. Three broad classifications are provided per the respondents' roles or positions in their orgainsations: directors, managers (e.g., business planning managers, water production and distribution managers, projects and contracts managers, customer care managers, water managers), and project/financial analysts and consultants (Table 2.4). All the participants hold senior-level positions in their respective organisations. This rich background, experience and relevant organisations of the experts guarantee the reliability of their feedbacks for this study. Therefore, it is believed that the number of experts used in the Delphi survey constituted a representative pooling of judgments.

2.3.4.2 Number of Delphi panelists

The literature is inconclusive on the optimal size of a Delphi panel. Literature outside construction management (CM) also supports this evidence. For example, Reid (1998) cited in Powell (2003) observed panel sizes between 10 and 1,685 in the nursing and allied health fields. Drawing on relevant literature, Rowe and Wright (1999) also noted panel sizes ranging from three to 80. A review of 20 publications from two top-ranked CM journals (see Appendix 4) showed wide variation in sizes of Delphi panels. Panel sizes in the 20 peer-reviewed CM studies ranged between four and 34. In a recent review, Ameyaw et al. (forthcoming) also observed panel sizes between three and 93 in CM studies. While Hallowell and Gambatese (2010) suggested a minimum of eight panelists for construction-related Delphi studies, Adler and Ziglio (1996) also recommended 10–15 homogenous experts on a Delphi panel as reflected in Rajendran and Gambatese (2009).

Variations in numbers of Delphi participants, however result from several factors, including; the scope or nature of the problem under investigation, number of available experts, capability of the researcher/facilitator, preferred geographical representation of the researcher, and available resources (time and money) (Hasson et al., 2000; Manoliadis et al., 2006; Fink et al., 1991; Chan et al., 2001; Delbecq et al., 1975; Hallowell and Gambatese, 2010; Powell, 2003).

A minimally sufficient number of panelists should be used (Hsu and Sandford, 2007). It should be noted that each theme (or part) of the questionnaire recorded a different number of experts, ranging from 37 (Part 3, Question 1), 40 (Part 3, Question 2 A&B), 39 (Part 3, Question 2C) to 41 (Part 4), as shown in Table 2.4. A total of 53 experts participated in round one. During the analysis, responses of participants who did not meet the selection criteria were excluded and were not invited in subsequent rounds. Thirty-seven to forty-one experts participated in the first two rounds of the survey. A panel of 37–41 practitioners is large enough to guarantee diversity of views and small enough to enable experts to handle feedback with ease (Schmidt et al., 2001).

The third and final round is treated separate and drew on 10 experts selected from the panelists (see Chapter 9 and Table 9.4).

2.3.4.3 Number of rounds, response and attrition rates and survey format

The number of rounds in a Delphi study aims at (i) reaching convergence (consensus) amongst panelists by minimising variance in their responses and (ii) improving accuracy (precision) through controlled and anonymous feedback and iterative process (Hallowell and Gambatese, 2010). The number of rounds in Delphi method is determined by the desired degree of consensus sought by the researcher (Hsu and Sandford, 2007) and ranges between two and seven (Rowe and Wright, 1999; Adnan and Morledge, 2003; Ameyaw et al., forthcoming), but two to three rounds are preferred, as reflected in most construction research studies (Appendix 4). Three rounds are used in this study, which has the merits of reducing fatigue and optimising response rate among participants and allowing for both feedback and revision of original scores (Hon et al., 2011). Obviously, too many rounds would waste panelists' time, and stopping prematurely could yield less valuable results (Schmidt, 1997).

In Round 1, based on seven-point grading systems in Table 2.2, the panelists were requested to rank the risk allocation criteria based on their importance, rank the risk factors according to their likelihood of occurrence and severity, and rank the critical success factors according to their importance, as shown in Appendix 1. In Round 2, the panelists were provided with consolidated results from Round 1, and further requested to reconsider their original ratings, if deemed necessary. Appendix 2 also illustrates the format of the Delphi questionnaire for Round 2.

In round three, the selected experts (Table 9.4) were asked to evaluate the set of critical risk factors against a set of risk allocation criteria (determined in rounds one and two) based on a five-point measurement scale (Table 2.2 and Appendix 3). This scale offered the expert respondents the ability to grade their responses with respect to the private or public sector‘s capability to manage a set of critical risk factors, thus enhancing the ability to quantify the risk allocation proportions between the public and private parties to a PPP project. Similar studies (e.g., Lam et al., 2007; Xu et al., 2010; Cheung and Chan, 2011) adopted a five-point Likert scale to determine risk allocation between the public and private sectors.

Thus, both rating systems (seven-point and five-point) are then given the characteristic of an interval scale, which renders the respondents‘ feedback suitable for different statistical analyses (Odeyinka et al., 2012), such as mean analysis, in order to arrive at meaningful outcomes.

In order to achieve and maintain a high response and minimize attrition rates, several steps were taken from drafting to administration of the questionnaire:

1. After identifying and qualifying potential experts, the *qualified* experts have been informed of the study requirements (including time commitments) and were provided with a basic set of background information. The context, scope and benefits of the study and all risk factors (including technical terminology) are explained in the background information.

2. Written communication with the selected experts has been simple, clear and without ambiguity. Clear and simple communication potentially ensures high response and low attrition rates (Moglia et al., 2009; Somerville, 2007).
3. Some selected experts have been kept in regular contact. They are updated with the progress of the PhD research and seeking their views on other relevant areas through ‗informal' ways.
4. The survey questionnaires are designed to be simple and straightforward, making them easy to complete. The length of the questionnaire is reasonable in order to facilitate timely response and to ensure a good response rate (McCampbell and Stewart, 1992; Hallowell and Gambatese, 2010).
5. Statistical feedback (mean values and Kendall's coefficient of concordance) of round one and questionnaire for subsequent rounds were provided within the shortest possible time in order to sustain the interest of the participants.
6. A 2-week period deadline (Delbecq et al., 1975) was set for the participants within which to respond to the questionnaires.
7. There were systematic follow-ups and reminders through phone calls, emails and personal visits to non-respondents, which were initiated within two days after the deadline for a given round. The Delphi literature has shown that a systematic follow-up contact to non-respondents is an effective approach to ensure a high response rate (Somerville, 2007; Yeung et al., 2007; Chan et al., 2001).
8. A pilot study with three academics with Delphi survey and PPP experience was conducted prior to the main study (i.e., before sending out the questionnaire for round one) to assess the appropriateness of the questionnaire, with respect to clarity, logical sequence and length (see section 2.4.2).

2.3.4.4 Controlled and anonymous feedback and measures of consensus

According to Rowe and Wright (1999, pg. 370) feedback ―is the means by which information is passed between panelists so that individual judgment is improved and debiasing may occur". Thus, individual experts are fed with the responses of the anonymous panelists. However, without the iterative and feedback processes, the process is not a ‗Delphi' (Hallowell and Gambatese, 2010). Statistical feedbacks between the rounds were statistical mean and Kendall's *W* values.

In the CM literature, the common statistical measures of consensus include Kendall's *W* (see Xia et al., 2013; Xu et al., 2010; Chan et al., 2001; Yeung et al., 2007). This study adopted the Kendall's *W* to measure agreement among the participants (see section 2.5.3).

2.4 DELPHI SURVEY OBJECTIVES

As indicated earlier, a Delphi survey was adopted as the primary data collection tool. However, rather than using a single approach, a mix approach was adopted to deal with the difficulties of conducting a Delphi survey in a challenging environment like Ghana. Surveys through self-administered, email-based and personal interviews were adopted, depending on the location and preference of an expert respondent. Each method has its merits: for example, personal interviews ensure a two-way communication with the expert respondents with the merit of sorting out possible problems associated with clarity of questions (Cooper and Schindler, 2006) and allowing the panelists to share information on the success factors, risk factors and RAC, while email-based Delphi survey saves time and money and ensures anonymity while providing access to many expert respondents. Because Delphi questionnaire survey extracts factual information and draws on the professional and experiential knowledge of the experts, the main objectives of the survey are:

- ✧ To establish the important risk allocation criteria for PPP procurement.
- ✧ To identify the critical risk factors on PPP water supply projects.
- ✧ To investigate the risk allocation of corresponding critical risk factors in PPP water projects.
- ✧ To determine the critical success factors for PPP water projects in Ghana.

This study is exploratory and was not conducted with reference to any specific water supply project in Ghana; therefore, estimations were based on professional and experiential knowledge of the industry experts. The current study explores the domain of epistemic approach to risk (Charette, 1989) or objective risk (Winch, 2010) which allows industry experts to provide useful views based on their individual experiential knowledge.

2.4.1 Questionnaire Design

2.4.1.1 Structure of questionnaire

The questionnaire covered the following areas:

1. Important risk allocation criteria (principles)
2. Probability of risk occurrence and risk severity
3. Risk allocation
4. Critical factors for successful water PPP implementation

The round one questionnaire has four parts as shown in Appendix 1:

Part One: Defines 40 risk factors to guide the experts' judgments regarding risk probability, risk severity, and risk allocation in Question 2 of Part Three.

Part Two: Solicits experts' background information, including personnel designation, sector category, relevant industry experience, PPP experience, number and type of PPP of projects they have participated, and whether they have been involved in PPP training programmes.

Part Three: Deals with risk allocation criteria, risk assessment and risk allocation under two questions. Question 1 – requests experts to indicate the importance of risk allocation criteria based on a seven-point grading system. Question 2 – asks experts to indicate (a) probability, (b) severity, and (c) preferred allocation of each risk factor. It is worth noting here that the obtained data on ‗preferred risk allocation' of the risk factors is not reported in this thesis, because it is outside the scope of the thesis.

Part Four: Asked experts to rank the importance of critical success factors for water supply PPPs, based on a seven-point grading system.

2.4.1.2 Ranking scales

The ranking scales for assessing the variables in the questionnaire are based on a seven-point grading system (Table 2.2). A seven-point system has the merits of (i) rendering the resulting data suitable for different statistical analyses and (ii) alleviating

Table 2.2 Rating systems for Delphi questionnaire survey

	Criticality/importance of variables:			
Rating score	Risk allocation criteria	Risk probability and severity	Risk allocation	Critical success factors
1	Not important	Extremely low	Very low ability	Not important
2	Very low importance	Very low	Low ability	Very low importance
3	Low importance	Low	Moderate ability	Low importance
4	Moderate	Moderate	High ability	Moderate
5	Important	High	Very high ability	Important
6	Very important	Very high	-	Very important
7	Extremely important	Extremely high	-	Extremely important

leniency and central tendency problems associated with ordinal scales (Chan and Tam, 2000; Cronbach, 1951). It has been used in similar construction management studies (e.g., Seyed et al., 2010; Chan and Tam, 2000; Yeung et al, 2010).

2.4.2 Expert Review of Questionnaire

As reported earlier, before sending out the questionnaire to the expert panelists, the questionnaire was sent to three academics active in PPP research and Delphi method application. They were selected based on their recent publications in this area (e.g., Adinyira et al., 2010; Sohail and Cavill, 2008) and successful application of Delphi in their studies. The academics included one professor and two PhD holders who were requested to assess the appropriateness of the questionnaire with respect to relevance of the factors (i.e., risk allocation criteria, risk factors and success factors), clarity of instructions and definitions, complexity, structure and length of questionnaire. Some suggested changes were made to the final draft questionnaire as advised by the academics.

2.5 STATISTICAL ANALYSIS METHODS

Statistical analyses were conducted on the resulting data from the Delphi questionnaire survey, mainly mean score ranking (MS), risk significance (or expected value, EV), Kendall‘s coefficient of concordance (*W*) and factor analysis (FA) using the Statistic Package for Social Science (SPSS) 21.0. These statistical measures are briefly discussed.

2.5.1 Mean score (MS) ranking

Mean score ranking method has been widely applied in construction management research to determine the significance of factors or variables, including causes of delay in building construction in Hong Kong (Chan and Kumaraswamy, 1996); PPP framework development (Cheung, 2009) and risk ranking and allocation in PPP projects (Roumboutsos and Anagnostopoulos, 2008; Cheung and Chan, 2011). These authors used MS to conduct evaluation from their survey results. Therefore, MS is adopted to determine the relative ranking (significance) of the factors/variables from the survey results using the measurement scales (Table 2.2). MS is determined by:

$$MS = \frac{7n_7 + 6n_6 + 5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{N} \qquad (2.1)$$

where MS = mean score of a variable; n = score given by respondents based on a seven-point scale from one to seven; and N = number of respondents that rated the variable.

2.5.2 Risk Significance Index (Expected Value)

Many risk management researchers view risk as the probability that a risk factor (e.g., cost overrun, completion delay or poor technical performance) occurs combined with its severity to impact on the project. With this notion, project risk is quantified as a joint function of probability of occurrence and severity, which can be measured by

$$\text{Risk} = f(\text{probability, severity}) \qquad (2.2)$$

$$\text{Risk impact} = (\text{probability} \times \text{severity})^{0.5} \qquad (2.3)$$

As discussed in the literature review section of this thesis, this approach to risk quantification is well-established in decision theory and is termed expected value (Carter et al., 1994) or average risk estimate (Tweeds, 1996). The approach has been used in many studies (Chan et al., 2011; Roumboutsos and Anagnostopoulos, 2008; Shen et al., 2001). For example, Chan et al. (2011) used the technique to determine the significance of risk factors in PPP projects in China.

2.5.3 Kendall's Coefficient of Concordance (*W*)

The degree of consensus among the panelists is measured using the Kendall‗s *W* (Kendall and Gibbon, 1990). In this thesis, Kendall‗s *W* is used to ―make a realistic determination of whether any consensus has been reached, whether the consensus is increasing, and the relative strength of consensus" (Schmidt, 1997, pg. 765), regarding the ranking of factors. *W* measures the current consensus among the panelists, and has gained popularity due to its simplicity of application and understanding. It ranges from 0 to 1, where a value close to 1 indicates strong consensus and vice versa. The formula is given as:

$$W = 12 \frac{\sum_{i=1}^{n} \left(R_i - R\right)^2}{p^2 \left(n^3 - n\right) - pT} \qquad (2.4)$$

where W = Kendall‗s coefficient of concordance; n = number of risk factors being ranked; R_i = ranks assigned to i^{th} risk factor; R = mean value of R_i values; p = number of respondents; and T = correction factor for the tied ranks.

2.5.4 Cronbach's Alpha Reliability Analysis

Cronbach‗s alpha model is among the common reliability coefficients. Cronbach‗s alpha reliability analysis is conducted to statistically examine whether the risk allocation criteria, the success factors and the risk factors in the Delphi questionnaire reflected the constructs they were intended to measure. It indicates the wider validity and applicability (Oyedele, 2013) of above factors from the literature review. Cronbach‗s alpha reliability is based on the average correlation of variables in a test and ranges between 0 and 1 (Li, 2003). An α-value of 1 denotes that a test is perfectly reliable while a value of 0 means a test is completely unreliable (Cronbach, 1951). SPSS (2003) recommends that an α-value must be greater than approximately 0.70 to indicate a good internal consistency or reliability. Using SPSS, the statistic can be computed by (Li, 2003):

$$\alpha = \frac{k\,\overline{\mathrm{cov}}/\overline{\mathrm{var}}}{1+(k-1)\overline{\mathrm{cov}}/\overline{\mathrm{var}}} \tag{2.5}$$

where k denotes the number of items in the scale; $\overline{\mathrm{cov}}$ refers to the average covariance between items; and $\overline{\mathrm{var}}$ refers to the average variance of the items. On the other hand, where the variables are standardized to have common variance, above formula is simplified as:

$$\alpha = \frac{k\bar{r}}{1+(k-1)\bar{r}} \tag{2.6}$$

where $\bar{r}$ denotes the average correlation between variables.

2.5.5 Factor analysis

Factors analysis (FA) is a powerful and frequently-used statistical technique in CM research. In recent times, the number of published papers of factor analysis in construction management research has grown significantly (Lingard and Rowlinson, 2006). FA is a collection of statistical techniques for reducing correlational data into a smaller number of dimensions or principal factors. Principal component factor analysis (PCFA) is more suited for data reduction purposes (Fabrigar et al., 1999). The basic assumption in PCFA is that underlying dimensions can be used to explain complex phenomena (Yeung et al., 2010; Chan et al., 2004). Thus, it is a useful tool for identifying a relatively small number of factors that can represent relationships among sets of several interrelated variables (Marija, 2003; Norusis, 1993).

In this research, PCFA is employed to identify the underlying cluster of critical success factors associated with PPP water supply projects. The main advantage of using PCFA is that the factors-solutions can be used for further advanced analysis. Steps in conducting FA are (Chan et al., 2004, pg. 192):

1. Establish the factors/variables (e.g., success factors) relevant to water PPPs through a robust method, such as questionnaire.
2. Compute the correlation matrix for all success factors.
3. Extract and rotate each success factor.
4. Interpret and label principal success factors as underlying factors or constructs.

Appropriateness of FA must be determined to proceed with the factor analysis, through important measures such as Kaiser–Meyer–Olken (KMO) and Bartlett‘s test of sphericity (Fox and Skitmore, 2007).

2.5.5.1 Kaiser–Meyer–Olken (KMO)

The KMO test is a measure of sampling adequacy regarding the partial correlation among the variables or distribution of the values for the application of factor analysis (Chan et al., 2011; George and Mallery, 1999). The value of KMO statistic varies between 0 and 1, in which a value below 0.5 suggests that the value of partial correlation among the attributes is large and therefore the technique would not be valid (Norusis, 1993). In construction management research, a KMO value of ≥0.5 is recommended (Norusis, 1993; George and Mallery, 1999).

2.5.5.2 Bartlett's test of sphericity

Bartlett's test of sphericity tests whether there is an identify matrix or not, and must be less than 0.05 (Oyedele, 2010). Thus, it indicates the existence of correlation among the variables; all diagonal and off-diagonal terms are 1 and 0, respectively.

The success of above tests relates to sample size. Hence, in CM research strong emphasis has been put on data and sample size (Lingard and Rowlinson, 2006).

2.5.5.3 Factor extraction and rotation procedures

As factor extraction seeks to establish factor-solutions, linear combination of the factors are formed. The first factor-solution accounts for the largest amount of variance in a sample and successive factor-solutions explain smaller portions of the variance. Factor rotation achieves a simple structure that is easily interpretable. In this study, varimax rotation is chosen because it produces a rotated component matrix that is easy to interpret (Akintoye et al., 2000) and is widely adopted in construction management research (Ahadzie et al., 2008; Chan, 2012; Chan et al., 2011; Oyedele, 2010). The eigenvalue is also adopted because it is a widely used cutoff criterion in construction management research and is the sum of the squared factor loadings of the variables, representing the amount of variance explained by a factor (Cheung et al., 2000). Hence, factors with eigenvalues above 1.0 are regarded significant.

2.6 MODELLING: FUZZY SYNTHETIC EVALUATION (FSE) METHOD

Fuzzy mathematics is a modern mathematics that is used to handle ill-defined and complex fuzzy phenomena, given that incomplete and vague data characterise real-world problems

(Singh and Tiong, 2005). Its theoretical basis is the fuzzy set theory which was first introduced by Zadeh (1965). A fuzzy set refers to a set with varying degree of membership which ranges in the closed interval between 0 and 1. The membership function values represent the degree to which an individual element belongs to the set. This means that an element may belong to a fuzzy set by a lesser or greater extent, indicated by a smaller or larger membership value (Singh and Tiong, 2005). Since its introduction, its content continues to be enriched and has been applied to practical problems (Wei et al., 2010). Fuzzy mathematics uses linguistic variables to model fuzziness inherent in human cognitive process, and the linguistic variables are not numbers but words in a natural language, such as high, low, moderate, that describe the fuzzy concept. Thus, fuzzy decision-making approach is characterised by membership functions, linguistic variables, computation of natural language, etc. Zadeh (1994) and Boussabaine (2014) noted that fuzzy concept provides a suitable tool for modelling decision-making processes and analysing complex systems when the pattern of indeterminacy is attributable to innate variability and/or vagueness.

Fuzzy synthetic evaluation (FSE) is among the most important research content in fuzzy environment and one of the most useful approaches to multi-criteria synthetic evaluation (Wei et al., 2010; Sadiq and Rodriquez, 2004). FSE is capable of classifying samples at a known centre of classification (Lu et al., 1999). It is a method for assessing multi-criteria decision-making (Xu et al., 2010), which are often uncertain and conflicting in nature (Sadiq et al., 2004). For example, in project management, decision-makers (e.g., project managers, engineers, regulators and stakeholders) often view project risk level in terms of linguistic variables, as very low, low, moderate, high, very high, etc (Boussabaine, 2014; Tah and Carr, 2000; Sadiq et al., 2004). FSE is known to be good at dealing effectively with such uncertain, vague and linguistic variables that can be used for approximate reasoning and subsequently manipulated for propagating the uncertainties throughout the decision process (Sadiq et al., 2004; Sadiq and Rodriquez, 2004). Given that project managers‘ decision-making process is associated with their expertise to deal with vague or fuzzy concepts that are frequently expressed in linguistic terms, FSE concept can aid project managers to arrive at reliable and practical decisions from uncertain and vague facts by representing them linguistically (Boussabaine, 2014). In addition, FSE concept is able to incorporate experts‘ knowledge, and also suitable for small sample (or panel) sizes (Sachs et al., 2007). For these advantages, FSE is adopted in this research study as discussed below.

FSE is increasingly used in scientific research and modelling for informed decisions. Examples include reservoir water quality modelling (Lu et al., 1999), health risk assessment (Sadiq and Rodriquez, 2004), risk-based decision-making for drilling waste discharges (Sadiq et al., 2004), human resources management (Hsu and Yang, 1999), construction project risk assessment (Zhao et al., 1997), risk assessment in drilling projects (Liu et al., 2013), and urban air quality assessment (Onkal-Engin et al., 2004).

There have been attempts to exploit FSE in the construction project risk management field. Yeung et al (2010) presented a model to assess the risk level of PPP tollroad projects in which expert knowledge based on linguistic variables were incorporated into the analysis using FSE. Gao and Jiang (2008) demonstrated a decision model for allocating construction project risks between the client and the contractor in which experiential knowledge of construction experts and linguistic principles were incorporated into the analysis by using FSE. Xu et al. (2010) described a model for risk allocation in PPP projects using FSE. The system, called fuzzy model, allocates risks between the direct public and private partners, and one risk variable is covered to enable detailed demonstration of the model. Liu et al. (2013) proposed a knowledge-based system for scientific drilling project risk assessment. Their approach is a method in which risk probability, severity, non-detectability and worsening factor are quantified using linguistic variables and FSE. Lo (1999) demonstrated a linguistic approach to fire safety risk assessment in buildings using FSE approach. Their study makes use of linguistic descriptions of risk probability and severity to help cater for vagueness and subjectivity. The authors argued that FSE has advantages in dealing with complex evaluation with multi-attributes and multi-levels. For example, project risk assessment entails a large number of critical risk factors (i.e., attributes) and critical risk groups (i.e., categories), which are often multi-layered, unclear, inaccurate and fuzzy in nature. And therefore, FSE is more practical in dealing with both subjectivity and multi-criteria.

In this thesis, the FSE method is used for critical success factor modelling (Chapter 7), risk assessment modelling (Chapter 8), and risk allocation decision modelling (Chapter 9). Specifically, it is applied to:

i. model the impact of CSFs on successful implementation of PPP water project success.
ii. assess the risk index (or level) of principal risk factors and overall risk level of PPP water supply projects.
iii. model the risk allocation decision-making between the government and the private sector entity.

2.6.1 FSE Procedure

FSE decision-making model involves the following steps (Wei et al., 2010: Xu et al., 2010; Liu et al., 2013):

1. Establish a set of basic criteria (or factors) $U = \{u_1,\ u_2,\ \ldots,\ u_m\}$ where $u_i = (i = 1,2,\ldots,m)$

represent the evaluation of the i^{th} factor;

2. Establish a set of grade alternatives, expressed in linguistic terms, for the factors $V = \{v_1,\ v_2,\ \ldots,\ v_n\}$ where $v_j = (j = 1,2,\ldots,n)$ is the evaluation grade j. Simply, the grade alternative is the adopted measurement scale. For example, in this study, the 7-point grades to evaluate the perceived success factors are (see Table 2.2): $v_1 =$ not important (NI), and $v_7 =$ extremely important (EI), for degree of importance of the success factors;
3. Establish a set of weightings by computing the weight vectors of the evaluation factors as: $W = \{w_1,\ w_2,\ \ldots,\ w_m\}$, where $w_i = (i = 1,2,\ldots,m)$ represents the weighting of an evaluation factor i and $(0 \le w_i \le 1)$;
4. Determine a fuzzy evaluation matrix $R = (r_{ij})_{m \times n}$ where r_{ij} expresses the extent to which the basic criterion (factor) u_i is satisfied by an alternative v_j in a fuzzy environment. The fuzzy function matrix R can be expressed as:

$$R = \begin{vmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{vmatrix}$$

5. Determine the final fuzzy evaluation by considering the weightings (step 3) and fuzzy evaluation matrix (step 4) through the following equation:

$$D = W \bullet R = (d_1,\ d_2,\ \ldots,\ d_n) \qquad (2.7)$$

where, D denotes the final evaluation matrix; W is the weighting vector; R is the fuzzy evaluation matrix; and $\bullet$ denotes the fuzzy composition operator.

2.6.2 Fuzzy Mathematical Functions

Successful application of the FSE method requires the choice of an appropriate function that adequately processes the contents (i.e., weightings and membership functions) of equation 2.7. There are four basic FSE functions (Lai and Hwang, 1994; Lo, 1999):

$$M(\wedge,\vee), b_j = \bigvee_{i=1}^{m}\left(w_i \wedge r_{ij}\right) \ \forall\, b_j \in B \tag{2.8}$$

$$M(\bullet,\vee)\, b_j = \bigvee_{i=1}^{n}\left(w_i \times r_{ij}\right) \ \forall\, b_j \in B \tag{2.9}$$

Lo (1999) stated that equations (2.8) and (2.9) are more suited for single-item problems, because they consider only major attributes while ignoring minor attributes. In project risk assessment, for example, because each attribute must have an effect on the overall risk level or index, both functions are inappropriate to process contents of Eq. (2.7).

$$M(\bullet,\oplus), b_j = \min\left(1, \sum_{i=1}^{m} w_i r_{ij}\right) \ \forall b_j \in B \tag{2.10}$$

$$M(\wedge,+), b_j = \sum_{i=1}^{m}\left(w_i \wedge r_{ij}\right) \ \forall\, b_j \in B \tag{2.11}$$

The min-operation in Eq. (2.11) ignores or misses some data with smaller weightings, thereby producing similar output as equations (2.8) and (2.9) (Lo, 1999).

Eq. (2.10) is most appropriate and adopted in this thesis, because it overcomes the weaknesses of the other three functions. It is suited when several attributes are considered and the difference in the weighting of each attribute is minimal (Lo, 1999). Suitability of Eq. (2.10) also lies in its ability to sum up ($\oplus$) the product of weighting and membership function of individual attributes. Application of Eq. (2.10) is demonstrated in chapters 7, 8 and 9. FSE application is flawed if inappropriate mathematical function is selected.

2.7 EXPERT RESPONDENTS' BACKGROUND/INFORMATION

The questionnaires were sent out to targeted public and private institutions and industry experts who were willing and able to contribute to the research. A reminder system comprising emails, telephone calls and personal visits were made to participants to encourage them to participate to the survey. The three-round Delphi questionnaire survey was conducted between 14 February and 10 July 2013. Given that 37 to 41 industry experts participated in the first two rounds, these sample sizes could be criticised as being small. They are, however, bigger than that of similar Delphi studies: 34 experts (Xu et al., 2010); 4 experts (Iyer and Sagheer, 2010); 11 experts (Rajendran and Gambatese, 2009); and a PhD study that used 31 experts (Yeung, 2007). The small sizes, however could be explained by the following key factors:

- ✧ PPP is budding in both public and private sectors, where few experienced practitioners are knowledgeable in PPP procurement and its risk management.
- ✧ This study is limited to water supply projects. Therefore, a qualified expert respondent must also be knowledgeable in the water industry and its associated risks.

Hence, as mentioned in section 2.3.4 and Table 2.4, each part of the questionnaire had a different number of valid responses. It must be stressed, however that these numbers were adequate for subsequent statistical analyses.

2.7.1 Expert Respondents' Designation and Orgainsations

Information on the industry experts are presented in tables 2.3 and 2.4. The experts' institutions, positions, relevant industry experience, and PPP experience are indicated to provide a context for the robustness of the analyses and results reported in relevant chapters of this thesis. Table 2.3 shows both industry and PPP experience of the respondents with average (mean) years of 13.054 and 4.162, respectively. Also, 68.3% have been involved in various PPP training programmes.

Table 2.3 Background of Experts

Respondent Profiles	Categorisation	Count	Percentage (%)
Type of organisation	Public organisations	29	70.7
	Private organisations	10	24.4
	Mix (of above)	2	4.9
Number of years of industrial experience	Up to 5 years	12	29.3
	6 – 10 years	7	17.1
	11 – 15 years	9	22.0
	More than 15 years	13	31.7
Number of years of PPP research/ experience	Up to 5 years	29	70.7
	6 – 10 years	5	12.2
	11 – 15 years	7	17.1
Number of PPP projects participated	Less than 3 projects	26	63.4
	3 – 5 projects	11	26.8
	Above 5 projects	4	9.8
Type of PPP projects participated	Lease/affermage	0	0.0
	Concessions/BOT-type	16	39.0
	Management contract	11	26.8
	Mix (of above)	14	41.1
Mean years of industrial experience		13.054	
Mean years of PPP experience		4.162	
Mean number of projects participated		2.081	
Number of participants with PPP training			68.3
Number of participants without PPP training			31.7

Table 2.4 also presents the organisations and current positions of the expert participants. It further shows the number of experts who completed the respective parts of the questionnaire. They are directors, managers or consultants/PPP analysts in their organisations with many years of experience. The institutions represent a spectrum of key institutions with direct involvement in water infrastructure services in Ghana. A careful

examination of the organisations show that they cut across public water utilities (public client), sector regulators, private consultants, private water investors, procurement authority and PPP unit. This rich experience and background of the industry experts guarantees the reliability of their responses.

Table 2.4 Positions and Organisations of Delphi panelists

	Parts of questionnaire completed							
	Part 3, Q1: risk allocation criteria		Part 3, Q2 A&B: risk assessment		Part 3, 2C: risk allocation		Part 4: critical success factors	
Organisation:	*n*	%	*n*	%	*n*	%	*n*	%
Ghana Water Company Ltd	8	21.6	9	22.5	9	23.1	10	24.4
Public Utilities Regulatory Comm.	4	10.8	4	10.0	4	10.3	4	9.8
Ghana Urban Water Ltd	7	18.9	7	17.5	7	17.9	7	17.1
PPP Advisory Unit	5	13.5	6	15.0	6	15.5	6	14.6
Public Procurement Authority	2	5.4	3	7.5	3	7.7	3	7.3
Private sector firms	11	29.7	11	27.5	10	25.6	11	26.8
Total	37	100	40	100	39	100	41	100
Position:								
Director	5	13.5	6	15.0	6	15.4	6	14.6
Manager	21	56.8	23	57.0	22	56.4	24	58.5
Project analyst and consultant	11	29.7	11	28.0	11	28.2	11	26.8
Total	37	100	40	100	39	100	41	100

2.8 CHAPTER SUMMARY

This chapter has provided in detail the (i) research methods and (i) expert respondents‘ background information for this study. How each research objective is achieved by these methods is described.

The adopted methodology is a three-stage: data acquisition methods, statistical analysis and modelling methods. Delphi questionnaire survey is the main data collection tool for this research. It covers specific issues related to PPP water project risks, risk assessment and risk allocation, and critical success factors. The questionnaire was revised based on the comments and suggestions of PPP and Delphi experts. Statistical methods that include mean score ranking, reliability analysis, factor analysis, as used in this thesis, are described. The applied modelling technique, fuzzy synthetic evaluation, is also described in detail. A combination of all these methods contributed to achieving the research aim and objectives.

The expert respondents‘ information covered their respective organisations, positions or roles, years of industrial and PPP experience. 37–41 expert respondents were adequate to conduct statistical analysis on the resulting data. The information supplied by the respondents suggests that they have diverse professional backgrounds and have relevant experiential knowledge and expertise to merit the reliability of the study. The next chapter puts the study into context by delving into Ghana‘s PPP evolution and experience in applying PPP in the water sector.

Literature Review

The Literature Review is usually organised in the following way:

2.1 INTRODUCTION

2.2. BACKGROUND TO THE TOPIC

a. Detail the general background

b. Explain Importance

c. Define Key terms

2.3 REVIEW OF LITERATURE

a. Background

b. Development of Research

General → Specific

c. Latest Studies

2.4 WHAT HAS NOT BEEN STUDIED

a. Highlight the research gap:

There is limited research on...

However, few studies have examined...

2.5 EXPLAIN HOW YOU WILL FILL THIS RESEARCH GAP

2.6 SUMMARY

Chapter 3: PPP Experience, Drivers and Success Factors in Ghana's Water Sector

A Literature Review discusses previous research in the field. It should be structured in a clear way with the previous studies grouped logically. It should include:
a summary of important previous findings, a synthesis of studies that are similar, a discussion of all current research that is relevant to your topic, a critical appraisal of previous studies. An important part of the review is a discussion of what has not been achieved by previous research (the research gap) and an explanation of how the thesis will fill the research gap.
This chapter reviews the literature on the PPP experience, drivers and success factors in Ghana.

This Literature Review is very effective partly because the writer includes the following:

Structure

Introduction	Section 3.1
Background	Section 3.2 and 3.3
Existing problems	Section 3.4
Current Issues in the field	Section 3.5
Review of existing case studies	Section 3.6
Possible solutions to current problems	Section 3.7
Research Gap	Section 3.8
Summary	Section 3.9

Content

- Introduces the content of the chapter in Section 3.1, paragraph 1
- Outlines key ideas and introduces the major studies to be reviewed in the introductory section (e.g. Section 3.1)
- States the aims of the chapter (e.g. Section 3.1, paragraph 1, final sentence)
- Divides the literature reviewed into separate sections based on topic
- Uses quotations to add authority (e.g. Section 3.6.1, paragraph 5)

- Synthesises similar studies and discusses them together (e.g. Section 3.5 paragraph 2, sentence 1)
- Defines key terms (e.g. Section 3.7)
- Critiques studies cited e.g. However, *the research failed to address…* (e.g. Section 3.7.1 paragraph 3, final sentence)
- Highlights gap in current knowledge (e.g. Section 3.8)
- Develops research questions (e.g. Section 3.8, paragraph 1, sentence 3 and sentence 5)
- Highlights the importance of the study filling the research gap (e.g. Section 3.9, paragraph 3, final sentence)
- Provides a succinct summary of the chapter (e.g. Section 3.9)

<u>Language</u>

- Links to the previous chapter (e.g. Section 3.1, paragraph 1, sentence 1)
- Uses the final sentence of Section 3.1 as a transition to the rest of the chapter (e.g. Section 3.1, paragraph 3)
- Structures paragraphs in a clear logical way e.g. Section 3.4.1:

Background	sentence 1
Problems	sentence 1, 2, 3, 4
Analysis	sentence 5, 6
Conclusion	sentence 7

- Introduces new subsection with an introductory sentence (e.g. Section 3.5 paragraph 1, sentence 1)
- Uses tentative language when making predictions e.g. *suggest* and *is likely to* (e.g. Section 3.5.5, last paragraph)
- Uses a variety of citation styles. Cites important studies as the subject e.g. *Jefferies et al. (2002) developed…* (e.g. Section 3.7.1, paragraph 2, sentence 1) and citing at the end of the sentence for less specific and grouped information e.g. *for the public (Marin et al, 2009; Saltiel and Maywah, 2007)* (Section 3.7.2.3, paragraph 1, sentence 2)

<u>To consider</u>

In general, this chapter is effective. However, it could be improved in the following aspects.

Section 3.6 should start with a brief overview before discussing ‘The “Attempted” Lease Contracts’ in 3.6.1.

Avoid overusing subsections. It is better to group information under fewer subheadings.

Use more formal quantifiers, e.g. *Numerous studies* is better than *Many studies* (Section 3.7.2.1, paragraph 1, sentence 1).

Avoid vague language (e.g. Section 3.8, paragraph 1, sentence 2).

CHAPTER 3 PPP EXPERIENCE, DRIVERS AND SUCCESS FACTORS IN GHANA'S WATER SECTOR

3.1 INTRODUCTION

Having detailed the research approach and methodology in Chapter 2, the current chapter presents Ghana's PPP evolution and experience in the water sector and then investigates current implementation by analysing some project cases. This enables lessons/experience to be drawn from the project cases. The chapter also reviews the key drivers for and emerging trends in PPP application in the local water sector. Finally, based on the analysed project cases, the chapter qualitatively explores the perceived critical success factors (CSFs) for implementing PPPs in the Ghanaian water supply sector. This chapter aims to enhance the understanding of PPP water practice in the country and also serves as the foundation for the thesis.

This chapter draws on previous published and grey literature on Ghana's water sector (e.g., Nyarko, 2007; Ameyaw and Chan, 2013b; Bohman, 2010; Fuest and Haffner, 2007; Ameyaw and Chan, 2012; Whitfield, 2006; Hirvi, 2012), government's policy and regulatory documents (e.g., the National Water Policy (Government of Ghana, 2007), the PPP Policy (Government of Ghana, 2011), Growth and Poverty Reduction Strategy II (Government of Ghana, 2005)), and PPP projects documentation (e.g., the World Bank, 2004; Global Water Intelligence, 2012). This is a qualitative approach that allows the researcher to combine different research materials in order to gain an in-depth understanding of the subject matter at hand.

3.2 BRIEF GENERAL COUNTRY DATA

Ghana, Fig. 3.1, is a West African country with a diverse ethnic population, indicating a considerable rural–urban migration and a modest population growth in rural areas. It shares 2,093 km of land borders with the three French-speaking countries of Côte d'Ivoire (668 km) to the west, Togo (877 km) to the east, and Burkina Faso (548 km) to the north (Sosuh, 2011). To the south are the Gulf of Guinea and the Atlantic Ocean. Ghana has a total land area of 238,533 km^2. Its population is estimated at 21.6 million in 2005, with 54% living in rural areas and 46% in urban areas (GII, 2011), and at 24.39 million in 2010 (World Bank, 2011). While the rural population grows at 1.5%, the urban population grows at a rate of 4.5% per annum due to the influx of rural migrants in search for greener pastures (WaterAid, 2005; 2008). The gross domestic product (GDP) per capita for 2009 and 2010 was estimated at US$1,098 and US$1,283, respectively (World Bank, 2011).

Ghana has experienced a relative political and economic stability in recent years, with the current GDP growth of around 6% per year from the average annual rate of 5.5% for 2000–2005 period, and an annual GDP growth rate of 6.2% was reported in 2006 (GII, 2011; AfDB/OECD, 2007). The 2010 GDP growth rate was 6.6% (World Bank, 2011). This economic growth is attributed to the continued strengthening of democracy and a stable political atmosphere in the country. Nevertheless, Ghana‘s political situation could be enhanced further by tackling growing perceptions of corrupt practices in the public sector (Osei-Tutu et al., 2010; AfDB/OECD, 2007). Reducing the opportunities for corrupt practices will improve performance of the water sector through efficient and equitable allocation of resources and fair award of contracts. Despite the perceived advantages of Ghana‘s decentralisation reform, some commentators argued that the increasing decentralisation in services provision has created fertile grounds for corrupt practices

(AfDB/OECD, 2007).

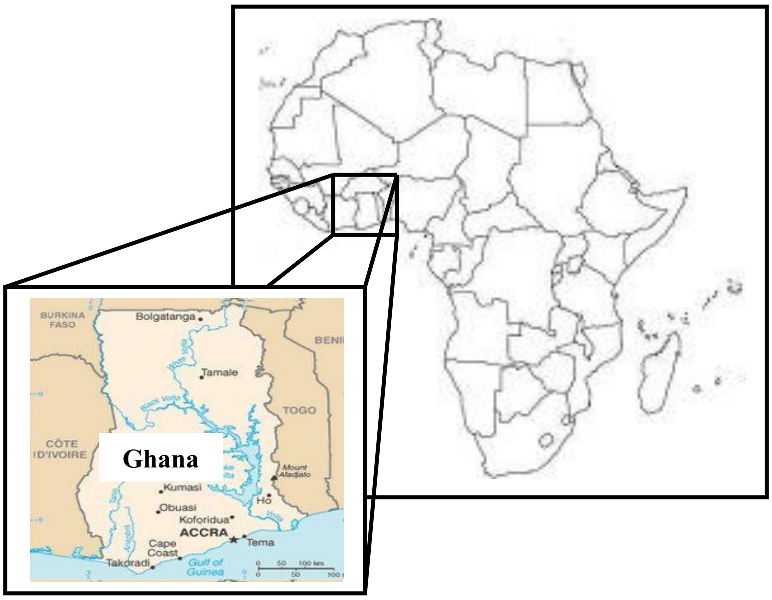

Fig. 3.1 Location of Ghana in Africa (Adapted: Fuest and Haffner, 2007)

Poor access to safe water and improved sanitation services is a serious public health concern, contributing to 70% of diseases in the country (AfDB/OECD, 2007). There are wide disparities in access to safe water and improved sanitation services, depending on income levels, between rural and urban areas and across the 10 administrative regions (Osumanu, 2008).

3.3 PPP EVOLUTION HISTORY AND EXPERIENCE

The idea of PPP in the water sector began in the early 1990s, as summarised in Table 3.1. Driven by rapid urbanisation, population growth, economic crisis, political instability, under-pricing, under-investment and diminishing operational capacity (Whitfield, 2006; Nyarko, 2007; Fuest and Haffner, 2007), the then government launched a 10-year World Bank-sponsored Economic Recovery Programme (ERP, 1983–1993) to improve efficiency in the water sector through institutional strengthening, personnel development, rehabilitation and expansion of existing systems and services (Ainuson, 2010; Bohman, 2010). In 1987, a 5-year rehabilitation and development plan (as part of the ERP) for the sector was developed, which subsequently led to a Water Sector Restructuring Project (WSRP). The WSRP aimed at introducing PPP into the sector as a response to its grave problems and inefficiencies. This prompted the creation of various bodies to facilitate the PPP process and the separation of the urban water sector from the small-town & rural sector in 1998.

Table 3.1 Milestones in water sector reforms for PPPs in Ghana

Year	Event
Early 1990s	Discussion of PPP options began.
1995	Sir Williams Halcrow & Partners Ltd investigated possible PPP options.
	First PPP scheme (2 Lease contracts) were proposed and adopted by the stakeholder groups.
1996	An Advisory Committee was formed to supervise and advise the PPP process.
1998 (Sept)	Invitation for prequalification of 10- and 30-year lease contracts for the urban water systems was launched.
1998	Separation of the urban sector from the small-town and rural sector.
1999	Azurix expressed interest in a 20-year build-own-operate-transfer (BOOT) contract in the urban water sector. The process was halted following allegations of corruption.
2000 (July)	A 2nd reformulated invitation for prequalification for a 10-year lease contract was launched. This included private investment and bidding began in 2001.
2001 (May)	National Coalition Against Water Privatisation was created.
2002	PPPs introduced in the small-town water sector.
2003	Intensive stakeholder consultation to address opposing groups' concerns.
2005	First urban water management contract between GWCL and Aqua Vitens Rand Ltd (AVRL) signed.
2011(February)	First seawater desalination BOT project between GWCL and Befessa Aqua of Spain signed.
2011(June)	National PPP Policy launched.

Responsibilities for urban water supply services were then transferred to a newly-established public semi-autonomous company (Ghana water Company Limited, GWCL) in 1999. Hitherto, Ghana Water & Sewerage Corporation (GWSC) was responsible for the entire sector. On the other hand, water supply and sanitation responsibilities for small-town & rural communities were transferred to local governments, under the facilitation of the Community Water and Sanitation Agency (CWSA).

Overall, the practical experience in developing and implementing PPPs in the water sector of Ghana is highly limited. Following the discussions of PPP in the early 1990s, the first contract was not implemented until 2005. Initial ambitious contracts with a high level risk transfer were deserted in 1998 following fierce public protests and unfavourable investment environment during this period (see section 3.6.1). For example, in 1999, Azurix submitted an unsolicited proposal to undertake a 20-year BOOT project in the national capital, Accra. However, the process was halted following corruption allegations.

However, realising the contribution of the private sector to resolving the sector‘s inefficiency and infrastructure backlog, in 2010 the government embarked on a PPP programme to attract more private participation. A National PPP Policy was issued in June 2011 to facilitate private participation in the major infrastructure and services sectors that include water, power/energy, public housing, transport, health, oil and gas, and agribusiness (Government of Ghana, 2011). The policy clearly outlines procedures and models of private sector participation. The adoption of the policy further reflects the government‘s desire to meet the infrastructure needs of the growing population through private capital and managerial expertise.

Currently, there are a number of projects in their preparatory stages, including the Nungua Seawater Reverse Osmosis (SWRO) BOOT project (see section 5.3.3).

3.4 DRIVERS FOR PPP APPLICATION TO WATER SUPPLY PROJECTS

There are several reasons for PPP application to water supply projects. This section presents six keys drivers: inadequate public funding; need for improved management and efficiency; growing water demand; poor asset condition and lack of maintenance; low coverage rate and high non-payment; and low labour productivity and quality.

3.4.1 Inadequate Public Funding

Public funding to the water sector is far inadequate (see Ameyaw and Chan, 2013b). With escalating national water needs the government is financially constrained due to overgrown national expenditures. Available estimates suggest huge financial requirements for infrastructure and access expansion in the urban sector. Water Business (2010), for example, estimated US$100 million annual requirement for infrastructure development alone, against an inflow of US$35 million (only US$2 million from the government, US$3 million from GWCL‘s revenues and US$30 million from development partners). On access expansion, US$1.49 billion is required to meet demand by 2020, but regrettably, an average of 35% financial inflows have been realised over the years (GWCL, 2009). The issue of under-investment is largely attributable to various financial crises; GWCL‘s failure to make efficiency gains from external grants and loans; neglect, and failure by successive governments to enforce cost-recovery tariffs for political reasons (Hirvi, 2012; Fuest and Haffner, 2007; Nyarko, 2007; Bohman, 2010). Under GWCL management, rates fell to levels that failed to support both operation and maintenance and investment requirements, leading to huge infrastructure funding deficits and inefficiencies. In 2003, for example, the utility incurred a loss of US$34 million (Larbi, 2005) due in part to under-pricing and inefficiencies. Evidently, PPP is underlined by a political desire to address the fiscal space problems in providing public infrastructure services.

3.4.2 Need for Improved Management and Efficiency

The urban water utility and water infrastructure is under public ownership. Sadly, they are fraught with grave operational and management inefficiencies (Nyarko, 2007). The sector‘s main areas of challenge are high non-revenue water levels, low water quality, low labour productivity, chronic water theft, high operational costs, acute water shortages and service intermittency. The running of the urban water systems heavily relies on government subsidies and bail-outs of international financial institutions and development partners. Public-ownership and monopoly nature of the sector limits competition, thereby generating inefficiencies. Therefore, the sector is not responsive to customer needs, which in turn encourages bill non-payment. Another rationale of PPP is to tap private management expertise to improve efficiency and quality of water infrastructure and services, to enhance customer-oriented management practices, and to apply novel technologies for innovative solutions (Flinders, 2005).

3.4.3 Growing Water Demand (Demand-Supply Imbalance)

Ghana is experiencing a rapid population growth rate of 2.7% per annum, with a greater percentage of the population residing in urban settings. The population has increased significantly over time, from 6.7 million in 1960 to 24.6 million in 2010 (Ghana Statistical Service, 2012). The urban population has grown from a low rate of 15.44% in 1950, 23.25% in 1960 to a high rate of 51.47% in 2010 and is predicted to reach 64.69% by 2030 (UN Habitat, 2010). Thus, the urbanisation rate is estimated at 4.5% per year.

With above statistics, it is evident that the population continues to grow faster than the development of water supply infrastructure to keep pace. The total installed capacity of

737,000m^3/day (Ainuson, 2010) of the existing water systems continues to decline. Whitfield (2006) noted that currently, one-third is inoperable, thereby putting GWCL's production capacity at 50% of current demand (Water Business, 2010). Average daily production capacity of GWCL is 551,000m^3 against average demand of 939,000m^3/day (GII, 2011). In addition, over 50% of the amount of water produced is lost to leaks and widespread commercial theft. The diminishing capacity of GWCL, high system losses and the population explosion suggest that a large population faces acute water shortages, evidenced by chronic service intermittency.

The outright solution is to rehabilitate existing water systems, develop new treatment plants, and extend the distribution infrastructure to un-served areas. This would require substantial private investment and innovative solutions in designing and constructing new water plants and networks.

3.4.4 Poor Asset Condition and Lack of Adequate Maintenance

Taking into account the installed capacity and the actual production capacity statistics given above, the current daily idle rate of the production plants is 25.24% (186,000m^3). This is partly responsible for the water shortages in the urban sector. This high idle rate results directly from capacity utilisation problems as a result of inefficient use of the water plants. The diminishing capacity of water plants is attributable to decades of neglect and disrepair due to funding constraints (Nyarko, 2007). Conversely, the poor network condition is evidenced by high leakage rates, ranging from 50–60%, given that a large section of the distribution network is over 70 years (Nyarko, 2007). Besides, it has been argued that public sector lacks the technical expertise to tackle water losses. Therefore, private participation will not only inject private capital, but also management expertise to enhance the quality, effectiveness and efficiency of public water systems and services.

3.4.5 Low Coverage Rate and High Non-payment

Large portions of the population lack water services, which is part of the systematic water supply challenge in Ghana. Current coverage rate is estimated at 59% in the urban sector served by GWCL. In Accra, for example, only 51.6% of the residents are served with piped-water (UN Habitat, 2008). In low-income neighbourhoods, coverage rates range from below 5% to 20% (Ainuson, 20010) whereas connection rates average 90% in high-income residential areas and just 16% in poor communities (UNDP, 2006). The current official customer base of GWCL is only 438,034 out of which 315,384 are billed and 122,650 are unbilled (Today, 2012). Hidden within above coverage figure are widespread water rationing, service intermittency and non-reliability.

Water theft and bill non-payment are other serious problems affecting the sector‘s operations, rendering it less profitable. The high poverty rate in the country is a contributing factor, as over 28% of the urban settlers fall below the poverty line (Ainuson, 2010). This makes an argument that those unable to pay for water services are likely to engage in water theft and non-payment of bills. It is hoped that the private sector would be able to expand access to piped-water and mitigate water theft and non-payment risks.

3.4.6 Low Labour Productivity and Quality

Labour productivity is measured by the number of workers per 1,000 connections. GWCL was overstaffed with 4,300 employees most of whom were unqualified professionals (ISODEC, 2002). Nii Consult (2003) noted that by industry standards 50% of GWCL‘s staff is redundant. In 2006, GWCL‘s labour productivity was estimated at 60 workers per 1,000 water connections (Kauffmann and Perard, 2007), compared with international best practice of 2–3 workers per 1,000 connections (Haarmeyer and Mody, 1997). The late 1970s and early 1980s economic crisis did not only deprive the sector of adequate investment, but also witnessed the mass exit of skilled manpower which impacted the utility‘s operational efficiency (Whitfield, 2006). PPPs are able to improve labour productivity to cut down costs, invest in maintenance and build local capacity.

With mounting budget shortfalls, and failure of the public sector to adequately maintain and expand water systems, water services become unsustainable. Like other countries, in Ghana debt and economic crises, coupled with astonishingly frail and below-expected performance enthused sustained pressures for water sector reforms (Kessides, 2004) that comprised competitive restructuring, water policy-making, tariff reforms and creation of regulatory structures, with the introduction of PPP as the core goal (Ainuson, 2010). Critics of PPP policy, however argued that it fails to serve the interest of the larger population. In the early 2000s, a strong national campaign (led by Integrated Social Development Centre (ISODEC)) was launched against water PPP. Some of these factors have influenced PPP trends in Ghana‘s water sector.

3.5 EMERGING TRENDS IN WATER SUPPLY PPPs

This section provides an overview of shifts in approaches to water supply PPPs in Ghana. Based on review of relevant literature and some PPP projects (see Table 3.2 for some project cases) some emerging trends are identified, which indicate a shift in the nature of contracts, responsibilities of partners and location. As shown in Table 3.2, 10 project cases were selected for detailed analysis. These projects were examined (i) on a case-by-case basis to assess projects‘ performance and draw lessons (reported in Ameyaw and Chan, 2012, 2013c; Ameyaw et al., 2014) and to identify the key risk factors (reported in Ameyaw and Chan, 2013a) and perceived success factors (reported in section 3.7.2 of this thesis) for that project and (ii) collectively to detect emerging trends of PPP in the local water sector. The latter is dealt with in this section. The choice of a project case is based on at least one of the following predefined criteria:

- It had to be a PPP water supply project of any model or contractual arrangement.
- It must have been attempted, under construction, or implemented and operational for at least one year. This is because it is possible identity risks, success factors and lessons based on this criterion.
- Information regarding the project‘s nature and contractual structure is publicly available. There are many projects without sufficient information and therefore were not selected for analysis.

Each project case satisfied at least one or all of above selection criteria. Collection of evidence or information on individual project case was achieved by reviewing the project documentation and reports (Baxter and Jack, 2008) obtained from GWCL, the sector ministry (Ministry of Water Resources, Works and Housing (MWRWH)) and general projects‘ literature (Adinyira, 2008; Tuffour, 2010; Akabang, 2010; Nyarko, 2007). Table 3.2 shows that the selected projects are a mix of urban and small-town projects. This reflects the structure of the water supply sector in Ghana where the sector is divided into two, as mentioned previously. This means that the selected projects spread across the country, which helps to capture the general emerging trends.

3.5.1 Dominance of Management Contracts

Globally, there is a shift away from concession contracts, which dominated the water market in the early 1990s, towards management contracts (BPDWS, 2011). The first two urban water projects were BOOT and lease contracts, which required significant private investment. However, both were never implemented, though the government and her development partners preferred such ambitious modalities (Agyeman, 2007). From Table 3.2, all PPP projects (except case 10) implemented in the water sector are management contracts which aimed at leveraging private management skills to enhance operational efficiencies, where central and local governments were obliged to provide investments. Two reasons underline the option of management contracts in the urban water sub-sector:

i. interest of international operators in contracts with less financial obligations – for fear of economic uncertainty, currency risks and political insecurity; and
ii. local resistance by civil society groups and NGOs.

3.5.2 Growing Water Supply PPP in Small Towns

Early attempts at PPP focussed on the urban water sector. PPP was therefore unknown in small towns until 2000 (Larbi, 2005). And since then, there has been a gradual shift of partnership contracts to the small-town sector, typically in the form of management contracts with local governments (Table 3.2) who initiate projects with the assistance of CWSA. Some of these projects have been successful, while others were fraught with problems (Akabang, 2010; Ameyaw and Chan, 2014; Tuffour, 2010). There is a growing interest among district and municipal assemblies for improving water supply services in terms of efficiency, effectiveness and sustainability (Berko et al., 2004). Reasons for this trend include growing demand for improved water supply services in small towns, overwhelming service delivery responsibilities, and financial constraints of local governments (WaterAid, 2008; BPDWS, 2011; WSP, 2010). However, the trend is associated with challenges resulting from lack of PPP knowledge and skills by both local governments and private operators and economic viability of small town projects.

Table 3.2 Selected PPP projects in the water supply sector

ID	Case Study	Contract status	Project scope	Parameters PPP model	Private operator mix	Sub-sector	Year	Popn. served
1	Attempted Lease Projects	Developed but failed to be implemented	Water supply + investment	Lease contracts (10 & 30 yrs)	International	Urban	1999 -2002	n/a
2	Accra-North Project	Abandoned	Bulk water supply+ investment	BOOT (20 yrs)	International	Urban	2000	n/a
3	Urban Water Management Contract	Implemented but failed	Water supply + limited investment	Management contract (5 yrs)	International	Urban	2006-2011	$7x10^6$
4	Yeji Water Supply	Successful	Water production + distribution, O&M	Management contract (5 yrs)	Small local private company	Small-town	2007-	30,000
5	Atebubu Water Supply	Implemented but failed	Water production + distribution, O&M	Management contract (5yrs)	Small local private company	Small-town	2003-08	29,595
6	Bekwai Water supply Scheme	Successful	Water production + distribution, O&M	Management contract (5yrs)	Small local private company	Small-town	2002-07; 2008-_13	30,000
7	Tumu Water Supply	Successful	Water production + distribution, O&M	Management contract (5yrs)	Small local private company	Small-town	2008-2013	12,000
8	Wassa Akropong Water Supply	Implemented but terminated after a year	Water production + distribution, O&M	Management contract (5yrs)	Small local private company	Small-town	2003-08	6,170
9	Enchi Water Supply	Implemented	Water production + distribution, O&M	Management contract (5 yrs)	Small local private company	Small-town	2002-07	9,270
10	Nungua Seawater Desalination Project (SWRO)	Under construction	Bulk water supply (60,000m^3/day)	BOT (25 yrs)	International	Urban	2011	$5x10^5$

Source: Extracted from Ameyaw and Chan (2013b). BOT: Build-operate-transfer; O&M: operation and maintenance; n/a: not available; Popn: population

3.5.3 Growing Involvement of Domestic Private Companies

Multinational water companies flooded the global urban water market in the early 1990s (Marin, 2009). In Ghana, all urban water PPPs (attempted or implemented) involved foreign water operators, such as Bi-Water, Suez, Saur, Vivendi and Aqua Vitens Rand Ltd (AVRL). There is a new twist in Ghana: previous studies revealed an increasing focus on involving small domestic private operators in small towns in the provisioning of drinking water (Larbi, 2005; Adinyira, 2008; Public-Private Infrastructure Advisory Facility, 2011). These operators may stand as favourites in mitigating social and political risks, because small towns are less ―conspicuous politically”, and have local knowledge to steer through project environments (WSP, 2011; BPDWS, 2011). Table 3.2 shows that small local private operators are gaining roots. Examples include the Bekwai water supply scheme operated by Vicco Ventures Ltd.

3.5.4 Management Contracts between Local Public Utilities

BPDWS (2011) observed an increasing focus on establishing management contracts between well-performing and under-performing public utilities. This arrangement reflects a case where a public utility manages another public utility in or outside a country. A typical example was the management contract between AVRL and GWCL (Ameyaw and Chan, 2012). Today, a newly-established autonomous public company, Ghana Urban Water Ltd (GUWL), manages the operations of GWCL following AVRL‘s exit in June 2011. It is a one-year management contract, and lessons from the erstwhile contract could inform performance of both companies. However, the shorter duration may hinder GUWL‘s ability to initiate and implement decisions to ensure longer-term improved performance.

3.5.5 Public Funding remains a Challenge in Water Supply PPPs

Ameyaw and Chan (2012, 2013b) revealed that water-related projects are heavily reliant on multilateral and bilateral funding, with a declining share of public financing. One estimate shows a funding gap of US$1.5 billion to renew and extend infrastructure (GWCL, 2004). It remains vague if and how future funding could be secured from international financial institutions, because concessions in Africa only extended water infrastructure with donor funding (Fuest and Haffner, 2007). The dominance of management contracts implies huge financial implications for both central and local governments. Available evidence suggests government‘s inability to honour its financial obligations both in urban and small-town sectors. For example, under the urban water management contract (Case 3, Table 3.2) financial obligations such as fees and incentives of the operator were borne by the World Bank (Kingman, 2008). Moreover, high risk perceptions coupled with global fall in private finance (Lobina and Hall, 2006) suggest that private investment in water supply in Ghana is likely to remain constrained, without adequate structures.

3.5.6 Water Supply PPPs are Donor-driven

Private participation in the water supply sector is promoted by donor agencies as a sector strategy to improve drinking water delivery, neutralise damaging political interference and inject transparency and efficiency (Public Private Infrastructure Advisory Facility, 2011; Fuest and Haffner, 2007). Notable agencies include the World Bank and International Monetary Fund (IMF). Support comes in the form of financing, capacity building and research in support of PPP water supply projects. For example, Case 3 (Table 3.2) was largely funded by the World Bank and other development partners. Furthermore, 20% of required funds to support the initial lease contracts (Case 1, Table 3.2) came from donors (Larbi, 2005).

As part of the EU-funded Small Towns Water Supply Project (1998–2004), a feasibility study on the socio-economic potential of selected towns was conducted by foreign consultants (CONAN Consult and BURGEAP), which led to private sector involvement in the management of water supply in Atebubu and Bekwai – representing the first wave of small-town water PPPs in Ghana. See Eguavoen and Youkhana (2008), Ameyaw et al. (2014) and Berko et al. (2004) for further examples.

3.5.7 Comparison with Global Experience

The trends presented above reflect those observed at the global level and in other developing countries by recent studies, including WSP (2011), BPDWS (2011), and Marin (2009). Extensive global and country reviews by these authors/organisations since the 1990s indicate increased shifts towards management contracts, falling full concessions, a growing involvement of domestic private operators (accompanied by withdrawal of multinational operators), falling private investment, and growing PPPs in small towns. The Ghanaian case (at this early stage) is mirroring these trends, with peculiarities such as continuous limited public funding and management contracts between public water utilities.

3.6 CASE STUDIES

3.6.1 The "Attempted" Lease Contracts

From 1995 to 2002, the urban water sector made advances in pursuing PPP as a viable option for improving service levels and leveraging private-capital (Larbi, 2005). The World Bank commissioned foreign consultants to deliberate on several PPP modalities for the sector (Halcrow and Partners, 1995). A lease option was selected in 1995 following consultations with the stakeholders that included GWCL, donor agencies, government departments

/agencies, private sector and non-governmental organisations (Fuest and Haffner, 2007).

A 30-year (called Business Unit A) and a 10-year (called Business Unit B) lease packages comprising 27 and 73 water systems, respectively, were opened for bids in 1999, to be subsequently leased to two private water companies. The pre-qualified bidders were major multinational corporations, including Bi-water, Vivendi, Suez, and Saur (International Fact-Finding Mission, 2002; ISODEC, 2002). The successful companies leasing each business unit were to assume operation and management responsibilities and to inject US$70 million for the water systems' rehabilitation and improvement (Fuest and Haffner, 2007). The responsibility for financing new water systems and expansion of existing systems remained with the government.

Adoption of PPP was a condition to expand the World Bank's financing in Ghana's ill-performing water sector (Amenga-Etego, 2003). Also, the PPP policy was influenced by the decision of the IMF and the World Bank to grant Ghana entry into the Heavily Indebted Poor Country (HIPC) initiative (Fuest and Haffner, 2007; Amenga-Etego, 2003). The government welcomed the policy as it needed capital for investment.

Under the lease contracts, economic tariffs were to be approved by the Public Utilities Regulatory Commission (PURC) in order to achieve full cost recovery on the operations of the private firms. Tariff increases, however were to be linked to performance. It has been argued that economic tariffs will be very expensive for most urban poor to afford.

However, the projects were delayed and subsequently cancelled in 2002, following fierce opposition from civil society groups who embarked on anti-PPP campaigns. Public resistance stemmed from the fear of

> *"[...] water tariff increases, staff dismissals from the GWCL and the notion that the provision of an essential good such as water should not be at the discretion of private enterprises*" (Fuest and Haffner, 2007, pg. 177).

The contracts called for a 50% staff retrenchment (ISODEC, 2002). Economically, high staff numbers (than required) imply a low labour productivity, increase cost of operations and negatively affects cashflow. Further arguments against the projects were that: the policy was not pro-poor, it lacked transparency, and the pre-qualified bidders had poor performance records in similar assignments in other countries (Larbi, 2005).

Other important factors include; then poor global economic trends unfavourable to private investment in the water sector, and a regional political instability (i.e., a civil war in Ivory Coast in 2002). These risks prompted the pre-qualified bidders to reduce their level of investment (Amenga-Etego, 2003; Nii Consult, 2003). These factors propelled the government towards a management contract to reform and improve performance of GWCL.

3.6.2 The Urban Water Management Contract

The management contract, Fig. 3.2, was implemented within the frames of the Urban Water Project (UWP) which was funded by the World Bank (US$103 million), the Nordic Development Fund (US$5 million) and the government of Ghana (US$12 million), amounting to US$120 million. The overall aim of the UWP was to upgrade the urban water infrastructure and expand access to piped water. UPW has four components:

1. Network Expansion and Rehabilitation (US$ 92.5 million);
2. Public-Private Partnership Development (US$ 11 million);
3. Capacity Building and Project Management (US$ 1.5 million); and
4. Severance programme (US$10 million).

On 22 November 2005, a 5-year management contract for operation and management of 80 urban water systems was awarded to a Dutch-South African consortium, Aqua Vitens Rand Ltd. (AVRL), through an international competitive bidding process. The contract between GWCL and AVRL officially started on 5th June 2006 and ended in June 2011. The overall objective of the management contract was to restore long-term financial sustainability and commercial viability of the urban utility (MWRWH, 2009). GWCL remained the asset owner and was responsible for investment, development and expansion of the water systems. It had an additional responsibility for day-to-day monitoring of the contract, with assistance from external technical and financial consultants.

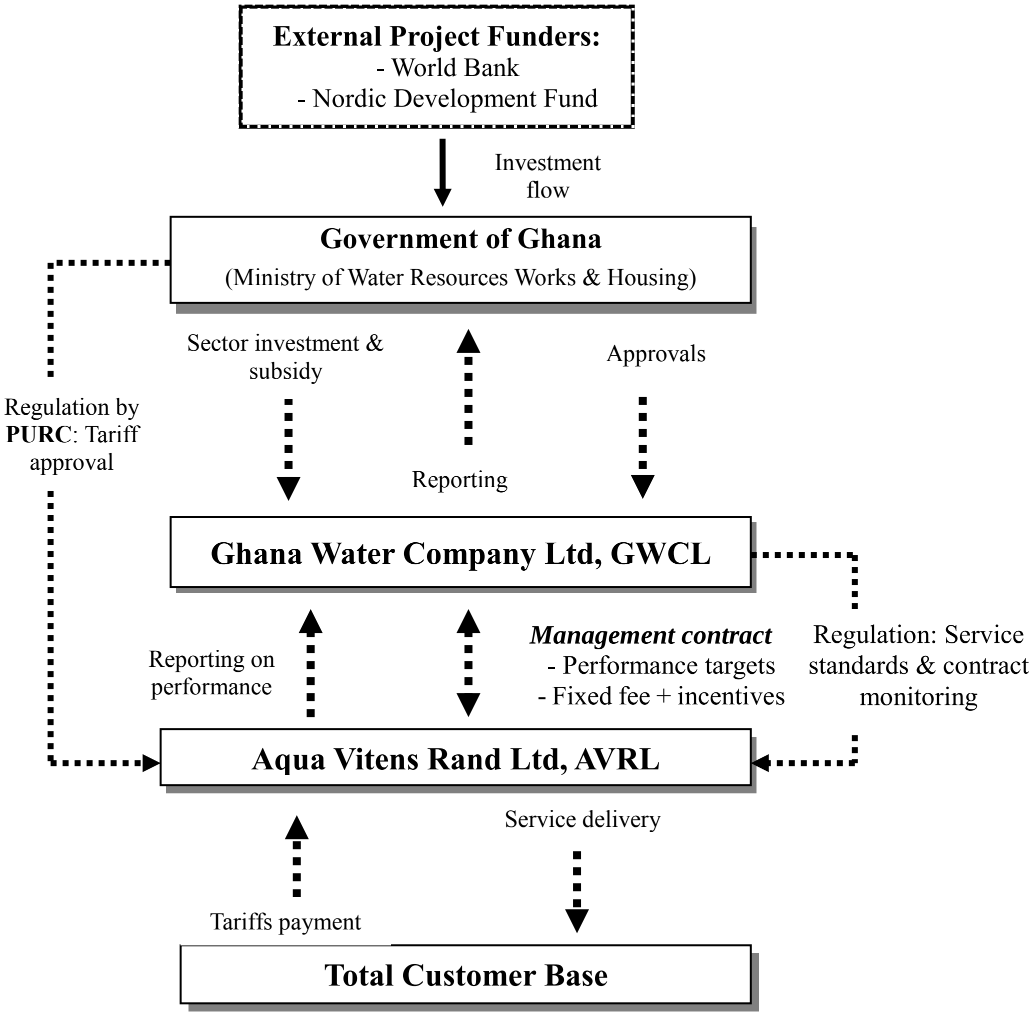

Fig. 3.2 Structure of the management contract (Source: Author)

An economic regulator, PURC, was responsible for approving tariff revisions over the contract‘s life. AVRL‘s core business included daily operation and management of urban water systems: raw water abstraction; potable water production and distribution; detecting and regularising illegal connections, billing, and collection; maintaining and improving customer database; reporting on monthly basis to GWCL; and capacity training for seconded staff (Hirvi, 2012). AVRL was obliged to reduce NRW by 5% annually, and to improve customer service as well as overall efficiency of GWCL. The operator provided key management team of 10–15 expatriates, with 2,800 seconded staff from GWCL.

AVRL was paid a fixed fee to run GWCL‘s operations, and a financial incentive for achieving or exceeding performance targets. Bonus payments were tied to critical quantifiable performance targets such as billing and revenue collection, water production, treated water quality, non-revenue water, energy consumption and chemical usage, etc. In contrast, the operator‘s base fee was to be reduced by penalties based on the extent to which performance fall short of targets. The base fee portion of the contract formed the basis for competitive bidding, and AVRL was selected based on the lowest management fee. A US$9.6 million was used to support payment of the AVRL‘s fee and the financial consultants who evaluated the operator‘s performance for the for the 5-year period.

Ameyaw and Chan (2012, 2013c) analysed the project‘s performance and concluded that it was less successful, because the project was fraught with risks. Detailed discussion of these risks is presented in Ameyaw and Chan (2013a). For instance, GWCL lacked adequate monitoring capacity to ensure delivery of performance targets. PURC also lacks the autonomy, financial and human resources for effective regulation (Fuest and Haffner, 2007). Eventually, AVRL failed to meet the contractual targets in terms of: access expansion; reliability of service; demand management and non-revenue water; water quality standards, total capacity utilisation, and energy (electricity) usage (ISODEC, 2011). Some lessons from the project are discussed in section 3.6.4.

Details of the contract can be found in Ameyaw and Chan (2013b), and the assessment of the contract performance can be found in Ameyaw and Chan (2012, 2013c).

3.6.3 Nungua Seawater Reverse Osmosis (SWRO) BOOT Project

The Nungua Seawater Reverse Osmosis (SWRO) project is a 25-year BOOT water purchase agreement between GWCL and Befesa Desalination Development Ghana Limited, the project company, a consortium between Abengoa Water (56%) and Daye Water Investment (44%). The project reached a financial close in early November 2012 with a US$88.7 million 12-year loan from Standard Bank of South Africa while the remaining US$38.1 came from stakeholder loan and equity. This gave a debt to equity ratio of 70:30 (Global Water Intelligence, 2012). The US$126.80 million project involves design, construction and operation of a 60,000 m^3/day capacity potable water reverse osmosis desalination plant, at a water rate of US$1.36/$m^3$. The investment is backed by MIGA‘s political risk insurance of US$179.2 million against expropriation, government breach of contract, war and civil disturbance, and transfer restriction. The offtaker is GWCL, supported with a guarantee from the Ministry of Finance and Economic Planning (MOFEP). The project, which is under construction, is expected to provide water to 400,000–500,000 people in Nungua and Tema in Accra.

3.6.4 Lessons from the Urban Water Management Contract

This section looked into three urban case studies. The Urban water management contract is closely examined in order to draw out lessons for design and implementation of future contracts and to inform the current study. This is because, among the three, it is the only project that has been implemented and AVRL largely failed to hit the performance targets.

3.6.4.1 Insufficient and delayed investments

The success of the management contract, for example, in reducing non-revenue water, depended on the success of the planned investments granted under the UWP. The investments, however were far from adequate considering the expansion and rehabilitation needs of the water infrastructure, and have been significantly delayed. The entire distribution network was in a deplorable condition and that non-revenue water could not be anticipated to decline until most of the network is rehabilitated. Regarding the water system expansion and rehabilitation component, only 22.7% (US$21 million) of the budgeted investment (US$92.5 million) was expended (AVRL, 2011). Achieving a significant non-revenue water reduction requires major and costly rehabilitation of the network which can only be realised in the long-term. In the short-term, efforts seemed to have focused on dealing with commercial losses (mainly prevalent commercial theft). Therefore, a target of not more than 25% by the end of the contract seemed too ambitious and unrealistic.

3.6.4.2 Deficient baseline data

It is impossible to evaluate an operator‘s performance in the face of deficient baselines data (Fall et al., 2009; Kirkpatrick et al., 2004). Absence of sufficient baseline data impeded GWCL from measuring the progress and impact of AVRL with respect to performance targets (Ameyaw and Chan, 2012). On public sector consumption, for example, the operator could not establish baselines to accurately measure consumption due to lack of metering, irregular reading of meters, intermittent water supply, and low metering ratios. Meters were hardly read and that estimated consumption figures were often used for billing public institutions (Fichner et al., 2010).

3.6.4.3 Insufficient performance of AVRL

AVRL was regarded to have made no significant improvement to service standards, which formed the basis for not renewing the contract. Hence, the main risk in this management contract is insufficient performance of AVRL: it failed to expand access to piped water, improve service reliability, reduce water-losses, and improve water quality standards (Ameyaw and Chan, 2013b). Some commentators argued that AVRL‘s poor performance resulted from its inexperience in a challenging environment like Ghana (Zaato, 2011) and lack of technical expertise.

3.6.4.4 Poor asset condition

Satisfactory asset quality is a condition for a successful management contract (Ringskog et al., 2006). Because most of the pipeline networks in the service areas were aging (over 70 years) (Aduah et al., 2011), which have shown to be worse than predicted, the poor network condition not only limited AVRL from restoring service continuity but also increased water loses and network contamination. Also, failure to improve system losses stemmed from the ageing distribution networks (beset with leaks) and prevalent commercial water theft in the service areas.

3.6.4.5 Inexperienced partners

The government lacked both expertise and experience to plan, implement and monitor the project (Ameyaw and Chan, 2013a,b). Being a newcomer and its first contract, AVRL also had no prior experience in similar projects. Both parties therefore were unable to effectively deal with most of the challenges encountered at the contract‘s implementation phase. For example, both the public‘s and the government‘s unrealistic expectations were poorly managed.

3.7 CRITICAL SUCCESS FACTORS (CSFs) FOR PPP PROJECTS

3.7.1 Definition and Review of Previous Studies

CSFs are

> *"those few key areas of activity in which favourable results are absolutely necessary for a manager to reach his/her goals…those few areas where things must go right"* (Rockart, 1982, pg. 4).

Ferguson and Dickinson (1982) also defined CSFs as

> *"events or circumstances that require the special attention of management because of their significance to the [project]. They may be internal or external and be positive [...] in their impact. Their essential character is the presence of a need from special awareness or attention to avoid unpleasant surprises or missed opportunities or objectives"* (pg. 15).

They are the central factors intrinsic in a project which must be upheld so that teamworking can occur in an efficient way and they operate in all phases of a project (Jefferies et al., 2002). Since the early 1990s, numerous studies have reported various success factors for PPP projects across different infrastructure sectors. This section briefly reviews some of these published studies with the aim of identifying the key success factors reported. In the UK, Li et al. (2005) investigated the importance of 18 CSFs for PPP/PFI projects in the construction industry across 16 and 45 public and private sector respondents, respectively. Based on mean analysis, the paper showed strong and good private consortium, appropriate risk allocation and available financial market as the three most important factors, and factor analysis further revealed five factor components as effective procurement, project implementability, government guarantee, favourable economic conditions, and available financial market. While the paper enhances understanding of the factors, it did not address their overall impact on project success.

In Australia, Jefferies et al. (2002) developed a framework of CSFs by examining the perceptions of build-operate-own-transfer (BOOT) modality, and tested the framework tested against Stadium Australia. While the research identified strong, experienced and competent consortium, efficient approval process and innovative financing as significant, the findings were not very useful in measuring their significance and collective contribution to the project‘s (Stadium Australia) success.

Through a questionnaire survey, Zhang (2005) solicited the opinions of 46 international PPP practicing (29) and academic (17) experts on the relative importance of CSFs for PPP in general. Statistical (significance) analyses revealed the five key CSF groups as (1) economic viability, (2) appropriate risk allocation, (3) sound financial package, (4) reliable concessionaire with strong technical strength, and (5) favourable investment environment. Agreement analysis, using rank agreement factor, further indicated satisfactory agreement in the ranking of the factors. However, the research failed to address the extent to which the nominated critical factors contribute to the overall outcome of a PPP project.

Adopting Li et al.‘s 18-CSF list, Chan et al. (2010) surveyed the views of 87 PPP experts from China and Hong Kong in order to determine the relative importance of the factors. The research highlighted four critical factors as favourable legal environment, appropriate risk allocation and risk sharing, commitment and responsibility of public and private sectors and stable macroeconomic condition, and five principal factors, namely stable macroeconomic environment, shared responsibility between public and private sectors, transparent and efficient procurement process, stable social and political environment, and judicial government control. Some contrast in the significance and classification of the same factors by Li et al. (2005) and Chan et al. (2010) highlights the fact that there is little consensus on the success factors for PPPs.

Focusing on BOT projects, Tiong (1996) introduced a CSF model for tendering and negotiating projects based on five principal factors, namely right project selection, strength of the consortium, technical solution advantage, financial package differentiation and differentiation in guarantees. It was established that financial and technical strength of the consortium is the most important CSF in a BOT tender. Despite the usefulness of his model to BOT promoters, Tiong failed to address any link between the principal factors and chances of winning BOT concessions. In a discussion to Tiong (1996), Gupta and Narasimham (1998) also suggested training of the public personnel, short construction period and supportive community as additional success factors to BOT projects. According to Li et al. (2005), ‗social support' is a less important project success factor for PPP projects. In the water sector, and in developing countries, however public acceptance of PPP for water supply is a prerequisite for success (Hall et al., 2005), because the public is a major stakeholder. This suggests that existing CSF frameworks must be cautiously reviewed to establish the extent to which they generalise to other contexts and sectors.

Qiao et al. (2001) developed a CSF framework for BOT projects in China based on a survey of 30 project companies involved in water, highway, rail, port and power projects. The results showed eight most important CSFs as follows: appropriate project identification, stable political and economic situation, attractive financial package, acceptable tariffs, appropriate risk allocation, selection of suitable subcontractors, and technology transfer. However, the extent to which these critical factors will influence a candidate project‘s outcomes was not addressed.

Babatunde et al. (2012) investigated Li et al.‘s 18-CSF list and their relative significance among 49 PPP practitioners in Lagos State, Nigeria. Based on the observed significance of the factors, their research reported the top-nine success factors as competitive procurement process, thorough and realistic assessment of the cost and benefits, favourable framework, appropriate risk allocation and risk sharing, government involvement by providing a guarantee, political support, stable macroeconomic condition, sound economic policy and availability of suitable financial market. This research makes a contribution to CSFs for PPPs in developing countries.

Drawing on extant literature, reported case studies and 37 case-based interviews in China, Zhao et al. (2013) qualitatively identified 14 success factors for BOT power plants under macro and micro (project) levels. Success factors under the former include local economy development, public acceptance, environmental regulation, political stability, legal landscape and economic policy. Micro level factors are project profitability, technology complexity, supplier‘s capacity, developer‘s business capacity, developer‘s management capacity, contractor‘s capacity, and previous success. While the findings offer useful reference for policy-makers and investors, the qualitative and subjective approach of the research makes it less useful for indicating which factors significantly contribute to the success of PPP power projects.

Ismail (2013) studied the perceptions of public and private participants on the important success factors of PPP projects in Malaysia. From survey-based responses from 179 respondents, the research established support for good governance, commitment of the public and private sectors, favourable legal framework, sound economic policy and availability of financial market as the top five success factors for successful implementation of PPPs.

In examining three case studies in United Arab Emirates (UAE), Dulaimi et al. (2010) observed that political support is the most significant success factor followed by strong private consortium, and a consortium‘s lack of appropriate knowledge and skills is the significant failure factor. Their findings therefore support earlier studies regarding political support (e.g., Li et al., 2005; Flinders, 2005; Chen, 2008) and the need for the private partner to bring together relevant expertise and knowledge in managing a PPP (e.g., Tiong, 1996; UNIDO, 1996; Zhao et al., 2013). In a similar study, Chen (2009) also examined the Chengdu No. 6 Water Plant B in China with the aim of identifying factors that impacted on its successful implementation. His study found support for strong commitment of the central and local governments and the foreign private participant, reasonable risk allocation, experienced consortium, political support and adequate private financing.

More importantly, studies on CSFs for PPP water projects are both limited and culture-dependent. In a related study, Meng et al. (2011) introduced a framework of CSFs for transfer-operate-transfer (TOT) water projects in China through a review of case studies. They indicated that the most significant factors include project profitability, asset quality, fair risk allocation, competitive tendering, use of professional advisors, etc. Their work contributes to our understanding of water projects success factors, but not without limitations. First, their study drew on very limited samples of the TOT model, thereby missing other important success factors. Second, their paper failed to address the relative importance of the factors and thus an inclusion criterion for a factor to be on their ‗CSF framework' is nebulous. Also, the relative importance of the factors to one another was not treated, but assumed to be independent. Treating a set of success factors as independent of each other is deceptive (Toor and Ogunlana, 2008), because, in reality, success factors are interrelated (Li et al., 2005).

From the above selected literature, similarities of the success factors for PPPs are obvious, and priority is placed on nominating perceived critical factors based on perception of public and private sector participants. A large proportion of the reviewed studies arrived at their nominated CSFs based on their mean scores (Li et al., 2005; Chan et al., 2010; Tiong, 1996; Babatunde et al., 2012) or case studies (Dulaimi et al., 2010; Chen, 2008; Zhao et al., 2013). However, the CSFs' relationships and quantitative impacts on overall project success has not been addressed in many empirical studies. Therefore, it is imperative to establish the key principal success factors, their interrelationships and contribution to successful implementation of a candidate project. The current research makes a contribution to filling this research gap.

In addition, there is no research to date on CSFs for water supply PPPs in Ghana. In the following section, perceived CSFs are qualitatively identified and described to widen readers' view of CSFs for PPP water supply projects, through analysis of local case studies.

3.7.2 CSFs for PPP Water Supply Projects in Ghana

Real-life project cases in Table 3.2 provide firm support for exploring the PPP practice in the water sector, and for identifying and analysing perceived CSFs for water projects. At this stage, the selection of the CSFs is systematic, but both judgmental and subjective (Tiong, 1996), as the process drew on documented lessons and experiences from both failed and successful water supply projects. A detailed review was conducted on those projects which were stalled, terminated, in operation, or under construction (see Table 3.2, and Ameyaw and Chan, 2012, 2013a,b; Ameyaw et al., 2014). Information for individual project to support the CSFs was obtained from diverse sources including (i) annual and performance reports, project documentation, information made public by sector institutions and (ii) articles by professional institutions, and journal and conference papers by local/international researchers. The discussion is further supported by relevant literature and experiences from other countries and sectors. Each project case is an example of a PPP water supply project in a region. Case 2, for example, is the representation of PPP practice in the urban sector (both cities and big towns), while Case 6 represents PPP practice in small-towns of the northern region. A small-town, as used here, refers to a settlement of between 2,000 and 50,000 inhabitants that need improved water supply services (CWSA, 2005).

3.7.2.1 PPP policy and implementation unit

Many studies (Infrastructure Consortium for Africa, 2009; Meng et al., 2011; Abdel-Aziz, 2007; Carrillo et al., 2008) have duly paid considerable attention to availability of diverse expertise in investment and financing, procurement laws, technical, legal, and asset appraisal with knowledge of PPP procurement methods, negotiation and tax issues. Investment and legal experts, for example, will guide the procurement process in accordance with best practices and to ensure effective contract designs to avoid future conflicts that could mar benefits, particularly in Ghana where legal systems are under-developed.

In Ghana‘s effort to develop its PPP program, above areas of skills and expertise could be achieved through skills enhancement of a PPP policy and implementation unit. The recently launched PPP Advisory Unit (PAU) and policy are generic and apply to all sectors and government levels. However, considering the grave challenges and potential for increasing PPP activity, a water sector-specific policy will contribute to addressing the sector's needs in line with the overall policy. PAU's responsibilities include: (a) policy/guidelines development, (b) procurement through implementation of PPPs – projects identification and assessment, development of projects documentations, optimum selection of concessionaire and PPP delivery system, proposals evaluation; and (c) approval of projects (Government of Ghana, 2011; Abdel-Aziz, 2007). However, capacity building programs are necessary to establish PPP knowledge and best practices, and such programs must cover general PPP topics, specialised topics and sector-specific issues.

3.7.2.2 Public acceptance/support

Ghana's PPP story cannot be told without mentioning the vocal nature of civil society groups (trade unions, consumers, community organisations, water activists, environmentalists, political groups, and mass media) ideologically opposed to water PPPs. They were successful in stalling the sector's PPP reform for almost 15 years (Fall et al., 2009) and forced the government to abandon Case 1 in 2002. Owing to the attack from the public and other groups, the utility and the whole country paid painful lessons as donors relented on their activities and the utility continuously suffered operational and financial losses. Learning from this, an intensive stakeholder consultation was held in 2003 to address the main concerns of opposing groups. In the urban sector, the first project (Case 2) could not have been implemented without effective communication and stakeholder engagement.

Also, the introduction of PPP in the small-towns in early 2000s integrated stakeholder consultations to mitigate the risk of community resistance. To a large extent, this approach has softened the ground to allow private participation in the sector, despite some initial resistance in some small-town projects (e.g., Case 4). Therefore, public acceptance of the PPP policy is a prerequisite for successful implementation.

3.7.2.3 Government (political) commitment

Experience suggests that successful water supply PPPs are beneficiaries of favourable political commitment. A partnership with a committed government produces noticeable and sustained benefits for the public (Marin et al., 2009; Saltiel and Maywah, 2007). This is because politics is closely related to both the development and implementation of public sector reforms (Li et al., 2005). A political decision to make water supply partnerships work drives governments to create a conducive environment for partnerships to thrive. The success of Case 5 was partly attributable to political will and commitment from the local government authority. On improved collection efficiency in Case 2, the government played a crucial role in its willingness to support rigorous service cut-offs and (sometimes) court actions for non-payment. On the other hand, insufficient political commitment for cases 5 and 7 presented great risks to both projects, evidenced by non-fulfilment of local governments' financial obligation and conflicts. As a useful lesson, later projects, particularly Case 6, attracted much support from the district government.

3.7.2.4 Adequate financing

In Ghana, water-related projects are financed by donors or development partners to about 90% of total costs (Ameyaw and Chan, 2013b). The government's financial contribution is always minimal and insufficient. Adequate financing has a great impact on the sustainability and success of PPP water supply projects (IFC, 2010). Substantial initial investment is required for rehabilitating, upgrading, and extending existing and developing new water infrastructure. Therefore, adequate financing efforts must be made to tackle the huge capital outlay of water supply projects to match with innovative financing tools well-suited to their projected cashflow (Zhang, 2005).

The urban management contract (Case 2), as hinted, was largely unsuccessful due to insufficient financing from the government and its development partners to rehabilitate and expand the water systems. Popularity of management contracts, especially for small-town projects, puts heavy financial responsibility on the government, suggesting that future contracts, therefore, should incorporate innovative combination of sources of financing and sound financial packages characterised by thorough financial analyses, reasonable financial charges and appropriate countermeasures for interest and exchange rates (Zhang, 2005).

3.7.2.5 Quality water infrastructure and workforce

Satisfactory water asset condition is a precondition for successful water supply PPPs (Ringskog et al., 2006). Investors are wary of taking on assets with major rehabilitation needs, and may not invest in or will offer a lesser price for highly-deteriorated assets. Assets' conditions may be worse than expected (Haarmeyer and Mody, 1997) where both parties fail to capture the true state of existing infrastructure.

Good asset condition reduces operational challenges, costs, renegotiations and subsequent tariff increases. A potential operator can consider the quality and placement of current workforce, and the current state of existing treatment plants and distribution networks through a thorough review of technical reports (Meng et al., 2011), if available. In Case 2, redundant and low-skilled staff were laid-off through a well-designed government's voluntary retirement package before signing on an agreement.

3.7.2.6 Effective regulatory and legal structures

A potent regulatory and legal regime cannot be overlooked in any PPP program. An enabling regulatory and legal environment is the foundation of sustainable private sector involvement in urban water infrastructure services (Bennett, 1998). A good legal and regulatory system reflects the principles of transparency, competition, predictability, independence, accountability, and coherence (ADB, 2009). It ensures: (a) appropriate and affordable tariffs, (b) attraction of private investors by minimising risks, (c) fair decisions to both the concessionaire and consumers, (d) enforceability of contracts, and (e) minimisation of corrupt practices. Currently, there is no PPP law, and all projects are guided by applicable public procurement laws. To attract private investors, the government must pursue strong regulatory and legal structures, free from political interference.

3.7.2.7 Strong and competent private operator

The choice of the most suitable private entity is the most significant determinant of a project‘s success and thus the realisation of tangible and sustained results (UNIDO, 1996; Jefferies et al., 2002; Marin et al., 2009). This could explain why multinational and well-established water companies dominated the global water market in the 1990s. This factor implies a strong consortium with rich experience and a proven track record in similar undertakings. And its absence results to poor performance and subsequent public dissatisfaction and resentment. Lowest management fee, rather than competence and strength, was the influencing factor in the choice of operating company for Case 2 (Zaato, 2011), which impacted on its (AVRL) ability to make any satisfactory improvement to service delivery (Fall et al., 2009; Ameyaw and Chan, 2012). In contrast, a reason for the success of cases 6 and 7 is the choice of a strong domestic operator.

3.7.2.8 Efficient risk allocation

Being a high risk sector, the overall success of water supply projects is the clear risk identification and efficient risk allocation (Chan et al., 2010; Gavin, 2010; Meng et al., 2011; Li et al., 2005; Chung et al., 2010; Jin and Doloi, 2008). Allocation of risks should be assessed in terms of its impact on the consumers and the project under scrutiny (Abdel-Aziz, 2007). A better risk allocation would ensure: (a) satisfactory outcomes, (b) reduced project‘s costs, (c) appropriate risk mitigation and management strategies, (d) reduced conflicts between partners, and (e) affordable water rates and project profitability (see Chapter 6). On the other hand, wrongful risk allocation leads to project failure, because the poorly-assigned parties will lack the capacity to take the appropriate mitigation actions (Chan et al., 2010). In Ghana, however proper risk allocation is hardly adopted in water supply contracts and has received insufficient attention from practitioners and researchers (Ameyaw and Chan, 2013b).

3.7.2.9 Profitable water supply projects

Aside government‘s main objective to provide water services to the public, profitability of the project is of high importance. In a small-town water project, the local government enjoys a 15% of total revenues to support its water infrastructure expansion. To a private operator, profitability is the first concern and is reluctant to participate in ‗social‘ projects that would not offer good returns. Therefore, consumers should be able to afford cost-reflective tariffs capable of covering operation and maintenance costs, taxes, asset expansion/renewal, and ensuring a good level of profits for both parties. To attract private investment, both central and local governments should support economic tariffs (devoid of political expediency) while striking a balance between consumers‘ affordability and profit margins of operators and governments (Qiao et al., 2002; Meng et al., 2011).

Cases 5 and 8 were unprofitable, and the latter was subsequently terminated. The profitability risk resulted from suppressive and uneconomic tariffs, low water demand, non-payment of bills, poor physical asset condition, and high operational costs. Profitability analysis must therefore be conducted at the early stages of water projects.

3.7.2.10 Well-designed, flexible contracts

A PPP contract evolves as a partnership between the private and public sector participants. It should be flexible to adapt to changing economic and socio-political conditions through *non-opportunistic* renegotiations that nurtures an enabling environment for (cooperation) partnership between both sectors, integration of new priorities arising from the participation of all stakeholders during the decision-making process into the operating contract, and negotiation between the operator and the regular on service levels in, for example, less-profitable (low-income) zones within service areas (Saltiel and Maywah, 2007). Well-designed, flexible contracts could reduce the incidence of conflicts. A *one-fit-all* contract template is applied to small-town projects and is inflexible to prevailing conditions of localities and water assets (Ameyaw et al., 2014). This places unnecessary constraints on smooth implementation of the projects.

3.7.2.11 Local capacity building

To both local and central governments, PPP is complex. Capacity building to improve the professional skills and competencies of all key stakeholders will ensure successful development and implementation of projects. It is a common wisdom that a high percentage of staff of GWCL and those in charge at sector and government levels are less knowledgeable in PPP procurement. Hence, well-designed capacity training programs are best suited in the Ghanaian case. In the small-town sector, Public-Private Infrastructure Advisory Facility offers capacity building for the production of information memorandum, bidding, and business plan documents for water projects (e.g., cases 8 and 9).

3.8 KNOWLEDGE GAP

The review of local and international literature revealed knowledge gaps. The literature describing previous research in CSFs for PPP projects vary in scope and content, and shows differences in focus and very little consensus on these factors. The literature covers general and model-specific PPPs and different infrastructure sectors across countries, including power/energy, construction and transport. Though this body of literature significantly contributes to our understanding of PPP success factors, relevant questions not yet adequately addressed in the literature include: (a) What CSFs are valid for implementing PPP water supply projects? The focus of past research was not on water based PPPs and the author‘s search revealed one related study (Meng et al., 2011). Moreover, given the distinct characteristics of the water sector (see section 4.3 of this thesis), its success factors are likely to vary compared to other infrastructure sectors. For example, because water supply projects are associated with mixed public policy objectives (Ameyaw and Chan, 2013a), it seems likely that factors that influence their smooth implementation will likely differ. Phua (2004) shared similar views and argued that project success factors differ by sector. (b) And given a set of CSFs, what is the possibility that they would lead to a successful implementation of a project candidate, if given special and continual attention. This question has been ignored in all reviewed studies. Empirical studies that adopt appropriate modelling methods are needed to adequately address these questions.

3.9 CHAPTER SUMMARY

The chapter explored Ghana‘s PPP experience, drivers and trends and perceived CSFs in the water sector by investigating past project cases. It is found that Ghana has a limited experience in the development and implementation of projects under PPP procurement. However, there is a renewed national effort toward PPP following the issuance of the PPP policy in 2011.

Also, three projects cases were presented with the objectives to (a) draw out lessons/experiences and (b) identify the CSFs for implementing water PPPs in Ghana. Some lessons are insufficient and delayed investments, deficient baseline data, insufficient performance of AVRL, poor asset condition and inexperienced partners. The qualitatively established CSFs include public support, adequate financing, effective regulation and legal systems, efficient risk allocation, political support, etc. Finally, this chapter partly underscored the relevance of this research study by pointing out an area requiring further empirical research to advance Ghana‘s PPP program.

The chapter describes the unique characteristics of the water sector and its risk environment and the common PPP modalities applied to water supply projects. It contributes to understanding the riskiness and complexity of the sector.

Chapter 4: Understanding the Water Sector, Its Risk Environment and PPP Models

This Literature Review differs from Chapter Three because it does not build to a research gap, but focuses on a review of three topics.

It is very effective partly because the writer includes the following:

Structure

Introduction	Section 4.1
Explains Key Ideas	Section 4.2
Reviews Literature on Water Sector	Section 4.3
Reviews Literature on PPP Models	Section 4.4
Reviews Literature on Current Trends	Section 4.5
Summary	Section 4.6

Content

- Starts with a reference to the content of the previous chapter and outlines the focus of the current chapter
- Summarises key ideas in the introduction, and introduces the major studies to be reviewed (e.g. Section 4.1)
- Highlights the importance of the topic discussed in this chapter (e.g. Section 4.1, paragraph 1, sentence 2)
- States the aims of the chapter (e.g. Section 4.1, paragraph 3)
- Explains key background to the topic (e.g. Section 4.2)
- Uses examples to clarify explanations (e.g. Section 4.2.3, sentence 5)
- Introduces key points in each sub-section by synthesizing similar studies and discussing them together, e.g., in Section 4.3.1, the three key ideas pertaining to capital intensity and large sunk costs are synthesised and discussed (e.g. Section 4.3.1 paragraph 1, sentence 1; paragraph 2, sentence 1 and paragraph 3, sentence 1)
- Concludes the chapter effectively by summarising key issues discussed and introduces the content of the following chapter

- Indicates the research gap (e.g. Section 4.6, Paragraph 2, sentence 3) identified by the review of research on the water sector and PPP models

<u>Language</u>

- Links to the previous chapter in the introduction (e.g. Section 4.1, paragraph 1, sentence 1)
- Links sentences in paragraphs with grammatical structures (pronoun reference) rather than overusing linking words e.g. Section 4.3:

Topic sentence	sentence 1
These characteristics	sentence 2
These attributes	sentence 3

- Uses specific topic sentences at the start of paragraphs (e.g. Section 4.3.4, sentence 1)
- Summarises subsections with a clear final paragraph (e.g. Section 4.3.5)
- Introduces subsections with a short paragraph classifying key terms and outlining the subsection (e.g. Section 4.4, paragraph 1)
- Structures sections in a clear logical way e.g. Section 4.4.6:

Definition of system	paragraph 1
Explanation of working of the system	paragraph 2
Comparison with other systems	paragraph 3-4
Uses of key term	paragraph 5
Finances of key term	paragraph 6
Advantages and disadvantages of system	paragraph 7

- Finishes the chapter with a short summary paragraph linking to the following chapter

<u>To consider</u>

In general, this chapter is effective. However, it could be improved in the following aspects.

Avoid informal language, e.g. *tagged* (e.g. Section 4.1 paragraph 3, sentence 2) *bad shape* (e.g. Section 4.4.4, paragraph 3, sentence 2).

💡Use *e.g.* when citing only one name as a reference for information that has been suggested by more than one researcher. For example, *e.g. Cohen et al., 2004.*

💡 Avoid using questions for subtitles (e.g. Section 4.3).

CHAPTER 4 UNDERSTANDING THE WATER SECTOR, ITS RISK ENVIRONMENT AND PPP MODELS

4.1 INTRODUCTION

The previous chapter discusses Ghana's PPP practice and experience in the water sector. This chapter explores the nature of and PPP activities in the water supply sector through analysis of project cases. The water sector of any economy is the core of both social-wellbeing of the people and economic development. In other words, inadequate access to water strains development because water is paramount to inclusive food security, livelihoods, public health, human dignity, economic and sustainable development (ADB, 2009).

However, the sector has unique characteristics that render private sector participation challenging and that present regulatory design and enforcement as important determinants of PPP performance in the sector (Ouyahia, 2006).

This chapter describes the value chain and the special features of the water supply sector. It captures why the sector has long been tagged as hard to finance and risky investment for the private sector (Vives et al., 2006). In addition, models for engaging the private sector in water services and infrastructure development are described, followed by an overview of current status of PPP with a focus on developed and developing countries.

4.2 VALUE CHAIN OF THE WATER SUPPLY SECTOR

The entire water sector focuses on sustaining economic development through investments in drinking water supply, sanitation services and wastewater management, and environmental protection and enhancement (ADB, 2009). The value chain of the urban water supply consists of four components (Figure 4.1):

1. water abstraction and storage
2. water treatment
3. treated water transmission and distribution
4. customer interface

This section provides a shared understanding of the stages involved in getting water to the final consumer. It paints a picture of the functions and structure of the water supply value chain. All, or specific functions can be handled by the public or private sector, or both, with a common goal of getting water of acceptable quality to the consumer.

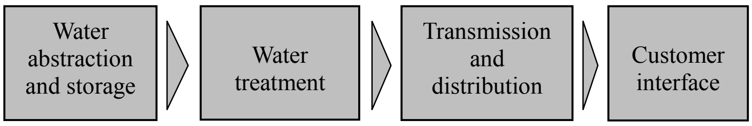

Fig. 4.1 Value chain of water supply sector (ADB, 2009)

4.2.1 Water Abstraction and Storage

The water abstraction and storage component of the value chain refers to tapping raw water from surface water (lakes, rivers and springs) or from underground and storing it in reservoirs and built tanks (Mukokoma, 2010). Depending on the source, this may entail high energy usage (Cohen et al., 2004). Water is a natural resource, and therefore legal licences are required for its abstraction. This may prove difficult to obtain in areas where water resources are stressed.

4.2.2 Water Treatment

Treatment adds value to the raw water to make it wholesome in order to protect public health. Treatment costs (about 32% of operational costs) and procedures (technology) are influenced by water source (Mukokoma, 2010) and degree of treatment. Cost of chemicals for treatment may be associated with inflation risk. Using 3-year data for 12 drinking water treatment plants in Texas, USA, Tolman et al. (1998) established that the cost of chemicals for water treatment expands by US$95/mg (million gallons) from a base of US$75 when regional raw water is contaminated. Common procedures used by water utilities include screening, clarification, filtration and disinfection.

4.2.3 Treated Water Transmission and Distribution

The transmission and distribution stage of the chain involves infrastructure (mains) to move bulk water from the production source and then distribute it to consumers through supply networks (Alegre, 2006). This requires large investments, particularly where a new system is required (Ouyahia, 2006). This might explain why low coverage levels are reported in developing countries, where economic resources are scarce. Per an arrangement, a utility may buy bulk water from another, which may be moved over a long distance at significant monetary, energy and environmental costs. For instance, the California State Water Project (SWP) conveys water from San Francisco Bay-Delta to Southern California and is the largest single energy consumer in the state. Reportedly, SWP uses an average 5 billion kWh/yr (i.e., 2–3%)[1] of total electricity consumed in California (Cohen et al., 2004).

[1]This figure is more than 25% of the total electricity usage for the entire New Mexico state. The amount of energy does not include energy used to deliver that water to residential customers in southern California

4.2.4 Customer Interface

Customer interface is the last stage of the value chain and includes customer connections, metering, billing for water delivered, bill collection and other services to make customers happy. Water distribution to consumers is done through household connections, utility standpipes, and utility tanker supply; small-scale private water carriers; privately-managed standpipes and kiosk networks; and community-managed organisations (ADB, 2009; World Bank, 2010). All or some of these are found in low-income countries. In developing countries, it is not uncommon for some customers (domestic or industrial) to bypass the chain to tap their own water supply from rivers, springs, lakes, private wells, etc. (abstraction stage), which may be unsafe and a threat to their health. This happens when reliability of supply from the public or private water supply utility is poor or when the customers' location is cut off from the water distribution networks (ADB, 2009). The unique characteristics distinguishing the sector from other service and infrastructure sectors are discussed in the following section.

4.3 WHY IS THE WATER SUPPLY SECTOR UNIQUE?

The water supply sector tends to possess unique characteristics that differentiate it from other infrastructure sectors, such as power/energy, telecommunications and transportation. These characteristics are of much concern for private infrastructure providers because they expose the projects to high risks and complicate service delivery, thereby creating the need for complicated interaction with host governments (Arndt, 2000; Haarmeyer and Mody, 1998; Wibowo and Mohammed, 2010). The water sector thus is the source of many risk factors. These attributes underscore the lower levels of investment by the private sector in the sector, and hence, a need for government's commitment to put in place pragmatic approaches to risk reduction or mitigation in order to attract more private investment. This section of the thesis discusses the special characteristics of the water sector.

4.3.1 High Capital Intensity and Large Sunk Costs

The water sector is capital intensive (Armstrong et al., 1994; Hassanein and Khalifa, 2007; Brocklehurst and Janssen, 2004) and is associated with large sunk costs (Haarmeyer and Mody, 1998). This limits direct competition in the sector and creates the need for governments to play a regulatory role to protect the public from exorbitant tariffs and private investors from political risks such as expropriation. According to Hassanein and Khalifa (2007) the ratio of fixed assets to annual tariff revenue is 10:1, against 4:1 and 3:1 for the electricity and telecommunication sectors, respectively. Most assets of the sector are underground, rendering them difficult to be moved once installed (Haarmeyer and Mody, 1998). And water assets have a life-span of between 30 and 50 years (or 80 years if well maintained), with depreciation rates ranging from 3% to 5% per year (Hassanein and Khalifa, 2007; Ménard and Peeroo, 2011).

Keeping tariffs below cost recovery levels and compounded by inadequate collection, as observed in many developing countries, means that the payback period for investments in the sector is lengthy, often amortized between 15 and 30 years (Kessides, 2004; Idelovitch and Klas, 1995; Haarmeyer and Mody, 1998; Hassanein and Khalifa, 2007). Long-term private capital is indeed crucial in financing these large and bulky investments (Haarmeyer and Mody, 1998), but will "generally depend on the perceived risks and the rewards in compensation" (Idelovitch and Klas, 1995).

Absence of domestic capital markets – small-size local commercial banks, short tenors of loans, financial institutions lacking expertise and experience in project financing – in developing countries hinder private participation (Shendy et al., 2011). On the other hand, heavy reliance on foreign lending presents currency risks. Hence, the development of capacity of local financial institutions will help to mitigate these risks.

4.3.2 Multiple Public Policy Objectives

Public water systems have mixed policy objectives that highlight political as well as regulatory risks and uncertainties (Haarmeyer and Mody, 1998; Lobina, 2005). These objectives include economic efficiency; resource and environmental protection and enhancement; security; affordability, particularly for the poor; political goals; and public health protection from contamination. To ensure growth and development, all infrastructure and service sectors of an economy ought to satisfy multiple public policy objectives, but the case of the water sector is more acute because of the dire public health and environmental consequences resulting from poor service provision (Haarmeyer and Mody, 1998). Moreover, water has been critical to poverty alleviation, improved health status and sustainable development strategies.

Consequently, many countries have developed construction and operating standards, tight and extensive systems of regulations governing maximum contaminant levels, monitoring systems, emergency response planning, training systems, and public education and research to better protect drinking water supply and receiving waters and ecosystems, with strong participation of sector stakeholders. For example, the U.S. Environmental Protection Agency (EPA), active water sector partner, ―is working with its security partners to coordinate protection of the nation‘s drinking water supply from terrorist attacks, other intentional acts, natural disasters, and other hazards" (Homeland Securities and EPA, 2007). Another example is the EU Water Framework Directive, covering 27 countries, which is an important trend towards an ecosystem-based approach to water resource management. It has an ultimate objective of a *"good"* overall quality of all waters, the fulfillment of which involves high costs to public water supply users (who bear full capital and operational costs), agricultural and industrial water users (where the full-cost recovery principle is applied) (Kallis and Butler, 2001).

4.3.3 Highly Fragmented Sector, plus Diverse Institutional Setups

Unlike other network industries (gas or electricity), the high costs associated with water transportation limits the scope for long-distance transmission, rendering water systems localised or decentralised (Ménard and Peeroo, 2011). Ideally, water is transmitted to water-stressed areas but at high cost, as indicated previously. Generally, water supply systems benefit from very sizeable economies of density, so private entities are less incentivised to extend the services to locations with small and/or dispersed inhabitants (Ménard and Peeroo, 2011). Localisation of water systems limits economies of scale and investments, particularly in dispersed settlements, small towns and rural communities.

Additionally, the sector is institutionally fragmented, manifested in a range of vertical and horizontal stakeholders (ADB, 2009). Stakeholders range from individual water users to national and international institutions such as multilateral and bilateral donors. Existing public institutions, sometimes with conflicting roles and diverse interests, cross public departments and ministries for health, education and environment, local government, and agriculture. Power relationships between these multiple state and non-state stakeholders indicate significant sector risks (ADB, 2009). On the one hand, the sector combines different sources of funding (from donor agencies, community, private and public sector investment which may be poorly coordinated) and service delivery using a mix of market mechanisms and tight public regulation to ensure universal access to water and to control resource utilisation (Boesen et al., 2008).

4.3.4 Asset Condition Uncertainty

One significant characteristic of the water sector is the high degree of uncertainty about asset condition and thus exact investment needs. Because 70% to 80% of assets are buried in the ground (Infrastructure Canada, 2004), private investors are faced with difficulties in obtaining detailed information on the state of the physical asset (pipes, underground tanks, valves) and customer base (Rees, 1998), particularly where existing public utilities maintain poor records. The situation is further worsened by massive underinvestment as well as poor and untimely maintenance leading to asset deterioration and subsequent high water losses (Idelovitch and Klas, 1995). As argued by Haarmeyer and Mody (1998) and Brook (1997), the private sector‘s inability to generate realistic rehabilitation costs of an existing infrastructure may result in tariff setting and adjustment uncertainty, hence increased renegotiations.[2] Poor asset condition poses unexpected operational challenges and losses. However, regulatory provisions for tariff adjustment and contract renegotiation could attract and retain private capital and expertise.

4.3.5 Numerous Sector Performance Indicators

The sector has multiple performance indicators which ―provide first order signals on sector risks" (ADB, 2009, pg. 9). These include

- cost recovery,
- non-revenue water levels,
- billing and collection practices,
- cross-subsidies,
- water supply duration,

[2] See Lobina (2005, pp.61-62) for renegotiation cases.

- labour productivity,
- metered coverage,
- water supply coverage,
- water quality and quantity, and
- cost (tariffs).

These are quantitative performance indicators for a water supply system and can be used as the basis for setting performance targets for water supply utilities. They are useful for comparing the efficiencies of water utilities and offering customers a measure of the quality of the overall service they receive and the level of public health protection provided by water utilities (World Health Organisation, 1997).

For example, non-revenue water (the combined effects of physical leaks and unauthorised consumption) is used to measure the operational efficiency of a utility. Earlier studies indicated that public utilities in developing countries have high non-revenue water levels, ranging between 40% and 60% of water produced (Haarmeyer and Mody, 1998). An efficiently managed system‘s water loss ranges from 10% to 20% (Idelovitch and Klas, 1995). The above indicators may point to underinvestment in new capacity, weak financial management and commercial systems, inefficient business processes, lax sector regulation, and corruption (ADB, 2009).

Based on these characteristics, the sector is institutionally, socially and technically complex to develop, manage, and regulate (Ménard and Peeroo, 2011), presenting numerous risks to either the public or private sector or both, based on the organisational structure of a utility. This explains why the sector is less prone to private sector participation. For PPP water supply projects, these complexities and risks are further compounded by additional external uncertainties and risks occurring in the contractual relationships between the private and public sectors as a result of the inherent differences in working practices and strategies (Ibrahim et al., 2006; Thomas et al., 2006). The next section discusses various PPP options for engaging the private sector in the water sector.

4.4 PPP MODELS IN THE WATER INDUSTRY

In the water sector, governments, municipalities and water utilities follow diverse business models regarding the degree of private- and public-sector participation in the provision of water supply services and infrastructure. In general, two broad classifications could be made (Augenblick and Custer, 1990; Abdel-Aziz, 2007): service-based models that tap the private sector‘s innovative skills, technical know-how, and management expertise to optimise costs and operational efficiencies, often in existing water supply systems; and finance-based models that utilise private-capital for new water supply infrastructure to bridge the public sector‘s infrastructure gap, with little or no governments‘ financial commitments. This section briefly reviews the popular models of private sector participation to provide a shared understanding of the nature of and the typical risks associated with some of the business models.

4.4.1 Service Contracts

Service contracts have very short periods, usually 1 to 3 years, and are therefore the simplest PPP model in the water sector (ADB, 2008a). Under a service contract arrangement, the public water utility retains asset ownership and overall responsibility for operation and maintenance of the water system, except for the specific services that are outsourced to a private operator (Idelovitch and Klas, 1995).

Service contracts can cover a number of water-related services, including maintenance of water systems, emergency repairs (e.g., pipe bursts), meter reading and meter installations, billing and collection, non-revenue water reduction, upgrading of existing systems, construction (or extension) of new facilities, etc (Idelovitch and Klas, 1995). Hence, most risks including commercial, operating, financing of investments and working capital and overall performance remain with the public water utility, while performance risk relating to the specific services is borne by the private firm.

The key advantage of service contracts lies in the fact that payments to the service contractor are dependent on the actual work done, and there is not guaranteed remuneration to the service contractor (Idelovitch and Klas, 1995). For instance, a service contract for domestic meter installations would specify that the contractor be paid a unit price for each meter installed. Service contracts are less common in the water sector, presumably due to their limited-scope services and low margins, making them less attractive to both public and private sectors. On the other hand, a service contract may require an effective supervision by the water utility to ensure that quality standards and targets are satisfied.

4.4.2 Management Contracts

A management contract allows a public water utility to transfer its traditional operation and management responsibilities to a private firm, often for 3 to 5 years, giving the private firm the management authority to make day-to-day decisions (ADB, 2008b; Idelovitch and Klas, 1995). The core objective of management contracts is to improve operating and management efficiencies in a publicly-owned water supply company. The management contractor is paid a fixed fee for performing managerial functions and performance incentives tied to achieving or exceeding set targets, such as bill collection, improved efficiency, coverage, reduction of non-revenue water, reduction of energy usage, increase in hours of water supply, or volume of water produced (World Bank, 2006). The fixed fee often forms the basis for competitive bidding, whereas bonus payment incentivizes the operator to improve efficiency and productivity. In practice, as in most developing countries, the operator‘s fee is paid from national budget, or funded by donors or external development partners.

The public water authority (through the government) retains asset ownership and financial responsibility for the service delivery and has to finance investment programmes and working capital. In designing management contracts, the basic challenges are determining (World Bank, 2006):

(a) which performance/service targets are measurable and under the influence of the management contractor and how sensitive the contractor‘s remuneration should be to the fulfillment of the contractual targets; and
(b) the extent of the management contractor‘s powers over, for example, employment and investment funds.

In practice, key top management staff is provided by the private firm while the bulk of employees are provided by the public utility.

Comparatively, a management contract is less challenging to implement, because the private firm‘s fee (or remuneration) is not dependent on the consumer tariff, and the public water authority needs not to design and implement measures that shield the contractor from tariff-related policy and non-payment risks (World Bank, 2006). Therefore, a management contract assigns less risk to the private party, so the public utility retains much risk.

Several experiences suggest that management contracts have been used for stage preparations, preceding more ambitious contracts like leases and concessions (Ringskog et al., 2006; Mugabi and Marin, 2008; Baurmert and Bloodgood, 2004). In this case, their main rationale is to transform a previously poorly-managed public utility when consumer records and data on the physical water asset are unreliable.

4.4.3 Affermage-leases

―Affermage-lease" describes a class of PPP arrangements whereby a private firm is responsible for operating, maintaining and managing a water supply system, but not responsible for capital expenditures (World Bank, 2006). A lease and an affermage are similar, but there is a difference between them. In a lease contract, the private firm rents the water supply asset for a specified period, finances working capital, and retains the water revenues but makes specified (lease or rental) payments to the asset owner, the public authority. This lease payment must be sufficiently high to cover loans/debts and partly pay for capital programmes.

Under an affermage, collected revenues are shared between the contracting authority and the private operator. Thus, the public partner is paid an affermage fee, which is dependent on prevailing demand and tariff levels whiles the operator keeps the remaining revenue (World Bank, 2006). Technically, the affermage fee represents a set rate for every unit of water sold to customers.

Under affermage-lease arrangements, the firm operates and maintains the water systems, and its margin is largely influenced by water sales and operating costs, which incentivizes the firm to lower costs, and improve billing and collection efficiencies. Moreover, the public partner is responsible for financing investment programmes for major replacements, major infrastructure extensions as well as tariff and cost recovery policies (Idelovitch and Klas, 1995). The public authority's investment programmes, however, are coordinated with the operating company, and the responsibility of designing and managing investment programmes is project-specific.

The duration for lease contracts ranges from 5 to 10 years but can be extended for 20 years depending on the project‘s circumstances. Coupled with the lengthy period, the operating firm bears much risk which makes the design and implementation of an affermage-lease more challenging, compared to management or service contracts. Conversely, when the risks involved in an affermage-lease project are limited, competition from potential private firms is triggered, which is beneficial to the public sector (Idelovitch and Klas, 1995). The public partner retains risks associated with capital investments, while the operating company bears all operating and commercial risks including tariff-related policy and non-payment risks. In most cases, the (host) government is therefore required to implement policies to counter these risks (World Bank, 2006) in order to provide the operating firm some comfort.

If well designed and effectively regulated, affermage-leases provide the private firm enough incentives to improve efficiency and operating performance. Nonetheless, a major shortcoming is the possibility of the firm reducing the level of investment in operations and maintenance on the water assets, especially in the later years of the project, with the intention to increase profits (ADB, 2008b).

4.4.4 Water Concessions

Under water concessions, the responsibilities of operating and maintaining assets as well as financing and managing all capital investments (for system upgrades, rehabilitation, expansion of the system) are transferred to a private consortium (the concessionaire), while the contracting authority (or host government) remains the legal asset owner (ADB, 2008b;

Rivera, 1996). Moreover, all assets, including those developed by the concessionaire during the project term, revert to the contracting party on expiration of the concession contract, for example, after 25 years. The public sector‘s main role lies in establishing service targets/standards and effective regulation of tariffs and quality of water supply services (Baurmert and Bloodgood, 2004; Arndt, 2000).

Concession arrangements are normally long-term, averaging 20 to 30 years. The duration is dependent on the level of private investments and the payback period necessary for the investor to recoup all investment costs (Idelovitch and Klas, 1995) and also earn sufficient profits. However, in the case where some capital investments (e.g., for long-lived assets) have not been fully amortized on expiration of the concession contract, the concessionaire is compensated appropriately (Idelovitch and Klas, 1995). Given the large capital expenditures and the long payback periods, water concessions tend to be associated with exclusive rights (e.g., the La Paz–El Alto concession) for the service areas.

Concessions are more risky for the private investor, because major risks relating to service delivery and investment – commercial/revenue, operating/performance, inflation rate, interest rate, tariff-related policy risk, etc – are borne by the concessionaire. In addition, in practice, the private partners are wary of cost reflective tariffs, non-payment by customers, and quality of existing assets which poses operating challenges if they are in bad shape than projected (e.g., the United Water concession in the USA).

Although water concessions are difficult to implement, combining responsibility for full service delivery (operation and management) and investments for service expansion in one operating company provides enough incentive (a) to the concessionaire to make efficient and effective investment decisions, since their outcomes (or consequences) will impact it directly; and (b) for technological innovations, because the concessionaire will benefit directly from any efficiency gains (Idelovitch and Klas, 1995) in the form of increased returns on investment. For some governments or public water authorities, as the case in most developing countries, the complexity of water concession contracts poses regulatory risks; the public sector partners struggle with regulation regarding performance monitoring, contract enforcement, and water tariffs. Moreover, the long-term of water concessions requires that contracts must be well-designed and responsive to changing political and economic environment in the host country, but there is a difficulty of predicting events over the contract period (ADB, 2008b)

4.4.5 Joint Venture

A joint venture (JV) allows the public and private sector partners to either incorporate a new company under a commercial code, or assume co-ownership of an existing water utility through a transfer (or sale) of part of equity, for example 49%, of the public utility to one or more private investors (Meng et al., 2011; ABD, 2008b). The latter arrangement is popular in countries such as China and is popularly known as transfer-operate-transfer scheme (Meng et al., 2011).

In a JV, the amount of government or private ownership varies widely across projects and countries. In essence, the private partner invests in a water supply project that was financed and constructed by the government and operated by a public authority. The JV is associated with a concession to operate the water system for an agreed period that details the objectives and expectations of the JV, the obligations as well as the rights of both partners. The day-to-day management responsibility is assigned to the private partner, whereas the public sector doubles as co-owner and regulator of performance of the contract, tariffs and quality of water services in order to protect public interests and ensure social stability (Meng et al., 2011). Assigning the management control to the private investor provides it some sense of security for its interests and investments and it is incentivized to provide efficiency gains from its participation (World Bank, 2006). On expiration of the concession, the ownership reverts to the public sector authority.

As a success factor, good corporate governance is necessary to achieve corporate or political independence and operational efficiency and to avoid potential conflicts and disputes between the partners (Meng et al., 2011). Other the other hand, the private partner is wary of asset quality, profitability, and tariff-related policy, and damaging regulation, particularly in an environment with poor regulatory tradition.

JVs for public water supply services have various strengths over other PPP models. A JV limits private investor control, thereby helping to secure a private participation in water supply services (World Bank, 2006). Co-ownership of a public water company may indicate the host government‘s commitment towards a true partnership with the private sector, and integrates strengths of the private partner with local knowledge and social issues of the public sector in the project country (ADB, 2008b; World Bank, 2006). Two key challenges can be observed in the application of JVs in the water sector: first, the public authority‘s dual responsibilities as co-owner and supervisor of the JV may result to conflict of interest (ADB, 2008b) due to political reasons. Second, the absence of competitive tendering following direct negotiations with the private investors often leads to selection of an incompetent private partner(s) and severe losses (Meng et al., 2011).

4.4.6 Build-Operate-Transfer (BOT) and Similar Models

Build-Operate-Transfer (BOT) and similar models describe a class of concession whereby a private sector firm or consortium finances and creates new water infrastructure, such as water treatment facility, according to output specifications (or performance standards) established by the public water authority or the host government (Liddle, 1997; Ranasinghe, 1999). Variations of BOT-type arrangements include Build-Operate-Transfer (BOT), Design-Build (DB), Design-Build-Finance-Operate (DBFO), Build-Own-Operate-Transfer (BOOT) (ADB, 2008a, b; World Bank, 2006; Wang et al., 2000). Some of these contractual arrangements are briefly presented here.

In a BOT project, private sector sponsors make equity investments (typically 10–30% of the total project cost) in a private project company that will *build* the new project, *operate* it for a predetermined period sufficient enough to permit the investors to recoup all capital costs (project debt and equity investment) and earn sufficient profits, and then *transfer* it to the host government (Augenblick and Custer, 1990). Through the support of export credit guarantee institutions, bilateral and multilateral lenders, and more importantly host governments, the PC, on the other hand, raises debt financing (typically 70–90% of the total project costs) from commercial sources (Augenblick and Custer, 1990). Unlike other less ambitious projects, the duration of BOT projects is dependent on the years required to retire the project debt and to secure a return to project sponsors.

Compared to other PPP arrangements presented earlier, BOT projects are extremely complex – legally, financially, lengthy transaction period, and risk allocation and management. These complexities are largely influenced by project and country circumstances (Zhang and Tiong, 2010). In practice, BOT water projects transfer a higher level of risk to the private participant (Ranasinghe, 1999; Oyedele, 2013; Xenidis and Angelides, 2005; UNIDO, 1996; Wang et al., 2004), and experience has shown that key risks that stress these projects include completion risks, construction cost overruns, demand and revenue risks, water pricing, host country‘s currency risks, and insufficient water supply resulting from long droughts (as experienced in the Izmit domestic and industrial water supply project in Turkey and the Chengdu No. 6 BOT water project in China) (Zheng et al., 2007; Chen, 2009; Wibowo and Mohamed, 2010; Ameyaw and Chan, 2013a; Zayed and Chang, 2002; World Bank, 2006; Seyed et al., 2010).

There is a difference between a water concession and a BOT contract: a water supply concession generally entails operation of and expansions to existing water systems and services within specified service areas (section 4.4.4). In practice, a concession may entail the development of new systems, such as a water treatment plant. Conversely, a BOT water project typically involves large *"greenfield"* investments that require huge private finance, for both nonsovereign borrowing and equity (ADB, 2008b). Comparatively, BOT arrangements are increasingly common in the transportation (e.g., toll roads) and energy sectors than in the water (and sewerage) sector, especially in the 1990s.

In the water sector, BOT contracts are used extensively for large and complex bulk water treatment plants (e.g., Chengdu No. 6 Water Plant in China) or sewerage treatment facilities (e.g., Nanzih BOT Wastewater Treatment Plant in Taiwan), but the model is not ideal for water distribution, or sewerage collection systems (Meng et al., 2011; Idelovitch and Ringskog, 1995). In recent times, most private activities in the global water sector concerns potable water treatment activities following the boom in the desalination markets and increasing demand for water treatment across countries (Perard, 2010).

Under a bulk water supply BOT contract, water demand is often guaranteed by the public sector entity through a purchase agreement, thereby eliminating demand and revenue risks. China is one country that has applied extensively the BOT-type arrangements in its water sector following rapid population explosion, urbanisation and industrialisation (Chen and Messner, 2005). In practice, the BOT model is always varied to suit the host country's economic, legal and political systems.

The key advantage of BOTs lies in their ability to attract the much needed outside finance to develop water-related infrastructure and transfer much risk to the PC. A BOT arrangement is much beneficial to the private sector when the public sector guarantees demand. On the other hand, governments who want to develop their water infrastructure through BOT approach need to understand and embrace the complexity and time-consuming nature of the procurement process, and then guarantees reasonable margins that the private sector investors anticipate (Augenblick and Custer, 1990). Bulk water BOTs projects become distressed when the public sector authority reneges on its financial obligations – quasi-commercial risk.

Other variations of BOT-type arrangement include (ABD, 2008b; Rivera, 1996):

(a) *BOOT (build, own, operate and transfer):* Under a BOOT arrangement, a private sector firm (or a consortium of firms) *finances, builds, owns, and operates* a water system (e.g., a water treatment plant) for a specified period of time and *transfers* it to public partner. The facility must satisfy predetermined conditions during the transfer period. The contractual arrangements, complexities and the high level of risk to the private sector are similar to the BOT approach. In essence, the private participant is granted a franchise to develop and operate the new infrastructure at its own costs.

(b) *Design–build–finance–operate (DBFO):* Under this model, the private firm is responsible for *designing, building, financing,* and *operating* a new water infrastructure or a major component (according to the standards of the public sector partner) for a period time, usually a long-term. The facility reverts to the public partner on expiration of the concession term. In effect, DBFO arrangements transfer much risk to the private firm. When successfully implemented, a DFBO removes the temptation for the public partner to scimp repairs in tough financial times, because the private firm would be paid an annual fee for keeping the water facility in good order. Moreover, DBFOs permit the private sector to innovate in both the design and construction of water supply facilities, in order to meet stringent requirements and reduce operation and maintenance costs in the future. The private investor uses both debt and equity to finance the new infrastructure. However, the degree of financial responsibility that is borne by the private firm varies across projects – the main variation among DBFO arrangements (ADB, 2008b).

(c) *Design–Build–Own–Operate–transfer (DBOOT):* DBOOT allows the private consortium to *design, build, own,* and *operate* a complex water treatment facility under a ―take or pay agreement" and to *transfer* the facility to the host government after the contract period. A typical example of a DBOOT project is the Tampa Bay Seawater Desalination project in Florida, USA. The model allows for reduced costs while maintaining government control, minimized risk to the government, and private sector innovation and operational efficiency.

(d) *Design–Build–Operate (DBO):* This model, also called build-transfer-operate (BTO), allows the private sector entity to *design* and *build* a water facility and then *transfers* it to the contracting authority upon completion, while operating the facility for an agreed period (Black, 2009). A typical example of a DBO contract is the operation of the Tampa Bay Water‘s water treatment plant by Veolia Water North America, since September 2011.

4.4.7 Hybrid Models

Given the water sector‘s differing needs and characteristics, and changing environment, economic and socio-political conditions across countries, business models (termed *hybrids*) that integrate different characteristics of a range of contract arrangements are developed and applied in the water sector. Hybrid models incorporate the attributes that suit a particular water supply project‘s requirements and the operating conditions, in a particular setting (ADB, 2008b). Broadly speaking, hybrid models are variable and dependent on country and project circumstances. The advantages of these models lie in the fact that they offer a ‗customized‘ solution regarding scope of services, risk allocation, and responsibilities of the partners under the project, and examples include (ADB, 2008b):

(a) A *management contract plus* model is whereby the performance-based component of a management contract is sufficiently large enough to transfer real risk to the private operator. As indicated earlier, the payment of performance incentives to the operator is often tied to achieving or exceeding set targets. Achieving such targets means that the operator puts extra inputs at risk – thereby assuming sufficient risk.

(b) An *affermage–lease plus* model permits a private firm co-finances new investments, as opposed to a traditional affermage/lease in which the public water authority remains asset owner and therefore undertakes and finances new investments. Thus the model enable both sectors to pull financial resources together to execute the project.

4.5 CURRENT STATUS OF PPP IN THE GLOBAL WATER INDUSTRY

Starting from the early 1990s, public water management/operation has become an increasing area for PPP application worldwide, though with diverse arrangements and drivers in both developed and developing countries as well as the water-stressed and the water-rich regions (Black, 2009). In the developed countries, the focus was to refresh the aging water supply (and wastewater) infrastructure and to develop new water systems that meet emerging stringent environmental requirements. In developing countries, however, the PPP activity was hailed and promoted by international financial institutions (IFIs) – notably the World Bank, IMF, ADB, OECD and other donor agencies – as a solution to the problems in the water sector, regarding access expansion, quality of service, efficiency, and effectiveness (Nickson and Vargas, 2002; Nickson, 1996, 1998).

The private sector was expected to provide expertise and much-needed funding in order to eliminate the chronic underinvestment in the water sector following massive political interferences and rent-seeking behaviour by vested and bureaucratic interests (Marin and Izaguirre, 2006; Hall et al., 2005). Between 1990 and 2005, private investment in excess of US$50 billion was committed to over 380 water infrastructure projects in low– and middle–income countries (Marin and Izaguirre, 2006). As of 2011 the level of investment reached over US$65 billion in 762 projects in 62 low– and middle–income countries (see Fig. 4.2).

Unfortunately, country-level empirical studies indicate that performance can be best described as mixed, and private sector investments were partially realised, particularly in developing countries (Hall and Lobina, 2006). Obviously, the early PPP arrangements ―reflected excessive optimism” by both the public and private sectors – that the ‗*promised*‘ investments were unrealistic, and the social and political constraints of raising previously subsidized public water services to cost reflective levels were largely underestimated (Black, 2009; Marin and Izaguirre, 2006). OECD (2009a) summarised that the difficulties and failures of water PPPs in the 1990s emerged from a poor understanding of the risks (and opportunities) associated with a complex sector like that of water.

Having suffered investment losses, the private sector has lost the courage for further investment in developing countries. These early experiences and lessons have contributed to shaping the PPP landscape in the global water sector. Current practice and debate point to the fact that the nature and form of PPP in the water sector is evolving (Palaniappan et al., 2006). Today, both public and private sectors are exploring PPP constructions best suited to local needs, the socio-political contexts, the local needs and capabilities, and the risks involved in water sector projects.

4.5.1 Trends in PPP in Low– and Middle–income Countries

The discussion here draws heavily on the World Bank‘s infrastructure[3] database that maintains and updates data on the number, amount (investment), and type of business models (management or lease contracts, concessions, greenfield projects, and divestitures) for engaging the private sector in the water sector of developing countries. Despite the relevance of the data source, two key limitations are noted:

a. the data concerns PPP activity in low– and middle–income countries, excluding developed economies, and
b. the database only captures projects that are publicly available.

Progress in terms of the number of projects and investments over the last two decades are shown in Fig. 4.2. The number of projects increased from the early 1990s to mid 2000s, peaked in 2007 (representing 10.63% (81)), fell sharply to 25 projects in 2010, and slightly rose to 31 in 2011. Greenfield and concession contracts are the most popular PPP models in the water sector, representing respectively 41.73% (318) and 38.71% (295) of all private

[3]World Bank Infrastructure Database (http://ppi.worldbank.org/explore/ppi_exploreSector.aspx?sectorID=4)

activities between 1991 and 2011. Management and lease arrangements account for 15.75% (120) while divestiture contracts represent just 3.81% (29) of all projects, over the same period.

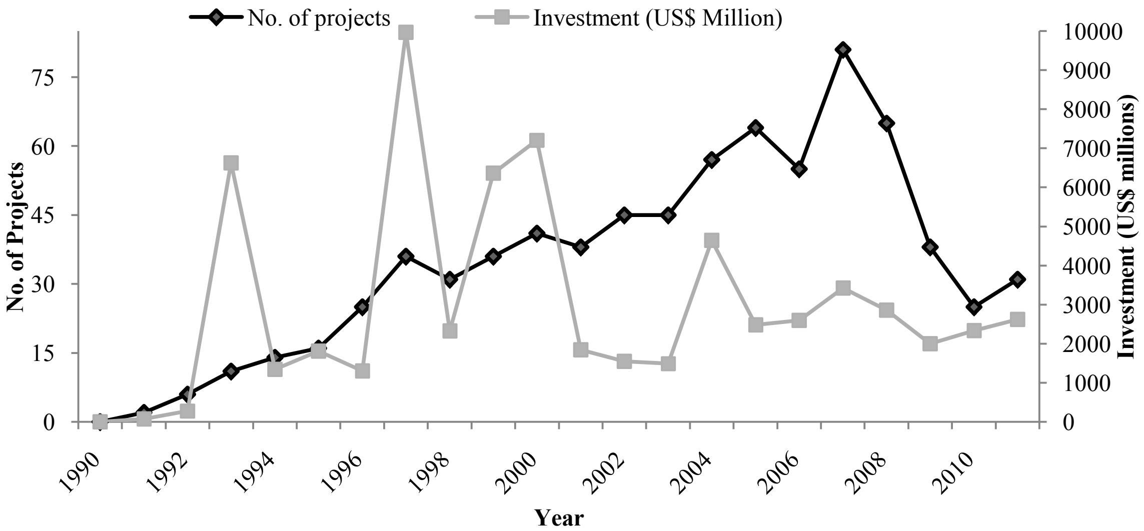

Fig. 4.2 Trends in water PPPs in developing countries (Based on World Bank PPP database)

The business model with the largest share of investment is concessions, representing 60% (US$ 39,261 million) of the total investments between 1991 and 2011, followed by greenfield and divesture projects that account for 23% (US$14,811 million) and 15% (US$9,680 million) respectively. Unsurprisingly, management contracts and leases account for just 2%, because private capital is not targeted under these arrangements.

Though divestitures are the least common, representing 15% of total investments signifies that they are among the most expensive PPPs (Palaniappan et al., 2006). Conversely, the dominance of water concessions and greenfield projects regarding the largest share in investment and the largest share in the number projects, respectively, is because the private ownership and operation of the water asset guarantee greater protection to private investors against the possibility of the government altering the rules of the game during the contract life (Palaniappan et al., 2006). In addition, greenfield contracts often include water purchase agreements that shield the investor against demand, political and revenue risks and make access to nonrecourse financing fairly easy (Marin and Izaguirre, 2006). Importantly, the dominance or popularity of various models in a country or region is dependent on various factors, including a stable political atmosphere, national history and conditions, sound financial climate, supportive policies, and public perception (Palaniappan et al., 2006).

There are wide variations in private participation in water services among regions. According to the World Bank‘s data, as of 2011, East Asia and Pacific is the region with the largest investment share of US$30,203 million (representing 46% of total investments) and the largest share in PPP projects of 427 representing 56% of total projects, followed by the Latin America and Caribbean region with US$26,786 million (41%) investment share in 228 (30%) projects. On the number of projects, South Asia is trailing behind all the regions with just 13 projects, after Middle East & North Africa and Sub-Saharan Africa of 24 and 26 projects, respectively.

However, in terms of investment Sub-Saharan Africa region has the least share of US$266 million (0.4%), because a large number of projects in this region are management and lease contracts (i.e., 22 out of 26 projects). A close scrutiny of the data and the trend suggests that the private sector is moving into particular regions with strong emerging markets, and withdrawing from others, particularly those tagged as risky investment destinations. Clearly, in those risky investment destinations management contracts and leases are more preferable to the private sector.

Recall that the urban water sector consists of two parts: treatment plant, which entails developing and operating drinking water and wastewater treatment plants, and water utility, which involves operating drinking water and wastewater pipe networks. As indicated earlier, given the boom of global (seawater) desalination markets and growing need for drinking water treatment (Perard, 2010) following growing concerns over water resources scarcity and climate change impacts in some regions across the globe (OECD, 2009a), recent private activities in the water sector concerns treatment activities in water and wastewater rather than urban utilities. Between 1990 and 2011, for example, 58% (439) of private activities concerned treatment out of which 136 (31%) were for drinking water treatment.

Perard (2010) also noted that between 2005 and 2010, 78% of newly signed projects were for potable water treatment. By 2011, 320 urban water and wastewater utilities were run by private operators, representing 41% of all PPP projects in low– and middle–income countries.

Hence, a careful examination of available data and arguments by various authors hint that PPPs in the water sector has not surged in the last two decades, but are rather evolving across regions and countries. For example, local and regional private operators (e.g., in Russia and China) as well as public water companies operating in other countries (e.g., AVRL in Ghana) are playing a significant role. Palaniappan et al. (2006) argued that local operators will dominate the water market in the near future, and after a fall in private investments in some regions, private sector investment will pick up again but with new players and diverse, innovative strategies and responsibilities, in areas such as wastewater reclamation and re-use (as happening in Namibia), application of advanced filtration membranes for water treatment, and desalination (OECD, 2009a; Global Water Intelligence, 2008). Whatever form and nature PPP assumes in future, risks will continue to receive attention from both academia and industry.

4.5.2 Trends in PPP in Developed Countries

Even in the developed world, country-specific data on water PPP is inconsistent, and available data on contractual models is generally unavailable (Palaniappan et al., 2006). In developed countries, private participation in the water sector is described as *dominant*[4], *significant*[5], or *minor*[6] in terms of the number of people served by the private sector. In countries such as the UK, Czech Republic and France PPP is dominant, while it is significant in Hungary, Greece, Spain, and Italy (Palaniappan et al., 2006). Regarding PPP models, divestiture is common in England and Wales; DBO and operation and maintenance contracts are typical of the USA; concessions and leases are common in France and Czech Republic; and BOTs are popular in Ireland (Palaniappan et al., 2006; Black, 2009). Given the limited data, it is difficult to determine which models are growing overtime and in which regions, as detailed in the case of developing countries.

4.6 CHAPTER SUMMARY

This chapter is important because it underpins this thesis and informs the rest of the chapters presented in this thesis. It has provided the characteristics of the water supply sector and explained why the sector is risk-prone and risky for private sector participation. Furthermore, the popular models for private sector participation in the water sector are described in detail, which is followed by a review of current status of PPP in the international water industry. It revealed which models are increasingly applied, and in which regions.

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[4]*Dominant* means having more than 50% of the population served by the private sector;
[5]*Significant* means having between 25% and 50% of population served the private sector;
[6]*Minor* means having below 25% of the people served by the private sector.

More importantly, this chapter showed that PPP in the water sector has not declined, but has been evolving across countries. It also showed that risk factors in the water supply sector influence the choice of models and trends in private activities. The implication is that more research is needed to study the emerging risk issues in the water sector. The following chapter discusses the risk management process in PPP procurement, with a special attention on risk, risk identification, risk assessment and risk allocation.

Chapter 5: Risk Management Issues and Risk Allocation in PPT Procurement

This chapter reviews the literature concerning ‘risk’.

It is very effective partly because the writer does the following:

Introduction	Section 5.1
Defines key terms	Section 5.2
Reviews Risk Management	Section 5.3
Reviews Risk Allocation	Section 5.4
Reviews Risk Allocation Modelling	Section 5.5
Knowledge gap	Section 5.6
Summary	Section5.9

Content

- Summarises key ideas in the introduction, including an outline of the chapter and the major studies to be reviewed (e.g. Section 5.1)
- Highlights the importance of the topic (e.g. Section 5.1, paragraph 1, sentence 3).
- States the aims of the chapter (e.g. Section 5.1, paragraph 2)
- Defines key terms (e.g. Section 5.2)
- Quotes a definition for the key term (e.g. Section 5.2, paragraph 1)
- Explains the quote (e.g. Section 5.2, paragraph 2-3)
- Gives alternative definitions (e.g. Section 5.2, paragraph 4)
- Sums up definitions and gives a new definition to be used in the thesis (e.g. Section 5.2, paragraph 8)
- Critiques studies reviewed (e.g. Section 5.3.1.1, paragraph 2 sentence 2).
- Groups approaches (e.g. Section 5.3.2.2)

- Establishes the need for the research in later chapters by highlighting the common shortcoming of current procedures (e.g. Section 5.4.2 final paragraph)

Language

- Links to the previous chapter in the introduction (e.g. Section 5.1, paragraph 1, sentence 1).
- Lists key points, using the same grammatical form for each point (e.g. Section 5.3.1, section 4).
- Provides clear introductory paragraphs for sections (e.g. Section 5.3, first paragraph) and Sums up sections (e.g. Section 5.3.2.4, final paragraph).
- Uses a table to sum up the models reviewed (Table 5.4)
- Summarises the main findings in two sections to highlight the importance of the research gap (e.g. Section 5.6 and 5.7)

To consider

In general, this chapter is effective. However, it could be improved in the following aspects.

- Avoid vague phrases such as *some,* e.g. rather than *some common techniques* use *A number of common techniques* (e.g. Section 5.3.1, section 4).
- Avoid overuse of direct quotes.
- Avoid listing approaches try and link them so the review flows.
- Avoid overuse of subheadings (e.g. Section 5.4.1.1 -5.4.1.5).

CHAPTER 5 RISK MANAGEMENENT ISSUES AND RISK ALLOCATION IN PPP PROCUREMENT

5.1 INTRODUCTION

Previous chapters explained reasons why the Government of Ghana, like any other government, adopted water PPPs (Chapter 3), and the characteristics of the water sector and applicable PPP modalities (Chapter 4). However, risks arise as both public and private sectors come together to provide water services and infrastructure. Risk affects desired outcomes of a project, and an awareness and a thorough understanding of these risks and how they affect the parties‘ objectives in a project are imperative.

This chapter defines risk and explains the risk management process with regard to PPP procurement. Risk management refers to a systematic approach to handling risk (Edwards and Bowen, 1998). The risk management process entails risk identification, risk assessment, risk allocation, risk treatment, and risk management (monitoring and review) (Nicholas and Steyn, 2012; Tummala and Burchett, 1999; Fischer et al., 2010; Wang et al., 2004; Arndt, 2000). All these stages are covered in this chapter, with particular attention to the first three processes.

Various strategies for allocating risk, relevance of risk allocation, limitations to risk allocation, etc are discussed. Finally, empirical studies on risk allocation in PPP are reviewed.

5.2 RISK AND UNCERTAINTY DEFINED

In the construction project management literature, risk has been used in several different meanings or interpretations with different words (Al-Bahar et al., 1990) which best describe the researchers' intentions. Its usage has been inconsistent with no standard definition. Al-Bahar et al. (1990, pg. 543) defined risk as:

> *"The exposure to the chance of occurrences of events adversely or favorably affecting project objectives as a consequence of uncertainty."*

Like other definitions in the literature, Al-Bahar et al.'s definition points to the inherent characteristics of risk: risk event/factor, likelihood of an occurrence, consequences (losses or gains), and uncertainty. These are the conditions for riskiness. A risk event or risk factor refers to what might materialize to negatively or positively affect a project, or it is a variable whose value is unknown but its outcome potentially affects the entire project (Ehrhardt and Irwin, 2004).

The probability of occurrence is considered together with the severity or consequences of a risk. This is the notion of project risk, and that risk is a joint function of both concepts – likelihood and severity (Nicholas and Steyn, 2012). The *likelihood* measures the probability or the chance of some risk event occurring and the *severity* represents the extent of damage (or loss), if the risk factor eventuates. Nicholas and Steyn (2012) explained that a project may be assessed as risky whenever at least one — either the severity or the likelihood — is huge. In practice, however, a risk factor with a high probability of occurrence but of small severity is likely to be ignored in order to save time and financial resources.

Risk is less seen as an opportunity, such as profit. Some definitions (by US Project

Management Institute, PMI; UK Association for Project Management, APM)[7] also focus on the positive (or upside) associated with risk, but risk analysts normally do not speak of this. Ward and Chapman (2003) warned that it is mistaken to focus on the downside risk, ignoring the upside. In a BOT water supply project, for example, there is a risk that demand will be greater than forecast, which will increase the profits of the investor.

Substantial literature (Royal Society, 1991; Irwin et al., 1997; Al-Bahar et al., 1990; Edwards and Bowen, 1998; Ehrhardt and Irwin, 2004) has focused (and continue to focus) on negative effects of risk to project objectives. This may be explained by the fact that adverse consequences are likely to occur frequently than opportunities, or they may cause heavy losses and undermine the benefits of the project. Hence, to connect with real world practice, this thesis mainly focuses on the downside of risk.

Royal Society (1991 in Edwards and Bowen, 1998, pg. 339) defined risk as:

> *"[...] the probability that an adverse event occurs during a stated period of time."*

Also, looking at private participation in infrastructure projects, Irwin et al. (1997, pg. 4) explained that

> *"In project finance…risk frequently refers to the ways in which actual results may be worse than planned."*

Risks in a PPP project affect the objectives of the participants. An increase in risk, for example, magnifies the volatility of and reduces expected returns of the private investor. In a typical PPP water supply project, the public authority and the private proponent encounter different set of risk factors, depending on the project modality (Chapter 4).

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[7]PMI (2000): Risk – an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective, p. 127.
APM (1997): Risk – an uncertain event or set of circumstance that, should it occur, will have an effect on the achievement of the project objectives, p. 16.

The foregoing definitions and those suggested by other authors (e.g., Nevitt and Fabozzi, 2000) indicate that ‗uncertainty' is associated with risk in a project. Uncertainty exists when the probability of occurrence of different outcomes are unknown (Taha, 1997), but can be measured, in principle, through assignment of subjective probabilities (Raftery, 1994; Jeffreys, 2004; Flanagan and Norman, 1993).

Though some authors (e.g., Knight, 1921; Al-Bahar et al., 1990) sometimes distinguish risk and uncertainty, in a real (PPP) project it is not always possible. For example, an investor may be uncertain whether the host government will expropriate investments or renege on its promises/obligations in the future. In the case of PPP water projects, as discussed in Chapter 6, it is common to find cases of both risk and uncertainty. Moreover, because in most real projects subjective probabilities are assigned to both risk and uncertainty, distinction may not matter and may be unhelpful (Ehrhardt and Irwin, 2004). This thesis does not distinguish risk from uncertainty.

Following foregoing definitions and discussion, this research study broadly defines risk as:

> *the probability of occurrence of a specific event or combination of events during the life of a PPP water supply project to the detriment (loss) of the project. It implies the eventuation of a risk factor whose outcome(s) adversely impacts on the realisation of objectives (outcomes) of the project and whose exact value (impact) cannot be predicted with certainty*[8].

This is the premise of this PhD thesis, and as such, by minimising risk probability and severity through effective risk allocation project objectives will be achieved. This definition implies that risk is quantifiable, lending itself to analysis and assessment through both simple and advanced computational methods. The literature acknowledges that the

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[8] See Ehrhardt and Irwin (2004) for a general definition of risk

ability to quantify risk is a step toward its effective management. Project, as used in the above definition, refers to a water supply business – water supply services and/or infrastructure provision.

Water supply projects are affected by multiple risk factors. The values of certain factors, such as demand, water availability, tariff levels, collection efficiency, inflation and interest rates are significant drivers for a project‘s outcomes. Unfortunately, project participants cannot predict future values of these factors with certainty (World Bank, 2006). For example, empirical evidence suggests that water demand prediction is not always accurate following the uncertainties in the factors that influence future demand.

5.2.1 Risk and Responsibility

In analysing risks and responsibilities for water supply projects, the initial step is to identify the main areas of functions and risk. Each function is a bundle of specific responsibilities with corresponding risks. World Bank (2006) presented the key functions for water services provision as management, operation and maintenance, and investment and finance. The allocation of these functions is mainly dependent on the chosen PPP modality. Chapter 4 presents the responsibilities under different modalities.

Risk represents the uniqueness of individual projects (Nicholas and Steyn, 2012). It is impossible to eliminate risk, but it can be managed through systematic approaches. The risk management process is described in the following section.

5.3 THE RISK MANAGEMENT PROCESS (RMP)

In order to ensure successful outcomes of a project through a reduction of the potentially catastrophic consequences of risks, project participants need to deal with these risks in an effective manner. While earlier authors (Cooper and Chapman, 1987; Hertz and Thomas, 1983; Chapman and Ward, 1997; Charette, 1989; Carter et al., 1994) have proposed different processes of risk management, the common objective is to enumerate, understand and deal with risks that evolve in the context of the project. The risk management process (RMP) is a

> *"logically consistent and structured approach to enumerating and understanding potential risk factors and assessing consequences and uncertainties associated with these identified risk factors"* (Tummala and Burchett,1999, pg. 223).

Simply, RMP is a systematic method to dealing with identified risk factors (Edwards and Bowen, 1998) in order to drive the desired outcomes of a project.

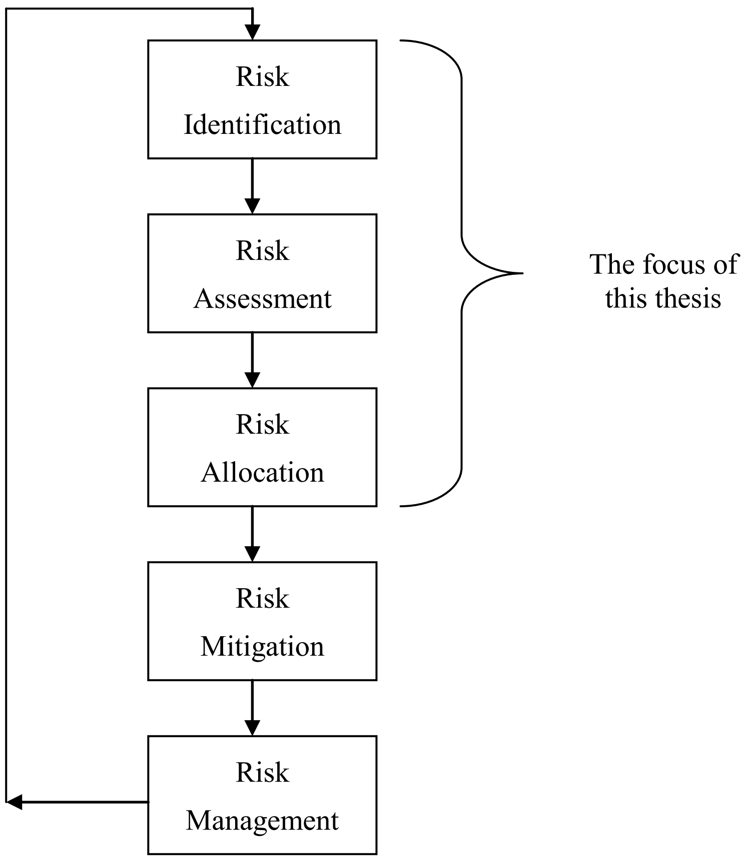


Fig. 5.1 The Risk Management Process for PPP (Arndt, 2000)

RMP consists of the following key elements as shown in Fig. 5.1 above, and include (i) risk identification, (ii) risk assessment, (iii) risk allocation, (iv) risk treatment, and (v) risk management (Fischer et al., 2010; Arndt 2000). Each of the elements of the RMP is discussed in the following.

5.3.1 Risk Identification and Classification

Risk identification, as a process, is the first stage of the RMP and includes various methods to identify all potential risk factors associated with the project, and forms the basis for the subsequent actions.

Risk identification is a systematic and continuous process of identifying, classifying and evaluating the initial significance of risk factors associated with the project (Bajaj et. al., 1997; Williams et al., 1998). Therefore, risk identification has a feature of being a continuous process (a continual search for new/emerging risks which may arise in future), given the dynamic nature of operating environments and the long-term periods of some PPP projects.

Lubka (2002) investigated the role of risk identification in the total RMP and concluded that its significance is linked to the necessity of knowing all risk factors facing the project. By risk identification project participants are able to establish sources of risks, exposures to risk, hazard factors and perils. Until a risk is identified and understood, appropriate courses of action cannot be undertaken to mitigate its consequences, which might cause the project to fall short of planned budget, quality or performance standards by a considerable margin.

Similar to the numerous definitions of risk, several authors have proposed various classification or taxonomy of risks for diverse purposes. The categorisation seems to depend mainly upon the sector, the location of the project (i.e., domestic or international) and the nature and potential consequences of the risks (Wang et al., 2004; Al-Bahar et al., 1990). However, risks are commonly classified based on their sources, and the project‘s life-cycle stage at which they are likely to eventuate. Chapter 6 presents a classification of PPP water supply project risks. Benefits of risk classification include:

(a) to broaden the risk managers‘ consciousness about the risks involved,
(b) to effectively assign responsibilities between public and private partners for handling risk occurrence and severity, and
(c) to develop appropriate risk mitigation strategies according to the nature of identified risk factors (Al-Bahar et al., 1990; Jin and Doloi, 2008, 2009).

Research into risk identification is directed toward enumerating risk factors specific to projects in specific sectors or countries, and common methods include review of extant literature, interviews and surveys with experts, and case studies (Ameyaw and Chan, 2013a). However, in practice, risk identification heavily relies on the experience and knowledge of the professionals engaged in the risk identification process to identify and categorise relevant risk factors (Arndt, 2000). Some common techniques are summarised below.

5.3.1.1 Brainstorming

The technique, originally developed for business management in the 1950s, has effectively been used in risk management. In risk identification, brainstorming is where selected project team members share views about possible risk factors, their sources and consequences on the project. To promote original thinking and identification of comprehensive risks possible, risk assessment is avoided while risk factors are being identified by the group (Nicholas and Steyn, 2012). The originality of the technique lies in the fact ―group thinking is more productive than individual thinking" (Chapman, 1998, pg. 337).

Brainstorming as a risk identification technique is effective if the group is characterised by experienced project members of diverse backgrounds and perspectives of the project under scrutiny, in order to identify risks of all categories. Its main weaknesses include criticism or analysis of generated ideas (risks and their consequences in this case) is not permitted until a later time and the influence of peer pressure in group interaction can stifle participants' ideas (Chapman, 1998).

5.3.1.2 Delphi technique

As discussed in Chapter 2, Delphi is a group survey technique for soliciting opinions of experts on a particular topic, with the aim of reaching a consensus. Under Delphi, members of a selected panel are requested to enumerate potential risks and their effects on the project. Therefore, the generation of the most comprehensive list of risks possible is strongly influenced by the experience and knowledge of the expert panel. Clearly, the technique overcomes some shortcomings of brainstorming which succumbs to dominance of few individuals, because respondents are asked individually and their identities are anonymous. However, it is expensive and time consuming compared to other methods (Delbecq, 1975, Chan et al., 2001) and therefore project managers may be unwilling to adopt it.

5.3.1.3 Checklists

Checklists are originally created from the experiences from previous similar projects, and evolve over time as new experience is gained from recent projects and contributions are received from experts (Nicholas and Steyn, 2012). They are simple to use, less demanding and less costly in terms of time and money. Checklists are likely to be useful only when the current project is much similar to past projects, and may be applicable to the entire project, or to specific project phases, or certain tasks within the project (Nicholas and Steyn, 2012). Risk checklists have other serious shortcomings (see Ward, 1999, pg. 331).

5.3.1.4 Nominal group technique (NGT)

NGT is a silent generation of risks, round-robin feedback and discussion of risk issues and independent voting on or ranking of identified risk factors. Overall, it encourages individual participation, and overcomes some shortcomings of brainstorming *vis-à-vis* few individuals‘ dominance of generation and discussion of risks (Chapman, 1998). Nonetheless, it has been contested that NGT does not completely avoid the problems associated with group dynamics (Arndt, 2000).

5.3.1.5 Work Breakdown Structure (WBS)

Project risks are identified through analysis of the WBS, where each work package is studied for potential risks with management, customers, operations, equipment, and resource availability (Nicholas and Steyn, 2012) that are probable to obstruct the project from meeting its outcomes. Each work package is assessed for both internal and external risks. Tummala and Burchett (1999) applied WBS to identify the potential risk factors associated with an EHV transmission line project in Hong Kong. WBS makes risk identification fairly simple through simplification of the project structure into manageable units.

5.3.1.6 Project analogy

Under the project analogy technique previous records, project team members' recollections as well as post-completion summary reports from past similar (analogous) projects are assessed to identify risks in current or future projects. Project analogy becomes a useful tool for identifying risks in the event of better project managers' memories (ability to recall) and proper documentation *vis-à-vis* accuracy, completeness and well-catalogued of earlier projects (Nicholas and Steyn, 2012).

5.3.1.7 Cause-and-effect diagram (CE)

Cause-and-effect diagram, also called fishbone or Ishikawa diagram, is a graphical representation of potential sources (*causes*) and outcomes (*consequences*) of risks. CE is often the outcome of brainstorming, and is divided into broad risk categories – e.g. design and construction, financial, water resources issues, etc – where each category is further broken down into more detailed sources of risk (Nicholas and Steyn, 2012). For example, Wibowo and Mohamed (2010) proposed six risk categories with 39 specific sources for privatised water supply projects based on a CE diagram. The weakness with CE diagram is that it provides no basis for further analysis and therefore its use is limited to ―deterministic problems in a very specific domain" (Ahmed et al., 2007).

A mix of risk identification techniques is commonly applied in project situations. An empirical Chinese construction industry survey on the application of risk management techniques revealed that brainstorming, experts' consultation and risk checklists are the top three techniques for risk identification (Tang et al., 2007). Similarly, Bajaj et al. (1997) found that historically-based checklists supplemented by brainstorming were the frequently used methods in New South Wales, Australia. In Nigeria, Ijaola (2012) found that brainstorming and case based approach (project analogy) were the main risk identification methods employed by contractors. Probably it is because these techniques are both less expensive and time consuming. Following the identification of significant risks, the next stage in the RMP is to assess their significance to the project outcomes.

5.3.2 Risk Assessment

Risk assessment is a qualitative or quantitative evaluation of how identified risk factors can adversely affect the achievement of project outcomes, by determining their significance. The process is crucial because it assists project managers to invest time and financial resources in the project “areas where they can make the most significant contribution to the eventual project outcome” (Arndt, 2000, pg. 50). Risk assessment methods for risk management are broadly grouped into qualitative and quantitative methods.

5.3.2.1 Qualitative approaches

Probability–Impact grids (qualitative and numerical scoring)

A common risk assessment approach is the use of probability–impact grids which require individual risk events to be subjectively assessed with probability of occurrence and degree of severity (Ward, 1999; Chapman and Ward, 1997; Pyra and Trask, 2002; Royer, 2000). The outcome is a single rating (or ranking) for each risk factor that allows risk managers to determine which risk factors require considerable attention. Each risk factor is either scored *qualitatively* (e.g., Low), or *numerically* (e.g., Low = 1, High = 5), where the latter generates risk ratings or magnitudes (i.e., rank ordering of individual risks).

Table 5.1 illustrates a probability–impact grid in which a risk factor is assessed qualitatively as *low, medium or high*. Different projects adopt various qualitative labels and classes to suit their circumstances.

Table 5.1 Qualitative scoring in a probability–impact grid

		Probability		
		Low (L)	Medium (M)	High (H)
Impact	Low (L)	1	1	2
	Medium (M)	1	2	3
	High (H)	2	3	3

Source: Ward (1999, pg. 332)

Subjective risk ratings are generated with the help of experienced project managers (Tummala and Burchett, 1999). Despite its subjectivity, probability-impact grid is widely used, because it provides a basis for risk assessment where the focus is to highlight potential risk factors rather than the precise prediction of their magnitudes (Ahmed et al., 2007). It is also a fairly simple approach, less demanding and easily understood, cost effective (Ward, 1999), and lends itself to further quantitative analysis. For these reasons, risk assessment seems to be biased towards qualitative and numerical scoring.

5.3.2.2 Quantitative approaches

Quantitative techniques aid risk managers to quantify risks in monetary terms, even in the event of several uncertain variables. Songer et al. (1997) stated that the poor initial performance of privatised tollroads was an indication that traditional techniques of project risk analysis were insufficient, and as such, improved risk assessment methods provide sufficient information for informed decisions in PPP projects. Common methods are briefly described below.

Monte Carlo simulations

Monte Carlo simulation is a method that takes into consideration “the effects of near-critical paths and merge-point bias” (Nicholas and Steyn, 2012, pg. 252), and assesses the impact of all uncertain input variables on the project outcomes (Newton, 1992; Songer et al., 1997). Thus, following large Monte Carlo simulation runs analysts are informed which variable(s) will considerably contribute to the overall project risk. In a BOT water project, these uncertain factors may include demand, construction and residual risks. See the application of the tool in a privatised tollroad project in Songer et al. (1997).

Sensitivity analysis

Sensitivity analysis evaluates effects of changing conditions on the project (Pery, 1986). It works by altering risk variables (one at a time) – e.g., tariff levels and demand levels – that are very sensitive to the overall project success, giving a fair comprehension of the project‘s response to changing conditions. This technique has many flaws, including: the sensitive risk variables are treated independently, making it impossible to truly assess their combined impact, and the sensitivity diagram (results) gives no likelihood of occurrence of evaluated risk factors (Woodward, 1995).

Probability analysis

The advantage of probability analysis over sensitivity analysis is that the former specifies probability distributions for the risk variables and assesses the situations where any or all of the variables can alter their initial values simultaneously (Pery, 1986). Thorough analyses are aided by computer-based models. However, this approach is more subjective in the absence of reliable historical data (Tweeds, 1996 in Li, 2003).

Decision tree analysis

This approach graphically structures a decision-making process with the objective to evaluating outcomes from risk events. The graphical representation of decision process shows current probable course of action and future possibilities (Pery, 1986). In practice, its application is common with investment decision-making, and thus the expected monetary values (EMV) placed on both decision and chance nodes enable the determination of expected benefits from pursuing a particular course of action (Russel and Taylor, 2000).

There are many other risk assessment techniques including utility theory, event tree analysis, fault tree analysis, fuzzy set theory, team theory, statistical approach, discrete event simulation, mathematical programming, and software for risk analysis. For a more detailed discussion of these techniques, readers are referred to Vose (2003), Ahmed et al. (2007), Li (2003) and Chapman and Ward (1997).

5.3.2.3 Risk analysis practices

Though risk analysis aid project managers to understand and prioritise risks, empirical studies have shown that risk analysis in the construction industry is low, informal and inconsistent, and subjective (Hayes et al., 1986; Birch and MacEvoy, 1992; Akintoye and MacLeod, 1997). Tang et al.'s (2007) survey indicated that ―joint evaluation by key participants" and ―qualitative analysis" (pg. 950) are the frequently used techniques for risk assessment in the Chinese construction industry. Ijaola (2012) also found that risk analysis is hardly conducted by contractors in Nigeria. Lack of knowledge in risk management and commercial pressures are the main explanatory factors commonly cited in the literature.

5.3.2.4 Risk assessment modelling and decision frameworks

Extant literature shows various methods for measuring risk. Based on these approaches, a number of frameworks and models have been proposed for PPP project risk assessment.

Table 5.2 Review of risk assessment models/frameworks

Author(s)	Study/model name	Basic tool/theory	Nature	Remarks
Salman et al. (2007)	BOT viability model	Analytical hierarchy process (AHP) method	Generic	Incorporates qualitative knowledge from experts. Final decision factors are influenced by decision-makers‘ preferences, bias and subjective evaluation
Thomas et al. (2006)	Probability-impact assessment framework	Fuzzy-fault tree; Delphi method	Tollroad	Model incorporate systematic processing of expert subjective judgement. Demonstrated for risk assessment in BOT road project
Feng and Kang (1999, 2000)	Risk measurement and ranking	Multi Attribute Utility (MAU) theory	Transport project	Evaluates primary and secondary risk factors during the negotiation process in BOT contracts. Suitable for risk measurement and analysis.
Ke et al. (2011)	Risk assessment framework	Arithmetic mean	Generic	Project risk computed as function of probability and severity. A risk significance index influenced by experts‘ bias and subjective assessment
Seyed et al. (2010)	Fuzzy multi-attribute decision model	FTOPSIS, FLINMAP	Power project	Suitable for raking of identified risk factors, but fails to indicate the risk level of a project. Demonstrated for risk ranking in BOT power project.
Yeung et al. (2010)	Fuzzy risk assessment model	Fuzzy set theory	Tollroad	Derives the risk index of the assessed project. Incorporates and transforms subjective expert opinion
Zayed and Chang (2002)	Utility prototype model	Utility theory; Analytical hierarchy process (AHP)	Generic	A prototype model that incorporates expert subjective knowledge. Effective for measuring the risk level of a project.
Feng and Kang (2008)	Multi-attribute utility decision model	Multi Attribute Utility (MAU) theory	Transport	The outcome, attribute, state of a risk factor and utility of among negotiators are assumed to be independent
Kang et al. (2005)	Dynamic multi-objective programming model	Mathematical programming method	High speed rail	Developed to determine the primary and secondary risks., and analysed negotiation problems in BOT concession contracts. Similar to Feng and Kang (1999, 2000) and Feng and Kang (2008).
Songer et al. (1997)	Monte Carlo risk assessment methodology	Monte Carlo simulation method	Tollroad	Simulation for revenue dependent infrastructure project risks. Demonstrated for risk evaluation in a tollroad project. Requires objective and reliable project data as input

To mention a few, as summarised in Table 5.2: BOT viability model (Salman et al., 2007); fuzzy-fault tree probability–impact assessment framework (Thomas et al., 2006); risk probability–impact framework (Ke et al., 2011); fuzzy multi-attribute decision model (Seyed et al., 2010); utility prototype model (Zayed and Chang, 2002); dynamic multi-objective programming model (Kang et al., 2005); fuzzy risk assessment model (Yeung et al., 2010); and multi-attribute utility model (Feng and Kang, 2008).

While these models contribute to risk assessment using diverse approaches, most have shortcomings. Ke et al. (2011) proposed a risk assessment framework for PPP projects through a Delphi survey method. Their framework has the following shortcomings: (i) the preferences and subjective judgment of the decision-makers wield substantial influence on the model outcome and (ii) the model heavily relies on decision-makers' level of experience, education, and risk attitude. Zayed and Chang (2002) proposed a model based on the AHP method to generate BOT risk index. Their model (i) relied on a small academic group and hence was constrained in determining the exact influence of the risk factors on the risk index, and (ii) failed to account for the uncertainty/vagueness inherent in mapping of decision-makers' evaluation to a number.

Salman et al. (2007) proposed a decomposed evaluation model, based on the analytical hierarchy process method, to assess the most common significant decision variables that affect the feasibility of BOT projects. Their model aimed at aiding decision-makers to determine the important factors contributing the most to viability of BOTs. The decision factors were derived from multiple completed projects. Its direct application in a different environment, however may miss some important local decision factors; 11-factor decision variables may be inadequate in a real-life large-scale infrastructure project. Also, the model has some weaknesses that originate from the AHP method: (a) fails to treat the uncertainty/vagueness inherent in the decision-makers' (evaluation or judgement) assignment of weights and performance levels to the decision factors, and (b) the scorings (ratings) of the decision-makers are subjective, thereby influencing the final viability decision factors.

Thomas et al. (2006) proposed a risk probability–impact assessment framework based on Delphi survey and fuzzy-fault tree technique. The framework involved systematic processing of experts' judgment and scenario modeling of critical risks in BOT road projects. Clearly, a major limitation is that the (i) model can evaluate a limited number of risk variables at a time, making it tedious and time-consuming and (ii) study is focused on road transportation projects — the critical risks cannot be generalized to other industrial sectors, e.g., water/wastewater. Seyed et al. (2010) proposed a model for risk identification and assessment in BOT projects. The FTOPSIS (Fuzzy Technique for Order Preference by Similarity by Ideal Solution) and FLINMAP (Fuzzy Linear Programming Technique for Multidimensional Analysis of Preference) methods were used to rank the risks. Seyed et al.'s (2010) model accounts for the human imprecise evaluation associated with risk assessment in real-life situations. Feng and Kang (2008) used the multi-attribute utility (MAU) theory to assess potential risks in concession contract negotiation of BOT projects. Their model showed that concession period of a BOT contract is the primary risk factor that dominates the negotiation process. As a limitation, Feng and Kang's model (i) is based on the assumptions that the outcome, attribute, state of a risk factor and utility among negotiators are independent. Risk items are likely to vary following negotiators' interactions, in a real-life situation. (ii) It does not account for the uncertainty associated with decision-makers' evaluation of individual risk factors. Yeung et al. (2010) applied the FSE technique to calculate the risk level of PPP highway projects in China, and concluded that such projects are risky, due in part to a high risk of political intervention. Using the FSE method, Xu et al.'s model deals with multi-criteria and subjectivity associated with decision-makers' risk assessment. Its main advantage over other models (e.g., Seyed et al.'s (2010) model) is that the FSE model generates the risk index of the assessed project as well as each critical risk group's contribution to the project's overall risk level.

Feng and Kang (1999, 2000) applied the MAU theory to measure and rank risk factors for BOT contracts. The proposed model examined risk preferences of the negotiators in a BOT contract, thereby establishing the primary and secondary risk factors inherent in such projects. Despite the MAU model's additive and multiplicative utility functions, it was constructed with the assumptions that the ‗events, event attributes and utility functions' are independent, and hence, cannot be used to explain the interactive behaviour of negotiators in the negotiation process (Kang et al., 2005).

The dynamic multi-objective programming approach was applied by Kang et al. (2005) to establish a risk assessment model that introduced an iterative algorithm for the model solution. The results indicated that the sum of the interactive utility value could establish whether or not the interactive relationship was characterised by independence among decision-makers (negotiating parties).

Songer et al. (1997) demonstrated a Monte Carlo risk assessment methodology for a privatised tollroad project. The model offers enhancements – sensitivity analysis, probability distributions, correlations, and external (global) variables – and serves as a flexible decision-making tool for privatised project feasibility assessment by assessing which of many risk variables most considerably contribute to the overall risk level of the project. Their model, however (i) covered few primary risks, while ignoring high-risk factors such as changes in law and government regulation, which commonly affect PPPs in many jurisdictions, and (ii) Monte Carlo analyses require objective project data, which may be difficult to obtain at early stages of a project.

Overall, the reported risk assessment models/frameworks are limited by cultural perspectives and type of industrial sectors. Thus, these studies are country- and (mostly) sector-specific, e.g., tollroads, power/energy plants rather than water projects. The argument is that critical risks vary according to country, type of sector and project circumstances.

5.3.3 Risk Allocation

Risk allocation is the next important stage in the RMP after risk identification and risk assessment. Risk allocation means establishing *sensible* risk sharing mechanisms between the direct project participants. In a PPP project, a risk factor is either assigned to the private proponent, the public authority, or shared between them in a specified manner. Risk allocation varies across projects and is explained in detail in section 6.4.

5.3.4 Risk Treatment / Response

Risk response refers to

> *–the process of understanding the risks to which a project is exposed and attempting to reduce [control] the significance of those risks prior to their occurrence”* (Arndt, 2000, pg. 54).

It is the process of applying risk assessment to develop management strategies to reduce potential risks that can negatively affect the project. Generally, risk treatment is considered in terms of avoidance (elimination), reduction (mitigation), retention, and transfer (spread), as briefly explained below. Other options suggested by Vose (2003, pg. 7–9) are: accept (do nothing), increase, and get more information.

5.3.4.1 Risk avoidance

Risk avoidance is often used for significant (high probability and impact) risks, and entails varying current investment strategies, operating methods, project plans, contract strategies, construction materials and/or techniques, and designs (redesign and detailed design) in order to eliminate indentified risks (Vose, 2003; Pery, 1986). For example, risk identification and analysis in the Izmit Su BOT Water Scheme (Turkey) indicated the need for redesign and robust construction techniques in order to mitigate an earthquake risk.

5.3.4.2 Risk reduction

Risk reduction is similar to risk avoidance in that similar actions can be employed to deal with a given risk factor. Risk reduction focuses on reducing both the consequence and likelihood of occurrence of identified risks. According to Vose (2003), risk reduction measures suit situations where remaining risks are not of high magnitudes and potential gains prevail over risk reduction costs. Actions include (Baker et al., 1999; Hampton, 1993; Vose, 2003):

(a) Portfolio effect – spreading risk over multiple areas,

(b) Quality education and training to staff,

(c) Duplication – building or maintaining multiple systems (redundancies) such as standby systems, back-up computers to reduce impact of loss on primary systems, and

(d) Performing more inspections, e.g., for water treatment plants.

5.3.4.3 Risk retention

Risk retention is a management option for handling risk factors that are controllable by either PPP party, especially those risks that eventuate frequently but of less severity (Baker et al., 1999). Risk retention methods can be *active* – where the respective participant is aware of such risk(s) and decides to bear it after analysing potential costs of alternative treatment options or *passive* – where a party is unaware or ignorant of such risk(s), such as unidentified risk factor (Baker et al., 1999). Regarding the former, control may be exerted to minimise probability of occurrence or impact, if it eventuates, while in the latter, a party assumes risk without any idea of its possible costs.

5.3.4.4 Risk transfer

Risk transfer takes four common routes in construction projects (Pery, 1986): owner (client) to contractor/designer; contractor to subcontractor; client, designer, contractor, subcontractor to insurer; and contractor, subcontractor to surety. Under these routes, the effect(s) of a materialised risk is shared or wholly borne by the assigned entity.

In a PPP, risk transfer is central and is viewed as a tool for ensuring VfM to the public sector. Risk transfer process is guided by principles (and influenced by several factors) (see section 5.4.2), with the aim to achieve *optimal* risk allocation. This necessitates provision of appropriate incentives for assuming risks, consideration of participants‘ objectives, and abilities of the parties to bear the risk (HKIS, 2009). Practically, it is impossible to transfer all risks. In BOT water contract, for example, where apparently the private proponent bears the risk of construction time and cost overruns, the consumer will nonetheless suffer hardship (for lack of water) should the project delay or the private partner declare bankruptcy, as in the case of the Tampa Bay seawater desalination project (Rand, 2003).

Overall, the application of risk treatment techniques varies across countries. A UK industry-wide survey by Akintoye and MacLeod (1997) found that risk transfer is the most frequently used response while risk reduction is less used. Their study further indicated wide differences in risk allocation among firms. Other recent empirical surveys (Baker et al., 1999; Tang et al., 2007; Ijaola, 2012) also showed that risk reduction is used most often and the first two studies hinted that risk avoidance and risk retention, respectively, are the least used.

5.3.5 Risk Management – risk monitoring and review

Risk monitoring and review starts after a risk has materialized, and seeks to understand how the risk has impacted the project and devises measures to correct these effects. The purpose of risk management is to restore the project to its 'pre-risk' state within the shortest possible time at least possible cost (Arndt, 2000).

The risk monitoring and review process observes effectiveness of the contract and adopted risk response strategies, identifies any new risks and devises appropriate countermeasures (HKIS, 2009; Tummala and Burchett, 1999). In practice, tools for risk monitoring and review include risk management plans, risk registers, periodic risk status reporting, periodic document reviews and periodic trend reporting (Tang et al., 2007; HKIS, 2009).

5.4 RISK ALLOCATION

PPPs are justified because they offer improved VfM through the realisation of optimal risk allocation (Quiggin, 2005; Li et al., 2005; Chung et al., 2010; Arndt, 2000; Wibowo and Mohammed, 2010; Abednego and Ogunlana, 2006; Loosemore et al., 2005; Loosemore and McCarthy, 2008). The *effective* allocation of risks that ensures improved performance, efficiency, and overall success of the project is the core of any PPP project (Irwin et al., 1997; Lobina and Hall, 2003; Norton de Matos, 1996; Quiggin, 2004). In a PPP project, actual outcomes may deviate from those anticipated from the onset due to the occurrence of risk events (Arndt, 2000). The contractual agreement, therefore must assign (allocate) the responsibility for handling those risks to the project. Risk allocation is the determination of the best party to assume identified risks and their associated consequences should they materialise during the life of the project. Roumboutsos and Anagnostopoulos (2008) defined risk allocation as:

> *"... a primary measure of assignment between the project's direct participants, that is, between the public and private sector, excluding end users [consumers]"* (p. 752).

For the purpose of brevity, this thesis embraces above definition and focuses on two parties: the private firm, and the host government. The study lumps together the taxpayers and the government, referring to the group as the ‗public sector' (or government), and no distinction is made between stakeholders (shareholders and lenders) of the private firm, but collectively referred to as the ‗private sector'. This is another premise of the study, with the view that by allocating the project risks to the direct partners, they may decide to redistribute the responsibilities for those risks to other entities.

As illustrated in Figure 5.2, the direct private operator decides how to reallocate risks among insurers, consumers (those paying the cost of water services), lenders/creditors and shareholders, whereas risks allocated to the host government are eventually assumed by its taxpayers (Irwin et al., 1997; World Bank, 2006). Hence, if the risk occurs, the risk bearing party is solely responsible for dealing with its consequences. However, given its nature, risk may be allocated (or shared) between the direct participants in proportions, to avoid future renegotiations and opportunistic behaviours (Guasch and Straub, 2009; Marques and Berg, 2011; Williamson, 1979).

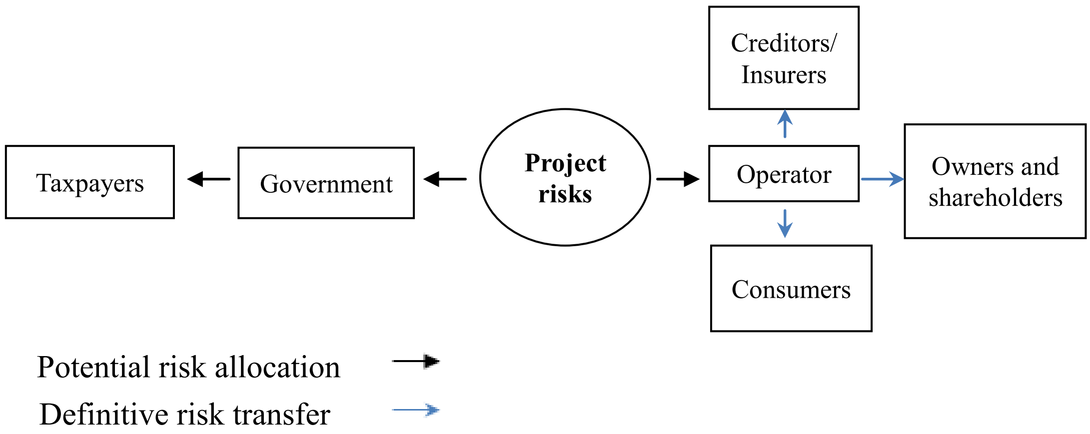


Fig. 5.2 Risk allocation for a water concession (World Bank, 2006)

The guiding principle is optimum, rather than maximum, allocation of significant risks (UNIDO, 1996; Li, 2003; World Bank, 2006; Marques and Berg, 2011; Chen and Hubbard, 2012; Tahir, 2007). Achieving this (optimum risk allocation), however is not easy and straightforward (Wibowo and Mohamed, 2010), because host governments are willing to transfer as much risk as possible while private firms are mindful of and unwilling to accept them (UNIDO, 1996) or do so at high costs to the public.

Risk allocation is achieved through contractual provisions, which serves as a mechanism through which to enforce a direct participant‘s pre-agreed promise of retaining the responsibility for handling the consequences after assigned risks eventuate (Chang, 2012). According to Siebert (1987 in Arndt, 2000, pg. 59), risk allocation

> *"can be interpreted as a system of contractual arrangements…for the different types of risk and among different participants."*

Thus, *ex-ante* risk allocation responsibility must be well supported by the contractual structure (Norton de Matos, 1996) and further linked to payment mechanisms (Chang, 2012).

In a typical PPP water project, risks are often allocated through the remuneration of the private firm, or the tariff formula provided in the contract (World Bank, 2006). This is based on the principle that increased profit is a function of improved performance (such as cost reduction, high collection rates, and low non-revenue water levels) and thus by the firm‘s ability to manage assigned risks. By this, evasion of consequences of risk factors the firm or the government agency agreed to bear cannot go unpunished, making agreed-upon risk allocation achievable.

Quiggin (2005) argued that the standard form of PPP contracts, in practice, does not necessarily yield optimal risk allocation, except for rare cases. Weak or poorly-designed contracts lack both clarity and certainty and are sources of risks, creating fertile grounds for potential conflicts between partners, renegotiation and termination. Nonetheless, effective risk allocation holds multiple gains and contributes to reducing overall project risk level. Some relevance of risk allocation are briefly discussed below.

5.4.1 Significance of Risk Allocation

Risk allocation is all about achieving efficient risk allocation between the direct project participants. A well thought risk allocation in PPP projects has multiple benefits, including the following.

5.4.1.1 Cost savings

Risk allocation affects risk-bearing cost and thus efficient risk allocation results in cost reductions to the public contracting authority, customers and the private firm (ADB, 2000; World Bank, 2006). Efficient risk allocation targets the ―lowest overall cost” for the project (Li, 2003; Akintoye et al., 2003), thereby incentivizing the risk-bearing parties to improve operational efficiency and to reduce the costs of water infrastructure services. Evidence of economic savings from efficient risk allocation is ample (Haarmeyer and Mody, 1998). For example, NAO (2000) reported 10%–20% cost savings in PFI projects in the UK, attributable to efficient risk allocation between the private and public sectors.

5.4.1.2 Attractive prices to the public

Clear and efficient risk allocation encourages meaningful bidding from all competitors that results in prices that are attractive and affordable to the consuming public (ADB, 2000). Open and transparent competition for contracts results in realistic bids that reflect the knowledge of the competitors of their own competencies and awareness of external risk factors to avoid (Marques and Berg, 2011).

5.4.1.3 Reduced overall project risk level

Risk allocation triggers a reduction in overall risk level of PPP projects (Arndt, 2000). PPPs enable allocation of risks to the participants who are capable to control and manage such risks and thus efficient risk allocation could minimize economic costs associated with project risks (Asenova, 2010).

5.4.1.4 Reduced renegotiation incidence

Efficient allocations could avoid future contract renegotiations, whereas flawed risk allocations breed renegotiations in winning bids (Marques and Berg, 2011; Asenova, 2010). Misallocation of risks in water PPPs leads to frequent, and firm-led renegotiations in which the private sector benefits more due to imbalances in information, legal and technical skills and support (Marques and Berg, 2011). In a study of 307 water and transport concessions between 1989 and 2000 in five Latin American countries, Guasch and Straub (2009) found that 76% of the water concessions were renegotiated after 1.6 years.

5.4.1.5 Time saving

There is empirical evidence from mature PPP markets (NAO, 2003; Blanc-Brude et al., 2006; MacDonald, 2002; Fitzgerald, 2004) that risk allocation guarantees on-time delivery of PPP projects. Drawing on a large number of European PPP tollroad projects executed from 1990 to 2005, Blanc-Brude et al. (2006) observed that those projects were delivered on time. The reason being that the public sector hardly offers incentives to speed up works and must observe cumbersome bureaucratic procurement procedures till the project is completed, which likely results to time overruns.

5.4.2 Determinants of Risk Allocation

Risk allocation in PPP procurement is premised on a number of established principles or rules that must be followed (Loosemore et al., 2005; Abrahamson, 1989; Irwin et al., 1997; Lam et al., 2007; Loosemore and McCarthy, 2008). These principles, termed risk allocation criteria (RAC) by Xu et al. (2010), guide *what* (risks to be allocated) and *who* (ability of a party) should bear risks, and *how* (optimal strategies to minimize impacts) and *when* (best time to allocate risks) the parties should be assigned risks in the project (Abednego and Ogunlana, 2006).

The general consensus supported by empirical studies (e.g., Li, 2003; Li et al., 2005; Ke et al., 2010a; Cheung, 2009), risk management textbooks (e.g., Winch, 2010; Yescombe, 2007; Loosemore et al., 2005), project practical guides (e.g., Thobani, 1999; Association for Project Management, 1997; Shendy et al., 2011; Institute of Civil Engineers, 1998), and governments' guidance (Partnerships Victoria, 2005; HM Treasury, 2006; Hong Kong Efficiency Unit, 2003; Government of Ghana, 2011) is that risk should be allocated to the party that is best able to control and manage it at the lowest cost and that is least risk-averse, as summarised in Table 5.3. The idea is to assign appropriate risks to the appropriate party to ensure effective management of assigned risks (Loosemore and McCarthy, 2008). A risk-taking party must be able to (Loosemore et al., 2005; Lam et al., 2007; Loosemore and McCarthy, 2008; World Bank, 2006):

- ❖ *Foresee (or predict the occurrence) and assess relevant risk factors*. For example, a party able to accurately foresee and assess water demand risk can implement apt measures to manage such risk in future. This capability means that adverse consequences / outcomes of demand risk is less likely to be overestimated or underestimated (Casey, 1979). However, the level of accuracy is partly subject to availability of reliable data.
- ❖ *Avoid, minimize, monitor or control the risk factor or its occurrence.* A party may be able to control water scarcity by reducing non-revenue water drastically or by exploring alternative water sources, but at a cost. In the 20-year water concession between the Municipality of Sofia and Sofijska Voda AD (SV), Bulgaria, the risks assigned to the concessionaire were those that fell within its control (World Bank, 2006).
- ❖ *Minimize or control the loss (impact) of the risk on water services if it eventuates*. The risk-bearing party must be capable of reducing or controlling a risk impact in terms of cost and customer inconvenience. For example, the private partner may be better than its public counterpart at minimizing or controlling the impact of payment failure through improved services and flexible credit terms to different customer groups.

- *Sustain, diversify, or absorb the consequences of relevant risk factors*. The risk-bearing party should be able to, for example, diversify foreign exchange rate risk across different assets denominated in foreign currencies, or absorb it.
- *Bear the relevant risk at the lowest cost*. Bearing a risk is associated with cost. Therefore, a least risk-averse party can insure or hedge against the risk in financial markets and distribute the cost thinly among several taxpayers or consumers.
- *Determine whether a party will benefit from assuming a risk*. A party bearing a risk may benefit in terms of enhanced credibility, reputation and planning efficiency (Abrahamson, 1984), and financial gains. A private water operator may acquire a good reputation if it is able to improve operational efficiencies, such as non-revenue water reduction and increase in service hours in intermittent systems.
- *Assume and manage the direct loss of the risk in case of occurrence*. Risk should be assigned to the party that is best capable of shouldering and managing it in order to minimise the severity, extra cost and delay in restoring service.
- *Determine whether the premium charged by the risk-taker is reasonable and acceptable to the public client*. The operator bears, for example, foreign exchange risk in water contracts by charging high tariffs. The government may question whether it is getting VfM by allocating this risk to the operator if the government can actually retain it at a lower cost (Matsukawa et al., 2003). Thus compensating the private partner for assuming risk(s) that may belong with the government is costly and inefficient.
- *Risk should be allocated to the party that prefers to assume the risk*. This criterion describes attitude of a contracting party towards risk, which could be risk neutral, risk-averse or risk prone (Xu et al., 2010). The less risk-averse party is more able to control the risk and thus best able to management it. A case in point is expropriation

risk, in which the government is less risk-averse than the private investor because governments have full control over this risk (Medda, 2007).

Table 5.3 Principles and limitations of risk allocation in PPP procurement

Principles for risk allocation (Risk allocation criteria, RAC)	Literature
Ability to foresee (or predict the occurrence) and assess relevant risk factors	Thomas et al. 2003; Lam et al., 2007; Gao and Jiang, 2008; Loosemore and McCarthy, 2008; World Bank 2006
Ability to avoid, minimise, monitor and control the risk factor or its chance of occurrence	Hong Kong Efficiency Unit, 2003; Thomas et al., 2003; Lam et al., 2007; Gao and Jiang, 2008; Loosemore and McCarthy, 2008; World Bank, 2006
Ability to minimise or control the loss when the risk occurs	Hong Kong Efficiency Unit, 2003; Thomas et al., 2003; Lam et al., 2007; Gao and Jiang, 2008; Loosemore and McCarthy, 2008; World Bank, 2006; Irwin et al., 2007
Ability to sustain, diversify or absorb the consequences of the risk	Thomas et al., 2003; Lam et al., 2007; Loosemore and McCarthy, 2008; World Bank, 2006
Ability to bear the risk at the lowest price	Irwin et al., 2007; Hong Kong Efficiency Unit, 2003
Ability (expertise and resources) to assume and manage the direct loss of the risk effectively and efficiently	Zhu et al., 2007; Liu and Wang, 2006; Loosemore and McCarthy, 2008
Ability to determine whether the premium charged by the risk undertaker is considered reasonable and acceptable	Thomas et al., 2003; Lam et al., 2007; Gao and Jiang, 2008; Loosemore and McCarthy, 2008
Ability to benefit from taking on a risk (enhanced credibility, reputation, and efficiency in risk management)	Lam et al., 2007
Risk attitude of a project participant (risk neutral, risk prone, or risk averse)	Gao and Jiang, 2008; Loosemore and McCarthy, 2008; Chung et al., 2010
Limitations of risk allocation	**Literature**
Economics, commercial requirements, and debt financier‘s requirements	Arndt and Maguire, 1999; World Bank, 2006
Bargaining power and negotiation tactics	Arndt and Maguire, 1999; Thomas et al., 2003; Chen and Hubbard, 2012
Company and national culture and policies	Arndt and Maguire, 1999;
Cooperation history	Jin and Doloi, 2008
Partner‘s risk commitment	Jin and Doloi, 2008
Social and environmental issues (risk management environmental uncertainty)	Jin and Doloi, 2008; Thomas et al., 2003
High allocation cost	Jin and Doloi, 2008; Irwin et al., 1997
Need for work, market compulsion caused by competition	Thomas et al., 2003
Power relations between actors (institutions and resources)	Chen and Hubbard, 2012
Availability of information on risks	World Bank, 2006; Irwin et al., 2007

Source: Adopted and expanded from Xu et al. (2010)

Unfortunately, some of the RAC are often violated during negotiations that lead to the final risk allocation, because of risk perception differences among PPP participants (Thomas et al., 2003; Quiggin, 2004; Marques and Berg, 2011). Failure to apply these RAC creates confused responsibility for risk that results in non-detection of problems and conflicts (Loosemore and McCarthy, 2008). Ultimately, risk allocation will increase, rather than reduce, overall project risk.

Conversely, observing above criteria establishes a shared perception of risk allocation and incentives to effectively manage assigned risks (Loosemore and McCarthy, 2008). It also indicates the parties' risk management capability, which is a major determinant of risk allocation (Chang, 2012).

However, adopting above criteria as the basis for risk allocation is not a straightforward matter, but may require thorough analyses, negotiations and effective legal contracts (Irwin et al., 1997). In addition, these criteria make use of natural language in the expression, which present some ambiguity in practical situations (Lam et al., 2007). This is because their application is based on experienced and subjective qualitative judgement of decision-makers, heavily influenced by human attitude and bias (Barnes, 1983) which often distorts the final risk allocation decision (Lam et al., 2007). It is not unsurprising that many of the reviewed risk allocation frameworks (Table 5.4) were not based on these RAC, but on subjective judgements and preferences of decision-makers.

5.4.2.1 Other influencing factors

Some authors (Arndt and Maguire, 1999; Loosemore, 1999; Thomas et al., 2003; Jin and Doloi, 2008; Grimsey and Lewis, 2004; Chen and Hubbard, 2012) found that risk allocation is always influenced by other relevant factors, including power relations between the key actors in PPPs, willingness to accept risks, understanding of risks, availability and accuracy of information on risks, bargaining power and negotiation tactics, company and national culture and policies, economics, commercial requirements, and debt financier requirements. Jin and Zhang (2011) recommended that both public and private partners must seriously consider these factors to ensure improved risk allocation. See Table 5.3 and section 5.4.4 for a brief discussion.

5.4.3 How to Achieve Risk Allocation in a PPP

Very few academic research and literature has focused on how risk allocation actually translates into the contract structure (World Bank, 2012). This stage follows after the contracting parties have agreed on final allocation of risks and responsibilities, ensuring that all agreed-upon allocations are legally binding and enforceable. The following risk allocation strategies or mechanisms are commonly associated with PPP water projects. Readers are referred to World Bank (2006, pg. 108-120) and Ehrhardt and Irwin (2004, pg. 55-58).

5.4.3.1 Rate of return bands and profit-sharing

This is a simple risk-sharing arrangement which provides that if the private operator‘s profit falls below a predetermined level, (water) tariffs will be revised upward so that the operating company‘s ill-financial health is restored. Similarly, if profitability exceeds a specified level, consumers share in the gain via reduced tariffs. This risk allocation mechanism mitigates bankruptcy, revenue risks and costly government bail outs.

5.4.3.2 Cost pass-throughs

This arrangement allows the private firm to pass on cost to consumers following changes in the prices of certain important inputs, such as fuel, sales tax, and water quality standards. Often, factors responsible for cost variations are beyond the firm‘s control. In the Tangiers concession, the operator buys bulk water from a public supplier. A rise in the price of bulk water warrants a tariff increase so that the concessionaire neither loses nor benefits (World Bank, 2006).

5.4.3.3 Tariff indexation formulae

Tariff indexation formulae are similar to cost pass-throughs in that price increases are borne by consumers. The indexation formulas automatically adjust tariffs at regular intervals, say every four months, in anticipation to changes in certain determinants of the cost of service provision but not the service provider‘s real costs, or in response to specific situations (World Bank, 2006). An indexation formula may adjust tariff according to a consumer price index (or retail price index) which reflects general inflation, or a custom price index that reflects variations in the operator‘s possible costs, such as fuel, exchange rate, taxes, staff and imports (Ehrhardt and Irwin, 2004).

5.4.3.3 Tariff resets (trigger-point reset)

Tariff reset as a risk allocation mechanism recognises incomplete contracting and overcomes the weakness of tariff indexation formula. This arrangement permits tariffs, subsidies or service standards to be reset if predetermined, significant variables fall out of predefined ranges (Ehrhardt and Irwin, 2004). Tariff resets are commonly associated with important variables (including water demand, energy prices, inflation, exchange rate and currency devaluation) in long-term PPPs such as water concessions and BOT-type contracts (World Bank, 2006).

5.4.3.4 Extraordinary tariff resets

Extraordinary tariff reviews or shipwreck clauses are designed to handle special circumstances such as when the private firm strikes a disaster or suffers very huge losses which can trigger bankruptcy, or makes large profits on its operations (Ehrhardt and Irwin, 2004). For example, the public authority will be compelled to renegotiate the contract terms in order to avoid bankruptcy, and under unacceptably hefty profits, the operator will come under political pressure to shrink consumer tariffs. Shipwreck clauses overcome the weaknesses of the foregoing allocation mechanisms and thus provide other means to address extraordinary events (Ehrhardt and Irwin, 2004).

5.4.3.5 Other risk allocation mechanisms

Other important allocation arrangements that mainly allocate risk between the private firm and the contracting authority and other parties to a PPP contract include bonuses and penalties, government guarantees, termination triggers and payments, transition periods at commencement, and contract duration. Interested readers are encouraged to consult World Bank (2006, pg.118-120).

5.4.4 Limitations to Risk Allocation in Practice

5.4.4.1 Power relations and resource dependency

Chen and Hubbard (2012) argued that power relations among the direct parties in a PPP distorts risk allocation in favour of the most powerful party. ‗Power' refers to institutions (e.g., the PPP contract, public procurement laws, customs and behaviours of parties) and resource (e.g., financial) holding capacity of the partners. The authors demonstrated that maximum risk may be allocated to the public sector based on opportunism when the private party (i.e., stronger party) commands financial resources that the contracting authority (i.e., weaker party) relies on to provide infrastructure services (resource dependency).

5.4.4.2 High allocation cost

Achieving optimal risk allocation in practice often comes at a high cost (that may outweigh potential benefits) which is likely to deter project participants. Irwin et al. (1997) explained that:

> *"An allocation assigning each of a project's many risks according to each party's control over the outcome and its costs of risk bearing may require…expensive monitoring arrangements, and possibly the high costs of settling disputes in court"* (pg. 8).

Thus, risk allocation could prove extremely expensive to apply (Irwin, 2007).

5.4.4.3 Degree of risk transfer to the private partner

Both lenders and equity holders of the PC to the project influence the extent of risk transfer. Equity holders' risk exposure is just up to their equity stake and would not accept any exposure above that (World Bank, 2012). This is because governments do discriminate against equity, but in favour of debt. They sometimes guarantee debt repayments, or minimum revenue linked to repayment of loans (Ehrhardt and Irwin, 2004).

Lenders also are uncomfortable in bearing non-commercial risk, particularly legal and political risks, and are concerned about the (a) general legal regime governing the PPP project and (b) allocation of risks as stipulated in the contract agreement (Labadi and Ramasastry, 2000). To the extent that where both conditions remain unclear and inconsistent, lenders are reluctant to finance the project. Lenders characteristically assume risk concomitant to their expected returns (World Bank, 2012) in order not to lose out.

5.4.4.4 Negotiation capacity constraints

Weak negotiation capacity of the public sector in many countries (Bloomfield, 2006; Chen and Hubbard, 2012; Meng et al., 2010; Grimsey and Lewis, 2004) offer their private counterparts opportunities, in most cases, to persuade governments to assume commercial risks which cushion the private firm against market effects, result in liabilities that add to host governments' fiscal challenges, and encourage price rigidity and reduction in the private sector's incentive to pursue efficiency. Also, exasperated with protracted negotiations and repeated renegotions, the private sector often gives in to risks that can be better handled by the public sector (ADB, 2000). This tendency distorts risk allocation.

5.4.4.5 Unique characteristics of risk

The unique characteristics of risks (see Chapter 6) make their identification and allocation a complex task (World Bank, 2006). Therefore, Davenport (1991) argued that it impossible to identify a project's many risk factors and some risks may be poorly-defined in the contract agreement.

5.4.4.6 Risk re-allocation

This situation arises following a party's failure or inability to handle assigned risk(s) when it crystallizes. Since government is the ultimate service provider and the need to ensure continued water services provision, for example, the pubic authority is compelled to 'bail out' the private operator, or refuse to impose contractual penalties, such as performance payment deductions (Iossa et al., 2007; Oyedele, 2013; Yescombe, 2007). In practice, bail outs are often driven by political reasons (Dailami and Klein, 1997; Ruster, 1997), with potential catastrophic long-term consequences.

However, aforementioned limitations do not defeat the essence of risk allocation in PPP contracts, as it drives VfM outcomes. With careful planning and contract design, most of these setbacks can be overcome.

5.5 RISK ALLOCATION MODELLING

Risk allocation practice remains the subject of academic research and literature. Previous researchers have proposed models/frameworks to guide risk allocation decision in PPP. Some previous studies have been reviewed and summarised in Table 5.4. Thirteen studies from 2003 to 2011, which are not intended to be exhaustive, are covered. Simple descriptive statistics (mean and percentages), regression analysis, game theory, fuzzy set theory and artificial neural network (ANN) analysis are the various approaches that have been used in these studies. The models/frameworks can be classified into two. This first group is risk allocation preference (Li et al, 2005a; Ke et al,. 2010a, b; Thomas et al., 2003; Wibowo and Mohamed, 2010; Roumboutsos and Anagnostopoulos, 2008).

Thomas et al. (2003), for example, surveyed risk allocation preferences in BOT tollroad projects in India, concluding that risk allocation was strongly influenced by project stakeholders‘ risk perceptions. Li et al. (2005) surveyed the risk allocation preferences in construction PPP/PFI projects in the UK. Ke et al. (2010a) conducted a two-round Delphi survey to investigate risk allocation preferences in the Chinese‘s PPP market. Based on face-to-face interviews, Roumboutsos and Anagnostopoulos (2008) investigated risk allocation preferences in the Greek PPP market.

Table 5.4 Review of risk allocation models/frameworks

Author(s)	Study/model name	Basic tool/theory	Country	Remarks
Thomas et al. (2003)	Risk perception analysis	Mean / regression analysis	India	Investigate respondents' opinions on the party best capable of managing risks and their risk allocation preferences.
Li et al. (2005a)	Preferred risk allocation	Percentage	UK	The preferred risk allocation options are presented as percentages of total counts of responses of survey participants
Ibrahim et al. (2006)	Preferred risk allocation	Percentage	Nigeria	A risk is allocated to a party for which over 50% respondents are in favour of, and a risk is deemed project-specific if responses are less than 50%.
Medda (2007)	Risk allocation decision process	Game theory	UK	The two different behaviours of the direct participants generate the most fair offer, hence, reducing the likelihood of a bad outcome.
Lam et al. (2007)	Modeling risk allocation decision	Fuzzy set theory	Hong Kong	It transforms the linguistic principles and experiential expert knowledge of experts into a more usable and systematic quantitative-based analysis
Roumboutsos and Anagnostopoulos (2008)	Risk perception analysis and preferred allocation	Percentage	Greece	Approach is highly subjective and based on respondents' experience, background, and risk behaviour – averse, prone or neutral.
Jin and Doloi (2008)	Risk allocation decision-making model	Fuzzy inference systems (FISs)	Australia	Incorporate knowledge and experience from experts
Xu et al. (2010)	Fuzzy risk allocation model	Fuzzy synthetic evaluation	China	Effective for minimising biases and subjective judgement of experts
Wibowo and Mohamed (2010)	Risk perception analysis and preferred allocation	Statistical mean	Indonesia	High level of disagreement among respondents concerning the allocation of risks.
Ke et al. (2010a)	Risk allocation preference	Statistical mean	China	Rely on experience of the panelists, with good understanding of PPP risks.
Ke et al. (2010b)	Risk allocation preference	Percentage	China	Risk allocation based on popular opinion (greater than 50%).
Jin and Zhang (2011)	Optimal risk allocation model	Artificial neural network (ANN)	Australia	Facility for incorporating expert knowledge. The model mainly draws on transaction cost economics. The ANN model has a prediction error.
Jin (2011)	Neuro-fuzzy risk allocation model	Fuzzy logic and ANN	Australia	Outperforms multiple linear regression (MLR) models and fuzzy inference systems

While these studies contribute to our understanding of risk allocation preferences across cultures and PPP markets, they have some shortcomings: (a) risk allocation to the public or public participant is based on majority opinions (percentage counts); and (b) the subjective judgement and preferences of respondents heavily influenced the final risk allocations. For example, in their study, Ke et al. (2010a) indicated that ‗construction completion and operation cost overrun‘, and ‗corruption and land acquisition‘ should be *mostly* allocated (―major responsibility”) to the private and public partners, respectively. The term ‗major responsibility‘ is subjective and hard to be precisely interpreted in practice. By what proportion of risk is ‗major‘? The difficulty of risk allocation becomes the differences in perceptions regarding risk criticality and risk management capability of partners. Majority preferences and subjective opinions and human factors, such as personal experience, attitude towards risk and judgement biases do not yield optimal risk allocation.

The second group is decision support/expert systems (Medda, 2007; Jin and Doloi, 2008, 2009; Xu et al., 2010; Jin, 2011; Jin and Zhang, 2011). Decision frameworks are relevant tools that support risk allocation decision-making and have been applied to interpret risk allocation mechanisms in PPP procurement. In Medda (2007), the risk allocation process was modelled with a final offer arbitration game (game theory approach) and analysed as a bargaining process between the public/private partners. Risk allocation is the result of negotiations between the direct project partners (Chung et al., 2010). Here, asymmetries of bargaining power strongly influence how risks are ultimately allocated. Admittedly, the private sector is often advantaged, because it is supported by a corporate culture that draws on past experiences (Marques and Berg, 2011).

Recently, Jin and co-authors (Jin and Doloi, 2008, 2009; Jin, 2011; Jin and Zhang, 2011) have argued that the transaction cost economics (TCE) theory and resource-based view

(RBV) of organisational capability could interpret the risk allocation patterns in PPP procurements. These authors have, in various publications, applied above theories through expert systems, such as ANN and fuzzy logic. A fuzzy inference system (FIS) based decision-making model for risk allocation was proposed in Jin and Doloi (2008), in which they argued that risk allocation strategies in a PPP project should be based on ―partners‘ risk management routine, mechanism, commitment, cooperation history, and uncertainties (pg. 707). Jin and co-authors view risk allocation as a transaction of risk management responsibilities of the public client and the private consortium.

Their (Jin and co-authors) models make a significant contribution to the discussion on risk allocation, but have a limitation that is associated with ANN method. ANNs are unstable predictors and hence their proposed model (Jin and Zhang, 2011) has up to 20% error in forecast, suggesting that allocation of an evaluated risk may be distorted. Chang (2012) also argued that the TCE line of enquiry – as applied by Jin and co-authors – is flawed for three reasons: (i) the appropriateness of the unit of analysis (―risk management responsibility”); (ii) the operationalisation of transaction attributes; and (iii) the nature of governance structures.

5.6 KNOWLEDGE GAPS

Given a lack of reliable and objective data for application of other risk evaluation methods, most risk assessment frameworks/models (Table 5.2) draw on subjective, experiential knowledge of experts. This is particularly true for studies conducted in immature (or emerging) PPP markets where reliable historical data is difficult, if not impossible, to obtain. However, such frameworks/models fail to transform and objectify the subjective expert knowledge and thus their outputs are subjective, heavily influenced by both subjective judgement and preferences of the decision-makers. It is recommended that future empirical studies must observe this flaw and deal with the issue of subjectivity.

Because the RAC make use of natural language, and their application in real-world contexts draws on qualitative expert knowledge, human factors of subjectivity and bias often influence the final risk allocation decision in project settings. Unsurprisingly, many of the reviewed risk allocation models/frameworks in Table 6.4 were limited by this flaw, and/or were not based on the RAC. That is, such studies deem risk allocation to the public or private party to be based on majority opinion and preferences of decision-makers (e.g., Li et al., 2005a; Ke et al., 2010a) or decision-makers‘ risk perceptions and attitudes (e.g., Thomas et al., 2003), and the principles behind the allocations have not been clearly stated. To effectively incorporate the established RAC, and overcome the identified shortcomings of present models/frameworks, future research studies must adopt approaches that treat both the imprecise and subjective nature of risk allocation decision-making and to handle the simultaneous consideration of the multiple RAC and the multiple private and public decision-makers. Thus, drawing on the aforementioned RAC and expert knowledge as the basis for risk allocation, methods that relate to computation and reasoning of natural language may be useful.

5.7 CHAPTER SUMMARY

Like any infrastructure project, PPP water supply projects are associated with multiple risks. Project participants need to understand risk and put in place appropriate risk management approaches to monitor and control risks when they eventuate. This chapter has defined risk and explained the RMP. The process entails risk identification, risk assessment, risk allocation, risk mitigation, and risk management. In water supply projects, these concepts must be well understood and applied appropriately, if governments and private entities were to realise desired outcomes.

Risk allocation is defined to guide this research study. The chapter covered important issues on risk allocation, including significance of risk allocation, determinants of risk allocation, methods for achieving risk allocation, limitations and criticisms of risk allocation in PPP projects. Common measures for translating risk allocation into contracts include rate of return bands and profit-sharing, tariff resets, extraordinary tariff resets, cost pass-throughs, and tariff indexation formulae.

Finally, empirical studies on risk assessment and risk allocation were reviewed to identify knowledge gaps. Research approaches for both risk assessment and allocation can be classified under qualitative and quantitative methods. It was observed that there is a growing trend towards adoption of sophisticated quantitative techniques, such as ANNs, fuzzy logic, fuzzy set theory, which are deemed more robust. This chapter is important in that it also underpins the overall research study. The following chapter identifies and classifies potential risk factors associated PPP water projects in order to provide a shared understanding among project participants.

Chapter 6: Framework for Risk Identification and Categorization in PPP Water Supply Projects

This chapter reviews the literature concerning 'types of risk' and connects this to the research gap.

It is very effective partly because the writer includes the following:

Structure

Introduction	⇩	Section 6.1
Defines and categorizes key terms	⇩	Section 6.2-6.3
Reviews types of risk	⇩	Section 6.4-6.13
Discusses the research gap	⇩	Section 6.14
Summary		Section 6.15

Content

- Summarises key ideas in the introduction, including an outline of the chapter and the major studies to be reviewed (e.g. Section 6.1)
- Outlines the content of the chapter (e.g. Section 6.1, paragraph 2)
- Explains the aims of the chapter (e.g. Section 6.1, paragraph 2, final sentence)
- Details background to the chapter (e.g. Section 6.2.1)
- Highlights the importance of the topic (e.g. Section 6.2, paragraph 1, final sentence)
- Evaluates quality of previous research, e.g. *extensive literature review* (e.g. Section 6.2.2, paragraph 2 sentence 3)
- Details a research gap (e.g. Section 6.2.2, paragraph 9 sentence 1)
- Explains the contribution the thesis will make to the field (e.g. Section 6.2.2, paragraph 9 sentence 3)
- Uses examples to illustrate main ideas (e.g. Section 6.4.5, paragraph 2, final sentence)
- Highlights contribution the review makes to the thesis and to the wider field (e.g. Section 6.15, paragraph 3, sentence 1-2)

<u>Language</u>

- Links to the previous chapter (e.g. Section 6.1, paragraph 1)
- Uses paraphrase as a linking device: rather than repeating the name of the studies they are paraphrased, e.g. *the authors further* (e.g. Section 6.2.2, paragraph 3 sentence 2)
- Uses tentative language to generalize, e.g. *do not seem, may be, likely to (*e.g. Section 6.4.2)
- Summarises chapter (e.g. Section 6.15)

<u>To consider</u>

In general, this chapter is effective. However, it could be improved in the following aspects.

- Be critical of previous studies by highlighting why they were good studies or outlining any limitations in the study.
- Use correct reporting verbs ,e.g. *Cowen and Komives <u>argued</u>* (e.g. Section 6.6.4). The use of *argued* indicates that the writer is neutral about the study and is unsure if *Cowen and Komives* showed this clearly.
- Avoid starting sentences with *and* (e.g. Section 6.6.2 sentence 4).
- Avoid using *also* at the start of a sentence or paragraph; use *in addition* or *furthermore* instead (e.g. Section 6.13.2 paragraph 3 sentence 1).

CHAPTER 6 FRAMEWORK FOR RISK IDENTIFICATION AND CATEGORISATION IN PPP WATER SUPPLY PROJECTS

6.1 INTRODUCTION

Chapter 4 indicates that PPP water supply projects are full of risks. Broadly, these risks can be grouped into two: risks that are naturally associated with the water sector, and those that come about as a result of private sector participation. These two sources of risk explain the complexity and riskiness of water based PPPs. Chapter 5 therefore explains risk and the RMP in PPP procurement.

This chapter is divided into two. The first part reviews extant literature on risk identification and taxonomy in general PPP projects, with the view to establishing the significant risk factors. The second part suggests a framework for identifying and categorizing risk factors associated with PPP water supply projects. The contents of the identified risk factors are briefly discussed. This chapter forms the basis for questionnaire development for this research study.

6.2 OVERVIEW OF PPP PROJECT RISKS

6.2.1 Background

According to Al-Sharif and Kaka (2004), the PPP papers published during 1998 to 2003 in selected construction journals can be grouped under three headings: risk, procurement, and financial, with 44%, 35%, and 21% proportions of papers, respectively. From their analysis, risks in PPP projects are of high interest to the research community. This is further confirmed by Ke et al. (2009) in a two-stage literature review, in which PPP papers from 1998 to 2008 were analysed in terms of the number of PPP papers published in a year, the authors' contribution and the research focus in their studies. The authors noted that risk management – risk identification, risk assessment, risk allocation, risk management (i.e., risk monitoring and review), and financial, political and market risks – is one area increasingly investigated by researchers. This may be due to the value of effective risk management as a condition for successful PPP projects. However, there is limited research on risk identification and risk assessment in generating more positive and firm answers to the relevance of project risks (Unkovski and Pienaar, 2009). Khasnabis et al. (2010) also recommended future research into infrastructure PPPs to consider risks and uncertainties, because, as indicated earlier, risk identification is the basic stage of the PPP project RMP. Haarmeyer and Mody (1998) argued that regardless of the challenges associated with PPP water projects, pressures to keep them going have led to robust risk management in several contexts, giving a bright future.

6.2.2 Risk Identification and Categorisation

Several authors have proposed detailed risk factors (risk registers) and assessed their impacts on projects (Ibrahim et al., 2006; Ameyaw and Chan, 2013a; Ng and Loosemore, 1997; Roumboutsos and Anagnostopoulos, 2008; Xu et al., 2011; UNIDO, 1996; Xenidis and Angelides, 2005a). These authors further suggested various risk categorisations. This section explores some of the works that have been conducted by previous researchers in this area, narrowing down to water supply projects – the overall focus of this thesis.

UNIDO (1996) presented general BOT project risks under two categories – general/country risks and project-specific risks. Each category has three sub-categories: commercial, political, and legal risks are classified under the former, whereas construction and completion risks, developmental, and operating risks come under the latter. Based on an extensive literature review, Ibrahim et al. (2006) presented 61 risk factors inherent in PPP projects and classified them as exogenous – risks external to a project – and endogenous – risks occurring within the boundaries of the project plus risks arising from the relationship between the private and public sectors. All the risks were further classified into 13 sub-groups. Through a literature review, telephone interviews and a two-round Delphi survey with experts, Ke et al. (2010a) identified 37 risk factors in PPP projects in China. The authors noted that 13 risk factors out of the total are actual risks encountered in past PPP projects, including corruption, change in law, public opposition, tariff change, and financial risks.

Through documented experiences of several project cases, Xenidis and Angelides (2005a) offered practical insights into 27 financial risk factors in BOT projects. The authors further categorised the risks (i) according to the lifecycle stage at which each risk occurs and (ii) the source of origin of each risk factor. Under the latter categorisation, Xenidis and Angelides argued that the generators of BOT financial risks are _state-rooted' (government, public agencies, society), _concessionaire-rooted' (private sector participants) and _market-rooted' (economic framework).

In examining the complexity of risk-sharing mechanisms in PPPs, Grimsey and Lewis (2002) identified nine risk factors and presented two taxonomies: first, the developmental phase of a project where majority of risks relate to capital costs, e.g., design and construction costs; and second, the operational phase where most risks relate to revenue and recurrent costs, such as wages, asset operation, maintenance and insurance. Grimsey and Lewis (2004) identified and classified six key areas of PPP project risks as default, operating, public, financial, asset and sponsor risks.

Unkovski and Pienaar (2009) explored the analysis and management of PPP infrastructure project risks in South Africa. Data for the study were collected on South Africa‘s first PPP project (Department of Education office accommodation) through workshops and questionnaire survey with expert participants. They found that there are significant risks associated with PPP projects, but are less expensive and more manageable compared to adopting a traditional procurement method to implement public infrastructure projects. Unkovski and Pienaar acknowledged the need for risk identification in PPP projects, and presented three broad categories of risks: financial, technical, and legal, with sub-risk factors.

A study to establish risk allocation preferences of PFI/PPP practitioners in the UK revealed 66 risk factors (Li et al., 2005a). The authors presented a meta-classification method based on three levels of risk factors, with sub-categories: macro – risk factors external to the project (exogenous) and associated with social, economic, political and legal conditions; meso – risks associated with the project (endogenous) and involve location, technology, construction, and demand/usage risks; and micro, which refers to risks arising from stakeholder relationships following differences between the private and public partners in PPP project management. A similar classification was adopted by Ibrahim et al. (2006) in exploring PPP project risks in Nigeria.

A three-level risk classification for international construction projects in developing countries was presented by Wang et al. (2004). Through an extensive literature review, interviews and discussions with academics, and international surveys, 28 risk factors were identified and categorised as country, market, and project level risks. Country level risks refer to changes in law, approvals and permits, corruption, government policies, expropriation, etc. Corporate fraud, inflation and interests rates, human resources, market demand, competition, etc. refer to market-level risks, while project-level risk factors include cost overrun, poor design, site safety, poor project management and poor quality control.

A review of risk factors to PPP construction projects by Karim (2011) through mapping past influential studies around the globe revealed 81 risk factors, under ten categorisations, namely: operation, political, project selection, construction, legal, economic, market, relationship, project finance, and natural factors. Each broad category has some specific risk factors. The study indicated that the most frequent risks fell within the political and construction groups, specifically change in law, delay in project approvals and permits; and land acquisition, respectively. Wang et al. (2000) studied the criticality of political risks in China‘s BOT contracts, and identified the critical risk factors as change in law, delays in approval, creditworthiness of public agencies, force majeure, corruption, reliability of local governments, and expropriation.

However, few publications have focused on the water supply sector, despite its high risk profile. Previous studies, as presented above, tend to generalise or focus on other infrastructure projects including transportation, telecommunications, power and energy plants, and in established PPP markets (Roumboutsos and Anagnostopoulos, 2008). This chapter therefore contributes to filling this research gap.

A general review of risk management in the water and sanitation sector in the late 1990s by Haarmeyer and Mody (1998) highlighted six major risk classifications as —market and payment, construction, operational, currency rate and convertibility, regulatory and policy, and force majeure risks". Later classifications, to a large extent, are in agreement with this categorisation. The authors argued that these are key risk areas encountered by the public and private sectors, and that the identification, assessment and allocation procedure of regulatory and commercial risk factors remains a daunting task.

ADB (2009), in its guidance note, identified 49 generic risks in the urban water supply sector under three classifications: institutional, organisational and sector operations. Institutional risks arise from policy, law and regulation. Organisational risks entail planning, financial management, procurement and contract management, and human resources. Finally, sector operation risks derive from water harvesting, water treatment and distribution, and consumer interface risks. Choi et al. (2010) studied in detail the factors holding back PPPs in China‘s water sector, particularly international water operators. These risks were broadly classified as PPP project risks, and legal and regulatory hindrances. The study mentioned uneconomic water tariffs, price adjustment complexity and revocation of the fixed return policy of the Chinese government as major risks in the water market. Government breach of contract, weak local banking capacity, limited long-term financing, concessionaire selection uncertainties and joint-venture risks are other significant barriers (Choi et al., 2010).

Drawing upon the experiences of nine project cases from eight provinces in China, Xu et al. (2011) presented 11 critical risk factors impeding the performance of water PPPs as:

(1) political risk;

(2) legal risks;

(3) government credit risk;

(4) market demand change risk;

(5) inflation risk;

(6) product price risk;

(7) poor market forecast risk;

(8) contract risk;

(9) financing risk;

(10) absence of supporting infrastructure risk; and

(11) technical risk.

The authors further classified the risks according to the three-level risk classification proposed by Li et al. (2005a). A comparison with Choi et al.'s (2010) findings reveals financing, legal, water tariff, and contract risks as common barriers.

In a recent study, Cheung and Chan (2011) compared the severity of 20 risk factors between common public infrastructure projects delivered via PPP procurement in China: water and wastewater, power and energy, and transportation. Among all, public-related risks are the most critical. Regarding the water and wastewater sector, financing, completion, poor project evaluation approach, government intervention, and public credit risks (in order) emerged as the five most critical risks, far different from the other two sectors. This implies that risk-induced factors are sector-specific

Exploring risk criticality and allocation practice in the Indonesia's PPP water supply projects, Wibowo and Mohamed (2010) found that water pricing uncertainty is the most critical risk among 39 risks, followed by (in order) government breach of contract, raw water scarcity, construction time and cost overruns. A six-risk taxonomy, based on sources of risks, was proposed by the authors as political, operational, business, macroeconomic, land and construction, and *force majeure*. Wibowo and Mohamed's findings generally agree with results from other countries (e.g., Choi et al., 2010; Xu et al., 2011; Cheung and Chan, 2011).

Some researchers have identified the risks associated with specific PPP modalities. Looking into BOT water projects in China, Zeng et al. (2007) established a three-level hierarchy with an analytic hierarchy process (AHP) to identify risk factors. There are diverse risks relevant to BOT projects depending on the infrastructure sector in which the model is applied. Zeng et al. (2007) identified 28 risk factors and established eight classifications as political, bid and negotiation, economic, construction, operating, policy and legal, credit, and *force majeure* risks. Tax policy change, unstable interest rate, water resources price instability, etc. (in order) were ranked the most critical BOT water supply project risks in China. This suggests that from project identification through transfer there is a plethora of risks. Seyed et al. (2010) also categorised BOT project risks into two: the first concerns the character of BOT procurement and is associated with initiating process, financing and operational risks, and second, because BOT projects are mega, they involve economic, political and government regulatory risks.

From foregoing studies, most authors have identified PPP project risks through extensive review of extant literature (e.g., Ke et al., 2010a; Ibrahim et al., 2006; Li et al., 2005a; Wang et al., 2004; Karim, 2011; Choi et al., 2010; Cheung and Chan, 2011; Wibowo and Mohamed, 2010; Haarmeyer and Mody, 1998); interviews and surveys with experts (e.g., Zeng et al., 2007; Choi et al., 2010; Wang et al., 2004; Unkovski and Pienaar, 2009; Ke et al., 2010b); and case studies (e.g., Choi et al., 2010; Xu et al., 2011). Usually, case study analyses are sector- or country-specific (e.g., Xu et al., 2011; Ke et al., 2010a; Seyed et al., 2010; Abdul-Aziz, 2001; Zhong et al., 2008; Sohail and Cavill, 2008; Chen and Hubbard, 2012; Abednego and Ogunlana, 2006; Thomas et al., 2006) by identifying and presenting most critical risks and local best practices in the PPP arena (Roumboutsos and Anagnostopoulos, 2008).

The popular approach for risk classification is by using the source criteria, which several researchers view as the most useful (Seyed et al., 2010). Finally, some reported risks are general to all PPP projects, whereas others are sector-specific. For example, demand risk in tollroad projects is different from that of water supply projects, mainly due to sector differences and the nature of service or product. This situation may be responsible for the inability of researchers and practitioners to propose a single risk register to replace the multiple risk inventories applied by participants in their risk analysis process for PPP projects (Xenidis and Angelides, 2005a).

6.3 RISKS IN PPP WATER SUPPLY PROJECTS

Given their contradictory interests and objectives, the direct participants in a PPP water project have different perceptions of risks, and this has hampered the development of a common risk factor list for risk analysis (Xenidis and Angelides, 2005a). However, a comprehensive risk list with a wide coverage of significant risk factors across various PPP modalities and cultures will enhance risk analysis and allocation. A comprehensive risk list of 40 factors was qualitatively established through a three-stage process. Xenidis and Angelides (2005a, b) adopted a similar approach to identify the financial and legal risks associated with BOT projects.

First, an initial list of risks were identified from related studies and documented experiences of several local and international PPP water project cases that were accessed from academic and institutional literatures (e.g., Sentürk et al., 2004; Marin 2009; Xenidis and Angelides, 2005a, b; Nickson and Vargas, 2002; Nickson, 1996; Hirvi, 2012; BPDWS, 2011; Estache et al., 2009; Harris et al., 2003; Iossa et al., 2007; Orr et al., 2009; UNIDO, 1996). Refer to Table II in Ameyaw and Chan (2013a) for risk factors from local project cases. Second, the identified risk factors were grouped into 10 categories according to sources of their origin, and five categories based on the lifecycle phase where the risks eventuate during the project life. Both risk classifications, presented in Table 6.1, derived from the earlier literature review in this chapter.

Table 6.1 Summary of identified risk factors and risk categories

Risk categories and risk factors	Lifecycle phases of a PPP water supply project				
	Bid preparation	Operator selection to Contract signing	Project implementation	Management/ operation of water system	Transfer
Political risks					
Political discontent & early termination		X	X	X	
Change in government & political opposition	X	X	X	X	
Expropriation			X	X	
Political interference		X	X	X	
Government corruption	X	X	X	X	
Political violence and government instability	X	X	X	X	
Currency convertibility and transferability			X	X	
Financial risks	X	X	X	X	X
Financing and refinancing			X	X	
High operational costs				X	
Inflation rate risk			X	X	
Foreign exchange rate	X	X	X	X	
Interest rate risk	X	X	X	X	
Regulatory, Legal and Contractual risk					
Regulatory risk – weak and arbitrary regulator		X	X	X	
Absence of policy & legal frameworks	X	X	X	X	X
Poor contract design		X	X	X	
Procurement risk		X			
Sub-sovereign and contractual risk	X	X	X	X	
Market/Revenue risks					
Nonpayment of bills (payment failure)				X	
Fall in demand (low water consumption)				X	
Water pricing & tariff reviews uncertainty		X		X	
Unfavourable national/international economy	X	X	X	X	
Quasi-commercial risk			X	X	
Water theft				X	
Faulty demand forecasting				X	
Social risk					
Public resistance to PPP	X	X	X	X	
Technical and Operational risks					
Water asset condition uncertainty				X	
Insufficient performance of private operator			X	X	
Technology risk			X	X	
Pipeline failures during distribution				X	
Residual value risk					X
Design and construction risks					
Construction time & cost overruns			X		
Design & construction deficiencies			X	X	
Land acquisition			X		
Supporting utilities risk			X	X	
Relationship risks					
Conflict between partners (strained relations)		X	X	X	X
Lack of PPP experience	X	X	X	X	X
Water resources issues					
Raw water scarcity				X	X
Low quality of raw water				X	
Natural issues					
Climate change risk				X	
Force majeure			X	X	

Third, the risk-factor list was reviewed and filtered by three academics/practitioners with sound experience in PPP procurement. The evaluation process included a second review of the risk categorisation based on the two classifications. One of the experts added *‗refinancing'* and *‗land acquisition' risks*. This led to a comprehensive list of 40 risk factors (Table 6.1). Some of these risks (e.g., construction costs and delays) are associated with other infrastructure sectors, while others (e.g., water scarcity) are solely related to the water sector. In the following sections, the identified risk factors are briefly discussed to enhance understanding among project participants and to aid them in their risk management.

6.4 POLITICAL RISKS

6.4.1 Political Discontent and Termination Risk

Political discontent and (early) termination risk remains a concern for private water investors. It arises where a public water service provision deteriorates resulting from ‗perceived' poor performance of the project company (Iossa et al., 2007). The risk is often linked to insufficient performance of the operating company and is activated by consumers' disenchantment with service levels and massive rate increases. Government termination of a contract, however may be associated with protracted disputes over termination payments. An operator may also withdraw from a contract over difficulties in tariff increases and low collection rates. Public water utilities have kept prices below cost-recovery levels and efforts to raise tariffs and improve collection efficiency attract sustained public and sometimes political resistance (Harris et al., 2003).

6.4.2 Change in Government and Political Opposition

Water contracts suffer change in government and political opposition risk either to the PPP process or tariff levels. Some governments (or political parties) are ideologically opposed to PPPs, and newly-elected governments in developing countries do not seem to favour the impact of PPP (Estache et al., 2009). Raising tariffs to cost-recovery levels, for example, is less about affordability but so much about political opposition (BPD, 2011), particularly prior to national elections (Idelovitch and Klas, 1995). A newly-elected government may be unhappy with increased water rates which were permitted in the original contract and is likely to impose tariff reductions (for political gains) which could be detrimental for the project‘s viability.

6.4.3 Expropriation Risk

The main political risk is expropriation of asset or investment (Idelovitch and Klas, 1995). It is the risk of the host government nationalising the asset of a water business without a fair compensation to the private investor, reflecting a deliberate political action. Full expropriation (nationalisation) is the taking over an entire water supply enterprise, whiles partial expropriation (indirect/creeping) occurs when the government passes a policy that impacts on execution, costs or management of, for example, a water treatment facility such that it is impractical for the investor to stay in business (Jeffrey and Delmon, 2010). Expropriation actions completely deny the water investor of the right of enjoyment of its investment under the PPP contract. Though governments lack the right to nationalise private infrastructure without appropriate compensations, the challenge lies in establishing appropriate strategies to tame political actions that can put private investments (in the water sector) at risk and the likelihood that governments will respect those strategies (Irwin et al., 1997).

6.4.4 Political Interference

Water has a political effect which attracts governmental (political) interference in areas such as pricing and tariff reviews (Kauffmann, 2007). Political interference is the risk of government interfering in the activities of the regulator and violating contract provisions, which could undermine service provision. It implies undue influence from government officials who are only interested in short-term, unsustainable decisions for personal gains (Ke et al., 2010a). The success of a partnership project relies on political support and commitment rather than unwarranted interference.

6.4.5 Political Violence/Government Instability

The risks of civil strife, declared war, insurrection, terrorism acts, public disturbances, sabotage and revolution could prove detrimental to the profitability of private water investment, and often result from the host government‘s failure to keep law and order (Sachs et al., 2007). Government instability (e.g., coup d‘état) also is a threat to attracting and sustaining private investment. In Africa, for instance, military coups are frequent, and have been identified as the most popular challenge to continuity of governments (Collier and Hoeffler, 2005).

The main risk is that international law does not compel host governments to compensate international investors for all losses, but to protect international businesses (Irwin et al., 1997). Political violence and government instability present the following implications (Ameyaw and Chan, 2014; Guasch, 2004; Sachs et al., 2007; MIGA, 2009): (a) difficulty in getting good bidders, (b) discouragement of project sponsors, and renegotiation of contractual terms and planned investments – for fear of losing investments, (c) expensive guarantees and clauses to secure private investment, and (d) termination of operating contracts and the associated cost.

6.4.6 Currency Convertibility and Transferability Risks

Currency convertibility risk is the possibility that a private investor will be unable to convert revenues generated in a local currency into foreign currency for servicing foreign debt and making payments in foreign currency, or that investors will convert at punitive or low exchange rates (Matsukawa et al., 2003). Conversion difficulties may arise from active (i.e., imposition of exchange controls) or passive (i.e., lack of foreign exchange by the host country‘s central bank to execute remittances) regulatory measures (Irwin et al., 1997). Also, transferability risk arises when the host government limits transfer of foreign currency off-shore. Both risks could emanate from deliberate and/or weak macroeconomic policies and their effect depends on the structure of an investment as well as the host governments‘ policy frameworks. Water projects are vulnerable to both risks because revenues/income are generated in local currencies while investments are quoted in stable foreign currencies.

6.4.7 Corruption Risk

Country and global level experiences (Hall, 1999; Auriol and Blanc, 2009; Boehm and Polanco, 2003; Guasch and Straub, 2009; Stone and Webster, 2002) have revealed evidence of corrupt practices in PPP water supply contracts, involving private water companies and government officials. Boehm and Polanco (2003) showed that there is a high relationship between private participation in water projects and corruption risk. Corruption assumes different forms, including favourable contracts to the winning bidders, collusion and fraud, extortion and bribes to secure government benefits, by-passing competition, and procurement manipulations. These practices could devastate the expected benefits of PPP reforms in terms of expanded coverage, quality service, affordability and efficiency, and implies that cost associated with corrupted deals is borne by rate-paying consumers as inflated prices. Corrupt actions in contract awards result from lack of transparency / accountability and institutional weaknesses of legislative systems, especially in developing countries (Myint, 2000; Guasch and Straub, 2009).

6.5 FINANCIAL RISKS

6.5.1 Financing Risk

The major risk regarding attraction of private investment for water infrastructure is unavailability of sufficient funds, owing to failure to fulfill investment commitments by the private sector (Vives et al., 2006; Public Citizen, 2003; Marin, 2009; BPDWS, 2011). In developing countries where profit ratios are low due to affordability issues, private investment is deemed risky, and immature financial markets limit long-term domestic debt financing. Hence, foreign investors are reluctant to commit large funds without expensive government guarantees.

The capital intensive nature of water supply projects and affordability issues suggest that the challenge of financing is to secure long-term funding at sensible interest rates that match the lengthy payback periods linked to the huge financial commitments needed to expand and rehabilitate existing, and to build new, water infrastructure (Haarmeyer and Mody, 1998; Xenidis and Angelides, 2005a). This implies an optimal combination of different funding sources to establish a sound and flexible project financial structure and mitigate financing risks – delays, insufficient funds, high cost of finance, etc.

6.5.2 High Operational Costs

Increasing operational costs, more than projected, is attributable to the operating firm‘s responsibility and external, uncontrollable factors (Xenidis and Angelides, 2005a). A private firm may submit *'inaccurate'* estimates during the bidding stage as a deliberate attempt to win the contract. The winning bidder often overstates the financial savings to the public utility while underestimating the volume of work to operate and maintain the water supply infrastructure. This activates poor operating cost control which threatens successful service delivery and commercial viability.

Prevailing economic conditions in the operating environment beyond the firm's control could raise operating costs. For instance, debt-ridden and further impacted by currency risks and economic crisis, a firm could exceed its operating cost by 40% (OECD, 2009b; Public Citizen, 2003). Consequences of cost overrun include expensive and poor services, reduced profits, endangered creditworthiness of the firm, and financing and refinancing difficulties.

6.5.3 Inflation Rate Risk

Inflation risk has an effect on construction and operational phases of a PPP project. It increases costs of production, reduces purchasing power of consumers thereby reducing revenues, and impacts on loan repayment (Farlam, 2005; Mandri-Perrot and Menzies, 2010). Effects of increased inflation rate means that actual revenue flows could deviate from projected. Covering inflation risk remains an utmost concern for lenders in reducing their financial exposure and ensuring profitability of projects (Mandri-Perrot and Menzies, 2010).

6.5.4 Interest Rate Risk

Interest rate influences both cost and availability of funding, and arises due to changes in the rate at which a firm borrows money from financial market (National Treasury, 2004). In developing countries because infrastructure projects are mostly funded through foreign-currency-dominated loans secured at floating interest rates (Mandri-Perrot and

Menzies, 2010), a skyrocketing rate increases cost of borrowing, may raise tariffs and threatens profitability of the project. Interest rate is also one critical channel through which financial slowdown adversely impacts on profitability of operating PPP projects, to about a 10% fall (Burger et al., 2009).

6.5.5 Foreign Exchange Rate

Water supply revenues arise in the host country‘s currency, and where borrowings, supplies and investments are repaid in foreign currencies often give rise to currency losses. This is because foreign currencies often appreciate at high rates than inflation in the host country and the gap between collected revenues and borrowings in foreign currency (BPDWS, 2011). Currency risk erodes motivation of international water investors to realize efficiency gains (Lobina, 2005). Generally, private investors are reluctant to accept this risk or they demand contractual provisions that index tariffs to US-dollar equivalent. However, such guarantees may become unsupportable following local political and economic crisis.

6.6 REGULATORY, LEGAL AND CONTRACTUAL RISKS

6.6.1 Regulatory Risk (weak/arbitrary regulation)

A regulatory risk increases cost of operating water services, reduces attractiveness of investing in the sector (i.e., investment uncertainty), alters the competitive environment, and encourages the private sector to exploit the contract (Orr et al., 2009; Trémolet and Neale, 2002). An effective and independent regulatory system remains a challenge in water partnerships, particularly in developing countries where inexperienced municipalities and public utilities/institutions with little or no experience often emerge as regulators (Haarmeyer and Mody, 1998). Poor capacity and institutional development is the root of failure in urban water regulation (Nickson, 1996). Other causes include a change in policy or regulatory regime.

6.6.2 Absence of Policy and Legal Frameworks

Delivering sustainable water supply services and infrastructure through PPP procurement requires enabling policy, operating, regulatory and legal environments (Bennett, 1998; Li et al., 2005a). However, a major risk facing developing countries is shortcomings in, or absence of potent, policy and legal frameworks in support of PPP and investment financing (Chanda, 2011; Satpathy and Das, 2007; Xenidis and Angelides, 2005b). Legal risks refer to the means through which future disputes between contractual parties will be settled (Idelovitch and Klas, 1995). And where the host country‵s judicial systems are weak and under-developed, it is extremely difficult to recover payments from defaulted private and government customers (Ménard and Clarke, 2000), and disputes between parties are unavoidable and unresolved.

6.6.3 Sovereign and Contractual Risk

Uncertainties may occur within the operating environment and in government legislation and policies during the operational life of the project. These may include changes in drinking water quality standards; new environmental laws regarding abstraction, pollution, and ecosystems; a change in national/regional water policy and water allocation; depreciation of domestic currency; and new labour laws, which may prove critical to the project‵s implementation. The incidence of any of these factors often triggers renegotiation and modification of tariff and investment levels. The risk, however is that contracts may be inflexible to such unforeseen future occurrences (UNEP, 2006).

6.6.4 Poor/weak contract design

Cowen and Komives (1998) argued that meeting contractual targets is closely related to how well the contract is designed. Thus, the contract, which outlines rules and guides future behaviours of parties, is critical in ensuring the project‘s success. Future conflicts, and failure to achieve the contractual obligations is the outcome of flaws in contract design, regarding incentives, tariff designs, risk allocation and regulation (Ballance and Trémolet, 2005). According to Marin (2009), several contractual designs with apparent weaknesses/ irregularities have been applied in the water sector as a market test in different, challenging environments. This could partly explain the high rates of failure for PPP water supply projects (Harris et al., 2003).

6.6.5 Procurement risk

Procurement risk results from absence of mature procurement systems and competent professional advisors (internal/external), regarding project structuring (e.g., choice of PPP modalities and concessionaire) and project delivery. The risk extends from procurement planning through contract management and may lead to contracts in favour of international firms and few influential domestic companies or individuals with high-level political connections (Lobina, 2000). Procurement risk could prove critical for the project‘s success. Specifically, the resulting contract is weak, conflicts/legal dispute between the direct partners may occur, bidding/tendering process becomes less competitive, and the project‘s benefits may not be realised (ADB, 2009).

6.7 MARKET/REVENUE RISKS

6.7.1 Non-payment of Bills

Efficient service delivery, profits and project success are highly sensitive to timely settlement of customer bills. The private operator may be unable to recover payments (bills) from consumers, particularly in low-income countries where ability to pay for water services is a genuine issue for low-income customers (who represent large proportions of customers). Non-payment is also influenced by unaffordable tariffs, legal barriers to service cut-offs, unfavourable economic conditions, well-rooted habit of non-payment, and poor collection practices (Marin, 2009). Auriol and Blanc (2009) also observed capture by governments (public institutions) and the rich elites in Sub-Saharan Africa.

6.7.2 Fall in Demand

It is a decline in water consumption by consumers, for reasons including increased rates, high inflation, poor market appraisals, low per capita water consumption and over-measured consumption via metering (Haarmeyer and Mody, 1998), resulting to both low revenues and profits. For instance, in developing countries where water services are generously subsidized by governments, a drop in water demand is high following a transition to economic pricing (Brook and Cowen, 2001). Below-expected water consumption represents (i) a loss-making proposition and (ii) a disincentive to service expansion (Cowen and Komives, 1998).

6.7.3 Pricing and Tariff Review Uncertainty

Pricing and tariff review policy remains a huge challenge for most water utilities, evidenced by negative profit/price relationships (Auriol and Blanc, 2009). Adequate pricing of water services requires a precise approximation of demand-revenue ratio over the project‘s duration, and this estimate commands future price of service and the development of pricing policy in line with local regulatory structures (Xenidis and Angelides, 2005a). Data (from host government) and knowledge (of investor about the local market) required for pricing is obtained through market research and analysis, where poor pricing strategy may result from: misapplication of the computation method of the demand-revenue ratio, erroneous data for the computation of the demand-revenue ratio, unforeseen future changes (Xenidis and Angelides, 2005a), and misapplication of the tariff formula.

Pricing and tariff review also has a political dimension (see Dinar, 2000; Ameyaw et al., 2014; Harris et al., 2003; Harris et al., 2012). The risk undermines service levels and results in commercial losses and increased hidden costs, and further explains the poor profitability and inadequate financing in the water sector.

6.7.4 Unfavourable National/International Economy

The economic setting within which a PPP is to be implemented is of much concern to the project stakeholders, because a feeble economy with immature and under-sized stock market and structural deficiencies threaten the commercial viability or success of the project. Unfavourable national economy means the host government‘s inability to meet pre-agreed guarantees and sufficient funding, and unstable demand for water services (Xenidis and Angelides, 2005a). Following globalization almost all economies of the world are linked, a recession of a regional or the global economic environment adversely impacts on PPP water projects, regarding meeting capital investment, securing loans within time, getting good bidders, and overall project success.

6.7.5 Quasi-commercial Risk

A quasi-commercial risk occurs when a private investor enters into a contractual agreement with a public entity that reneges on its obligations. It is the uncertainty over the willingness and/or capacity of decentralised/local governments or public water utilities to fulfill their contractual obligations as suppliers or purchasers of, for example, bulk water. The risk results from deliberate actions, unexpected financial distress, poor creditworthiness, change in plans of public entities, and high unit price of water (Irwin et al., 1997; Basaran, n.d.).

6.7.6 Water Theft

Illegal water consumption, a component of non-revenue water is a significant utility concern in developing countries (Ameyaw and Chan, 2013a). Widespread water theft from distribution networks is one of the challenges undermining water utility projects, and a source of water and revenue losses to utilities and water quality risks to the public. Although its extent varies across countries, water theft is more acute in environments without legal support to deal with illegal tapping of distributed water.

6.7.7 Faulty Demand Forecasting

Errors in forecasted demand mean that future demand is inconsistent with projections. In water concessions/BOTs, because demand is predicted over a considerable period, say 20 years, both commercial viability and profitability are sensitive to accurate demand projections. The process, therefore relies on reliable data and appropriate techniques (surveys, experiments, experience, end-use analysis, gray forecast models) for demand prediction. However, the difficulty is that factors influencing future demand (population growth, weather variations, alternative water sources, etc) cannot be predicted with certainty and good methods can only give average outcomes, while actual demand may be less-than-accurate or over-estimated (World Bank, 2006). The consequences of inaccurate demand forecast are high prices, revenue shortfalls, renegotiations and revision of original contracts (Lobina, 2005).

6.8 SOCIAL RISKS

6.8.1 Public Resistance to PPP

Public resistance has proven detrimental to PPP in water services. Resistance has been remarkable and vocal, emanated from trade unions, community organisations, water professionals and political groups and encompassed vibrant interactions with political parties and systems, such as legal and electoral apparatuses (Hall et al., 2005; Kessides, 2004). It points to unsatisfactory social benefits yielded by PPP reforms, with negative outcomes for the poor, including tariff escalations, employee retrenchment, unmet service targets, limited financing for network expansion to low-income communities, hefty profits of operating companies, and service cut-offs for non-payment. Because it could delay or lead to the reversal and termination of a PPP project, public discontent must be understood in the host country‘s context and carefully managed.

6.9 TECHNICAL AND OPERATIONAL RISKS

6.9.1 Water Asset Condition Uncertainty

Water supply infrastructure is associated with a high degree of asset condition uncertainty (discussed in section 4.3.4). The risk is encountered in utility PPPs where management or full operation is transferred into private hands. Consequences of asset condition risk include discouragement of potential bidders, asset operation difficulties, insufficient operator performance, expensive conflicts and firm-led renegotiations (Rees, 1998; Brook and Cowen, 1997).

6.9.2 Technology Risk

Technology risk is the possibility that technical inputs may fail to deliver required output specifications, or technological improvements may render the technology inputs in the project out-of-date” (National Treasury, 2004). For example, a BOT water treatment plant may fall short of water quality standards due to technology risk. The risk results to frequent facility breakdowns, high operation and maintenance cost and low service levels.

6.9.3 Insufficient Performance of Private Operator

The private firm may fail to achieve the performance targets of the contract (e.g., coverage rate, water quality, service continuity, cost recovery, customer service, non-revenue water), and this is the main operational risk in PPP water supply projects (Haarmeyer and Mody, 1998). The risk primarily results from failure to choose the most suitable private firm with proven track record, which is the only greatest determinant of project success or failure (UNIDO, 1996). Insufficient performance prompts several repercussions, including: contract termination and associated legal disputes, activation of penalties on the project company, revenue shortfalls and reduced profits, and project funding/refinancing problems.

6.9.4 Pipeline Bursts

Pipeline bursts during water transmission and distribution is an operational challenge for water utilities, with consequences such as water losses and the associated revenues, water quality problems and damage to immediate infrastructure. Burst is a significant and fairly sudden event caused by a pipe break (Kang and Lansey, 2014). Apart from corrosion and tuberculation, other reasons for pipeline bursts are extreme cold temperatures (expansion of frozen water), excessive (traffic) weight, pressure surges and poor pipe installations.

6.9.5 Residual Value Risk

Residual value risk is associated with PPPs with transfer (e.g., BOT water treatment plants) and occurs at the end of the concession period. It is the risk that underlying water assets, on expiration or termination of a concession, will fail to be in the pre-determined condition for hand over to the public partner (National Treasury, 2004; Navarro, 2005). It implies a useful economic life or a low viable value for underlying water assets. Assets‘ value at the end of a partnership is influenced by the level of repair and maintenance undertaken during the project term.

6. 10 DESIGN AND CONSTRUCTION RISKS

6.10.1 Construction Cost Overrun

Risk of high construction cost is associated with new-build and expanded/rehabilitated water systems. Construction cost comprises both controllable and uncontrollable variables that include *force majeure*, co-operation and co-ordination costs, facilities management costs, site costs, (imported) equipment costs, costs of raw materials, labour/productivity costs, costs of insurance, etc. A good management of these cost variables ensures high potential for profits and attraction of lenders to finance the project. Conversely, high construction cost at the project‘s engineering and construction phase requires substantial finances (ADB, 2000), affects profitability of the project, and results to high tariffs and reduced demand (e.g., Izmit Su BOT water scheme in Turkey).

6.10.2 Construction Time Overrun

Short construction time is very critical for the PPP project‘s success, especially in low-income countries where interest and inflation rates are unpredictably high (Gupta and

Narasimham, 1998). Pribadi and Pangeran (2007) also noted that construction delays in PPP water projects are often related to poor coordination of PC, and delays in obtaining planning approvals and land-use rights. Moreover, natural factors (e.g., seismic issues) cause delays and re-design of facilities. Specifically, consequences of construction time overrun include late revenue inflows and lengthy payback period, increasing interest rate following late loan repayment, additional cost of finance and social and political concerns (Li and Liu, 2009).

6.10.3 Design and Construction Deficiencies

Design and construction deficiency is the risk that both designed and constructed water supply system fail to satisfy output specifications (Chan et al., 2011; National Treasury, 2004). Design deficiency is likely to cause design implementation problems (e.g., delays) while construction deficiency could cause the constructed facility to fall short of performance standards. Design and construction deficiencies may result from incompetent prime design consultants and/or contractors.

6.10.4 Land Acquisition Risk

In most long-term concessions, such as BOT water plants, the host government can provide, or offer support in acquiring, the land on which the water system will be constructed (Augenblick and Custer, 1990). The government may do this through its power of compulsory acquisition (also called *expropriation, compulsory purchase, eminent domain,* and *takings*) (Lindsay, 2012). Land availability within time and at a reasonable price could prove critical to the project‘s success, regarding early completion and reduced project development cost. However, which party bears the cost will vary from project to project.

6.10.5 Supporting Utilities Risk

Supporting utilities (water, energy/electricity, gas) needed for the construction and/or operation of the water supply project may be unavailable, especially for projects in developing countries where erratic electricity/water supply is commonplace. Such a tendency is critical to water supply projects at construction and operation phases. And as a countermeasure, the host government may provide relevant utilities under long term supply contracts over the project‘s period (Augenblick and Custer, 1990; Wang et al., 2000).

6.11 RELATIONSHIP RISKS

6.11.1 Conflict between Partners (strained relations)

Often, conflicts engulf water supply partnerships, which affect performance of the direct participants, waste time and resources and jeopardize the project‘s success. Conflicts originate from flawed contract designs regarding ill-defined roles and responsibilities, lack of clarity in risk allocation, difficulty with interpreting the contract, ambiguous performance targets; disagreement over the PC‘s performance; differences in working practices; and opposing interests and objectives (Trémolet et al., 2004; Lobina, 2005; Marin, 2009; Ibrahim et al., 2006).

6.11.2 Lack of PPP Experience

Adequate PPP experience may be lacking, particularly in countries with budding PPP programmes. This risk is common across public institutions/agencies (Liu and Wilkinson, 2011). Lack of PPP experience and knowledge by the host government implies an inadequate capacity to negotiate contracts and guarantees with multinational firms and international lenders, respectively (ADB, 2009; Farlam, 2005) and to conduct successful

PPPs. This risk generates tensed relations, protracted negotiations and repeated renegotiations, coordination and project implementability problems.

6.12 WATER RESOURCE ISSUES

6.12.1 Raw Water Scarcity

Water scarcity is an emerging big risk to water utilities (Orr et al., 2009). The risk is complex and has three related classes: (i) risk arising from *insufficient* water to satisfy basic human needs, (ii) risk resulting from the *consequences* of insufficient water (e.g., social unrests, and political crisis) and (iii) risk due to *poor water management decisions* in response to water scarcity (Orr et al., 2009). Water scarcity consequences are huge (energy and environmental) costs of accessing alternative sources (e.g., seawater desalination) and outburst of contentions between the private firm and the regulator, because water resources scarcity is seldom foreseen in contract arrangements (UNEP, 2006).

6.12.2 Low Quality of Raw Water

Low (or polluted) water quality is associated with (a) water resources at the catchment level and (b) potable water at transmission/distribution level. The former is primarily associated with population growth and increasing human and industrial activities. With increasing stringent drinking water quality standards in some countries, low raw water quality implies huge financial resources to protect catchments and water sources and high treatment costs (Kaufman, 2007) to meet quality standards.

6.13 NATURAL ISSUES

6.13.1 Climate Change Risk

While the water sector is the channel through which climate change impacts will be felt by other sectors (World Climate Conference, 2009), its effects on the sector are established: declining water availability (including falling groundwater levels), low water quality and increasing water demand (Danilenko et al., 2010; Zwolsman et al., 2011). WSAA (2012) observed that reduced revenues, reduced willingness to pay, flooding and surge storms and growing challenges to water services delivery are other consequences of climate change risk. Thus it will impact on the performance of long-term PPP projects that fail to establish flexible and responsive strategies to real time conditions.

6.13.2 *Force Majeure*

Every PPP contract defines possible *force majeure* risks in a unique way. They are unexpected natural or man-made events — insurrections, lock-outs, acts of public enemy, explosions, accident to machinery, fires, flash floods, earthquake, landslides, war, etc — and could be insurable or uninsurable. These events can potentially put significant stress on the water supply infrastructure, and their occurrences mean extra costs to remedy the situation.

The foregoing discussion of risk factors associated with PPP water supply projects supports the unique characteristics of risk (World Bank, 2006):

(a) Risks are interrelated – a change in or occurrence of one risk triggers another. An increase in interest rate, for example, automatically raises the cost of financing projects which will be transferred to consumers in increased tariffs. Figure 6.1 illustrates links between some of the major risk presented in this chapter. Consequently, the impacts of these risks determine the level of cashflow and success of any water supply project.

(b) One risk is often a bundle of other, more specific risks – construction risk, for example, involves other specific risks such as cost and time overruns, high cost of labour, and site condition risks.

Also, following the presentation in Table 6.1, the following three conclusions could be drawn:

(i) Risks occur in all phases of a PPP water supply project, indicating a need for effective risk identification and shared understanding of all relevant risks.

(ii) Most risks occur in more than one phase of a water supply project lifecycle, while very few occur in only one phase. Being aware of this tendency will facilitate development of appropriate risk mitigation strategies.

(iii) Most of the risks occur in the project implementation and management and operation phase. This explains why most water projects run into difficulties when a true partnership is not demonstrated by the participants. Similar observations were made by Xenidis and Angelides, 2005a).

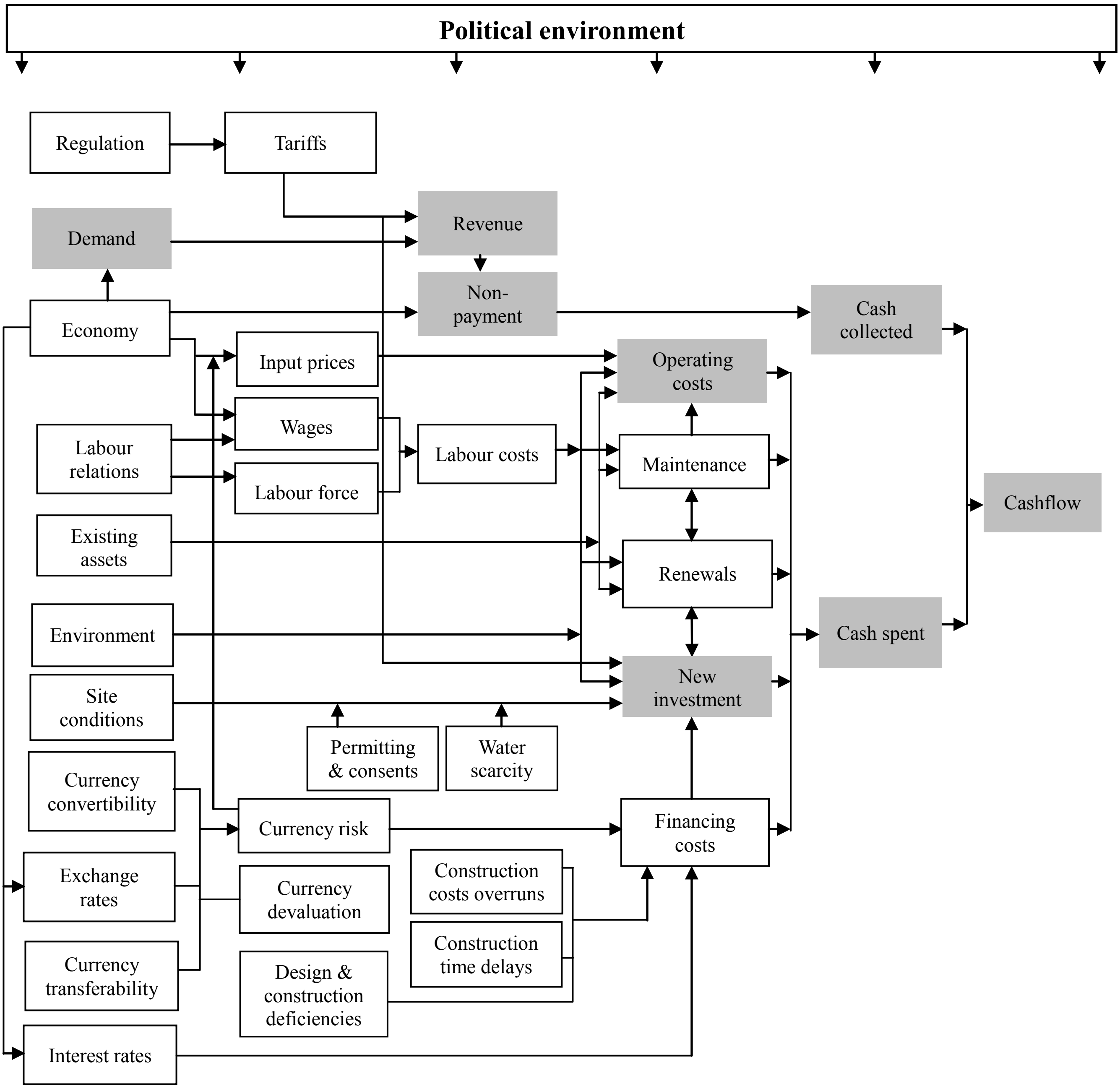


Fig. 6.1: Interrelationships between risks (Adopted and expanded from World Bank (2006))

6.14 KNOWLEDGE GAP

A review of the body of literature (both general and water sector-specific PPP) in this area (i.e., risk factors) revealed numerous factors that previous academic and institutional studies have identified to be significant to successful execution of PPP projects. However, in the context of Ghana there are as yet unanswered questions: (i) which of the identified water based PPP risk factors are critical to PPP projects? (ii) what is the risk level of PPP water supply projects to the public and private participants? and (iii) which factors significantly contribute to the risk level of such projects? As part of this research study, these questions are investigated to aid governments and private investors in their investment decision-making regarding water based PPPs.

6.15 CHAPTER SUMMARY

The chapter has revealed that PPP water supply projects are associated with numerous and significant risk factors that require an in-depth understanding by the project participants to facilitate effective risk management. This chapter reviewed empirical works relating to risk identification and categorisation, with a focus on PPP water management literature.

The chapter presented a framework for purposes of identifying and classifying risks in PPP water supply projects. Two classifications are presented, according to their sources and the project phase at which a risk is likely to occur. The source taxonomy is presented as Political; Financial; Regulatory, legal and contractual; Market/revenue; Social; Technical and operational; Design and construction; Relationship; Water resource issues; and Natural issues. Each category is broken down into specific risk factors affecting PPP water projects.

This chapter aided the development of questionnaire for the Delphi survey to study the opinion of industry experts concerning risk assessment and risk allocation. Thus, it has contributed to establishing the significant risk factors that could affect PPP water projects in Ghana and other countries. The 40 risk factors were then formulated into questionnaire for the Delphi survey. The next chapter presents ranked CSFs from a Delphi questionnaire survey and a CSF model based on the fuzzy set theory.

Chapter 7: Critical Success Factors (CFCs) For PPP Water Supply Projects

The results chapter of a thesis is often simply a presentation of results, including tables, diagrams and a description of the findings. It is often done without any interpretation or discussion of the results, which often comes in a separate chapter.

This chapter is very effective partly because the writer includes the following:

Structure

Introduction	Section 7.1
Statistical approach and results of analyses	Section 7.2
Reports of the results of two analyses	Section 7.3-7.4
Modelling and calculations of third analyses	Section 7.5-7.6
Discussion	Section 7.7
Summary	Section 7.8

Content

- Introduces the data that inform this chapter and explains data collection methods
- Summarises key ideas included in the chapter and gives an overview of the analysis to be used (e.g. Section 7.1)
- Explains the purpose and aims of the chapter (e.g. Section 7.1, paragraph 1, final sentence)
- Outlines the content of the chapter (e.g. Section 7.1, paragraph 2)
- Summarises findings in a table (e.g. Table 7.1)
- Validates choice of methodology (e.g. Section 7.4, paragraph 2, sentence 1).
- Discusses possible limitations of the methodology chosen and defends it (e.g. Section 7.4 paragraph 3, sentence 3-5)
- States limitations of the findings (e.g. Section 7.8, paragraph 4, sentence 1) and attempts to identify aspects that would enhance confidence in the findings
- Discusses results with reference to previous studies (e.g. Section 7.7, paragraph 2, sentence 2)

- Explains implications of the results, e.g. *The implication is…This means …* (e.g. Section 7.7, paragraph 2, sentence 3 and sentence 7)
- Explains the contributions the findings make to the wider field of study (e.g. Section 7.7, paragraph 4, final sentence)
- Analyses results, e.g. *this is an effective approach* (e.g. 7.7.2, paragraph 3, sentence 7)
- Recommends action based on the findings (e.g. Section 7.8, paragraph 2, final sentence)
- Links to the previous chapter (e.g. Section 7.1, paragraph 1, sentence 1)
- Provides an introductory paragraph for important main sections (e.g. Section 5.5)

<u>Language</u>

- Uses positive language to highlight contribution e.g. *these useful findings* (e.g. Section 7.8, paragraph 4, sentence 4)
- Uses tentative language to highlight lack of certainty e.g. *This may suggest that* (Section 7.3, paragraph 3, last sentence)
- Explains how to interpret a table e.g. *the values in this column* (Section 7.2.1 paragraph 2, sentence 2)

<u>To consider</u>

In general, this chapter of the thesis is effective. However, it could be further improved in the following aspects.

Include more discussion of how the results from the current thesis contribute to the understanding of the topic and compare the results with previous studies in the general discussion, instead of doing it at the end in the conclusion. Key points can then be summarized in the conclusion.

Avoid being vague, e.g. *this is discussed later* (e.g. Section 7.5.3 final sentence). It is better to state clearly where it will be discussed, e.g. *this is discussed in Section 9.3*.

CHAPTER 7 CRITICAL SUCCESS FACTORS (CSFs) FOR PPP WATER SUPPLY PROJECTS

7.1 INTRODUCTION

Chapter 6 presents and discusses risk factors associated with PPP water projects by drawing on academic and institutional literatures. This chapter reports on partial findings of the Delphi questionnaire survey. It primarily reports on the CSFs for successful implementation of PPP water supply projects in Ghana. This study seeks views originating from experts' professional and experienced judgment and therefore requires practitioners with insights of the country environment, water industry and PPP procurement. For purpose of reliable, quality and unbiased results on the factors that really determine project success, the survey targeted public and private institutions with interest and direct involvement in water PPPs, as they are responsible for decision-making regarding private participation in the water sector. As discussed in Chapter 2, because PPP procurement is new, purposive sampling and semi-snowballing approaches were deemed appropriate in order to identify well-qualified practitioners. Data was obtained from a panel of 41 industry experts through a ranking-type Delphi survey, in which the experts were required to rate the relative importance of each perceived CSF according to a seven-point grading system (1 = extremely low importance and 7 = extremely high importance). The panel of experts from diverse backgrounds (see Table 2.4) was appropriate to capture positive agreement among the panelists on the importance of the success factors and to sum up a broad knowledge base for the subject under investigation. The overall aim of the questionnaire (for CSFs) was to establish a checklist of CSFs to support construction of a fuzzy CSF model to assess the likelihood of successful implementation of PPP water supply projects. This chapter aims to (i) evaluate the identified CSFs for PPP water projects and (ii) model the impact of the CSFs on PPP project success.

Three separate analyses were performed on the resulting data using SPSS 21.0: the first analysis ranked the success factors based on their mean scores; the second analysis further explored and detected the underlying relationships among the CSFs through the principal component factor analysis (PCFA) method. PCFA has a data reduction capacity. The third analysis modelled the combined impact of the critical factors on PPP project implementation using fuzzy synthetic evaluation (FSE), which has the merit of dealing with subjectivity and multi-criteria. Following above analyses, a practical model is proposed to objectively assess and measure the level of importance of the CSFs for PPP implementation. The results of the data analysis are thoroughly discussed in this chapter.

7.2 STATISTICAL TESTS

Data from the quantitative Delphi survey was analysed using SPSS 21.0. Statistical tests performed on the ordinal data include mean analysis, reliability analysis, factor analysis and FSE modelling. The mean analysis was used to establish the relative importance of the success factors, reliability analysis was conducted to statistically check whether the 14 factors in the Delphi questionnaire are valid and reliable while factor analysis was used to establish which factors measured the same underlying construct. The output of the factor analysis was used as input variables for the fuzzy analysis. FSE modelling was used in identifying the critical latent factors that significantly contribute to project success and to quantify a project's success level.

7.2.1 Cronbach's Alpha Reliability Analysis

Prior to conducting further statistical analyses, an internal consistency of the dataset was tested using Cronbach's alpha reliability model. As noted in Chapter 2, reliability analysis is conducted to check the consistency of the CSFs and its scale, and helps to determine whether the set of 14 factors reflect the construct it was designed to statistically measure (Norusis, 1993). The overall alpha value of the 14 CSFs is 0.824, which is greater than approximately 0.70 (Field, 2005; SPSS, 2003). This suggests a good internal consistency and reliability with the data obtained from the Delphi questionnaire survey and thus the adopted seven-point grading system (measurement scale) is reliable. The result of the test is shown in Table 7.1.

In Table 7.1, important data is included in column 10 labeled ‗Cronbach's alpha if item deleted'. This is a measure to examine the contribution of each success factor to the reliability of the dataset (Oyedele, 2013). The values in this column are the values of the overall Cronbach's reliability if the CSF is excluded or deleted from the calculation. This means that a given alpha value is based on 13 but not 14 CSFs, in this case. Because the overall reliability is 0.824, any CSF effectively contributing to the dataset should have an alpha-value ≤ 0.824. However, a CSF that is not making contribution would have a value above 0.824. Because this rule was not violated, none of the factors is removed from the list of 14 factors.

7.2.2 Kendall's Coefficient of Concordance *(W)*

The round-by-round degree of consensus among the panelists was measured using Kendall's *W* (Schmidt et al., 2001), as presented in Table 7.1. With *W*, as explained in Chapter 2, it is possible to determine the level of consensus, establish whether consensus is improving or not. Delphi method has the merit of improving group consensus while reducing bias, given the anonymous nature of the process (Chan et al., 2001). The degree of consensus leveled off during the two rounds, from 0.163 to 0.166 in round one and two, respectively. This means that two rounds was optimal for this Delphi study. Though the low values of W indicate weak agreement among the panelists, however, they are significant given that 41 expert panelists evaluated 14 factors on a 7-point rating system.

Table7.1 Round-by-round Delphi results

ID	Critical success factor (CSF)	Round one		Round two					
		Mean index	Ranking	Mean index	Std. error (mean)	Std. deviation	Ranking	Criticality	Cronbach's alpha if item deleted
CSF3	Government (political) commitment	6.71	1	6.80	0.06	0.40	1	extremely important	0.813
CSF4	Adequate financing	6.39	2	6.39	0.10	0.66	2	very important	0.812
CSF2	Public acceptance/support	6.15	4	6.24	0.13	0.83	3	very important	0.818
CSF7	Strong and competent private partner	6.22	3	6.22	0.13	0.82	4	very important	0.806
CSF6	Effective regulatory and legal structures	6.12	5	6.20	0.12	0.78	5	very important	0.807
CSF14	Strong and competent public partner	6.12	6	6.20	0.16	1.01	6	very important	0.805
CSF1	PPP policy and unit	6.05	8	6.17	0.16	1.04	7	very important	0.823
CSF10	Strong commitment from project partners	6.07	7	6.15	0.15	0.96	8	very important	0.801
CSF5	Capacity building for local utility staff	5.71	10	5.90	0.15	0.97	9	very important	0.810
CSF11	Quality water asset and workforce	5.78	9	5.88	0.14	0.90	10	very important	0.820
CSF8	Competitive tendering	5.71	11	5.80	0.19	1.21	11	very important	0.814
CSF9	Profitable water supply projects	5.63	12	5.78	0.15	0.99	12	very important	0.824
CSF12	Flexible contracts with fair risk allocations	5.63	13	5.73	0.12	0.78	13	very important	0.808
CSF13	Internal coordination within government	5.54	14	5.66	0.17	1.09	14	very important	0.797
Kendall's *W*		0.163		0.166					
Asymptotic level of significance		0.000		0.000					
Delphi panel size (*n*)		41		41					
Overall Cronbach's alpha reliability									0.824

7.3 RANKED CSFs FOR PPP WATER SUPPLY PROJECTS

Establishing CSFs for PPP water supply projects is the third objective of this research. Analysis of the two-round survey data generated mean importance indices for the 14 CSFs using Eq. (2.1). Based on the 7-point measurement scale, a factor is regarded as ‗critical‘ if it scored a mean index ≥ 4.5. However, where two or more factors scored the same mean, the highest ranking is assigned to the one with the least standard deviation (Field, 2005). The mean indices range between 5.66 and 6.80 as shown Table 7.1. This suggests that the importance of all the CSFs range between ―very important” and ―extremely important”. The ―very important” factors are *Internal coordination within government; Flexible contracts with fair risk allocations; Profitable water supply projects; Competitive tendering; Quality water asset and workforce; Local capacity building for utility staff; Strong commitment from project partners; PPP policy and unit; Strong and competent public partner; Effective regulatory and legal structures; Strong and competent private partner; Adequate financing; and Public acceptance/support*. The ―extremely important” factor is *Government (political) commitment*. Eight factors scored mean importance values between 6.0 and 7.0 and the remaining factors displayed mean scores between 5.0 and 6.0. This suggests that all the 14 success factors are deemed ‗critical‘, and these factors (Table 7.1) are referred to as CSFs for implementing PPP water supply projects.

A closer examination of the round-by-round results revealed some changes in both mean scores and rankings in six factors: CSF2, CSF7, CSF1, CSF10, CSF5, and CSF11. These factors either gained prominence or remained unchanged. For example, CSF2 (public acceptance/support) ranked 4th with a mean index of 6.15 in round one but ranked 3rd with a mean score of 6.24 in round two. Thus, the two-round Delphi survey gave the expert respondents the opportunity to reconsider their original scores.

Standard error, the standard deviation of sample means, measures how representative a sample is likely to be to the population (Field, 2005; Ahadzie et al., 2008). A small standard error is an indication of similarity between most sample means and the population mean or that there is little variability between means of different samples (Field, 2005). Given that the standard error associated with the means is reasonably close to zero indicates that the chosen sample perfectly reflects the population (Table 7.1). Also, the standard deviations of 10 factors are less than 1.0, suggesting consistency in the panelists' consensus and little variability in the dataset (Field, 2005). However, four success factors (CSF13, CSF8, CSF1, and CSF14) have standard deviations above 1.0. This may suggest that there were differences to how these factors were interpreted and rated by the panelists.

7.4 FACTOR ANALYSIS OF CSFs

Since the third objective of this overall research seeks to predict the impact of the CSFs on successful implementation of PPP water supply projects, factor analysis, as explained in Chapter 2, was adopted to detect the underlying relationships among the 14 CSFs from the Delphi survey. This technique helps to statistically reduce (Oyedele, 2010) the 14 CSFs in order to derive the principal success factors that would serve as input variables for the FSE analysis. Factor analysis is appropriate in this case because of a lack of *a priori* knowledge about the factor structure (Field, 2005).

The appropriateness of using factor analysis was tested through Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity, anti-image correlation and measure of sampling activities (MSA). As a first stage of analysis, it is recommended that the strength of the relationship among the factors should be determined based on the partial correlation coefficients (or anti-image correlation matrix) of the factors (Akintoye, 2000). The anti-image correlation matrix showed that the partial correlation coefficients are close to zero, which suggests that factor analysis assumptions are satisfied (Norusis, 2003). The MSA on the diagonal of the anti-image matrix should be reasonably high (≥ 0.5) for a good factor analysis (Oyedele, 2010), and was 0.577–0.877, signifying no need to remove any factor from the factor analysis.

The values of the test statistic for KMO was 0.653, which is greater than the recommended threshold of 0.50 (Norusis, 2003), suggesting that factor analysis application is appropriate for the dataset. The value of the Bartlett‘s test of sphericity is relatively large (=242.696) and the associated significance is small (p-value = 0.000), which according to Lattin et al. (2003) indicates that the correlation matrix is not an identity matrix. It may be argued that 14 factors is not sufficiently large enough to conduct factor analysis. However, first, above preliminary tests indicate that the dataset is suitable for factor analysis, and second, the variables are equal to or more than those used in some reported studies. For example, Oyedele (2010) conducted factor analysis on 14 motivational attributes of architects and engineers while Cheung et al. (2000) reported a three-factor solution based on eight variables.

Principal component factor analysis (PCFA) produced a five-factor solution with eigenvalues greater than 1.00 and varimax rotation after seven iterations, explaining 74.5% of the total variance explained. The factor solutions indicate strong item loadings (0.50+) on each factor, which is greater than the recommended minimum item loading of 0.32 (Tabachnick and Fidell, 2001). The loading of each CSF is an indication of its contribution to the underlying components. The relatively high factor loadings (above 0.6 for more than four variables) lend support to appropriateness of the sample size (Ahadzie et al., 2008).

The five principal factors and their associated factors, reported in Table 7.2, are interpreted as follows:

- Factor 1: Commitment of the partners
- Factor 2: Strength of the consortium
- Factor 3: Asset quality and social support
- Factor 4: Political environment
- Factor 5: National PPP Unit

Table 7.2 Extracted factors and their attributes

ID	CSFGs (U)	Factor Loading	Eigenvalue	% of variance explained	Cumulative % of variance explained
Factor 1	*Commitment of partners (CSFG 1)*: u_1		4.814	32.955	32.955
CSF10	Strong commitment from project partners (u_{11})	0.866			
CSF14	Strong and competent public partner (u_{12})	0.821			
CSF13	Internal coordination within government (u_{13})	0.807			
CSF12	Flexible contracts with fair risk allocations (u_{14})	0.754			
Factor 2	*Strength of consortium (CSFG 2)*: u_2		1.815	12.965	45.92
CSF7	Strong and competent private partner (u_{21})	0.859			
CSF6	Effective regulatory and legal structures (u_{22})	0.838			
CSF9	Profitable water supply projects (u_{23})	0.568			
Factor 3	*Asset quality/social support (CSFG 3)*: u_3		1.537	10.978	56.898
CSF11	Quality water asset and workforce (u_{31})	0.831			
CSF2	Public acceptance/support (u_{32})	0.804			
CSF4	Adequate financing (u_{33})	0.570			
Factor 4	*Political environment (CSFG 4)*: u_4		1.408	10.056	66.954
CSF5	Capacity building for local utility staff (u_{41})	0.790			
CSF8	Competitive tendering (u_{42})	0.652			
CSF3	Government (political) commitment (u_{43})	0.569			
Factor 5	*National PPP Unit (CSFG 5)*: u_5		1.056	7.545	74.499
CSF1	National PPP policy and implementation unit (u_{51})	0.865			
KMO measure of sampling adequacy		0.653			
Bartlett's test of sphericity	Approx. Chi-Square	242.696			
	df	91			
	Sig.	0.000			

CSFGs: critical success factor groups

The above five principal factors are defined as critical success factor groups (CSFGs) in this thesis. In some cases the acronym CSFG with a number has been used to denote a particular principal factor, for example, CSFG1 has been used to denote Factor 1. By statistically establishing these CSFGs through PCFA, their collective impact on PPP water supply project success can be determined. The hypothesis is that:

a. There are five key CSFGs of PPP water projects which, if rightly put together and provided special and sustained management attention, would enhance the likelihood of successful implementation of such projects. In other words, these factors have favourable influence on water PPP implementation.

7.5 A FUZZY PREDICTIVE TOOL FOR EVALUATING PROJECT SUCCESS

Assessing the possibility of a project success involves different CSFGs (five in this case) with varying degree of criticality. For the purpose of comprehensiveness, each CSFG is evaluated in terms of its criticality to a project, from which the overall success level of a candidate project can be quantified. Hence, a FSE method is adopted to deal with this multi-factor and multi-level problem associated with predicting the success of a project. Because predicting a project‘s likelihood of success is fuzzy in nature and draws on approximate reasoning by human judgement or perception, fuzzy theory is deemed most appropriate (Xu et al., 2010; Boussabaine, 2014), as demonstrated in this study. Fig. 5a presents a step-by-step approach of the predictive tool and summarised below.

7.5.1 Set up the Evaluation Index Systems

In view of the factor analysis results, the evaluation index systems were set up. Here, the five principal factors (CSFGs) are defined as the first-level index as $U = (u_1,\ u_2,\ u_3,\ u_4,\ u_5)$.

The CSFs within each CSFG, as shown in Table 7.2, are also represented as second-level index system as follows: $u_1 = \{u_{11},\ u_{12},\ u_{13},\ u_{14}\}$, $u_2 = \{u_{21},\ u_{22},\ u_{23}\}$, $u_3 = \{u_{31},\ u_{32},\ u_{33}\}, u_4 = \{u_{41},\ u_{42},\ u_{43}\}$, and $u_5 = \{u_{51}\}$. These index systems become the input variables of the fuzzy evaluation tool (Fig. 5a).

7.5.2 Determine the Membership Functions of the CSFs and CSFGs

Fuzzy mathematics is used to derive the membership functions (MFs) of individual CSFs and CSFGs. Recall that the grade alternatives for evaluating the CSFs were defined on a seven-point rating scale as $V = (1,2,3,4,5,6,7)$, where $v_1 =$ not important (NI), $v_2 =$ very low importance (VLI), $v_3 =$ low importance (LI), $v_4 =$ moderate (M), $v_5 =$ important (I), $v_6 =$ very important (VI) and $v_7 =$ extremely important (EI), for degree of importance of the success factors. Hence, the MF of a given CSF, u_{in}, can be derived by the following equation (Xu et al., 2010):

$$MF_{u_{in}} = \frac{x1_{u_{in}}}{v_1} + \frac{x2_{u_{in}}}{v_2} + \frac{x3_{u_{in}}}{v_3} + \frac{x4_{u_{in}}}{v_4} + \frac{x5_{u_{in}}}{v_5} + \frac{x6_{u_{in}}}{v_6} + \frac{x7_{u_{in}}}{v_7} \qquad (7.1)$$

where u_{in} represents the n^{th} CSF of a particular CSFG i $(i = u_1, u_2, u_3, u_4, u_5)$; $MF_{u_{in}}$ is the membership function of a specific CSF u_{in}; $xj_{u_{in}}$ $(j = 1,2,3,4,5,6,7)$ denotes the percentage of the Delphi panelists who scored j for the degree of importance of a specific CSF u_{in}, which denotes the membership function; the terms $xj_{u_{in}}/v_i$ represents relation between $xj_{u_{in}}$ and its grade alternative instead of fractions; and the plus sign (+) is a notation instead of the usual meaning of addition. Given Eq. (7.1), the MF of a specific CSF u_{in} is written as:

$$MF_{u_{in}} = \left(x1_{u_{in}},\ x2_{u_{in}},\ x3_{u_{in}},\ x4_{u_{in}},\ x5_{u_{in}},\ x6_{u_{in}},\ x7_{u_{in}}\right) \tag{7.2}$$

which ranges between [0,1] and the summation of $MF_{u_{in}}$ must equal to unity:

$$\sum_{j=1}^{7} xj_{u_{in}} = 1 \tag{7.3}$$

As shown in Fig. 5a, MFs and weightings of all CSFs of a given CSFG (u_i) are combined to derive its membership function. This is discussed later.

7.5.3 Calculate the Weighting Functions of each CSFs and CSFGs

The weighting function, w_i, of a variable represents its relative significance as evaluated by the survey respondents. It can be derived from tabulated judgement, analytic hierarchy process (Hsiao, 1998) and normalised mean method (Lo, 1999). The latter is adopted to calculate the weightings of the CSFs and CSFGs because it is straightforward and has been used in previous studies (e.g. Lo, 1999; Xu et al., 2010; Yeung et al., 2010). The mean score of a CSF or CSFG is normalised to derive its weighting function using Eq. (7.4):

$$w_i = \frac{M_i}{\sum_{i=1}^{7} M_i},\ 0 < w_i < 1, \text{ and } \sum_{i=1}^{n} w_i = 1 \tag{7.4}$$

where w_i is the weighting of a particular CSF/CSFG i regarding the extent of its importance to successful implementation of a project; M_i denotes the mean score of a specific CSF/CSFG i from the survey. The weighting function set is given as:

$$W_i = \{w_1, w_2, \ldots w_n\} \tag{7.5}$$

7.5.4 Establish a Multi-criteria and Multi-level FSE Model

As shown in Fig. 5a, evaluating the possibility of successful implementation of a PPP project is a multi-criteria and multi-level task that involves three key stages. The first stage entails the establishment of the MF and weighting of each CSF based on the scores of the Delphi panelists. The second stage concerns establishment of the MF and weighting of each CSFG and assessing its contribution (impact) to a project's overall success level. The third stage is the assessment of the overall possibility of successful execution of a project, which is described by a single indicator – overall success index (OSI).

To evaluate a CSFG's impact on a project's success, a fuzzy evaluation matrix, D_i, is firstly set up for each CSFG after establishing the fuzzy MF for each CSF. Given the $m \times n$ values of entries and according to Eq. (7.2), the MFs of all the CSFs can be expressed in a function matrix as follows:

$$R_i = \begin{vmatrix} MF_{u_{i1}} \\ MF_{u_{i2}} \\ MF_{u_{i3}} \\ \cdots \\ MF_{u_{in}} \end{vmatrix} = \begin{vmatrix} x1_{u_{i1}} & x2_{u_{i1}} & x3_{u_{i1}} & x4_{u_{i1}} & x5_{u_{i1}} & x6_{u_{i1}} & x7_{u_{i1}} \\ x1_{u_{i2}} & x2_{u_{i2}} & x3_{u_{i2}} & x4_{u_{i2}} & x5_{u_{i2}} & x6_{u_{i2}} & x7_{u_{i2}} \\ x1_{u_{i3}} & x2_{u_{i3}} & x3_{u_{i3}} & x4_{u_{i3}} & x5_{u_{i3}} & x6_{u_{i3}} & x7_{u_{i3}} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ x1_{u_{in}} & x2_{u_{in}} & x3_{u_{in}} & x4_{u_{in}} & x5_{u_{in}} & x6_{u_{in}} & x7_{u_{in}} \end{vmatrix} \quad (7.6)$$

whose elements are given by $xj_{u_{in}}$.

The fuzzy evaluation matrix, D_i, can then be derived by using the weighting matrix $(W_i = \{w_{i1},\ w_{i2},\ \cdots\ w_{in}\})$ of the CSFs of a given CSFG i as follows:

$$D_i = W_i \bullet R_i = (d_{in},\ d_{in},\ \cdots,\ d_{in}) \quad (7.7)$$

$$= \left(w_{i1},\ w_{i2},\ \cdots,\ w_{in}\right) \bullet \begin{vmatrix} x1_{u_{i1}} & x2_{u_{i1}} & x3_{u_{i1}} & x4_{u_{i1}} & x5_{u_{i1}} & x6_{u_{i1}} & x7_{u_{i1}} \\ x1_{u_{i2}} & x2_{u_{i2}} & x3_{u_{i2}} & x4_{u_{i2}} & x5_{u_{i2}} & x6_{u_{i2}} & x7_{u_{i2}} \\ x1_{u_{i3}} & x2_{u_{i3}} & x3_{u_{i3}} & x4_{u_{i3}} & x5_{u_{i3}} & x6_{u_{i3}} & x7_{u_{i3}} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ x1_{u_{in}} & x2_{u_{in}} & x3_{u_{in}} & x4_{u_{in}} & x5_{u_{in}} & x6_{u_{in}} & x7_{u_{in}} \end{vmatrix} = \left(d_{i1},\ d_{i2},\ d_{i3}\ ,\ \ldots\ ,\ d_{in}\right)$$

where d_{in} is the degree of membership of the grade alternative, v_i, regarding a given CSFGi; the symbol "$\bullet$" is a fuzzy composite operation, which is handled by four models (refer to Chapter 2 for details). In this study, the weighted mean method is used since it averages out the single impact of a specific factor and is widely used in fuzzy decision environment (Chan, 2007; Yeung et al., 2010; Lo, 1999; Hsiao, 1998).

The weighted mean method ($M(\bullet, \oplus)$), according to Hsiao (1998), is defined as:

$$d_{in} = \min\left\{1,\ \sum_{i=1}^{m} w_{in} xj_{u_{in}}\right\}, \qquad n = 1, 2, \ldots, k \tag{7.8}$$

The symbol "$\oplus$" represents the summation with 1 as the upper limit. Hsiao (1998) explained that ‗the characteristic of this operation is that when the weighting functions w_i are normalised, $\sum_{i=1}^{m} w_{in} = 1$, the operator "$\oplus$" will regress to the addition of real numbers such that

$$d_{in} = \sum_{i=1}^{m} w_{in} xj_{u_{in}} \qquad n = 1, 2, \ldots, k \tag{7.9}$$

i.e. the operation regresses to $\mathrm{M}(\bullet, +)$‘ (p. 106). The effects of all the success factors and success categories are reserved in this model, and their weighting functions are also normalised. The obtained evaluation matrixes, $D_i = (i = 1,2,3,4,5)$, then constitute the fuzzy evaluation matrix, $\overline{R}$, for evaluating overall likelihood of a project‘s success:

$$\overline{R} = \begin{vmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \\ D_5 \end{vmatrix} = \begin{vmatrix} d_{11} & d_{12} & d_{13} & d_{14} & d_{15} & d_{16} & d_{17} \\ d_{21} & d_{22} & d_{23} & d_{24} & d_{25} & d_{26} & d_{27} \\ d_{31} & d_{32} & d_{33} & d_{34} & d_{35} & d_{36} & d_{37} \\ d_{41} & d_{42} & d_{43} & d_{44} & d_{45} & d_{46} & d_{47} \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} & d_{56} & d_{57} \end{vmatrix} \tag{7.10}$$

It is worthnoting that D_1, D_2, D_3, D_4, and D_5 represent Commitment of partners (CSFG1), Strength of consortium (CSFG2), Asset quality/social support (CSFG3), Political environment (CSFG4), and National PPP unit (CSFG5), respectively. Using Eq. (7.7), $\overline{R}$ is normalised through the weightings of the CSFGs $\left(\overline{W} = \{w_1,\ w_2,\ w_3,\ w_4,\ w_5\}\right)$ to establish the fuzzy evaluation matrix of stage three, as previously described (or as shown in Fig. 5a):

$$\overline{D} = \overline{W} \bullet \overline{R} \tag{7.11}$$

$$= (w_1,\ w_2,\ w_3,\ w_4,\ w_5) \times \begin{vmatrix} d_{11} & d_{12} & d_{13} & d_{14} & d_{15} & d_{16} & d_{17} \\ d_{21} & d_{22} & d_{23} & d_{24} & d_{25} & d_{26} & d_{27} \\ d_{31} & d_{32} & d_{33} & d_{34} & d_{35} & d_{36} & d_{37} \\ d_{41} & d_{42} & d_{43} & d_{44} & d_{45} & d_{46} & d_{47} \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} & d_{56} & d_{57} \end{vmatrix} = (D'_1,\ D'_2,\ D'_3,\ D'_4,\ D'_5,\ D'_6,\ D'_7)$$

where $\overline{D} = (D'_1,\ D'_2,\ D'_3,\ D'_4,\ D'_5,\ D'_6,\ D'_7)$ is the fuzzy evaluation matrix (or membership function) for the overall possibility of successful implementation of a project, which can be quantified by considering the set of grade alternatives $(V = 1,2,3,4,5,6,7)$ through Eq. (7.12):

$$S = \sum_{i=1}^{7} \overline{D} \times V^T = (D'_1,\ D'_2,\ D'_3,\ D'_4,\ D'_5,\ D'_6,\ D'_7) \times (1,2,3,4,5,6,7) \tag{7.12}$$

where S is the overall success level of a project, and V^T is the adopted grade alternative (or grading scale).

7.6 APPLICATION

Given above CSFs and CSFGs for PPP water supply projects in Ghana, what is the likelihood that a candidate project would be successful, if these factors are effectively combined and provided sustained attention? Using data from the Delphi questionnaire survey described earlier in this chapter (sections 7.1–7.4) (Chapter 2), the above fuzzy predictive tool is demonstrated.

7.6.1 Compute the Weighting Functions of the CSFs and CSFGs

The weighting of each CSF (second-level) and CSFG (first-level) are quantified based on the mean values computed from the Delphi survey, which are reported in Table 7.3. From Table 7.3, for example, given that *Factor 2 – Strength of Consortium* (u_2) comprises CSF7, CSF6 and CSF9 with mean values of 6.22, 6.20 and 5.78, respectively, the mean value of *Factor 2* (u_2) is 18.200. Hence, the weightings (w_{in}) of CSF7 (u_{21}), CSF6 (u_{22}) and CSF9 (u_{23}) can be quantified through Eq. (7.4) as:

$$w_{u_{21}} = \frac{6.22}{6.22 + 6.20 + 5.78} = \frac{6.22}{18.200} = 0.342$$

$$w_{u_{22}} = \frac{6.20}{6.22 + 6.20 + 5.78} = \frac{6.20}{18.200} = 0.341$$

$$w_{u_{23}} = \frac{5.78}{6.22 + 6.20 + 5.78} = \frac{5.78}{18.200} = 0.318$$

Above normalised weighting function set satisfies Eq. (7.4):

$$\sum_{i=1}^{3} w_i = 0.342 + 0.341 + 0.318 = 1.00$$

The weightings of the remaining CSFs for each CSFG are derived through above procedure, as reported in Table 7.3. Given that the total mean value of the first-level index systems $(u_1 = 23.740,\ u_2 = 18.200,\ u_3 = 18.510,\ u_4 = 18.500,\ u_5 = 6.170)$ is 85.120 (Table 7.3), the mean value of each CSFG i can be normalised to obtain its weighting through Eq. (7.4):

$$w_{u_1} = \frac{23.740}{23.740 + 18.200 + 18.510 + 18.500 + 6.170} = \frac{23.740}{85.120} = 0.279$$

$$w_{u_2} = \frac{18.200}{23.740 + 18.200 + 18.510 + 18.500 + 6.170} = \frac{18.200}{85.120} = 0.214$$

$$w_{u_3} = \frac{18.510}{23.740 + 18.200 + 18.510 + 18.500 + 6.170} = \frac{18.510}{85.120} = 0.217$$

$$w_{u_4} = \frac{18.500}{23.740 + 18.200 + 18.510 + 18.500 + 6.170} = \frac{18.500}{85.120} = 0.217$$

$$w_{u_5} = \frac{6.170}{23.740 + 18.200 + 18.510 + 18.500 + 6.170} = \frac{6.170}{85.120} = 0.072$$

$$\sum_{i=1}^{5} w_i = 0.279 + 0.214 + 0.217 + 0.217 + 0.072 = 1.00$$

Table 7.3 Weightings for CSFs and CSFGs for PPP water projects

ID	CSFGs and CSFs	MS for CSF importance	Weighting (w_{in}) for each CSF	Total mean value for each CSFG	Weighting (w_i) for each CSFG
CSF10	Strong commitment from project partners	6.15	$w_{u_{11}} = 0.259$		
CSF14	Strong and competent public partner	6.20	$w_{u_{12}} = 0.261$		
CSF13	Internal coordination within government	5.66	$w_{u_{13}} = 0.238$		
CSF12	Flexible contracts with fair risk allocations	5.73	$w_{u_{14}} = 0.241$	23.74	$w_{u_1} = 0.279$
Factor 1	*Commitment of partners* (u_1)				
CSF7	Strong and competent private partner	6.22	$w_{u_{21}} = 0.342$		
CSF6	Effective regulatory and legal structures	6.20	$w_{u_{22}} = 0.341$		
CSF9	Profitable water supply projects	5.78	$w_{u_{23}} = 0.318$	18.20	$w_{u_2} = 0.214$
Factor 2	*Strength of consortium* (u_2)				
CSF11	Quality water asset and workforce	5.88	$w_{u_{31}} = 0.318$		
CSF2	Public acceptance/support	6.24	$w_{u_{32}} = 0.337$		
CSF4	Adequate financing	6.39	$w_{u_{33}} = 0.345$	18.51	$w_{u_3} = 0.217$
Factor 3	*Asset quality/ social support* (u_3)				
CSF5	Capacity building for local utility staff	5.90	$w_{u_{41}} = 0.319$		
CSF8	Competitive tendering	5.80	$w_{u_{42}} = 0.314$		
CSF3	Government (political) commitment	6.80	$w_{u_{43}} = 0.368$	18.50	$w_{u_4} = 0.217$
Factor 4	*Political environment* (u_4)				
CSF1	National PPP policy and implementation unit	6.17	$w_{u_{51}} = 1.000$	6.17	$w_{u_5} = 0.072$
Factor 5	*National PPP Unit* (u_5)				
	Total of mean / normalised value of CRGs			85.12	1.000

CSFs: critical success factors; CSFGs: critical success factor groups; MS = mean score

7.6.2 Determine the Membership Functions of the CSFs and CSFGs

For a CSF, its MF is derived from the collective scorings of the Delphi panelists through Eq. (7.1). For instance, using *Government (political) commitment* (u_{43}), the survey outcome showed that the panelists ranked the importance of u_{43} as follows: 0% as ‗not important'; 0% as ‗very low importance'; 0% as ‗low importance'; 0% as ‗moderate'; 0% as ‗high importance'; 19.5% as ‗very important'; and 80.5% as ‗extremely important'. Hence, the MF of u_{43} is obtained as:

$$MF_{u_{43}} = \frac{0.00}{v_1} + \frac{0.00}{v_2} + \frac{0.00}{v_3} + \frac{0.00}{v_4} + \frac{0.00}{v_5} + \frac{0.195}{v_6} + \frac{0.805}{v_7}$$

$$MF_{u_{43}} = \frac{0.00}{\text{not important}} + \frac{0.00}{\text{very low importance}} + \frac{0.00}{\text{low importance}} + \frac{0.00}{\text{moderate}} + \frac{0.00}{\text{important}} + \frac{0.195}{\text{very important}} + \frac{0.805}{\text{extremely important}}$$

The MF for u_{43} is written through Eq. (7.2) as: (0.00, 0.00, 0.00, 0.00, 0.00, 0.20, 0.81). Using the same approach, the MFs for the remaining CSFs are determined and reported in column 4 of Table 7.4. Generating the MFs for the CSFs sets the basis to derive the MFs of each CSFG, as previously indicated.

7.6.3. Quantify the success index of each CSFG

FSE is associated with three levels of MFs, from levels 3 to 1. As explained earlier, level 3 is derived from the Delphi survey according to the experienced judgments of the 41 panelists. To evaluate the success index (SI) of a specific CSFG, a function matrix (i.e., MF) was derived first, based on results of level 3 (as shown in column 4 of Table 7.4) using Eq. (7.6), followed by the CSFG's fuzzy evaluation matrix. Using *Factor 2 – Strength of consortium* (u_2) as an example, the membership functions of all the CSFs in

Table 7.4 Membership functions (MF) for CSFs and CSFGs for PPP projects

ID	CSFGs and CSFs	Weightings (w_{in}) of CSFs	Membership function for CSFs (level 3)	Membership function for CSFGs (level 2)
Factor 1	*Commitment of partners,* u_1			
CSF10	Strong commitment from project partners	0.259	(0.00, 0.00, 0.02, 0.05, 0.10, 0.42, 0.42)	(0.00, 0.01, 0.02, 0.04, 0.22, 0.32, 0.40)
CSF14	Strong and competent public partner	0.261	(0.00, 0.00, 0.02, 0.05, 0.12, 0.32, 0.49)	
CSF13	Internal coordination within government	0.238	(0.20, 0.02, 0.02, 0.05, 0.27, 0.44, 0.00)	
CSF12	Flexible contracts with fair risk allocations	0.241	(0.00, 0.00, 0.00, 0.02, 0.39, 0.17, 0.42)	
Factor 2	*Strength of consortium,* u_2			
CSF7	Strong and competent private partner	0.342	(0.00, 0.00, 0.00, 0.02, 0.17, 0.37, 0.44)	(0.00, 0.00, 0.01, 0.05, 0.16, 0.43, 0.35)
CSF6	Effective regulatory and legal structures	0.341	(0.00, 0.00, 0.00, 0.05, 0.07, 0.51, 0.37)	
CSF9	Profitable water supply projects	0.318	(0.00, 0.00, 0.02, 0.07, 0.24, 0.42, 0.24)	
Factor 3	*Asset quality/social support,* u_3			
CSF11	Quality water asset and workforce	0.318	(0.00, 0.00, 0.00, 0.10, 0.17, 0.49, 0.24)	(0.00, 0.00, 0.00, 0.05, 0.12, 0.44, 0.39)
CSF2	Public acceptance/support	0.337	(0.00, 0.00, 0.00, 0.05, 0.10, 0.42, 0.44)	
CSF4	Adequate financing	0.345	(0.00, 0.00, 0.00, 0.00, 0.10, 0.49, 0.42)	
Factor 4	*Political environment,* u_4			
CSF5	Capacity building for local utility staff	0.319	(0.00, 0.00, 0.02, 0.05, 0.22, 0.42, 0.29)	(0.00, 0.00, 0.03, 0.04, 0.12, 0.31, 0.50)
CSF8	Competitive tendering	0.314	(0.00, 0.00, 0.07, 0.07, 0.17, 0.34, 0.34)	
CSF3	Government (political) commitment	0.368	(0.00, 0.00, 0.00, 0.00, 0.00, 0.20, 0.81)	
Factor 5	*National PPP Unit,* u_5			
CSF1	National PPP policy and implementation unit	1.000	(0.00, 0.00, 0.02, 0.05, 0.17, 0.24, 0.51)	(0.00, 0.00, 0.02, 0.05, 0.17, 0.24, 0.51)

this CSFG can be expressed in a function matrix as:

$$R_{u_2} = \begin{vmatrix} MF_{u_{21}} \\ MF_{u_{22}} \\ MF_{u_{23}} \end{vmatrix} = \begin{vmatrix} 0.00 & 0.00 & 0.00 & 0.02 & 0.17 & 0.37 & 0.44 \\ 0.00 & 0.00 & 0.00 & 0.05 & 0.07 & 0.51 & 0.37 \\ 0.00 & 0.00 & 0.02 & 0.07 & 0.24 & 0.42 & 0.24 \end{vmatrix}$$

Above matrix is further normalised through Eq. (7.7), which takes into account the weightings of CSFs of *Factor 2* and produces the fuzzy evaluation matrix:

$$D_{u_2} = W_{u_2} \bullet R_{u_2} = \left(w_{u_{21}},\ w_{u_{22}},\ w_{u_{23}}\right) \times \begin{vmatrix} MF_{u_{21}} \\ MF_{u_{22}} \\ MF_{u_{23}} \end{vmatrix}$$

$$= \left(0.342,\ 0.341,\ 0.318\right) \times \begin{vmatrix} 0.00 & 0.00 & 0.00 & 0.02 & 0.17 & 0.37 & 0.44 \\ 0.00 & 0.00 & 0.00 & 0.05 & 0.07 & 0.51 & 0.37 \\ 0.00 & 0.00 & 0.02 & 0.07 & 0.24 & 0.42 & 0.24 \end{vmatrix}$$

= 0.342x0.00 + 0.341x0.00 + 0.318x0.00,
0.342x0.00 + 0.341x0.00 + 0.318x0.00,
0.342x0.00 + 0.341x0.00 + 0.318x0.02,
0.342x0.02 + 0.341x0.05 + 0.318x0.07,
0.342x0.17 + 0.341x0.07 + 0.318x0.24,
0.342x0.37 + 0.341x0.51 + 0.318x0.42,
0.342x0.44 + 0.341x0.37 + 0.318x0.24

$$= \left(0.00,\ 0.00,\ 0.01,\ 0.05,\ 0.16,\ 0.43,\ 0.35\right)$$

Using the same procedure, the fuzzy evaluation matrixes of the remaining CSFGs are obtained as shown in column 5 of Table 7.4. Following this, the success index of each CSFG (or Factor) can be quantified through Eq. (7.12) as tabulated in Table 7.6:

$$S_{Factor1} = \sum_{i=1}^{7} D_{u_1} \times V^T = \left(0.00,\ 0.01,\ 0.02,\ 0.04,\ 0.22,\ 0.40,\ 0.32\right) \times \left(1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7\right) = 5.9441$$

$$S_{Factor2} = \sum_{i=1}^{7} D_{u_2} \times V^T = \left(0.00,\ 0.00,\ 0.01,\ 0.05,\ 0.16,\ 0.43,\ 0.35\right) \times \left(1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7\right) = 6.0724$$

$$S_{Factor3} = \sum_{i=1}^{7} D_{u_3} \times V^T = (0.00,\ 0.00,\ 0.00,\ 0.05,\ 0.12,\ 0.44,\ 0.39) \times (1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7) = 6.1835$$

$$S_{Factor4} = \sum_{i=1}^{7} D_{u_4} \times V^T = (0.00,\ 0.00,\ 0.03,\ 0.04,\ 0.12,\ 0.31,\ 0.50) \times (1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7) = 6.2039$$

$$S_{Factor5} = \sum_{i=1}^{7} D_{u_5} \times V^T = (0.00,\ 0.00,\ 0.02,\ 0.05,\ 0.17,\ 0.24,\ 0.51) \times (1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7) = 6.1710$$

7.6.4 Quantify the overall success index of PPP water projects

The obtained fuzzy evaluation matrixes, $D_i(i = 1,2,3,4,5)$, of all the CSFGs (i.e., level 2) are further transformed by considering their weighting matrix to derive the final fuzzy evaluation matrix of overall success index of a PPP water project (i.e., level 1). The matrixes of the CSFGs are represented as (see also column 4 of Table 7.5):

$$\overline{R} = \begin{vmatrix} D_{u_1} \\ D_{u_2} \\ D_{u_3} \\ D_{u_4} \\ D_{u_5} \end{vmatrix} = \begin{bmatrix} 0.00 & 0.01 & 0.02 & 0.04 & 0.22 & 0.40 & 032 \\ 0.00 & 0.00 & 0.01 & 0.05 & 0.16 & 0.43 & 0.35 \\ 0.00 & 0.00 & 0.00 & 0.05 & 0.12 & 0.44 & 0.39 \\ 0.00 & 0.00 & 0.03 & 0.04 & 0.12 & 0.31 & 0.50 \\ 0.00 & 0.00 & 0.02 & 0.05 & 0.17 & 0.24 & 0.51 \end{bmatrix}$$

And recall that the weighting matrix is: $\overline{W} = \{0.279,\ 0.214,\ 0.217,\ 0.217,\ 0.071\}$. By employing Eq. (7.11), final fuzzy evaluation matrix of overall success index of a PPP water project can be quantified:

$$\overline{D} = \begin{Bmatrix} 0.279 \\ 0.214 \\ 0.217 \\ 0.217 \\ 0.071 \end{Bmatrix} \times \begin{bmatrix} 0.00 & 0.01 & 0.02 & 0.04 & 0.22 & 0.40 & 032 \\ 0.00 & 0.00 & 0.01 & 0.05 & 0.16 & 0.43 & 0.35 \\ 0.00 & 0.00 & 0.00 & 0.05 & 0.12 & 0.44 & 0.39 \\ 0.00 & 0.00 & 0.03 & 0.04 & 0.12 & 0.31 & 0.50 \\ 0.00 & 0.00 & 0.02 & 0.05 & 0.17 & 0.24 & 0.51 \end{bmatrix}$$

$$= (0.00,\ 0.00,\ 0.02,\ 0.04,\ 0.16,\ 0{,}38,\ 0.40)$$

Now, the overall success index of a PPP water project is quantified through Eq. (7.12):

$$S_{overall} = \sum_{i=1}^{7} \overline{D} \times V^T = (0.00,\ 0.00,\ 0.02,\ 0.04,\ 0.16,\ 0.38,\ 0.40) \times (1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7) = 6.0965$$

Table 7.5 Determination of membership functions of Overall Success Index (Level 1)

ID	Critical Success Factor Group (CSFG)	Weighting (w_{in})	Membership function for level 2 (CSFGs)	Membership function for level 1 (overall success)
Factor 1	Commitment of partners	0.279	(0.00, 0.01, 0.02, 0.04, 0.22, 0.40, 0.32)	
Factor 2	Strength of consortium	0.214	(0.00, 0.00, 0.01, 0.05, 0.16, 0.43, 0.35)	
Factor 3	Asset quality/social support	0.217	(0.00, 0.00, 0.00, 0.05, 0.12, 0.44, 0.39)	(0.00, 0.00, 0.02, 0.04, 0.16, 0.38, 0.40)
Factor 4	Political environment	0.217	(0.00, 0.00, 0.03, 0.04, 0.12, 0.31, 0.50)	
Factor 5	National PPP Unit	0.072	(0.00, 0.00, 0.02, 0.05, 0.17, 0.24, 0.51)	

Table 7.6 Summary results

ID	CSFGs (U)	Success index	Linguistic	Ranking
Factor 1	Commitment of partners (u_1)	5.944	very high	5
Factor 2	Strength of consortium (u_2)	6.072	very high	4
Factor 3	Asset quality/social support (u_3)	6.184	very high	2
Factor 4	Political environment (u_4)	6.204	very high	1
Factor 5	National PPP Unit (u_5)	6.171	very high	3
OSI	Overall Success Index $(S_{overall})$	6.097	very high	-

Table 7.6 shows the model summary results that contain the success level and ranking of each CSFG and the overall success level. The FSE model shows that the overall success of PPP water supply projects in Ghana is 6.10. This means that, collectively, the CSFGs are *very important,* and if well combined and given adequate attention would improve the chances of successful implementation of water projects. In order words, there is a very high correlation between achievement of these critical factors and successful project. The model reflects the specific impact or criticality of the CSFs in implementing PPP water projects. It is able to measure or determine how critical a role each CSFG plays in affecting a project‗s success. Table 7.6 shows that *Political environment* is the top CSFG, followed by *Asset quality and social support*; *National PPP Unit*; *Strength of the consortium* and *Commitment of the partners*. The CSFGs should serve as the approach by which the government and private participants optimise the chances of successful water PPPs. They must have a thorough understanding of, and accord high relevance to, these factors.

Like previous studies (Dulaimi et al., 2010; Tiong, 1996; Jefferies et al., 2002), the initial selection and subsequent evaluation of the 14 CSFs was subjective and judgmental. Selection was based on qualitative approach by exploring past projects and review by an expert, and second, their assessment was based on experienced and professional judgements of industry practitioners.

However, the two-round Delphi survey minimised bias (Linstone and Turoff, 1975) during the data acquisition phase. In addition, the fuzzy set theory was adopted to handle subjectivity and multi-criteria. By this, the assessments were objectified, devoid of bias (Lo, 1999; Xu et al., 2010). This stage is ignored by almost all previous studies on CSFs. This chapter therefore makes a contribution in this area. The following discusses the contents of the CSFGs.

7.7 DISCUSSION

7.7.1 CSFG 1: Commitment of Partners

This factor group accounts for 32.955% of the total variances of the CSFs (Table 7.2) and has a *very high* success index of 5.94 and ranks fifth in the model (Table 7.6). It consists of four factors: strong commitment from project partners, strong and competent public partner, internal coordination within government, and flexible contracts with fair risk allocations. Achieving contractual targets of a PPP project is closely linked to a true *strong commitment of the project partners* (Table 7.1: mean = 6.15, rank = 8; and Table 7.2: significance = 0.866). Generally, commitment refers to dedication and interest of key actors in the project (Toor and Ogunlana, 2008), particularly, the public client, project team, project sponsor, and project company. They should be committed to time, quality and budget. This means that all project stakeholders ought to be willing to commit their best financial and human resources to the project throughout its lifecycle (Li et al., 2005b).

Strong and competent public partner (Table 7.1: mean = 6.20, rank = 6; and Table 7.2: significance = 0.821) is also rated as a critical factor for project success. Research (Liu and Wilkinson, 2011; Carrillo et al., 2008; Owen and Merna, 1997) has often criticised the experience and competence of public sector partners in PPP procurements. PPP, as different from traditional procurement and new in Ghana, has a low level of public sector experience and expertise. The implication is that the government must design and implement capacity building programmes to enhance public sector skills and knowledge to manage PPP projects (Carrillo et al., 2008). In the short-term, however, engaging external technical, legal, environmental and financial advisors to complement public sector expertise is crucial to PPP success (Li et al., 2005b). And the cost arising from hiring external advisors should be accounted for in the project‘s financial assessment.

Internal coordination within government (Table 7.1: mean = 5.66, rank = 14; and Table 7.2: significance = 0.807) is highly rated by the industry practitioners as an important success factor. PPP is a complex procurement arrangement, and water supply projects involve multiple governmental ministries such as ministries for water resources, health, lands and natural resources, and environment, and also departments and agencies including environmental protection agency, PURC, public procurement authority, standards board, etc. For any project to proceed smoothly, all these institutions must approve the suitability of relative issues. This process may be lengthy and frustrating and requires a healthy internal coordination among above relevant institutions. Effective coordination within government therefore requires strong leadership that necessitates establishment of a leading body (Meng et al., 2011).

An important feature of PPP is well-designed, *flexible contracts with fair risk allocations* (Table 7.1: mean = 5.73, rank = 13; and Table 7.2: significance = 0.754) for the project (Marques and Berg, 2011). PPP contracts, short-run or long-run, should be flexible to be able to respond to evolving circumstances (such as economic, social, environmental, political) through non-opportunistic behaviour *ex-post* (Guasch, 2004; Engel, 1997). Saltiel and Maywah (2007) showed that PPPs are likely to be successful where emerging concerns of participants are agreed upon and incorporated into the operating contract. The caution, however, is that contract design must limit *ex-post* opportunism by either party.

Fair risk allocation is an integral part of a PPP contract and its theoretical benefits in a project are well-known: overall cost minimisation, VfM, and improved efficiency (Chung et al., 2010; Arndt, 2000). Wang et al. (2000) also noted the failure or success of securing private finance is dependent on ‗fair risk allocation and a sound contractual structure' (pg. 201). In practice, however, imperfect allocation of risks represents one major disappointing result for water PPPs (Engel, 1997); too much risk is retained by the public client or transferred to the private partner. This has prompted Marques and Berg (2010) to suggest that (a) a risk matrix addressing the significant risk factors should be prepared prior to public tender and (b) risk allocation should be considered as an important award criterion.

7.7.2 CSFG 2: Strength of Consortium

Strength of consortium accounts for 12.965% (Table 7.2) of the total variance of the CSFs analysis and ranks fourth with a very high index of 6.0724 in the model (Table 7.6). This reinforces the argument that a strong private firm significantly contributes to project success (UNIDO, 1996; Li et al., 2005b; Chan et al., 2011) and perhaps explains dominance of large and well-established multi-national water companies in the global water industry (Hall et al., 2005). The factors in this group are strong and competent private partner, effective regulatory and legal structures, and profitable water supply projects.

Strong and competent private partner has the highest loading (Table 7.2: significance = 0.859) and a very high impact (Table 7.1: mean = 6.22, rank = 4) on project success. A project (e.g., BOT water treatment plant) is likely to be constructed within time and cost or executed successfully with a consortium with a wealth of expertise and experience (Jefferies et al., 2002; Tiong, 1996; Li et al., 2005b). A project, on the other hand, is highly likely to fail when the award criteria is mainly based on the lowest tariff or management fee rather than expertise. In Ghana's first country-wide urban water management (section 3.6.2), the operator (AVRL) was selected on the basis of lowest management fee of US$11 million for the 5-year period (Tucker et al., 2010). This partly explains the underperformance of AVRL regarding the contractual targets (Ameyaw and Chan, 2012).

Effective regulatory and legal structures are very important to successful implementation of water PPPs, especially in developing countries, and has been duly acknowledged by past studies (Arndt, 2000; Haarmeyer and Mody, 1998; Thobani, 1999). It has a high loading (Table 7.2, significance = 0.838) and a very high impact (Table 7.1, mean = 6.20, rank = 5) on project success. According to Guasch (2004), disappointing water PPP outcomes such as high incidence of opportunistic renegotiations resulted from frail or nonexistent regulatory and legal structures in many countries. The relevance of regulatory and legal regimes has prompted Arndt (2000) and Beato and Vives (1996) to argue that the private sector is less likely to invest in countries with weak legal structures. This comes from a perspective that contracts will not be enforceable under the prevailing legal and regulatory systems. In Ghana, the establishment of PURC has helped to an extent in this direction, but it does not take away the fact that there is a need for developing PPP regulatory expertise in PURC and other government agencies. This is an effective approach to mitigating regulatory risk in the sector. Currently, a PPP law is under preparation, and the utilities regulator, PURC, lacks practical utility industry experience (World Bank, 2013) to effectively regulate PPP projects. The implication is that PURC should be well-resourced, develop the right skills and address staff retention problems to be able to effectively execute its core functions, such as performance monitoring and price approvals.

A *profitable water supply project* is a prerequisite for the candidate project to be successfully executed as a PPP. Thus, the private sector would not partake in ‗social‘ projects that offer very little or no profits (Zhang, 2005). This CSF has a relatively high loading (Table 7.2: significance = 0.567) and a very high mean index (Table 7.1: mean = 5.78, rank = 12). Driven by profit incentive by private sector, and to ensure financial equilibrium of GWCL, both sectors are more concerned about projects with economic rationale, bringing to bear appropriate project identification – ideal candidate for a PPP (Qiao et al., 2001; Tiong, 1996). Apart from selecting the ideal project, the government must be committed to supporting ‗affordable' but cost-reflective tariffs, especially for revenue-based water projects. Indeed, compensating both customers and investors remains a challenge in Ghana and may carry a significant risk for the private sector.

7.7.3 CSFG 3: Asset Quality and Social Support

This factor group comprises three CSFs; quality water asset and workforce, public acceptance and support, and adequate financing. It is the second factor in the model with a *very high* index of 6.1835 (Table 7.6), suggesting it plays a critical role in determining project success. A PPP water project is less likely to succeed in the absence of any, or all, of these CSFs (Gupta and Narasimham, 1998; Hall et al, 2005; Hall and Lobina, 2006).

Quality water infrastructure and workforce has a high loading (Table 7.2: significance = 0.831) and a very high mean index (Table 7.1: mean = 5.88, rank = 10). This factor is crucial in utility (brownfield) PPP projects, where private investors take over an existing publicly-owned and operated water supply system, such as the transfer-operate-transfer model in China's water industry (Meng et al., 2011). Meng et al. explained that asset quality (including workforce) is a condition for attracting private investors. This comes from a high risk of asset condition uncertainty because approximately 80% (Infrastructure Canada, 2004) of water systems are fixed underground. Hence, investors are reluctant to take on rehabilitation needs of assets (Infrastructure Consortium for Africa, 2009). In Ghana, asset quality is central to the success of utility PPPs; existing pipe network is in a deplorable condition, evidenced by high distribution losses at about 51%. Also, in the urban water management contract (section 3.6.2), retrenchment of 1,600 (low quality and redundant) workers was funded by the then government as a precondition for private sector participation in the water sector (Ameyaw and Chan, 2013b).

The importance of *public acceptance and support* is demonstrated by its high loading (Table 7.2: significance = 0.804) and very high mean score (Table 7.1: mean = 6.24, rank = 3). This supports Gupta and Narasimham‘s (1998) view that that a successful PPP requires a supportive community. In contrast, public resistance has proven critical to delaying, stalling or reversing PPP in water services (Hall et al., 2005). Attempts to introduce PPP in water services in the late 1990s were resisted by civil society and political groups, which delayed Ghana‘s PPP process. This resistance resulted from suspected tariff hikes, commercialization of perceived ‗public‘ good (social tradition) and staff retrenchment (Nyarko, 2007), and was exacerbated by involvement of international water firms (Rebeiz, 2012). The lesson is that water PPPs, especially serviced-based, requires that concerns of the wider public and opposing groups are adequately addressed from the onset in order to gain their support. Utility staff should be regarded as stakeholders in the PPP process and retrenched, if necessary, through well-designed programmes that offer benefits to them.

The challenge for water infrastructure is to (i) develop and extend water infrastructure and (ii) refurbish existing deteriorated water systems to match growing populations and rapid urbanisation (Rouse, 2014). Hence, private sector‘s ability to provide *adequate financing* (Table 7.1: mean = 6.39; rank = 2; and Table 7.2: significance = 0.570) with associated lower capital costs is rated as a critical factor for successful PPPs. An investor‘s ability to arrange a long-term innovative and flexible capital (or financial package) that reflects project characteristics (e.g., lengthy payback period, affordability issues) is key to determining his chances of winning the project, and the eventual success of the project (Qiao et al., 2001; Tiong, 1996; Hall and Lobina, 2006).

In Ghana, one key reason for water PPPs failure is inadequate funds. This challenge results from immature domestic capital markets and a high level of perceived risk in a developing country like Ghana (Hall and Lobina, 2006; Wang et al., 2000). For example, in Ghana‘s first BOT SWRO project (section 3.6.3), Aqualyng first won the contract in 2008 but failed to start the project after two years (and was abrogated in 2010). This delay was due primarily to funding availability issues – Aqualyng‘s difficulty in raising finance (Global Water Intelligence, 2012). This is explained by the immature domestic capital market (commercial banks‘ reluctance and inexperience in providing long-term loans, limited financial capacity of local banks) coupled with the 2008 global financial crisis.

Given the huge sector funding needs and budgetary constraints, efficient combination of various funding sources – public funding, donor-funding, and private capital – to develop a sound financial structure for water infrastructure projects could be effective.

7.7.4 CSFG 4: Political Environment

Political environment accounts for 10.056% (Table 7.2) of the total variance of the CSFs analysis and ranks first with a very high index of 6.2039 (Table 7.6). This means that political environment group has the highest impact on PPP project success in Ghana. It has three CSFs that relate to support environment: capacity building for local utility staff; competitive tendering; and government (political) commitment. This factor lends strong support to previous findings (Flinders, 2005; Dulaimi et al., 2010; Banerjee and Munger, 2004) that favourable political environment is critical in PPP.

Capacity building for existing staff of a utility (Table 7.1: mean = 5.90, rank = 9; and Table 7.2: significance = 0.790) is rated critical to the success of water infrastructure services.

Meng et al. (2011) also observed that employee quality is an important success factor in transfer-operate-transfer projects. Water services are technical, complex and sophisticated and therefore require specialised skills to operate water systems. Unfortunately, skills shortage is a challenge in international infrastructure projects in developing countries (Rebeiz, 2012). The main challenge relates to inadequate trained and qualified professionals, following their mass exit from the public utility in the late 1970s and early 19980s (Whitfield, 2006). Rebeiz (2012) and Gupta and Narasimham (1998) therefore recommended appropriate training and development (T&D) programmes to be implemented at construction and/or operational stages of a project with a focus on three key areas:

(i) project analysis (strategic needs, resources requirements and delivery strategy);

(ii) task analysis (knowledge, skills and abilities); and

(iii) person analysis (professional, person and social maturity).

These will ensure efficient continuation of water services after the contract period.

Competitive tendering during procurement stage of a project is critical to the client organisation, which ranks very high with a high loading (Table 7.1: mean = 5.80, rank = 11; and Table 7.2: significance = 0.652). This is because tender competition for the water market will ensure VfM gains from private participation by drawing out private sector‘s production and pricing (tariff) efficiency (Webb and Ehrhardt, 1998; Hall, 1998). However, a body of experience (e.g., Xenidis and Angelides, 2005a; Public Citizen, 2003; Marques and Berg, 2011) has warned public clients against using price (or tariff) as the sole award criterion. Competitive tendering also gives more bargaining powers to the awarding authority while providing opportunity to select the most competent and experienced with a proven track record in similar projects. On the contrary, restricted competition for contracts through high-level political connection and ‗negotiated‘ approach (sole-sourcing) could erode expected benefits of a PPP. Meng et al. (2011) noted that municipal governments in China who adopted direct negotiations with water investors eventually suffered heavy financial losses, resulting from public sector‘s inexperience and capacity constraints against investors‘ manipulations during negotiations. Therefore, governments should adopt competitive tendering protocols that are supported by efficient procurement systems and institutions, several bids with no avenue for collusion and a transparent process.

Government (political) commitment, overall, ranked first in both rounds (Table 7.1: mean = 6.80; and Table 7.2: significance = 0.569), is identified as a CSF in water PPPs (Dulaimi et al., 2010). Successful water PPPs are beneficiaries of favourable political commitment. This suggests that political commitment is required of the Ghanaian government regarding economic pricing of water services and strict collection policies (service cut-offs and legal actions against theft and non-payment) to enable revenue-based PPPs thrive. A partnership with a committed government produces noticeable and sustained benefits for the public (Marin et al., 2009), because the drive to adopt PPP is dependent on national politics (Flinders, 2005; Banerjee and Munger, 2004). A political decision to make water supply partnerships work would drive governments to create a conducive environment and offer project-specific guarantees against certain risks, including foreign exchange, interest and inflation guarantees, equity participation, minimum revenue stream, guarantee of water purchase, exclusive rights, etc (Zhang and Kumaraswamy, 2001; Freshfields, 1995). That is, on the face of limited experience and absence of mature PPP legal and regulatory structures, sustained political commitment is likely to bolster private sector confidence in Ghana.

7.7.5 CSFG 5: National PPP Unit

Accounting for 7.545% (Table 7.3) of the total variance of the CSFs analysis, this principal factor ranks third in the FSE model with a very high index of 6.1710 (Table 7.6) and comprises one salient factor, *PPP policy and unit* (Table 7.1: mean = 6.17, rank = 7; and Table 7.2: significance = 0.865). This finding is an indication of the significance of a PPP policy and unit according the industry practitioners. Previous studies (Sanghi et al., 2007; Kumaraswamy and Zhang, 2001; Carrillo et al., 2008; Fischer et al., 2006; Infrastructure Consortium for Africa, 2009; Regan, 2012) have highlighted the positive impacts of dedicated PPP unit and policy on successful attraction and implementation of PPP projects. Infrastructure Consortium for Africa (2009) noted that a clear policy assists the public and private sectors to appreciate the core rationale for PPPs and how governments will make them happen. Before entering a PPP market, private investors look for the rationale for adopting PPPs, the guidelines by which governments will assess PPP projects in a consistent manner, the determination of who approves what and when from project selection to procurement, and the process of dispute resolution (Infrastructure Consortium for Africa, 2009). Consequently, Ghana‘s PPP policy (Government of Ghana, 2011) sets out timelines, important decision points, project selection criteria and transparent principles for evaluating PPP proposals. Also, a water PPP guideline could assist project identification or direct private investment toward specific areas of the water supply chain to meet sector priorities.

To ensure consistency and better quality in the way governments make decisions regarding the development, financing, construction, and management/operation of PPPs, private investors anticipate a central high-powered authority providing support to public sector project teams (Kumaraswamy and Zhang, 2001; Regan, 2012). This has given relevance to dedicated PPP units, which are created to address specific government failures or weaknesses in managing a PPP programme (Sanghi et al., 2007). A national authority, such as Ghana's PPP Advisory Unit, is instrumental in coordinating and overseeing all PPP activities and reconciling conflicts, promoting transparency and accountability, linking foreign investors with government bodies in local infrastructure projects, advocating legislative changes and acceptance of PPP policy, and influencing transaction flow and costs (Fischer et al., 2006; Kumaraswamy and Zhang, 2001). The existence of PAU suggests the government's commitment to PPP and signals to the private sector that the government has adequate expertise. Fischer et al (2006) put the functions of a PPP unit into four key functional areas: project support, framework development, knowledge management, and policy functions. The implications for PAU are two-fold. First, PAU requires technical skills and experience across different infrastructure sectors and disciplines, it must work across government to achieve PPP policy objectives, and the staff must be highly-qualified individuals with a good understanding of capital markets and commercial issues (Regan, 2012). Second, PAU needs to wield the necessary executive power (and high-level political support) with a mandate to promote good PPPs rather than merely acting as an advisory unit to public authorities (Sanghi et al., 2007).

7.8 CHAPTER SUMMARY AND CONTRIBUTION

The determinants of PPP project success have been the focus of considerable research in construction project management. Here, an attempt has been made to further our understanding on key determinants that influence successful implementation of PPP water supply projects. The objectives of this chapter were to identify and evaluate the critical factors that lead to successful implementation of PPP water projects; and to model the impact of the CSFs on overall project success.

The mixed method approach (case study analysis, literature review and Delphi survey) to success factor identification in PPP water supply projects adopted for this research study revealed 14 CSFs. This supports the opinion held by Toor and Ogunlana (2008) that research on project success factors should be conducted in each sector, to account for sector characteristics. Phua (2004) explained that generalisation of PPP project success factors ‗obscures between-industry' unique differences in factors that critically influence project success. A factor analysis was conducted to establish underlying relationships between the 14 factors, which revealed five factors. Using FSE, the extracted factors were adopted to construct a predictive model for assessing their impact on successful project implementation. These factors are (in order): political environment, asset quality and social support, national PPP unit, strength of consortium, and commitment of partners. These results generally lend support for previous arguments that the success of PPP projects requires public-private partners' commitment, strong consortium and favourable political environment (Tiong, 1996; Flinders, 2005; Dulaimi et al., 2010). It is therefore recommended that governments of developing countries pay particular attention and resources to legal and regulatory structures, domestic capital market, public procurement and politics.

The model showed that public-private participants stand to benefit from a *very high* chance of successful project implementation, if these CSFGs are effectively combined and given sustained management attention. By this model, (i) the success level of each CSFG and (ii) the collective contribution of all the CSFG to overall project success level can be described by a single indicator, termed success level and overall success level (or index), respectively. The model is a multi-attribute CSF framework that may serve as a success assessment tool for public-private audience in order to ensure efficient resource use and project implementation approaches. For policy-makers, the fuzzy model provides a guide to the issues that host governments need to pay attention to in preparing for and attracting private participation into the water sector. Thus, it helps identify key factors that could facilitate greater private participation and investment and overall project success, and provides a practical model for evaluating the impact of those factors. For private participants, the model can serve as a guide for identifying and pursuing good projects, avoiding risky projects and evaluating project success. It could point to areas of focus for further analysis.

This chapter has not provided a complete list of all the possible success factors that might influence successful implementation of PPP water projects. However, the convergence with extant literature provides confidence in the findings and for a specific project in a country, there would be unique factors that should be added to above CSFs. Thus the proposed methodology permits addition and removal of individual CSFs as new significant factors emerge and the current factors become less relevant overtime. With these useful findings, other researchers may apply similar methodology and factors to explore success factors for PPP in other sectors. Such exercise would allow for comparison to establish differences and similarities in PPP projects success factors.

The next chapter presents and discusses the critical risk factors in Ghana‘s PPP water supply projects and a mathematical risk assessment model based on the fuzzy set approach.

Chapter 8: Risk Factors in PPP Water Supply Projects: An Evaluation

This chapter is very effective partly because the writer includes the following:

Structure

Introduction	Section 8.1
Introduction of first analyses	Section 8.2
Results and discussion of risk factors	Section 8.3
Modelling of second analyses	Section 8.5
Findings of second analyses	Section 8.5
Discussion	Section 8.6
Implications and Summary	Section 8.7-8.8

Content

- Establishes a link between the focus of the previous chapter and the present chapter
- Summarises key ideas included in the chapter and gives an overview of the analysis to be used (e.g. Section 8.1)
- Explains the purpose and aims of the chapter (e.g. Section 8.1, paragraph 1, sentence 2-3)
- Introduces methodology used (e.g. Section 8.1, paragraph 2)
- Outlines the content of the chapter (e.g. Section 8.1, paragraph 1)
- Introduces the main contribution of the chapter (e.g. Section 8.1, paragraph 3)
- Rationalises the selection of results for discussion in the chapter and points to their contribution to the content of the chapter and the next (e.g. Section 8.3)
- States contribution findings will make to the wider community (e.g. Section 8.8, paragraph 2, sentence 1)
- States limitations (e.g. Section 8.8, paragraph 2, sentence 3 and 4)
- States contribution findings will make to theory (e.g. Section 8.8, paragraph 4)

Language

- Links to the previous chapter (e.g. Section 8.1, paragraph 1 sentence 1)
- Highlights key figures on tables (e.g. section 8.2.3, paragraph 4, sentence 2)
- Develops paragraphs in a logical way, e.g. Section 8.3.2, paragraph 1:

Topic sentence introduces paragraph	sentence 1
Outlines main findings	sentence 2-3
Comments on findings	sentence 4
Gives an example	sentence 5-6
Discusses consequences	final sentence

- Develops sections in a logical way, e.g. section 8.3.18

Paragraph 1	Main problem	sentence 1
	Details problem	sentence 2
	Reports findings	sentence 3
Paragraph 2	Discusses findings	

- Incorporates evaluative comments when presenting finding,s e.g. *the most critical* (e.g. Section 8.3.10, sentence 1)
- Discusses reasons using suitable academic language, e.g. *due to, it is therefore not surprising, hence, the results confirm, the implication is, is dependent on* (e.g. 8.6.2, paragraph 1, sentence 9-15)
- Includes a clear introductory sentence for main subsections (e.g. Section 8.5, sentence 1)
- Links to the next chapter (e.g. Section 8.8, paragraph 5)

To consider

In general, this chapter is effective. However, it could be improved in the following aspects.

Avoid overusing subsection numbers. The numbers are designed to aid the reader, however subsections with high numbers do not necessarily achieve this, e.g. *Section 8.3.22*.

Avoid just listing findings. It is better to group findings (e.g. Section 8.2.2).

Choose correct words, e.g. *massive* (e.g. Section 8.5.6, paragraph 3, sentence 2). Massive refers to things that are heavy, only in spoken English does it mean a large volume. *Indicate* (e.g. Section 8.5.6, paragraph 3, sentence 2) does not mean show. It means might show.

Avoid using the phrase *from the table* (e.g. Section 8.5.6, paragraph 4, point 3). It is better to state 'With reference to Table 8.9', or, 'as indicated by Table 8.9,'

CHAPTER 8 RISK FACTORS IN PPP WATER SUPPLY PROJECTS: AN EVALUATION

8.1 INTRODUCTION

Chapter 7 presents a list of CSFs for water supply partnerships and a model for predicting impacts of the CSFs on successful implementation of water projects. This chapter reports on the risk factors associated with PPP water supply projects. It aims to (i) evaluate and discuss in detail the significant risk factors and (ii) propose a fuzzy risk assessment model for PPP water supply projects, based on the outcome of a two-round Delphi questionnaire survey and FSE method. As a result, this chapter is divided into two. Part one focuses on the first objective whiles part two introduces a model for assessing (a) the risk level of principal risk factors (PRFs) and (b) the overall risk level of PPP water projects in Ghana. The approach is sequential; the results of part one are fed into part two. As explained in Chapter 2, data was derived from a 40-panel of experts through a two-round Delphi survey.

Similar to the previous chapter, different analyses were conducted on the resulting data using SPSS 21.0; Kendall‘s *W* was used to measure level of consensus and consistency among the panelists, mean ranking method was used to prioritise and rank the risk factors, followed by normalisation to establish the critical risk factors for subsequent modelling through the FSE method.

This chapter aids public and private decision-makers to achieve objective rather than subjective risk assessment, assisting them to determine appropriately the most significant risk factors and to determine the overall risk level of a project.

8.2 PPP WATER SUPPLY PROJECT RISK FACTORS

8.2.1 Degree of Agreement and Consistency among the Panelists

The panelists did have diverse backgrounds from within and outside the water industry. The thesis assumes that the analyses of the panel‘s feedback will not be affected by their backgrounds and therefore does not find it useful to highlight possible differences of perspectives of different expert groups. This thesis focuses on the collective opinion of the panelists. Kendall‘s *W*, using Eq. (2.4), was computed to measure the degree of consensus among the experts on their rankings for the 40 risk factors. The *W* value and the *p*-value for scored probability and severity rankings after round two were 0.227 and 0.00, and 0.121 and 0.00, respectively. These statistics are reported in Table 8.1. The low *W* values for both probability and severity rankings indicate a lack of consensus (Schmidt, 1997) among the panelists. However, because the respective *p*-values for probability and severity were < 0.05, the findings are (statistically) significant, implying that all the experts‘ rankings were consistent (Rasli, 2006). Given 40 panelists evaluating 40 risk factors on a 7-point grading system, these small values of *W* can be regarded as significant.

8.2.2 Overall Ranking of Risk Factors

Mean scores of the practitioners‘ professional and experienced judgment of the likelihood of occurrence and severity of the risk factors are presented in Table 8.1. The data from the Delphi survey were analysed using Eq. 2.1. The mean index for risk probability ranges from 2.85 to 5.58, which suggests that the likelihood of risk occurrence ranges from low to very high levels. The mean scores of risk severity ranges from 4.20 to 5.58, indicating that the risk severity ranges from moderate to very high levels. These ranges suggest that variations in the panelists‘ response are relatively large for risk probability (2.73) and relatively small for risk severity (1.38). Also, 23 out of the 40 risk factors have mean probability index ≥ 4.0, and all the 40 factors have mean severity index ≥ 4.0, which suggests that the panelists perceived 100% of the factors within moderate to very high severity ranges. This also implies that project managers may be more interested in the severity of a risk, should it eventuates. The ranges of the mean scores show that certain risks which are critical in other jurisdictions or sectors are not likely to have significant impact on water PPPs in Ghana.

8.2.3 Critical Risk Factors (CRFs) on PPP Water Projects

To determine the ‗critical risk factors‘ (CRFs), the overall impact of each risk factor was computed (column 9 of Table 8.1) using Eq. 2.3. Two approaches are used to establish the CRFs. First, using ―half-adjusting" principle (Ke et al., 2010a; Li, 2003), the 40 risk factors can be subjectively classified into three impact groups: (i) ―high impact" (mean index ≥ 4.50), (ii) ―moderate impact" (3.50 ≤ mean index < 4.50), and ―low impact" (mean index < 3.50), as shown in Table 8.2. This classification is in line with the seven-point grading scale used in the Delphi questionnaire survey.

The top 19 risk factors fall in the ―high impact" category. Unsurprisingly, these risk factors ranked *moderate* (4.05) to *very high* (5.58) in terms of probability, and *high* (4.70) to *very high* (5.58) with respect to severity. Generally, these factors relate to different risk groups including political, economic, construction and operation. Most of these risks are difficult to predict ahead of time in large-scale PPP water projects.

The ―moderate" risk category has 20 risk factors, which also relate to diverse risk categories such as operation (e.g., technology, insufficient performance), regulation and policy (e.g., weak regulation, absence of policy and legal frameworks), political (e.g., expropriation and nationalisation, political violence/ government instability), natural and environmental issues (e.g., *force majeure*, water scarcity, climate change, low quality of raw water), etc. Only one risk factor, ‗fall in demand‘, is considered to have a ―low" impact on PPP water projects in Ghana. This is not surprising as demand has always exceeded water supply in the urban water sector (Ameyaw and Chan, 2013b).

The second selection approach computes the normalised values by scaling between 0 and 1 for each risk factor using the following formula (Yeung, et al., 2010):

$$N_v = \frac{a + (x - A) \times (b - a)}{B - A} \tag{8.1}$$

where, N_v = normalised value of a specific risk factor; a = minimum value (= 0); b = maximum value (= 1); A = minimum mean index of the risk factors; B = maximum mean index of the risk factors; and x = mean index of a specific risk factor to be normalised.

The results are shown in Table 8.1 under ―Normalised values". Only risk factors with normalised values ≥ 0.50 (Joseph et al. 2011; Yeung, et al., 2010) were considered as critical and qualified for subsequent analysis. This approach showed that there are 22 CRFs on PPP water supply projects in Ghana, most deserving of private investors‘ and policy-makers‘ attention and that further require rigorous assessment. This normalisation is also important in order to ensure compliance with the requirement of factor analysis (FA), if necessary.

In this chapter, the 22 CRFs obtained through the normalisation approach are discussed in detail and subject to further analyses here and in the subsequent chapter. The following discussion provides some reasons why these risk factors emerged as most critical, more deserving of attention.

Table 8.1 Results of the two-round Delphi survey

Risk Factors	Round 1 n = 40				Round 2 n = 40					
	Risk Probability	Risk Severity	Risk Impact	Ranking	Risk Probability	Risk Severity	Risk Significance Index	Risk impact	Ranking	Normalised values
Foreign exchange rate	5.43	5.10	5.26	2	5.58	5.18	28.90	5.38	1	1.00
Corruption	5.13	5.50	5.31	1	5.13	5.58	28.63	5.35	2	0.98
Water theft	5.15	5.18	5.16	4	5.13	5.20	26.68	5.16	3	0.89
Non-payment of bills	4.95	5.48	5.21	3	4.90	5.38	26.36	5.13	4	0.87
Political interference	4.98	5.25	5.11	5	5.00	5.15	25.75	5.07	5	0.84
High operational costs	4.73	5.13	4.92	6	4.70	5.10	23.97	4.90	6	0.75
Pipeline failures during distribution	4.63	5.10	4.86	7	4.55	5.20	23.66	4.86	7	0.73
Lack of PPP experience	4.73	4.98	4.85	8	4.68	5.05	23.63	4.86	8	0.73
Inflation rate volatility	4.65	4.78	4.71	9	4.73	4.88	23.08	4.80	9	0.70
Construction time & cost overrun	4.35	4.70	4.52	14	4.50	5.03	22.64	4.76	10	0.68
Poor contract design	4.28	5.03	4.63	11	4.23	5.10	21.57	4.64	11	0.61
Supporting utilities risk	4.60	4.78	4.69	10	4.50	4.78	21.51	4.64	12	0.61
Interest rate	4.28	4.78	4.52	15	4.38	4.83	21.16	4.60	13	0.59
Political discontent & early termination	4.10	4.68	4.38	21	4.28	4.90	20.97	4.58	14	0.58
Design & construction deficiencies	3.95	4.88	4.39	20	4.05	5.13	20.78	4.56	15	0.57
Conflict between partners	4.33	4.63	4.47	16	4.38	4.70	20.59	4.54	16	0.56
Water pricing and tariff review uncertainty	4.35	4.83	4.58	12	4.20	4.88	20.50	4.53	17	0.56
Financial and refinancing risk	4.00	4.83	4.39	19	4.15	4.93	20.46	4.52	18	0.55
Land acquisition risk	4.30	4.70	4.50	16	4.25	4.78	20.32	4.51	19	0.55
Public resistance to PPP	4.28	4.85	4.55	13	4.25	4.75	20.19	4.49	20	0.54
Change in government & political opposition	4.20	4.73	4.45	18	4.20	4.73	19.87	4.46	21	0.52
Insufficient operator performance	4.08	4.70	4.38	22	4.05	4.83	19.56	4.42	22	0.50
Regulatory risk (weak regulation)	4.13	4.58	4.34	23	4.03	4.65	18.74	4.33	23	0.45
Technology risk	3.85	4.40	4.12	31	3.98	4.60	18.31	4.28	24	0.43
Unfavourable local / global economy	3.95	4.55	4.24	26	3.85	4.65	17.90	4.23	25	0.40
Low quality of raw water	3.80	4.78	4.26	24	3.78	4.73	17.88	4.23	26	0.40
Water asset condition uncertainty	3.98	4.53	4.24	25	3.85	4.55	17.52	4.19	27	0.38
Residual value risk	4.03	4.45	4.23	27	3.90	4.45	17.36	4.17	28	0.37
Procurement risk	3.78	4.60	4.17	28	3.75	4.55	17.06	4.13	29	0.35
Quasi-commercial risk	3.90	4.35	4.12	30	3.90	4.35	16.97	4.12	30	0.34
Force majeure	3.53	4.93	4.17	29	3.40	4.90	16.66	4.08	31	0.32
Sovereign and contractual risk	3.73	4.40	4.05	32	3.63	4.53	16.44	4.06	32	0.31
Faulty demand forecasting	3.68	4.35	4.00	33	3.55	4.38	15.55	3.94	33	0.25
Currency convertibility / transferability	3.60	4.23	3.90	34	3.58	4.30	15.39	3.92	34	0.24
Absence of policy & legal frameworks	3.38	4.25	3.79	37	3.40	4.48	15.23	3.90	35	0.23
Expropriation / nationaslisation	3.28	4.05	3.64	38	3.40	4.20	14.28	3.78	36	0.17
Climate change risk	3.60	4.08	3.83	35	3.48	4.08	14.20	3.77	37	0.16
Raw water scarcity	3.08	4.70	3.80	36	2.93	4.68	13.71	3.70	38	0.13
Political violence / Government instability	3.00	4.18	3.54	39	3.03	4.30	13.03	3.61	39	0.08
Fall in demand	2.88	4.30	3.52	40	2.85	4.20	11.97	3.46	40	0.00
Kendall's Coefficient of Concordance (W)	0.164	0.081			0.227	0.121				
p-value	0.000	0.000			0.000	0.000				

Risk impact = (Risk significant index)^0.5

Table 8.2 Risk criticality classification based on round-two of Delphi survey

Risk Factors	Round 2					
	*Factor grouping	Risk Probability	Risk Severity	Risk impact	Ranking	Risk criticality
Foreign exchange rate	PRF1	5.58	5.18	5.38	1	High
Corruption	PRF2	5.13	5.58	5.35	2	High
Water theft	PRF1	5.13	5.20	5.16	3	High
Non-payment of bills	PRF1	4.90	5.38	5.13	4	High
Political interference	PRF2	5.00	5.15	5.07	5	High
High operational costs	PRF1	4.70	5.10	4.90	6	High
Pipeline failures during distribution	PRF3	4.55	5.20	4.86	7	High
Lack of PPP experience	PRF3	4.68	5.05	4.86	8	High
Inflation rate volatility	PRF1	4.73	4.88	4.80	9	High
Construction time & cost overrun	PRF3	4.50	5.03	4.76	10	High
Poor contract design	PRF3	4.23	5.10	4.64	11	High
Supporting utilities risk	PRF2	4.50	4.78	4.64	12	High
Interest rate	PRF1	4.38	4.83	4.60	13	High
Political discontent & early termination	PRF2	4.28	4.90	4.58	14	High
Design & construction deficiencies	PRF3	4.05	5.13	4.56	15	High
Conflict between partners	PRF2	4.38	4.70	4.54	16	High
Water pricing and tariff review uncertainty	PRF1	4.20	4.88	4.53	17	High
Financing and refinancing risk	PRF1	4.15	4.93	4.52	18	High
Land acquisition risk	PRF2	4.25	4.78	4.51	19	High
Public resistance to PPP	PRF2	4.25	4.75	4.49	20	Moderate
Change in government & political opposition	PRF2	4.20	4.73	4.46	21	Moderate
Insufficient operator performance	PRF3	4.05	4.83	4.42	22	Moderate
Regulatory risk (weak regulation)	–	4.03	4.65	4.33	23	Moderate
Technology risk	–	3.98	4.60	4.28	24	Moderate
Unfavourable local / global economy	–	3.85	4.65	4.23	25	Moderate
Low quality of raw water	–	3.78	4.73	4.23	26	Moderate
Water asset condition uncertainty	–	3.85	4.55	4.19	27	Moderate
Residual value risk	–	3.90	4.45	4.17	28	Moderate
Procurement risk	–	3.75	4.55	4.13	29	Moderate
Quasi-commercial risk	–	3.90	4.35	4.12	30	Moderate
Force majeure	–	3.40	4.90	4.08	31	Moderate
Sovereign and contractual risk	–	3.63	4.53	4.06	32	Moderate
Faulty demand forecasting	–	3.55	4.38	3.94	33	Moderate
Currency convertibility / transferability	–	3.58	4.30	3.92	34	Moderate
Absence of policy & legal frameworks	–	3.40	4.48	3.90	35	Moderate
Expropriation / nationaslisation	–	3.40	4.20	3.78	36	Moderate
Climate change risk	–	3.48	4.08	3.77	37	Moderate
Raw water scarcity	–	2.93	4.68	3.70	38	Moderate
Political violence / Government instability	–	3.03	4.30	3.61	39	Moderate
Fall in demand	–	2.85	4.20	3.46	40	Low

Risk impact = (Risk significant index)^0.5
*See Table 8.3 for classification of risk factors

8.3 DISCUSSION OF CRITICAL RISK FACTORS

The results of risk probability, severity, impact and rankings are presented in Tables 8.1 and 8.2. Among the 22 CRFs, 19 have a high impact and three have a moderate impact on water PPP projects. However, the three risk factors – public resistance, change in government and political opposition, and insufficient private operator performance – are close to the high level, with mean impact scores of 4.49, 4.46, and 4.42, respectively. As mentioned earlier, the discussion of these factors is important, because it underpins this chapter and the subsequent chapter of this thesis. The discussion is primarily based on the results of round two of the Delphi survey, but reference may be made to the results of round one, where necessary.

8.3.1 Foreign Exchange Rate

The Delphi survey, overall, confirms that foreign exchange rate (FX) is the most critical risk factor, which ranked first with a risk significance index of 28.90, high probability of occurrence (5.58), high severity (5.18), and a high impact score of 5.38. FX risk arises because water revenues are generated in local currencies while costs are denominated in foreign currencies. The local currency (Ghana cedi) has experienced substantial depreciation against the major trading currencies (US dollar and UK pound sterling) since 1983, following a switch from a fixed exchange rate regime to a floating exchange rate regime (Dordunoo, 1994; Abor, 2005). Salifu et al. (2007) studied foreign exchange rate exposure of firms in Ghana and concluded that a large number of these firms are significantly (negatively) exposed to the cedi–US dollar and the cedi–UK pound sterling exchange rates movements.

Private water investors will face FX risk in Ghana because of (i) foreign funding due to weak capacity of domestic capital market, (ii) lengthy payback periods, (ii) pricing and tariff adjustment difficulty, (iv) and inputs/plant costs are foreign currency-denominated (Kessides, 2004; Shendy et al., 2011).

8.3.2 Corruption Risk

Water projects are very prone to corrupt practices, including falsified claims, bid shopping, unbalanced bids, payment games and over-billing. Corruption risk ranked first in round one and second in round two with risk significant values of 28.19 and 28.63, respectively. It has high probability (5.13) and severity (5.38) scores with a high impact value of 5.35. Though this is not a novel finding, but supports earlier finding that corruption has a long history in the water sector, dating back to 1958 (Bohman, 2010) and has gained significance in the sector. There have been various incidents of corruption in awarding water contracts to private companies (GII, 2011; Stone and Webster, 2002). In 2002, for example, a committee of enquiry unearthed grand corruption (fraud) in GWCL‘s management; the managing director and the chief manger made US$300,000 from contracts signed with two foreign private companies (Fon Ltd. and Somfer Ltd.) to supply water meters in preparing GWCL for two lease contracts (Stone and Webster, 2002). Corruption has the consequences of eroding anticipated gains from PPPs while transferring costs to consumers as increased tariffs and low-quality service.

Moreover, at national level, corruption is prevalent among public officials, including politicians (CDD-Ghana, 2000). Corruption prevalence in public procurement is attributable to a lack of commitment of the top political leadership to combating corrupt practices (Abdulai, 2009).

8.3.3 Water Theft

The risk ranked third with a high probability (5.13), high severity (5.20), a risk significance index of 26.68 and a high impact score of 5.16. Water theft is prevalent in the urban water sector (Fuest and Haffner, 2007), accounting for 70% of GWCL‗s non-revenue water which is over 50% of system input (Foster and Pushak, 2011; Nyarko, 2007). The high ranking of this risk indicates its impact on commercial operations of a service provider. Where the commitment of political leadership (legal framework) to the goal of supporting utilities to tackle illegal consumption is weak, as has been the case in Ghana, private operators will continue to battle with water theft without yielding desired results.

8.3.4 Non-payment of Bills

Ameyaw and Chan (2013a) observed that non-payment of bills is a major threat to sustainability of water services delivery. It was one of the key risks that threatened the success of the urban water management contract (section 3.6.2). Non-payment risk has two parts; household and institutional (‗capture‘). The former refers to situations where residential customers refuse, or are unable, to pay their bills for reasons such as unfavourable economic conditions, well-rooted habit of non-payment and poor collection practices. The latter relates to refusal by public/private agencies to pay bills, as is often the case in Ghana. This risk was ranked fourth with a significance index of 26.36, high probability (4.90), high severity (5.83), and a high impact value of 5.13. This is a disincentive to private investment. A political commitment is a prerequisite in enforcing strict collection measures, such as service cut-offs and court actions.

8.3.5 Political Interference

Political interference risk affects PPPs in all sectors, but water is unique given its social, public health, environmental and political repercussions. Unwarranted government interference has been identified as a major failure factor in water PPPs (Rivera, 1996; Kauffmann, 2007). This risk was ranked fifth with a high probability of occurrence (5.00), high severity (5.15), a risk significance index of 25.75 and a high impact value of 5.07. This signifies that political interference has remained stable in importance. Nyarko (2007) found that political interference is significant and adversely affects urban water supply services. It is significant and apparent in (1) tariff setting and adjustment and (2) appointments of top management (including managing director) and board members of GWCL. Economic tariffs and their timely adjustment are prerequisites for sustaining water supply systems and offering customers quality service. Unfortunately, governmental interferences are capable of holding down tariff increases and their timely implementation for political reasons, especially during election seasons. Tariff setting and approval has historically been the preserve of the sector ministers, prior to the creation of an ‗independent' economic regulator, PURC, which has not significantly addressed the problem.

8.3.6 High Operational Costs

High operational costs ranked sixth in both rounds, with a risk significance index of 23.97 and impact value of 4.90 in round two. This risk results from external (uncontrollable) factors and operator-responsibility. The former is attributable to existing pressing economic conditions in the country, such as FX rate movements, inflationary pressures, soaring energy prices, and reduced raw water quality. A combination of these factors partly explains the high operational costs associated with water services delivery in Ghana. For example, water supply services are highly dependent on energy and therefore vulnerable to energy price volatility. Energy cost accounts for over 20% of a water company‘s total operational expenditure (Haiduk and Ishemo, 2011). Tenkorang et al. (2013) assessed the impact of energy price changes on financial sustainability of water systems in Ghana. They observed that energy component to total supply cost for urban water systems is 29%; total operational costs/m^3 of water supply is US$0.44 for urban water systems; and the energy cost/m^3 of water supply for urban systems is US$0.13. Thus, in Ghana, energy (electricity and diesel) is a major component of water service total costs, given the frequent changes in local and international economic conditions.

8.3.7 Pipeline Bursts

Pipeline failures during distribution are technical, operational challenges in water systems. The risk ranked seventh in both rounds, with a high impact score of 4.86 and a significance index of 23.66. Pipe bursts are a source of public nuisance, loss of valuable water resource and revenue and disruptions in service delivery. A pipe burst may be related to a pipe‘s age and condition (maintenance/investment factors) (Goulter and Kazemi, 1998), apart from soil-related environmental conditions (Røstum et al., 1997). It remains a major concern to water managers in Ghana because a large portion of the urban distribution network is aging. In many urban areas, mains and distribution pipes were installed over 70 years ago (Nyarko, 2007) and have suffered from inadequate maintenance (Aduah et al., 2007). Hence, the network is unable to cope with the frequent pressure surges due to intermittent operating regime. Experience from the urban water management contract (section 3.6.2) suggests that, generally, the aging distribution network not only limited AVRL from restoring service continuity, but also increased system losses and contamination.

8.3.8 Lack of PPP Experience

Carrillo et al. (2008) specifically declared that the lack of PPP experience adversely impacts on the success of PPPs. Lack of PPP experience and knowledge exist in the public sector across countries (Liu and Wilkinson, 2011). This risk is of much concern to potential private investors and the government as indicated by its rating; both likelihood of occurrence (4.68) and severity (5.05) are high, with risk significance index of 23.63 and a high impact score of 4.86. Ghana‘s progression to adopting PPPs has been slow, following nearly 20 years of a heavily-contested policy process and fierce public resistance (Bohman, 2010). A lack of public sector capacity to promote, select and structure constructive PPP projects is common across infrastructure sectors and among relevant public agencies, such as PAU, PPA, PURC, GWCL, GUWL, etc., that struggle to keep up with the international private players. The background information of the survey respondents indicated an average PPP experience of 4.162 years. This low level of expertise and experience by public officials involved in PPPs require better training and capacity building in relevant areas of the PPP procurement process, such as commercial knowledge, legal and contract documents, sector knowledge, technical knowledge and best practice (Carrillo et al., 2008).

8.3.9 Inflation Rate Volatility

Inflation risk is of much concern to private investors and lenders due to their financial exposure and project profitability (Mandri-Perrot and Menzies, 2010), especially in developing countries where rate of inflation is very high (Gupta and Narasimham, 1998). Unsurprisingly, this risk ranked ninth with risk index of 23.08 and impact of 4.80. Current inflation rate in Ghana stands at 11.8 for July 2013 (Ghana Statistical Service, 2013), an acceleration for six consecutive months. Some commentators argued that this partly explains the current skyrocketing interest rates, continual depreciation of the cedi to major foreign currencies and slow economic growth. In a PPP project, inflation risk raises cost of production and operation and impacts on loan repayment. For example, in 2006, the cash income of GWCL barely supported its expenditure due in part to high annual inflation of around 10–15% (AVRL, 2011).

8.3.10 Construction Time and Cost Overrun

The most critical risks in PPP include construction time and cost overruns (Akintoye et al., 2003). The construction time and cost overrun risk ranked 10th, with the probability and severity scores of 4.50 and 5.03, respectively, and a high impact value of 4.76. The reasons could be: (a) unpredictable inflationary trends which aid inaccurate construction cost predictions; (b) difficulties in securing land-use rights and planning approvals for complex projects such as water treatment plants; and (c) fiscal space problems. Completion risk results in cost escalations and additional finance, delayed maturity period, high interest from untimely loan repayment (Thomas et al., 2003; ADB, 2000). Gupta and Narasimham (1998) therefore highlighted that an early revenue inflow to the promoter due to timely completion would significantly reduce payback period and ensure reduced tariffs.

However, cost escalations due to completion risk at the engineering and construction phase impose high tariffs that result in reduced demand and (potential) public resentment in the operational phase (e.g., Izmit Su BOT water scheme, Turkey).

8.3.11 Poor Contract Design

The problem of poorly-designed contracts relates to ambiguity and interpretation regarding incentives, contract terms and objectives, performance measurement, tariff revision and regulation (Cowen and Komives, 1998). The mean scores of the probability and severity for this risk are 4.23 and 5.10, respectively, with a significance index and impact score of 21.57 and 4.64 respectively, and ranked 11th. This ranking could be explained by Ghana‘s inexperience in this area of procuring public infrastructure and services. The urban water management contract exhibited two major flaws that must be avoided in future partnerships (AVRL, 2011): project objectives, roles and responsibilities of the parties were ill-defined; and there were difficulties with interpretation of the contract. This prolonged decision-making regarding investments, capital budgets, procurement, and outsourcing of services. For PPP water supply projects, objectives and performance standards should be relevant and specific rather than general, measurable against predefined objective performance indicators, and achievable within the concession period (Oyedele, 2013; Shahin and Mahbod, 2007).

8.3.12 Utilities (Electricity) Risk

Utilities (electricity) risk ranked high in terms of probability (4.50) and severity (4.78), ranking 12th with a risk significance index of 21.51. Ghana‘s energy crisis has been described as chronic, with unreliable electricity supply which affects production and distribution of potable water (Public-Private Infrastructure Advisory Facility, 2011). In urban settings, water services primarily depend on the national grid and therefore the frequent and unannounced power breaks result in interruptions in service delivery (Ameyaw and Chan, 2013a). Under the urban water management contract, widespread load shedding, persistent power outages and low voltage meant that reliable water supply within many service areas could not be guaranteed. This explains why the risk was rated high by the experts.

8.3.13 Interest Rate Risk

If a project company has a high leverage, a floating interest rate on its debt is not viable for lenders and investors (Yescombe, 2007). It makes the operating company financially vulnerable to changes in interest rates, which could potentially threaten profits and provision of public water services under the PPP contract. The risk ranked 13th with probability, severity and risk index scores of 4.38, 4.83 and 21.16, respectively. This is explained by the weaknesses in the local financial systems, and rising commercial bank prime lending rates of 18.20% and 25.10% in 2011 and 2012, respectively (The World Factbook, 2013). For example, the Ghana Commercial Bank‘s base rate per year stands at 21.76%. This potentially influences both costs and funding availability for PPP projects in the country. However, given the underdeveloped local capital market, PPP projects involve considerable foreign financing (e.g., the Nungua SWRO BOOT project (section 3.6.3)).

8.3.14 Political Discontent and Termination

Because private participation in public infrastructure is about (long-term) relationship with host governments, political discontent and (early) termination questions the continuing commitment of present and future governments to PPP deals (Asenova and Beck, 2003). This risk has probability and consequence scores of 4.28 (moderate) and 4.90 (high) respectively, a significance index of 20.97, a high impact value of 4.58 and ranked 21st and 14th in rounds one and two, respectively. Though Ghana has no history of premature termination of large-scale (water) projects (Ameyaw and Chan, 2013a), ranking this risk high comes from the expert respondents' view that a new government may not be committed to a project initiated by its predecessor, which is often the case in Ghana. Moreover, political risks are social governance risks (Barraqué, 2003). This means that a government may be dissatisfied with the private firm and unwilling to endure the shortcomings in service delivery following public disenchantment. The government may therefore come under public pressure to terminate the project.

8.3.15 Design and Construction Deficiencies

Design and construction quality are among the most critical risks in PPPs (Ball et al., 2003; Akintoye et al., 2003; Preiser, 1995). The risk ranked 15th, with overall impact, probability and severity scores of 4.56, 4.05 and 5.13, respectively. The experts perceived that water projects, by their very nature are highly sophisticated to design and construct because of their serious public health and environmental consequences (Haarmeyer and Mody, 1998). Failure to meet design and construction standards therefore has dire consequences on the operational phase, including the project's failure to meet water quality standards and acceptance testing, facility performance and operational problems, high operation and maintenance costs, imposition of fines (damages), and possible disputes between project partners. Chanter and Swallow (2007) pointed out that several problems faced in constructed products emanate from the design phase, where the client's or project's requirements are poorly captured. Design and construction deficiencies may also result from selection of inefficient prime design consultants and contractors.

8.3.16 Conflict between Partners

The risk was ranked 16th with a high impact value of 4.54. The panelists perceived a moderate likelihood (4.38) and a high severity (4.70) of the risk due to Ghana's inexperience in both PPP procurement and contract design. Respondents who were directly or indirectly involved in the urban water management contract recounted possible sources of conflict to include top management and government‘s high expectations of the operator‘s performance, ambiguous assignment of responsibilities, unclear contract language and interpretation challenges and communication difficulties between AVRL and GWCL. The existence of these factors is the origin of possible strained relations. Oyedele (2013) suggested a good working relationship between the public and private participants, which can be achieved through the true spirit of partnerships, commitment of senior executives and proactive relationship management (Zou et al., 2014; Smyth and Edkins, 2007).

8.3.17 Water Pricing and Tariff Review Uncertainty

The risk ranked 17th with moderate probability (4.20) and high severity (4.88) scores, a risk significance index of 20.50 and a high impact value (4.53). This finding showed that the risk has declined in importance overtime. The mid–late 1990s structural reforms have resulted to the divorce of policy formulation, service provision and regulation for the sector (Nyarko, 2007). The establishment of PURC has reduced the degree of political infiltrations in tariff setting and adjustment for water services.

However, the risk remains significant for two reasons. First, water pricing and tariff adjustment has long been both social and political sensitive issue, with a considerable level of governmental interference which is difficult to ignore (Nyarko, 2007). The executive secretary and board of PURC are appointed by the president and are subject to political pressures. Given high urban poverty rate (Ainuson, 2010) and governments‘ belief that water is a social good, they (governments) are forced to prevent PURC from approving tariffs above certain thresholds and applying the automatic indexation scheme to tariff setting. Second, PURC lacks adequate regulatory capability (due to inexperienced staff), full management autonomy and adequate practical experience of the utility industry (Fuest and Haffner, 2007; World Bank, 2013). The risk results from poor institutional and capacity development and political resistance to economic tariffs.

8.3.18 Financing Risk

The crux of the issue is how to fill the already huge gap between sector needs and financial resources. Available estimates show that US$1.49 billion is needed to expand urban water infrastructure to meet demand by 2020, and another US$811 million is required to meet an access rate of 85% by 2015 (GWCL, 2009). The risk ranked 18th, with moderate probability, high severity and high impact scores of 4.15, 4.93 and 4.52, respectively. The main risk is inaction or no investment, which reflects private underinvestment in the sector.

This could be explained by (i) the high risk perception level in Ghana‘s water projects (Ameyaw and Chan, 2013a); (ii) reluctance of transnational companies to provide sizeable funds in developing countries following negative experiences regarding private investment (MIGA, 2009); and (iii) immature local capital markets for long-term domestic debt financing for PPP infrastructure projects (Chanda, 2011). Local commercial banks are not only unwilling to offer long-term debt financing, but also inexperienced in large-scale project financing. Raising private finance for future PPPs must be based on sound contractual structures and fair risk allocations with enhanced credibility for water projects to enable good judgment from the financial market (Wang et al., 2000).

8.3.19 Land Acquisition

Land acquisition risk affects construction project organisation and schedule (Sentürk et al., 2004). The experts assessed land acquisition risk as moderate (4.25) and high (4.78) regarding probability and severity, respectively, and ranked 19th, indicating this risk could have a high impact (4.51) on PPP water projects in Ghana. This could be explained by the (1) land cost escalations in urban settings following population growth and rapid urbanisation; and (2) land tenure system where traditional landowning authorities hold allodial title to the land on behalf of the people. In a BOT water treatment project, the public entity through the government will secure the land through direct negotiations with landowners, or compulsory acquisition (expropriation). The land tenure system, however, makes it difficult for timely land acquisition, especially where the traditional ownership structure demands negotiations with various allodial titleholders. The negotiation process is often protracted, cumbersome and costly (Asumadu, 2003). Conversely, compulsory acquisition, with due regard to the law, is subject to prompt payment of fair and adequate compensation to landowners. It also is associated with risk of delay resulting from prolonged negotiations and contestation of valuations. Thus, costs arising from land access could be significant in terms of construction time and money.

8.3.20 Public Resistance to PPP

Public resistance is an important failure factor to private participation in water services (Hall et al., 2005; Hall and Lobina, 2012; Bennett, 1998). In this study, the risk factor ranked 13th in round one and 20th in round two with moderate probability (4.25), high severity (4.75), risk significance index of 20.19 and moderate impact (4.49). Earlier studies (e.g., Fall et al., 2009; Adam, 2011) indicated that public opposition to water PPPs has been more vocal and has delayed the PPP policy process for the water sector. This finding, however, indicates that public resistance has declined in importance, but it remains critical. Over the last 20 years, groups ideologically opposed to PPP may have recognised successive governments' failures or inability to provide funds to improve and build new water systems. They may have acknowledged that no single source of funds is adequate and that well-structured PPP contracts could attract private investment in water infrastructure. Also, since early 2000s, there have been some policy research and debate on the subject which has brought some understanding to the opposing groups. Lastly, successive governments have demonstrated conscious efforts at attracting private investment to major infrastructure sectors, including water, evidenced by the launch of the PPP policy followed by a draft PPP law. These reasons possibly explain the current weight of public resistance to water PPPs.

8.3.21 Change in Government and Political Opposition

Estache et al. (2009) pointed out that newly-elected governments in developing countries do not seem to favour the impact of PPP in public services. They are opposed to either the PPP process or tariff increases which often come with PPPs. This risk ranked 21st with a risk significance index of 19.87, moderate probability of occurrence (4.20), high severity (4.73) and moderate impact of 4.46. The socio-economic and political importance of water warrants governmental interference and (sometimes) opposition (Harris et al., 2012). In Ghana, politics cannot be separated from water services, because it is used as a political-currency prior to elections (Idelovitch and Klas, 1995). For example, serious politics surrounded the urban management contract during the 2008 elections. According to Adam (2011), the reason for not renewing the contract was attributable to the newly-elected president and his government's ideological opposition to private participation in public water services, as captured by Global Water Intelligence (2012, pg.

2):

> *"[...] the decision to revert to a public utility model reflected the government's belief that water is a social good and that the public sector should be responsible for its provision".*

Change in government and political opposition risk fails to provide for continuity, long-term political commitment and sustained initiatives to address the water sector's problems. The task for governments is to address this risk more effectively, in order to increase the private sector's confidence and allays investors' fears to attract more investment into the troubled sector.

8.3.22 Insufficient performance of private operator

Failure to meet contractual performance targets is the main operational risk in water contracts (Haarmeyer and Mody, 1998), which subjects the project company to performance failure payment deductions (Oyedele, 2013; Yescombe, 2002). This risk factor ranked 22nd with a moderate probability of occurrence (4.05), high severity (4.83), a risk significance index of 19.56 and moderate impact of 4.42. The expert respondents' evaluation of the risk may be influenced by the absence of many historical project cases upon which to base their assessments and the notion that performance in a PPP project is dependent on relevant factors, including a well-designed contract and sector regulation with clearly-defined measurable targets, availability of sufficient baselines and methods for performance assessments (Trémolet and Neale, 2002; Fall et al., 2009). This risk could result from selecting an incompetent private partner during the bidding stage of a project (UNIDO, 1996), which in turn is influenced by lack of or limited competition and strategic misrepresentation (Hall and Lobina, 2004).

8.4 IMPLICATIONS FOR PRACTICE

The foregoing analyses and discussion hold several implications for practitioners. First, a 40-risk factor list (with critical risk factors) provides the water authorities/PAU with a comprehensive checklist that can aid in developing PPP project risk assessment guidelines. Risks must be identified before they are allocated and mitigated appropriately (Nicholas and Steyn, 2012). This checklist has the advantage of being grounded compared to the one developed earlier (Ameyaw and Chan, 2013a), because the most critical risks were established by (a) experienced practitioners with knowledge of the Ghana‘s economy and water industry and PPP procurement (b) through a rigorous technique. This list includes new, significant factors that were not detected in Ameyaw and Chan (2013a).

Second, this chapter indicated that, over time (i) some risk variables have gained significance; (ii) others have declined in importance; and (iii) others have remained fairly stable. Both private and public sector should be aware of this dynamic nature of risks for purposes of risk prioritisation and effective risk management.

Third, cultural, economic and environmental conditions may affect risk perceptions. Thus, highly ranked risk factors in other countries may differ from Ghana. Wibowo and Mohammed (2010), for instance, indicated that raw water scarcity is the most significant risk variable in Indonesia whereas this risk factor ranked 38 out of the 40 risk factors. Cheung and Chan (2011) found that corruption is not a major risk for water PPPs in China, but it ranked second in the current study. Using the suggested risk factor list will aid PPP advisors to capture risk factors that reflect local political, social and economic conditions and the water sector characteristics, rather than relying on research conducted in different environments. This, however, is not to suggest that findings reported here are not relevant to other cultures.

8.5 FUZZY SYNTHETIC EVALUATION RISK EVALUATION MODEL

This section is the second part of the current chapter. Part one ranked and prioritised the most significant risk factors which were further discussed in detail. Its main contribution lies in the generation of the 22 CRFs.

In this section, a fuzzy risk assessment model based on Delphi and FSE methods is constructed as an analytic model. The proposed model draws on systematic processing of experienced and professional judgment of industry experts to assess the risk level of each principal risk factor (section 8.5.1) and the overall risk level of PPP water projects. Assessment of the overall risk level of PPP water projects, and determination of the factors contributing the most to the risk level could aid both public and private participants to become aware of the critical risks and develop appropriate countermeasures.

8.5.1 Category of Risks for PPP Water Supply projects

After determining the top risk factors, it is imperative for this study, as part of the fuzzy model development, to establish the factor structure (principal factors) of these factors. Since the objective is to assess the risk level of PPP water supply projects, the 22 CRFs were classified under three main categories. Among various classifications reported in the literature, the grouping suggested by Salman et al. (2007) and Özdoganm and Birgonül (2000) is adopted (with little modification) for this study because it systematically classifies the factors in accordance with the characteristics of different aspects of typical risks involved in a PPP project. The 22 factors were grouped according to their relation to eight factors under financial and economic category, eight factors under legal and socio-political category, and six factors under technical category (hereafter called principal risk factors, PRFs) (Table 8.3). Other statistical methods such as factor analysis (Field, 2005) can be used to detect the relationships among the risk factors, as in Chapter 7. However, factor analysis was not used because the sample size (40 participants) is inadequate for such analysis.

Table 8.3 Classification of critical risk factors

Critical risk factor (CRF) and Category	Risk Impact	Overall Ranking	Ranking within Category
Financial and Commercial (PRF 1): u_1			
Foreign exchange rate, u_{11}	5.38	1	1
Water theft, u_{12}	5.16	3	2
Non-payment of bills, u_{13}	5.13	4	3
High operational costs, u_{14}	4.90	6	4
Inflation rate volatility, u_{15}	4.80	9	5
Interest rate, u_{16}	4.60	13	6
Water pricing and tariff review uncertainty, u_{17}	4.53	17	7
Financing and refinancing risk, u_{18}	4.52	18	8
Legal and socio-political (PRF 2): u_2			
Corruption, u_{21}	5.35	2	1
Political interference, u_{22}	5.07	5	2
Supporting utilities risk, u_{23}	4.64	12	3
Political discontent & early termination, u_{24}	4.58	14	4
Conflict between partners, u_{25}	4.54	16	5
Land acquisition risk, u_{26}	4.51	19	6
Public resistance to PPP, u_{27}	4.49	20	7
Change in government & political opposition, u_{28}	4.46	21	8
Technical (PRF 3): u_3			
Pipeline failures during distribution, u_{31}	4.86	7	1
Lack of PPP experience, u_{32}	4.86	8	2
Construction time & cost overrun, u_{33}	4.76	10	3
Poor contract design, u_{34}	4.64	11	4
Design & construction deficiencies, u_{35}	4.56	15	5
Insufficient operator performance at operation, u_{36}	4.42	22	6

The significance of the factor grouping is two-fold; first, the PRFs are used as input variables for assessing the risk level of water PPPs, and second, grouping the CRFs into a systematic framework will facilitate risk management because it reduces the cognitive complexity of handling a tall list of 22 factors. Decision-makers can focus on these three risk areas. Here, the questions to be addressed are (i) which PRF contributes the most to the risk level of PPP water projects? and (ii) what is the risk level of water PPPs, given these PRFs? Both questions are addressed through the FSE method.

Assessing the overall risk level of a project involves different PRFs (three in this case) with varying degree of criticality on one level and risk factors (within each PRF) on next lower-level. In this case, each PRF is assessed in terms of its criticality, from which the overall risk level of water PPPs can be quantified. The multi-level FSE is used to analyse this multi-factor and multi-level decision problem inherent in evaluating the risk of projects. Thus, the membership grades level by level from the lowest risk factors are calculated, and the final determination of projects' risk level is derived from the membership grade of the top principal factors. Also, given that determining a project's risk index is fuzzy in nature and often draws on expert judgement, fuzzy set theory is considered most appropriate (Boussabaine, 2014). Fig. 5a summarises a step-by-step approach of the adopted approach, as indicated in Chapter 7.

The overall value of Cronbach's alpha coefficient of risk probability, risk severity and risk impact are 0.886, 0.935 and 0.923, respectively, which are greater than the recommended threshold of 0.70 (SPSS, 2003). Table 8.4 shows the alpha values for the three risk categories. This demonstrates a high degree of uniformity on the survey questionnaire and a good reliability and internal consistency of the risk factors (Norusis, 1993). Furthermore, Kendall's *W* for the impact of the 22 CRFs is 0.731, indicating a high degree of consensus among the Delphi panelists (Schmidt, 1997).

Table 8.4 Cronbach's alpha coefficients for the CRFs

Principal Risk factors	Cronbach's alpha values	
	Risk probability	Risk severity
Financial and commercial factor	0.737	0.832
Legal and socio-political factor	0.733	0.852
Technical factor	0.763	0.827
All 22 CRFs	0.886	0.935

8.5.2 Evaluation Index Systems

Given the three risk classifications, an evaluation index systems can be set up by defining the PRFs as the first-level index system as $U = (u_1,\ u_2,\ u_3)$. The CRFs within each PRF, as shown in Table 8.3, are also defined as second-level index system as:

$$u_1 = \{u_{11},\ u_{12},\ u_{13},\ u_{14},\ u_{15},\ u_{16},\ u_{17},\ u_{18}\}$$

$$u_2 = \{u_{21},\ u_{22},\ u_{23},\ u_{24},\ u_{25},\ u_{26},\ u_{27},\ u_{28}\}$$

$$u_3 = \{u_{31},\ u_{32},\ u_{33},\ u_{34},\ u_{35},\ u_{36}\}$$

These index systems are used as input variables for FSE analysis, as shown in Fig. 5a. It is worthnoting that the index systems hold for both risk probability and risk severity. The procedure follows what has been described in Chapter 7, and hence the equations are referred to but not repeated here. The difference is that the risk assessment in this chapter deals with two streams of data – risk probability and risk severity.

8.5.3 Calculate the Weighting Functions of the CRFs and PRFs

The weighting functions (reported in Table 8.5) of the CRFs (second-level) and PRFs (first-level) are calculated from the mean values computed from the survey, as explained in Chapter 7. For instance, from Table 8.5, given that *PRF3 – Technical* (u_3) comprises six

CRFs with a total probability mean value of 26.06, the weighting function of , for example, '*construction time & cost overrun* (u_{33})' can be quantified through Eq. (7.4) as:

$$w_{u_{33}} = \frac{4.50}{4.55 + 4.68 + 4.50 + 4.23 + 4.05 + 4.05} = \frac{4.50}{26.06} = 0.173$$

The weighting functions of the remaining CRFs within *PRF3* are calculated through the same procedure (see Table 8.5), and its normalised weighting function set satisfies Eq. (7.4) (see Table 8.5):

$$\sum_{i=1}^{6} w_i = 0.155 + 0.173 + 0.180 + 0.162 + 0.75 + 0.155 = 1.00$$

The weightings of the remaining CRFs for both probability and severity within each PRF category are derived through above procedure, as reported in Table 8.5. Given that the total probability mean value of the PRF categories $(u_1 = 37.77,\ u_2 = 35.99, \text{and}\ u_3 = 26.06)$ is 99.82 (Table 8.5), the mean value of each PRF i can be normalised to obtain its weighting function through Eq. (7.4):

$$w_{u_1} = \frac{37.77}{37.77 + 35.99 + 26.06} = \frac{37.77}{99.82} = 0.378$$
$$w_{u_2} = \frac{35.99}{37.77 + 35.99 + 26.06} = \frac{35.99}{99.82} = 0.361$$
$$w_{u_3} = \frac{26.06}{37.77 + 35.99 + 26.06} = \frac{26.06}{99.82} = 0.261$$

And above normalised weightings equals unity. Similarly, the weightings of the PRFs regarding risk severity are obtained as indicated in Table 8.5.

Table 8.5 Weightings for CRFs and PRFs for PPP water projects

Critical risk factors	Risk Probability (p) Mean probability	Weighting (w_{in}) of CRF	Total mean of PRF	Weighting (w_i) of PRF	Risk Severity (s) Mean severity	Weighting (w_{in}) of CRF	Total mean of PRF	Weighting (w_i) of PRF
Foreign exchange rate	5.58	0.148			5.18	0.128		
Water theft	5.13	0.136			5.20	0.129		
Non-payment of bills	4.90	0.130			5.38	0.133		
High operational costs	4.70	0.124			5.10	0.126		
Inflation rate volatility	4.73	0.125			4.88	0.121		
Interest rate	4.38	0.116			4.83	0.120		
Water pricing and tariff review uncertainty	4.20	0.111			4.88	0.121		
Financing and refinancing risk	4.15	0.110			4.93	0.122		
Financial and Commercial (PRF 1): u_1			37.77	0.378			40.38	0.367
Corruption	5.13	0.143			5.58	0.142		
Political interference	5.00	0.139			5.15	0.131		
Supporting utilities (energy) risk	4.50	0.119			4.78	0.124		
Political discontent & early termination	4.28	0.122			4.90	0.119		
Conflict between partners	4.38	0.118			4.70	0.121		
Land acquisition risk	4.25	0.118			4.78	0.120		
Public resistance to PPP	4.25	0.117			4.75	0.121		
Change in government & political opposition	4.20	0.125			4.73	0.121		
Legal and socio-political (PRF 2): u_2			35.99	0.361			39.37	0.358
Pipeline failures during distribution	4.55	0.155			5.20	0.159		
Lack of PPP experience	4.68	0.173			5.05	0.166		
Construction time & cost overrun	4.50	0.180			5.03	0.166		
Poor contract design	4.23	0.162			5.10	0.168		
Design & construction deficiencies	4.05	0.175			5.13	0.171		
Insufficient operator performance at operation	4.05	0.155			4.83	0.169		
Technical (PRF 3): u_3			26.06	0.261			30.34	0.276
Total of mean / normalised values of PRFs			99.82	1.00			110.09	1.00

8.5.4 Determine the membership functions of the CRFs and PRFs

MF of a CRF is obtained from the collective evaluations of the survey respondents through Eq. (7.1). Using *non-payment of bills* (u_{13}) as an example, the survey results showed that the respondents rated its probability of occurrence as follows: 0% as ‗extremely low'; 5% as ‗very low'; 10% as ‗low'; 22.5% as ‗moderate'; 25% as ‗high'; 27.5% as ‗very high'; and 10% as ‗extremely high'. Hence, the MF (risk probability) of u_{13} is derived as (Eq. 7.1):

$$MF_{u_{13(p)}} = \frac{0.00}{\text{extremely low}} + \frac{0.05}{\text{very low}} + \frac{0.10}{\text{low}} + \frac{0.23}{\text{moderate}} + \frac{0.25}{\text{high}} + \frac{0.28}{\text{very high}} + \frac{0.10}{\text{extremely high}}$$

The MF is written through Eq. (7.2) as: (0.00, 0.05, 0.10, 0.23, 0.25, 0.28, 0.10). Using the same approach, the MF for severity of u_{13} is determined as:

$$MF_{u_{13(s)}} = \frac{0.00}{\text{extremely low}} + \frac{0.00}{\text{very low}} + \frac{0.08}{\text{low}} + \frac{0.13}{\text{moderate}} + \frac{0.30}{\text{high}} + \frac{0.28}{\text{very high}} + \frac{0.23}{\text{extremely high}}$$

And the MF is written as: (0.00, 0.00, 0.08, 0.13, 0.30, 0.28, 0.23). Following the same approach, the MFs for the remaining CRFs are determined (see column 3 of Table 8.6 (risk probability) and column 3 of Table 8.7 (risk severity)). Generating the MFs for the CSFs sets the basis to derive the MFs of each PRF. After determining the MFs of the CRFs, the weighting function sets are required to compute the MFs of the PRFs.

Table 8.6 Membership functions (MF) for CRFs and PRFs for PPP water projects (risk probability)

CRFs and PRFs	Weighting (w_i) for CRFs	Membership function for level 3 (CRFs)	Membership function for level 2 (PRFs)
Financial and Commercial (PRF 1): u_1			
Foreign exchange rate	0.148	(0.00, 0.03, 0.00, 0.10, 0.33, 0.35, 0.20)	(0.01, 0.05, 0.08, 0.26, 0.31, 0.19, 0.10)
Water theft	0.136	(0.00, 0.05, 0.08, 0.15, 0.35, 0.18, 0.20)	
Non-payment of bills	0.130	(0.00, 0.05, 0.10, 0.23, 0.25, 0.28, 0.10)	
High operational costs	0.124	(0.00, 0.03, 0.13, 0.25, 0.35, 0.23, 0.03)	
Inflation rate volatility	0.125	(0.00, 0.03, 0.08, 0.33, 0.40, 0.08, 0.10)	
Interest rate	0.116	(0.00, 0.08, 0.15, 0.38, 0.18, 0.18, 0.05)	
Water pricing and tariff review uncertainty	0.111	(0.03, 0.13, 0.08, 0.33, 0.35, 0.05, 0.05)	
Financing and refinancing risk	0.110	(0.05, 0.08, 0.10, 0.38, 0.25, 0.15, 0.00)	
Legal and socio-political (PRF 2): u_2			
Corruption	0.143	(0.00, 0.03, 0.10, 0.10, 0.40, 0.25, 0.13)	(0.02, 0.08, 0.11, 0.27, 0.27, 0.17, 0.08)
Political interference	0.139	(0.00, 0.05, 0.08, 0.20, 0.30, 0.25, 0.13)	
Supporting utilities (energy) risk	0.119	(0.00, 0.13, 0.10, 0.23, 0.33, 0.15, 0.08)	
Political discontent & early termination	0.122	(0.00, 0.10, 0.15, 0.35, 0.25, 0.08, 0.08)	
Conflict between partners	0.118	(0.03, 0.05, 0.15, 0.35, 0.20, 0.18, 0.05)	
Land acquisition risk	0.118	(0.03, 0.15, 0.08, 0.30, 0.28, 0.10, 0.08)	
Public resistance to PPP	0.117	(0.10, 0.05, 0.13, 0.30, 0.18, 0.15, 0.10)	
Change in government & political opposition	0.125	(0.03, 0.08, 0.13, 0.43, 0.18, 0.03, 0.15)	
Technical (PRF 3): u_3			
Pipeline failures during distribution	0.155	(0.03, 0.08, 0.05, 0.33, 0.30, 0.15, 0.08)	(0.02, 0.09, 0.11, 0.32, 0.27, 0.13, 0.06)
Lack of PPP experience	0.173	(0.00, 0.10, 0.08, 0.28, 0.25, 0.20, 0.10)	
Construction time & cost overrun	0.180	(0.00, 0.08, 0.15, 0.33, 0.23, 0.10, 0.13)	
Poor contract design	0.162	(0.03, 0.13, 0.10, 0.28, 0.33, 0.13, 0.03)	
Design & construction deficiencies	0.175	(0.03, 0.08, 0.18, 0.43, 0.18, 0.10, 0.03)	
Insufficient pr. operator performance during operation	0.155	(0.08, 0.10, 0.10, 0.28, 0.35, 0.08, 0.03)	

Table 8.7 Membership functions (MF) for CRFs and PRFs for PPP water projects (risk severity)

CRFs and PRFs	Weighting (w_i) for CRFs	Membership function for level 3 (CRFs)	Membership function for level 2 (PRFs)
Financial and Commercial (PRF 1): u_1			
Foreign exchange rate	0.128	(0.00, 0.03, 0.10, 0.13, 0.33, 0.28, 0.15)	(0.00, 0.02, 0.07, 0.20, 0.37, 0.23, 0.11)
Water theft	0.129	(0.00, 0.00, 0.08, 0.23, 0.18, 0.23, 0.30)	
Non-payment of bills	0.133	(0.00, 0.00, 0.08, 0.13, 0.30, 0.28, 0.23)	
High operational costs	0.126	(0.00, 0.00, 0.00, 0.20, 0.53, 0.25, 0.03)	
Inflation rate volatility	0.121	(0.00, 0.03, 0.13, 0.15, 0.43, 0.20, 0.08)	
Interest rate	0.120	(0.00, 0.05, 0.08, 0.25, 0.35, 0.18, 0.10)	
Water pricing and tariff review uncertainty	0.121	(0.00, 0.05, 0.05, 0.25, 0.38, 0.18, 0.10)	
Financing and refinancing risk	0.122	(0.00, 0.03, 0.05, 0.25, 0.38, 0.25, 0.05)	
Legal and socio-political (PRF 2): u_2			
Corruption	0.142	(0.00, 0.00, 0.05, 0.08, 0.33, 0.35 ,0.20)	(0.01, 0.03, 0.06, 0.24, 0.33, 0.23, 0.10)
Political interference	0.131	(0.00, 0.08, 0.05, 0.23, 0.33, 0.33, 0.00)	
Supporting utilities (energy) risk	0.124	(0.03, 0.03, 0.05, 0.33, 0.30, 0.18, 0.10)	
Political discontent & early termination	0.119	(0.03, 0.03, 0.03, 0.25, 0.38, 0.23, 0.08)	
Conflict between partners	0.121	(0.00,0.05, 0.08 , 0.28, 0.38, 0.18, 0.05)	
Land acquisition risk	0.120	(0.13, 0.05, 0.05, 0.25, 0.38, 0.13, 0.03)	
Public resistance to PPP	0.121	(0.03, 0.05, 0.10, 0.20, 0.30, 0.25, 0.08)	
Change in government & political opposition	0.121	(0.08, 0.03, 0.08, 0.38, 0.28, 0.18, 0.00)	
Technical (PRF 3): u_3			
Pipeline failures during distribution	0.159	(0.00, 0.03, 0.05, 0.20, 0.30, 0.28, 0.15)	(0.01, 0.03, 0.05, 0.20, 0.37, 0.23, 0.10)
Lack of PPP experience	0.166	(0.03, 0.03, 0.05, 0.15, 0.35, 0.33, 0.08)	
Construction time & cost overrun	0.166	(0.00, 0.03, 0.03, 0.23, 0.48, 0.13, 0.13)	
Poor contract design	0.168	(0.03, 0.05, 0.00, 0.15, 0.38, 0.30, 0.10)	
Design & construction deficiencies	0.171	(0.00, 0.00, 0.03, 0.25, 0.40, 0.20, 0.13)	
Insufficient pr. operator performance during operation	0.169	(0.00, 0.03, 0.10, 0.20, 0.40, 0.25, 0.03)	

8.5.5 Evaluate the Risk Level of each PRF

Recall that the FSE approach has three levels of MFs, from levels 3 to 1. Level 3 is derived from the survey based on the experienced evaluations of the 40 industry participants. To evaluate the risk level (RL) of a particular PRF, a fuzzy matrix (i.e., MF) was derived first, based on results of level 1 (as shown in Tables 8.6 and 8.7) using Eq. (7.6), followed by the PRFs' fuzzy evaluation matrices. Using *PRF3 – Technical* (u_3) as an example, the MFs (probability) of all the CRFs in this category can be expressed through Eq. (7.6) in a fuzzy matrix as:

$$R_{u3(p)} = \begin{vmatrix} MF_{u31} \\ MF_{u32} \\ MF_{u33} \\ MF_{u34} \\ MF_{u35} \\ MF_{u36} \end{vmatrix} = \begin{vmatrix} 0.08 & 0.10 & 0.10 & 0.28 & 0.35 & 0.08 & 0.03 \\ 0.00 & 0.08 & 0.15 & 0.33 & 0.23 & 0.10 & 0.13 \\ 0.00 & 0.10 & 0.08 & 0.28 & 0.25 & 0.20 & 0.10 \\ 0.03 & 0.13 & 0.10 & 0.28 & 0.33 & 0.13 & 0.03 \\ 0.03 & 0.08 & 0.05 & 0.33 & 0.30 & 0.15 & 0.08 \\ 0.03 & 0.08 & 0.18 & 0.43 & 0.18 & 0.10 & 0.03 \end{vmatrix}$$

This matrix is further normalised using Eq. (7.7), which considers the weighting functions of the CRFs within u_3 (PRF3) and produces the fuzzy evaluation matrix as:

$$D_{u3_{(p)}} = W_{u3_{(p)}} \bullet R_{u3_{(p)}} = \left(w_{u31},\ w_{u32},\ w_{u33},\ w_{u34},\ w_{u35},\ w_{u36}\right) \times \begin{vmatrix} MF_{u31} \\ MF_{u32} \\ MF_{u33} \\ MF_{u34} \\ MF_{u35} \\ MF_{u36} \end{vmatrix}$$

$$D_{u_{3(p)}} = (0.155, 0.173, 0.180, 0.162, 0.175, 0.155) \times \begin{vmatrix} 0.08 & 0.10 & 0.10 & 0.28 & 0.35 & 0.08 & 0.03 \\ 0.00 & 0.08 & 0.15 & 0.33 & 0.23 & 0.10 & 0.13 \\ 0.00 & 0.10 & 0.08 & 0.28 & 0.25 & 0.20 & 0.10 \\ 0.03 & 0.13 & 0.10 & 0.28 & 0.33 & 0.13 & 0.03 \\ 0.03 & 0.08 & 0.05 & 0.33 & 0.30 & 0.15 & 0.08 \\ 0.03 & 0.08 & 0.18 & 0.43 & 0.18 & 0.10 & 0.03 \end{vmatrix}$$

$$= (0.02,\ 0.09,\ 0.11,\ 0.32,\ 0.27,\ 0.13,\ 0.06)$$

Similarly, the fuzzy evaluation matrix of severity of u_3 (PRF3) is obtained by using the weighting function set in column 2 and the MFs of its CRFs in column 3 of Table 8.7 as:

$$D_{u_{3(s)}} = (0.159, 0.166, 0.166, 0.168, 0.171, 0.169) \times \begin{vmatrix} 0.00 & 0.13 & 0.10 & 0.20 & 0.40 & 0.25 & 0.03 \\ 0.00 & 0.03 & 0.03 & 0.23 & 0.48 & 0.13 & 0.13 \\ 0.03 & 0.05 & 0.10 & 0.20 & 0.30 & 0.25 & 0.08 \\ 0.03 & 0.05 & 0.00 & 0.15 & 0.38 & 0.30 & 0.10 \\ 0.00 & 0.03 & 0.05 & 0.20 & 0.30 & 0.28 & 0.15 \\ 0.00 & 0.00 & 0.03 & 0.25 & 0.40 & 0.20 & 0.13 \end{vmatrix}$$

$$= (0.01,\ 0.03,\ 0.05,\ 0.20,\ 0.37,\ 0.23,\ 0.10)$$

Using the same procedure, the probability and severity fuzzy evaluation matrixes of the remaining PRFs are determined as presented in the last columns of Tables 8.6 and 8.7, respectively. Having determined the fuzzy matrix of each PRF, and combining both risk probability and severity, the overall risk level of a given PRF or PPP water supply projects can be quantified through Eq. (8.1) as follows (see column titled ‗Overall risk level‘ in Table 8.9). This formula is based on Eq. (2.3):

$$ORL = \sqrt{\left\{\sum_{i=1}^{7} \overline{D}_p \times V^T\right\} \times \left\{\sum_{i=1}^{7} \overline{D}_s \times V^T\right\}},\ 1 \le ORL \le 7 \tag{8.1}$$

where ORL is the *overall risk level* of a given PRF or PPP water supply projects, the subscripts ―p” and ―s” denote risk probability of occurrence and risk severity, respectively.

This is called defuzzification, which transforms or converts the resulting fuzzy numbers or values into crisp outputs to aid decision-making. The fuzzy MFs of the risk probability and risk severity are defuzzified using the adopted grading scale, V^T (Sadiq and Rodriquez, 2004). Therefore,

$$
\begin{aligned}
RL_{u_3} &= (0.02\times1+0.09\times2+0.11\times3+0.32\times4+0.27\times5+0.13\times6+0.06\times7)\times \\
&\quad (0.01\times1+0.03\times2+0.05\times3+0.20\times4+0.37\times5+0.23\times6+0.10\times7) \\
&= 4.356\times5.011 \\
&= 21.827 \\
&= 4.67
\end{aligned}
$$

And similarly,

$$RL_{u_2} = 4.523\times4.935 = 22.319 = 4.72$$

$$RL_{u_1} = 4.762\times5.060 = 24.100 = 4.91$$

The results are tabulated in Table 8.9.

8.5.6 Quantify Overall Risk Level of PPP Water Supply Projects

The obtained fuzzy evaluation matrixes, $D_i(i = u_1, u_2, u_3)$, of the PRFs (i.e., level 2) are further normalised by considering their weighting functions to generate the final fuzzy evaluation matrix of overall risk level of PPP water projects (i.e., level 1). The probability and severity matrixes of the PRFs are represented as (see column 3 of Table 8.8):

$$\overline{R}_{(p)} = \begin{vmatrix} D_{u_1} \\ D_{u_2} \\ D_{u_3} \end{vmatrix} = \begin{vmatrix} 0.01 & 0.05 & 0.08 & 0.26 & 0.31 & 0.29 & 0.10 \\ 0.02 & 0.08 & 0.11 & 0.27 & 0.27 & 0.27 & 0.08 \\ 0.02 & 0.09 & 0.11 & 0.32 & 0.27 & 0.13 & 0.06 \end{vmatrix}$$

$$\overline{R}_{(s)} = \begin{vmatrix} D_{u_1} \\ D_{u_2} \\ D_{u_3} \end{vmatrix} = \begin{vmatrix} 0.00 & 0.02 & 0.07 & 0.20 & 0.37 & 0.23 & 0.11 \\ 0.01 & 0.03 & 0.06 & 0.24 & 0.33 & 0.23 & 0.10 \\ 0.01 & 0.03 & 0.05 & 0.20 & 0.37 & 0.23 & 0.10 \end{vmatrix}$$

Given the probability weighting function set as $\overline{W} = \{0.378, 0.361, 0.261\}$, and using Eq. (7.11), the final fuzzy evaluation matrix of overall risk probability level of PPP water projects is calculated as:

$$\overline{D}_{(p)} = \begin{vmatrix} 0.378 \\ 0.361 \\ 0.261 \end{vmatrix} \times \begin{vmatrix} 0.01 & 0.05 & 0.08 & 0.26 & 0.31 & 0.29 & 0.10 \\ 0.02 & 0.08 & 0.11 & 0.27 & 0.27 & 0.27 & 0.08 \\ 0.02 & 0.09 & 0.11 & 0.32 & 0.27 & 0.13 & 0.06 \end{vmatrix}$$
$$= (0.02,\ 0.07,\ 0.10,\ 0.28,\ 0.28,\ 0.17,\ 0.08)$$

Also, given the severity weighting function set, the overall risk severity level is quantified as:

$$\overline{D}_{(s)} = \begin{vmatrix} 0.367 \\ 0.358 \\ 0.276 \end{vmatrix} \times \begin{vmatrix} 0.00 & 0.02 & 0.07 & 0.20 & 0.37 & 0.23 & 0.11 \\ 0.01 & 0.03 & 0.06 & 0.24 & 0.33 & 0.23 & 0.10 \\ 0.01 & 0.03 & 0.05 & 0.20 & 0.37 & 0.23 & 0.10 \end{vmatrix}$$
$$= (0.01,\ 0.03,\ 0.06,\ 0.21,\ 0.36,\ 0.23,\ 0.10)$$

Now, the overall risk level of PPP water projects in Ghana is quantified through Eq. (8.1):

$$\begin{aligned} ORL_{water\ \mathrm{PPP}} &= (0.02\times1+0.07\times2+0.10\times3+0.28\times4+0.28\times5+0.17\times6+0.08\times7)\times \\ &\quad (0.01\times1+0.03\times2+0.06\times3+0.21\times4+0.36\times5+0.23\times6+0.10\times7) \\ &= 4.570\times5.001 \\ &= 22.858 \\ &= 4.78 \end{aligned}$$

Table 8.8 Determination of membership functions of Overall Risk Level (Level 1)

ID Critical risk group (PRFs)	Weighting (w_{in}) for PRFs	Membership function of level 2 (PRFs)	Membership functions of level 1 (ORL)
Risk Probability (from level 2 to 1)			
Financial and Commercial (PRF 1): u_1	0.378	(0.01, 0.05, 0.08, 0.26, 0.31, 0.19, 0.10)	(0.02, 0.07, 0.10, 0.28, 0.28, 0.17, 0.08)
Legal and socio-political (PRF 2): u_2	0.361	(0.02, 0.08, 0.11, 0.27, 0.27, 0.17, 0.08)	
Technical (PRF 3): u_3	0.261	(0.02, 0.09, 0.11, 0.32, 0.27, 0.13, 0.06)	
Risk Severity (from level 2 to 1)			
Financial and Commercial (PRF 1): u_1	0.367	(0.00, 0.02, 0.07, 0.20, 0.37, 0.23, 0.11)	(0.01, 0.03, 0.06, 0.21, 0.36, 0.23, 0.10)
Legal and socio-political (PRF 2): u_2	0.358	(0.01, 0.03, 0.06, 0.24, 0.33, 0.23, 0.10)	
Technical (PRF 3): u_3	0.276	(0.01, 0.03, 0.05, 0.20, 0.37, 0.23, 0.10)	

Table 8.9 Risk indices / ranking of each PRFs and ORL of PPP water supply projects

Principal risk factors (PRFs)	Probability of occurrence		Severity		Overall Risk Level		Ranking
	Index	Linguistic	Index	Linguistic	Index	Linguistic	
Financial and Commercial (PRF 1): u_1	4.762	High	5.060	High	4.909	High	1
Legal and socio-political (PRF 2): u_2	4.523	High	4.935	High	4.724	High	2
Technical (PRF 3): u_3	4.356	Moderate	5.011	High	4.672	High	3
Overall Risk Level (ORL) of water PPPs	4.570	High	5.002	High	4.781	High	–

The FSE risk assessment model results shown in Table 8.9 indicate that the ORL of PPP water projects is 4.78, which is considered as *high*. Hence, PPP water projects in Ghana could be deemed as risky investments to both private and public participants. This corroborates with assertions of previous studies that PPP projects in the water sector of developing countries are risky (MIGA, 2009; Vives et al., 2006; OCED, 2009a) and explains the massive private underinvestment in the water sectors of these countries (Vives et al., 2006). Similarly, the risk indices of the PRFs are shown in Table 8.9, which can be used for risk prioritisation and management. The model is able to tell which PRFs deserve attention and resources when embarking on PPP projects in the local water sector. It shows that Financial and commercial is the most critical PRF, followed by Legal and socio-political, and Technical risk. All the PRFs have high risk levels.

From the outputs of the risk evaluation model in Table 8.9, some conclusions can be made:

- All the PRFs, except Technical risk, have ‗high‘ probability of occurrence ranging from 4.52 to 4.76. Financial and commercial factor has the highest likelihood of occurrence.
- It can be observed from Table 8.9 that all the PRFs have ‗high‘ severity indices, ranging between 4.94 to 5.06. Financial and commercial and Technical risks have the highest severity indices of 5.06 and 5.01, respectively.
- From the table, all the three PRFs have ‗high‘ overall risk levels between 4.67 and 4.91, suggesting that they have significant impacts on PPP water supply projects.
- Therefore, there is a positive consensus among the expert respondents that the principal factors are high-risk areas in PPP water projects in Ghana. However, the order of impacts differ, based on the specific factors being considered.

8.6 DISCUSSION OF PRINCIPAL RISK FACTORS (PRFs)

Each of the PRFs is briefly discussed in this section with indications of how they negatively affect the success of PPP projects.

8.6.1 PRF 1 – Financial and Commercial Risk

This risk category has the highest risk level of 4.91 and both high probability and severity indices of 4.76 and 5.06, respectively, and consists of eight significant risk factors as shown in Table 8.3. Based on the eight risk factors, the term ‗financial and commercial' supports the definition of Xenidis and Angelides (2005a) who explained financial and commercial risks as those that adversely affects a project's funding, cashflow and profitability. This finding confirms a previous study by Vives et al. (2006) that these risk variables affect the financial structures supporting project sustainability, given that most of them can change suddenly. The most significant risk factors in this category include foreign exchange rate, water theft, non-payment of bills, operational cost overruns, inflation, etc. (see Table 8.3). Water theft ranks second in this category and is associated with serious utility revenue losses (Frauendorfer and Liemberger, 2010; Meehan, 2013; Foster and Pushak, 2011; Kingdom et al., 2006). Frauendorfer and Liemberger (2010) highlighted that water theft is a socio-political issue, because tackling theft entails taking harsh managerial decisions that are likely to be politically unpopular. Water theft, in reality, is associated with high-income households and commercial and industrial users who account for substantial water losses and associated revenues. Vives et al. (2006) asserted that high foreign exchange and inflation rates adversely impact on the infrastructure sector due to the difficulty of securing long-term domestic financing in many developing countries. Foreign exchange risk often has a high damaging impact on water supply infrastructure projects in developing countries due to the mismatch between revenues and currencies in investment/costs (Matsukawa et al., 2003). It is therefore unsurprising that this risk factor ranks first overall and within this category (Table 8.3). Additionally, projects' profits are extremely sensitive to fluctuations in foreign exchange and interest rates (Thobani, 1999; Matsukawa et al., 2003). Hence, for successful foreign-funded PPP projects, a strong macroeconomic management by the government and economic pricing are necessary. The results confirm that ability to secure payment (non-payment of bills) from customers is another critical risk factor (Haarmeyer and Coy, 2002). The implication is that private participants will be less willing to run a water system if the contractual right to disconnect defaulters or a minimum rate of return is not guaranteed. Thus, smooth running and commercial success of revenue-dependent PPP water services is dependent on customers' ability and willingness to pay realistic tariffs (Singh and Kalidindi, 2006; Tiong, 1996). Poor pricing policies adversely affect a project's financial performance and fail to sustain investors' interests. This reinforces the finding of Choi et al. (2010) who highlighted uneconomic tariffs and price review difficulty as the key risks to foreign investors in China's water sector, and the argument that water pricing exposes investors to regulatory risk and political opportunism (Beato and Vives, 1996). Marques and Berg (2011) argued that the main cause of project failure relates to non-fulfillment of investment commitment by project partners. Adequate funding has implications on operator and overall project performance in the sense that without it the project company is unable upgrade existing water infrastructure and/or build new systems to improve service levels. Because financial and commercial events are associated with high project failures, governments and investors should thoroughly analyse these factors prior to embarking on a project.

8.6.2 PRF 2 – Legal and Socio-political Risk

With a high risk level of 4.72 and high probability and severity indices of 4.52 and 4.94, respectively, this principal factor ranks second and underlies eight significant risk factors as shown in Table 8.3. This factor corroborates earlier assertions that legal and socio-political risks remain a major concern in both medium and long terms in developing countries (MIGA, 2009). The monopoly nature, environmental as well as public health concerns of deficient water services have meant that host governments, at various levels, have tended to be involved in regulation of water supply services. This interaction with the government exposes the water sector to political, social, regulatory and legal uncertainties and risks (Wibowo and Mohamed, 2010; Zeng et al., 2007). Haarmeyer and Coy (2002) noted that absence of independent regulatory and judicial systems for fair and effective contract enforcement and dispute resolution in most developing countries expose private water investors to political opportunism and expropriation. The factor constituents in this risk category also confirm those reported in previous studies, such as country-level corruption (Kenny, 2009; Auriol and Blanc, 2009; Boehm and Polanco, 2003; Stålgren, 2006; Hall, 1999; Hellman et al., 2000), political interference, early termination (Ameyaw and Chan, 2013a; Vives et al., 2006), land acquisition (Wibowo and Mohamed, 2010), public resistance to PPP (Hall et al., 2005), etc. Stålgren (2006) noted that the major constraint to investment in emerging economies is corruption, because foreign investors and local government officials are involved in corrupt practices that increase transaction costs (Hellman et al., 2000). Land acquisition, ranking sixth in this category (Table 8.3), confirms previous findings (Sentürk et al., 2004; Karim, 2011; Lindsay, 2012) that land access has become more challenging in PPP infrastructure projects, playing a significant part in the cost to project participants and increasing the construction time. Public resistance can slow project implementation and impact on operator performance in realising the project‘s objectives. Final users could become more resistant to using and/or paying for the water services (Zou et al., 2008; Hall et al., 2005). Conflict between project partners affects the relationship among project participants, leading to possible legal battles that may impact on smooth implementation of a project (Zou et al., 2014). Haarmeyer and Mody (1998) suggested several countermeasures to legal and political risks in water PPPs. These include independent regulatory authority, local investor participation, political commitment to private sector participation, reputable judiciary, well-designed contract with clearly assigned rights and obligations, political risk insurance or guarantee and participation of multilateral organisations (e.g., World Bank). A recent example is Ghana‘s first 25-year SWRO BOOT treatment plant, in which the World Bank‘s MIGA has provided a political risk insurance of US$179.2 million against expropriation, government breach of contract, war and civil disturbance, and transfer restriction. The offtaker, Ghana Water Company Ltd., is supported with a guarantee from the Ministry of Finance and Economic Planning (Global Water Intelligence, 2012).

8.6.3 PRF 3 – Technical Risk

Ranking third with a high risk level of 4.67 and moderate likelihood of occurrence and high severity scores of 4.36 and 5.01, respectively, this principal factor contains six salient risk variables. As shown in Table 8.3, technical category can be traced to three sources of risks based on its factor constituents. These are (i) design and construction including design and construction deficiencies, and construction time and cost overruns; (ii) operational including pipeline failures during distribution and insufficient operator performance; and (iii) competence relating to PPP experience and contract design. Overall, the term ‗technical‘ in this context refers to the capacity and experience that the public and private sector has to design workable contracts, design and execute water supply facilities (e.g. distribution network or treatment plant) and operate the constructed facilities efficiently to meet contractual performance standards. Haarmeyer and Mody (1998) posited that investors and lenders often face the risk that the construction firm will fail to deliver the project on time, within budget, and per contract design specifications, which may affect both timing and cashflow levels. Construction time and cost overrun risk is a significant factor, raking third in this category (Table 8.3). For a successful BOT implementation, the water supply facility must be constructed within time and budget, to avoid high rates of inflation and interest (Salman et al., 2007; Gupta and Narasimham, 1998) and to guarantee reasonable profits to the investor(s). In practice, design and construction quality issues (ranking fifth in this category) are among the important factors in project implementation (Sun and Meng, 2009; Chanter and Swallow, 2007), resulting to constructability difficulties (Alarcón and Mardones, 1998) and poor facility performance (Oyedele, 2013).

The main operational risk in water PPPs is insufficient performance of the project company (Haarmeyer and Mody, 1998; Lobina, 2005), which is likely to trigger performance failure payment deductions (Oyedele, 2013). Lack of capacity and technical knowledge in the water sector, as the case in many developing countries, may limit the extent of project development and operation through poor contract enforcement and oversight, or result to poor contract designs, imposition of ambiguous and unrealistic performance targets and compulsory investments on the private investor (Vives et al., 2006). Possible ways of minimising technical risks include enlistment of a reputable concessionaire (UNIDO, 1996; Jefferies et al., 2002), local capacity development (Rebeiz, 2012; Nickson, 1996), and engaging external professional advisors (Meng et al., 2011; Li et al., 2005b).

8.7 THE PROPOSED MODEL AND ITS IMPLICATIONS FOR PRACTICE

The purpose of this risk assessment model is to provide a useful and practical aid in decision-making, as risk assessment of projects are characterised by crude and subjective evaluations (Birch and MacEvoy, 1992; Hayes et al, 1986; Yeung et al., 2010; Akintoye and MacLeod, 1997). Decision-makers will find this model useful, as it is the outcome of a disciplined industry ranking-type Delphi survey and a rigorous modelling approach. The value of any risk assessment exercise is low if these factors are ignored.

The risk factors and principal risks reflect local political, economic, social, cultural and sector characteristics. The risk factors that are most significant, by experienced and professional judgment and further confirmed statistically, were used for the risk modelling. This provides a practical and reliable factor list for developing PPP project risk assessment and management guidelines, and ensures the credibility of the model.

The ratings for assessment were extracted in a systematic manner. Thus, the method is based on subjective experienced and professional judgment of experts. However, the (two-round) Delphi technique has a merit of reducing biases (Chan et al., 2001) at the data acquisition stage. In addition, the fuzzy set theory adopted in the evaluation process objectified or transformed the subjective risk ratings through appropriate mathematical functions. Furthermore, FSE is easy to understand and the numerous computations can be implemented in a spreadsheet (e.g., Microsoft Excel).

By this model, the overall risk level of a PPP project, and each PRF, can be described by a single indicator (risk index). Relevant institutions, policy-makers and industry practitioners would therefore be motivated to work at reducing the risk level of such projects in order to attract more private investment. This could trigger institutional development and capacity building, and development of robust risk mitigation measures.

Finally, the FSE risk assessment model overcomes some weaknesses of other probabilistic risk models, such as Monte Carlo simulations and sensitivity analysis that require quality historical data. Given the limited number of PPP projects and experience in countries with emerging PPP programmes like Ghana, such data cannot be easily obtained. Therefore, combining expert knowledge and fuzzy set theory seems the most effective approach to practical risk assessment, especially at the early project stages.

8.8 CHAPTER SUMMARY AND CONTRIBUTION

The risky nature of PPP water projects has given prominence to risk assessment, as a means to determine significant risk factors and their effect on these projects. In this chapter, 22 critical risk factors relevant to PPP water supply projects in Ghana have been identified and classified (financial and commercial, legal and socio-political, and technical) to determine their likelihoods and severities. The application of FSE approach allows for the use of descriptive linguistic variables in the assessment of the likelihoods and severities of the identified risk factors. This enables the linguistic descriptions of the risk factors to be systematically modelled and quantified, and to determine the overall risk level of PPP water projects. Overall, initial mean analysis shows that the top-five risk factors with high impacts include foreign exchange rate, corruption, water theft, non-payment of bills, and political interference. The FSE analysis also indicates the Financial and commercial category of risks as the most important (risk level = 4.91), with the Legal and socio-political category ranking second with a high risk level of 4.72, and the Technical category ranking third with a high risk level of 4.67. Further to this, the fuzzy analysis reveals that PPP water projects in Ghana are risky, with an overall risk index of 4.78 (high).

Though this study was conducted in Ghana, the results can be extrapolated to other developing and emerging economies with mature or emerging PPP markets. Generally, the water sectors of these countries share common characteristics (Nickson 1996; Marin 2009; Blumberg, 2013) and therefore are likely to encounter similar key risks under PPP procurement, such as those established herein. However, researchers and practitioners should note that the risk factors adopted for this study were selected from previous studies and project cases and generalised, but for a unique project in a given country there is likely to be some country- or project-specific risk factors that the public and private participants should add to the established factors. Also, practitioners should note that the remaining 18 risk factors that were deemed less important in this chapter may prove critical in different contexts.

This chapter offers the following contribution to the risk management in PPP water infrastructure projects:

- Provides a 40-factor risk list, with established 22 CRFs through evaluation by industry practitioners and further categorised them into three principal groups. This provides a practical and reliable factor list for developing risk management guidelines;
- Offers an analytical methodology that can be applied with appropriate modifications to reflect specific projects and contexts by fine-tuning the risk and principal risk factors and the expert panel size. The FSE approach is systematic, practical and easy to understand and implement, and the calculations can be implemented in Microsoft Excel spreadsheet; and

- Aid public and private decision-makers to achieve objective risk assessment, assisting them to determine appropriately the most significant risk factors and risk categories and to determine the overall risk level of a project. Thus, the fuzzy approach is a multi-attribute risk assessment framework and may serve as a risk evaluation tool at the early stages of a project where detailed information is unavailable.

Therefore, this chapter makes a major contribution to the construction management and fuzzy set theory literature and to the PPP water industry by reporting critical risks that would be impactful and valuable to decision-makers.

The next chapter presents a mathematical model to allocate the 22 CRFs that were established in this chapter. The approach is based on the FSE method and value judgment of industry experts. Validation of the overall study is also presented in the following chapter.

Chapter 9: Risk Factors in PPP Water Supply Projects: An Evaluation

The Discussion chapter includes a discussion of both the results and the methodology chosen to evaluate risk factors in PPP water supply projects. There is also a discussion of the contributions and limitations of the findings and suggestions for future research directions.

This chapter is very effective partly because the writer includes the following:

Structure

Introduction	Section 9.1
Introduction and results of first analyses	Section 9.2
Describes model built on the findings in chapter 8	Section 9.3
Gives analysis of model	Section 9.4
Discusses model	Section 9.5
Validates model	Section 9.6
Summary	Section 9.7

Structure

- Summarises key ideas included in the chapter and gives an overview of the analysis to be used (e.g. Section 9.1)
- Refers to methodology used in the previous chapter (e.g. Section 9.1, paragraph 1, sentence 2)
- Explains key terms central to the results presented/focus of discussion in the chapter (e.g. Section 9.1, paragraph 1, sentence 3-4)
- Explains background (e.g. Section 9.1, paragraph 2)
- Explains the purpose and aims of the chapter (e.g. Section 9.1, paragraph 3, sentence 1)
- Outlines model used in chapter (e.g. Section 9.1, paragraph 3, sentence 2-3)
- Cites sources to provide the theoretical basis for the methodology (e.g. Section 9.2, paragraph 1)
- Introduces methodology used (e.g. Section 9.2, paragraph 1)
- Gives rationale for choice of model (e.g. Section 9.3, sentence 3-4)

- Gives credibility to the model by citing other researchers who have applied it (e.g.9.3.2, paragraph 3, sentence 2)
- Refers to similar methods used in earlier chapters (e.g. Section 9.3.6, paragraph 1, sentence 5)
- Discusses the implications and possible reasons for results clearly (e.g. Section9.6.2, paragraph 2, sentence 8-9)
- States contribution findings will make to the wider community (e.g. Section 9.6.3, paragraph 2, final sentence)
- States limitations (e.g. Section 9.7, paragraph 6)
- Suggests how further work is needed (e.g. Section 9.7, paragraph 6, sentence 2)

Language

- Links to the previous chapter (e.g. Section 9.1, paragraph 1 sentence 1)
- Describes methodology in general by using the present simple tense and passive voice (e.g. Section 9.2.2, paragraph 1, sentence 1)
- Describes methodology used in this thesis by using the past simple tense and passive voice (e.g. Section 9.4.1, paragraph 1, sentence 1)
- Links to the next chapter (e.g. Section 9.7, final paragraph)

To consider

In general, this chapter is effective. However, it could be improved in the following aspects.

Avoid just listing the discussion in discrete sections. It is better to try and group information. This chapter has 27 sections and subsections in 31 pages of text.

Report numbers in different ways and use approximations during the discussion to make it easier for the reader, e.g. *54.52% %* can be rewritten as slightly under 55% (e.g. Section 9.5, paragraph 2, sentence 2).

CHAPTER 9 RISK MANAGEMENT CAPABILITY ASSESSMENT AND RISK ALLOCATION MODEL

9.1 INTRODUCTION

Chapter 8 assesses the risk factors and overall risk level of PPP water supply projects in Ghana. A total of 22 (out of 40) risk factors were established as ‗critical' and need to be efficiently allocated between the public and private sectors. PPPs are justified because they offer improved VfM through the realisation of optimal risk allocation (Quiggin, 2005; Chung et al., 2010). Risk allocation is the determination of the best party to assume risks and their associated consequences, should they eventuate during the life of the project. That is, it is a primary measure of assignment between the direct public authority and the private sector entity (Roumboutsos and Anagnostopoulos, 2008).

PPP project success or failure heavily relies on whether an adopted risk allocation strategy can translate to effective project risk management (Jin, 2011). However, the risk allocation decision-making process is, in practice, intuitive, implicit and subjective, influenced by human attitude and bias in decision-making which often distorts the final risk allocation outcome.

This chapter proposes a fuzzy quantitative risk allocation decision model for PPP water supply projects by drawing on the fuzzy set theory and established risk allocation criteria (RAC) based on professional and experiential knowledge of industry experts. The model and the approach deal with the imprecise and subjective nature of risk allocation decision-making and handle the simultaneous consideration of the multiple risk allocation criteria and the multiple decision-makers. The model aim to guide governments and private investors in risk allocation decision-making to establish constructive PPPs. Drawing on the RAC (see Chapter 5, section 5.4.2) and qualitative expert knowledge as the basis for risk allocation, the FSE method which relates to computation and reasoning of natural language is applied for the risk allocation decision modelling.

Seven critical RAC are established through the Delphi survey (Chapter 2), and the 22 CRFs (established in Chapter 8) are evaluated on each RAC and allocated between the public and private sectors. The output variable of the fuzzy model is the risk allocation proportions between the government and the private partner according to their capabilities to manage the evaluated risk factors associated with water supply projects in Ghana. Moreover, for any evaluated risk event, the model quantitatively predicts each partner‘s risk management capability, based on a five-point grading system, ranging from 1, referring to *'very low'* capability, via 3, denoting *'moderate'* risk management capability, to 5, meaning *'very high'* management capability by the government or private party.

9.2 CRITICAL RISK ALLOCATION CRITERIA (RAC)

RAC guide the risk allocation decision-making. Nine RAC from the literature (e.g., Arndt, 2000; Medda, 2007; Oudot, 2005; Lam et al., 2007; Xu et al., 2010; Thomas et al., 2003; Gao and Jiang, 2008) were adopted for the first two rounds of the Delphi questionnaire survey (Table 9.1). Oudot (2005) has explained the theoretical foundations of these criteria. Using these criteria as the basis for allocating risks creates a common perception of risk allocation and incentives to effectively manage assigned risks (Loosemore and McCarthy, 2008), and is also helpful in arriving at an equitable decision in PPP agreements (Oudot, 2005).

The nine RAC were then evaluated numerically through a two-round Delphi survey in order to determine their significance. Using a ranking-type Delphi survey, it is possible to judge how important a role each risk allocation criterion plays in risk allocation decision-making. Delphi is a suitable method for item prioritisation (details of the Delphi survey is presented Chapter 2). The views originating from practitioners' experienced judgment are sought and this requires participants with adequate knowledge of the water industry and PPP risk management. Thirty-seven (37) industry practitioners with diverse backgrounds participated in the two-round Delphi survey. The panel was formed on the basis of a participant's years of relevant industry experience, professional background and knowledge, and recent/current position in his/her organisation. Experts were drawn from relevant public and private institutions as shown in Table 2.4. All the expert respondents have at least five years of appropriate industry experience and hold senior positions in their respective orgainsations.

A two-round Delphi survey is capable of minimising fatigue and optimising response rate among respondents, and allows for feedback and revision of original ratings (Hon et al. 2011). In round one, the experts were required to rate the relative importance of each risk allocation criterion according to a seven-point system (1 = extremely low importance and 7 = extremely high importance). In round two, the experts were provided with consolidated statistical feedback from round one and further requested review their original scores based on the mean values.

9.2.1 Cronbach's Alpha Reliability

Spector (1992) and Field (2005) suggested that a Cronbach's alpha coefficient of reliability should be computed when a ranking-type (or Likert) scale is used in a questionnaire. Therefore, it is necessary to check the internal consistency of the factors in the Delphi questionnaire, with the view to confirming whether the RAC and the adopted ranking scale actually measured the construct for which they were intended to. Using SPSS 21.0, the overall Cronbach's alpha value for the nine RAC for rounds one and two of the Delphi survey are 0.822 and 0.815, respectively (Table 9.2). These alpha values indicate a good reliability and internal consistency of the criteria (Oyedele, 2013).

9.2.2 Ranked RAC and Kendall's *W*

In order to measure the industry experts' perception on the importance of each risk allocation criterion, the mean index of each criterion is computed using Eq. (2.1). Thus, the mean scoring method is used to rank the importance of the RAC. Table 9.2 shows that the mean values of the RAC ranges from 4.76 to 6.22 (for round two), suggesting all the criteria are important. However, seven criteria scored mean values between 5.05 and 6.22 and were strictly selected for modelling the risk allocation decision-making process. The aim here is to select the most significant criteria with mean scores ≥ 5.0 (high). Generally, the top-seven criteria reflect risk management capabilities of PPP actors, and interestingly, are in agreement with the Ghanaian Government's principle of risk-sharing, as highlighted in its PPP policy document, which states that risks will be ―allocated to the party best able to control and manage them ..." (Government of Ghana, 2011, pg. 11).

The degree of consensus among the panelists was measured for both rounds, using Kendall's *W* (Schmidt et al., 2001). The degree of consensus of the nine RAC leveled off (Schmidt et al., 2001) in both rounds, from 0.224 in round one to 0.282 in two with respective *p-values* of 0.000. Though the Kendall's *W* values indicate low consensus among the panelists, they however suggest that two rounds was appropriate for the Delphi survey. Having established the relevant RAC, the following sections (9.3 and 9.4) outline and demonstrate a prototypic quantitative risk allocation model based on the FSE method.

Table 9.1 Determinants of efficient risk allocation in PPP procurement

ID	Risk allocation criteria (RAC)	Definition
1	Foresee and assess the risk	The ability to foresee the probability of risk occurrence and evaluate possible severity of the risk consequence
2	Control the chance of risk occurrence	The ability to avoid, minimize, monitor, and control the chance of risk occurrence
3	Minimise the loss if risk occurs	The ability to minimize the loss if risk occurs (minimize the severity, extra cost, and delay)
4	Sustain the consequence	The ability to sustain the consequences of the risk
5	Bear the risk at the lowest price	The ability to bear the risk at the lowest price
6	Obtain benefit from risk	Be able to enhance risk undertaker‘s credibility, reputation, and efficiency in risk management
7	Assume and manage the direct loss	Be able to assume and manage the direct loss
8	Obtain reasonable premium	Be able to get reasonable and acceptable premium
9	Risk attitude	Risk should be allocated to the party who prefer to assume the risk (risk neutral, risk prone, or risk averse)

Table 9.2 Results of a two-round Delphi survey

ID	Risk allocation criteria (RAC)	Round one		Round two	
		Mean index	Ranking	Mean index	Ranking
1	Foresee and assess the risk	6.03	2	6.22	1
2	Control the chance of risk occurrence	6.05	1	6.14	2
3	Minimise the loss if risk occurs	5.89	3	5.97	3
4	Sustain the consequence	5.14	6	5.27	6
5	Bear the risk at the lowest price	5.38	5	5.43	5
6	Benefit from bearing risk	5.43	4	5.49	4
7	Assume and manage the direct loss	4.92	7	5.05	7
**8	Obtain reasonable premium	4.86	8	4.97	8
**9	Risk attitude	4.54	9	4.76	9
	Sample *(n)*	37		37	
	Kendall's coefficient, *W*	0.224		0.282	
	p-value	0.000		0.000	
	Cronbach‘s alpha coefficient	0.822		0.815	

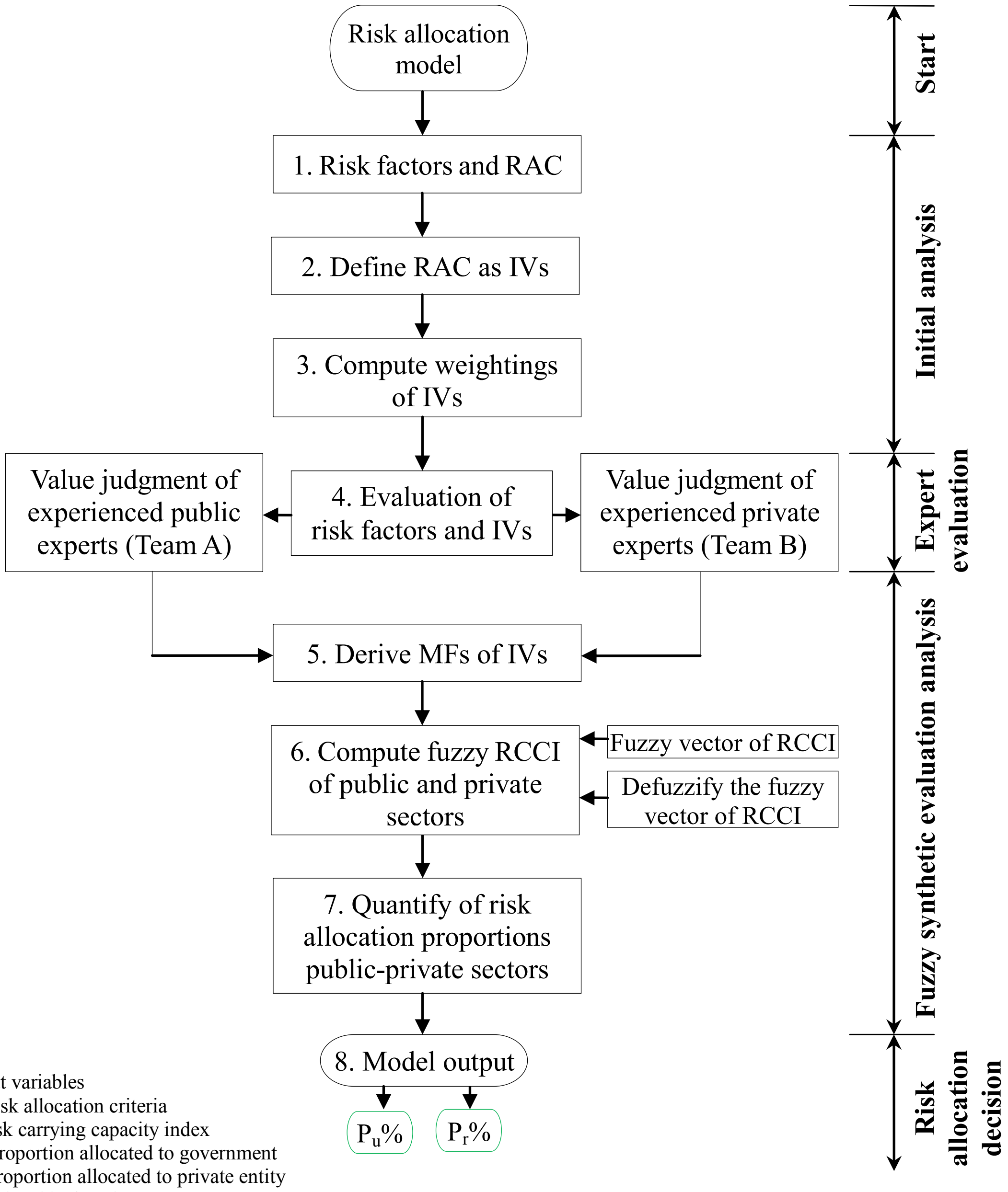
**Excluded from round three (risk allocation) of the Delphi survey

9.3 FUZZY QUANTITATIVE RISK ALLOCATION DECISION MODEL (FQRADM)

In practice, risk allocation decision-making is a complex process shrouded in vagueness and uncertainty. This research seeks to support the decision-making in risk allocation practice to help address the challenge of poor risk-sharing, by considering the most influential criteria. The risks to be allocated require expert knowledge, and thus a fuzzy quantitative risk allocation decision model (FQRADM) is proposed to aid the risk allocation decision-making between the direct public and private partners in PPP water projects. Arriving at a balanced risk allocation is a complex task, due to the nature of the decision-making problem, such as multi-criteria and subjectivity. Multi-criteria, as used here, comes from the perspective that risk allocation, in practice, involves multiple decision-makers evaluating the public and private participants' abilities to manage a set of risks based on predefined risk allocation criteria (Singh and Tiong, 2005). Subjectivity relates to the fact that the decision-making is largely based on the decision-makers' experience and expert judgement (Barnes, 1983), and arises from 'unquantifiable, incomplete, non-obtainable information, and partial ignorance' (Sadiq and Rodriquez, 2004).

The proposed model presents a systematic approach based on fuzzy set theory (Lam et al., 2007; Xu et al., 2010; Wei et al., 2010) to evaluate the capability of the public and private participants to bear a set of risk events. The model, Fig. 9.1, is a step-by-step system in which outputs of preceding steps are fed into following steps, which helps to deal with the imprecise and qualitative nature of the risk allocation decision process (Jin and Zhang, 2011; Lam et al., 2007) and to handle the simultaneous consideration of the multiple risk allocation criteria and the multiple decision-makers. The steps are summarised in Fig.9.1

and briefly described below.



Key:
IVs – input variables
RAC – risk allocation criteria
RCCI – risk carrying capacity index
P_u – risk proportion allocated to government
P_r – risk proportion allocated to private entity
MF – membership function

Fig. 9.1 Fuzzy-based risk allocation decision model

9.3.1 Step 1: Establish the Important Risk Allocation Criteria / Critical Risk Factors

The first step in applying the model is to establish the risk factors to be allocated and the RAC that would serve as the input variables. In this study, the process leading to establishment of the 22 critical risk factors and the RAC has been explained in Chapter 8 and sub-section 9.2.2 of this chapter, respectively. The seven RAC, as shown in Table 9.2 and Fig.

9.1, are defined as the input variables in step 2.

9.3.2 Step 2: Define Input Variables and Linguistic Terms

The top-seven risk allocation criteria (in Table 9.2) are defined as the *linguistic input variables* as $U = (u_1,\ u_2,\ u_3,\ u_4,\ u_5,\ u_6,\ u_7)$. To evaluate any risk factor, a five-point grading system was adopted to indicate the public and private partners' ability to foresee and assess the risk (u_1), control chance of the risk's occurrence (u_2), minimise the risk's loss (u_3), sustain the risk's consequence (u_4), bear the risk at lowest price (u_5), benefit from the risk (u_6), and assume and manage the risk (u_7), which represents the base variable of the input variables $(u_1 -\ u_7)$.

Using the fuzzy theory, the *linguistic terms* (of the grading system) are also defined to describe the *linguistic input variables* to enable the establishment of membership functions in the following stages. These *linguistic terms* are represented as second-level index systems as follows:

$u_1 = \{u_{11},\ u_{12},\ u_{13},\ u_{14},\ u_{15}\}$,

$u_2 = \{u_{21},\ u_{22},\ u_{23},\ u_{24},\ u_{25}\}$,

$u_3 = \{u_{31},\ u_{32},\ u_{33},\ u_{34},\ u_{35}\}$,

$u_4 = \{u_{41},\ u_{42},\ u_{43},\ u_{44},\ u_{45}\}$,

$u_5 = \{u_{51},\ u_{52},\ u_{53},\ u_{54},\ u_{55}\}$,

$u_6 = \{u_{61},\ u_{62},\ u_{63},\ u_{64},\ u_{65}\}$, and

$u_7 = \{u_{71},\ u_{72},\ u_{73},\ u_{74},\ u_{75}\}$.

The grading scale and its linguistic terms are shown in Table 9.3. A five-point scale has been used in many risk management (RM) studies to indicate a risk transfer proportion (Jin and Zhang, 2011) or a party's RM capability (Li et al., 2005; Ke et al., 2010a). Here, a similar scale is used, which ranges in a continuum from 1, denoting *'very low'* RM capability, to 5, denoting *'very high'* RM capability, as shown in Table 9.3.

Table 9.3 Grading system/linguistic terms for input variables

Scale/linguistic terms for input variables $(u_1 - u_7)$			Range of RM* capability	Constant (c_i)
Scale	Linguistic terms			
1	Very low	u_{i1}	0 – 0.250	0.125 (c_1)
2	Low	u_{i2}	0 – 0.500	0.250 (c_2)
3	Moderate	u_{i3}	0.25 – 0.75	0.500 (c_3)
4	High	u_{i4}	0.50 – 1.00	0.750 (c_4)
5	Very high	u_{i5}	0.75 – 1.00	0.875 (c_5)

*RM = risk management

The grading scale is further defined on the basis of the RM capability scale adopted by Lam et al. (2007). The scale suggests a range of RM capability from 0 to 1. Five ranges are defined and interpreted as shown under ‗Range of RM capability' in Table 9.3. This would help to obtain constants (c_i), last column of Table 9.3, that would normalise the membership functions of risk carrying capacity indices of the public-private partners.

9.3.3 Step 3: Compute Weighting Functions of Input Variables (IVs)

The weighting function, w_i, denotes the relative importance of the evaluated input variables expressed by the practitioners during the first two rounds of the survey described in section 9.2 (also see Chapter 2). The weighting functions of the input variables can be derived through the process described in section 7.5.3. The mean value of each criterion is normalised to obtain its weighting by using the same equation as follows:

$$w_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \quad , \quad 0 < w_i < 1 \text{, and } \sum_{i=1}^{n} w_i = 1 \tag{9.1}$$

where w_i is the weighting function of a particular risk allocation criterion i regarding the extent of its importance to RA decision-making; M_i denotes mean score of a particular criterion i. The weighting function set is given as

$$W_i = \{w_1, w_2, \ldots, w_n\} \tag{9.2}$$

9.3.4 Step 4: Set up Expert Teams from the Public and Private Sectors

Organise two expert teams from the public and private sectors to evaluate each risk factor against the adopted RAC (i.e., input variables). This step, as shown in Fig. 1, is termed ‗expert evaluation' and leads to generation of membership functions of the input variables. The expert evaluation can be achieved through Delphi method, interview, questionnaire survey, etc. In this study, based on the outcome of the first two rounds, a questionnaire was designed for the third and final round of the Delphi survey. The questionnaire focused on elicitation of industry experts' knowledge on allocation of the critical risk factors established through the first two-rounds, based on a water PPP in which they were directly involved and had adequate knowledge in the risk management. Following feedback from two practitioners regarding the structure of questionnaire, clarity of language/instructions and appropriateness and relevance of questions, and consequent refinement of questions, the final round of the Delphi survey was launched. This was the empirical data collection method for the current chapter. Two expert teams were established for this survey; Team A from the public sector, and Team B from the private sector (Table 9.4). To ensure a balanced view (Chung et al., 2010), each team comprised five experts directly involved in PPP water projects. They were purposefully sampled (Moglia et al., 2009) from the larger expert panel that participated in the earlier two-round Delphi survey, based

Table 9.4 Profile of expert panelists

Expert	Position	Industry experience (yrs)	PPP experience (yrs)	No. of PPP projects participated	Subsector	Organisation
Public sector (Team A)						
G1	Financial/PPP analyst	13	6	3	Public policy	PPP Advisory Unit
G2	Manger, Water	10	5	5	Regulation	Public Utilities Regulatory Commission
G3	Manager, Projects Construction & Contract Management	20	10	5	Public water services	Ghana Water Company Ltd
G4	Director, Benchmarking, Monitoring and Evaluation	24	18	5	Procurement	Public Procurement Authority (PPA)
G5	Manager, Business Planning	13	7	1	Public water services	Ghana Urban Water Ltd
Private sector (Team B)						
P1	Project manager	22	2	2	Developer	Denys B.V.
P2	Director	36	5	5	Consulting	WaterTech Ltd
P3	Project manager	15	10	2	Developer	PURC, Hydrocol Ltd
P4	Director	11	11	3	Consulting	Maple consult
P5	Associate	5	5	11	Project financing	Macquarie Group
Mean experience		16.90	7.90			

on their experience and backgrounds and willingness. Designation information of the industry experts is summarised in Table 9.4 with mean years of industry and hands-on PPP experience of 16.90 and 7.90, respectively, and they collectively have participated in 42 PPP water projects, both locally and abroad. For example, experts P1 and P2 work for international water companies currently embarking on BOT water projects in Ghana. The panel of experts included projects and contracts managers, water managers, directors, financial and project analysts from different subsectors and organisations (Table 9.4). These ten experts were deemed appropriate to provide reliable and useful response to the questionnaire given their ample experience in the water industry and in PPP water projects.

9.3.5 Step 5: Determine Membership Functions of the Input Variables

Fuzzy mathematics is used to derive the membership functions (MFs) of the input variables (or RAC). Given that the grade alternatives for evaluating the input variables were defined on a five-point scale (Table 9.3), the MF of a given input variable, u_i, can be obtained by the following equation (Liu et al., 2013):

$$MF_{u_i} = \frac{a_{i1}}{u_{i1}} + \frac{a_{i2}}{u_{i2}} + \cdots + \frac{a_{in}}{u_{in}} = \frac{a_{i1}}{very\,low} + \frac{a_{i2}}{low} + \cdots + \frac{a_{in}}{very\,high} = \frac{a_{i1}}{1} + \frac{a_{i2}}{2} + \cdots + \frac{a_{in}}{5} \quad (9.3)$$

where the ‗numerator', a_{ik}, is the degree of MF (or grade of membership) and denotes the percentage of respondents who scored the ‗denominator', u_{ik}, for the extent of a partner‘s RM capability; the terms a_{ik}/u_{ik} indicate relation between u_{ik} and its MF instead of fractions; and the plus sign (+) is a notation instead of the usual meaning of addition. The above MF of a specific u_i is written as:

$$MF_{u_i} = (a_{i1},\ a_{i2},\ \ldots,\ a_{in}) \quad (9.4)$$

which ranges between [0,1] and the summation of MF_{u_i} must equal to unity. Consequently, the MFs of all the input variables can be expressed in a fuzzy matrix as:

$$R_i = \begin{vmatrix} MF_{u_1} \\ MF_{u_2} \\ \vdots \\ MF_{u_n} \end{vmatrix} = \begin{vmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \dots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{vmatrix} \tag{9.5}$$

whose elements are given by a_{ij} .

9.3.6 Step 6: Determine Membership Functions of RCCI of Public-private Partners

Risk carrying capacity index (RCCI) is the risk allocation (RA) coefficient of the public or private partner for the evaluated risk factor. Consequently, the final risk proportion borne by a party is based on its RCCI. Having established the weighting function set W_i and the fuzzy matrix R_i of the input variables, the MF (also called fuzzy evaluation matrix), D_i , of the RCCI of the public or private partner for a risk factor is obtained by:

$$D_i = W_i \circ R_i = (d_1,\, d_2,\, \ldots,\, d_n) \tag{9.6}$$

$$= \{w_1, w_2, \ldots, w_n\} \circ \begin{vmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \dots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{vmatrix} = (d_1,\, d_2,\, \ldots,\, d_n) \tag{9.7}$$

where d_j is the degree of membership function with respect to D_i which is a fuzzy evaluation matrix. The symbol "$\circ$" denotes the fuzzy composite operation which can be performed by four models (see Lo (1999) for details). As in Chapter 7 (section 7.5.4), the weighted mean method is adopted because it averages out the single impact of a specific input criterion (Chan, 2007).

The $M(\bullet, \oplus)$ method (weighted mean method) is defined as (Hsiao, 1998):

$$d_j = \min\left\{1, \sum_{i=1}^{m} w_i a_{ij}\right\}, \qquad j = 1, 2, \ldots, n \tag{9.8}$$

The symbol "$\oplus$" denotes the summation with 1 as the upper limit. Hsiao (1998, p. 106) noted that ‗the characteristic of this operation is that when the weighting functions w_i are normalised, $\sum_{i=1}^{m} w_i = 1$, the operator "$\oplus$" regresses to the addition of real numbers such that

$$d_j = \sum_{i=1}^{m} w_i a_{ij}, \qquad j = 1, 2, \ldots, n. \tag{9.9}$$

i.e. the operation regresses to $\mathrm{M}(\bullet, +)$'. The effects of all the input variables (i.e., risk allocation criteria) are reserved in this model.

9.3.7 Step 7: Quantify the RCCI and Risk Management Capability of Public and Private Partners

The RCCI of the public or private partner can be calculated based on the MFs obtained $\{D_i = (d_1, d_2, \ldots, d_n)\}$ and the constants (C^T) of the measurement scale intervals (Table 9.3) by using the following equation (Xu et al., 2010):

$$RCCI_i = \sum_{i=1}^{5} D_i C^T = (d_1, d_2, d_3, d_4, d_5) \times (c_1, c_2, c_3, c_4, c_5) \tag{9.10}$$

$$0 < RCCI_{\mathrm{i}} < 1$$

where, *RCCI* denotes the overall *risk carrying capacity index* of a specific partner i (i = public or private partner), and let $RCCI_{gov.}$ and $RCCI_{private}$ denotes RCCI of the government and private entity, respectively; and D_i represents the MF of $RCCI_i$ for the evaluated risk factor.

Similarly, the risk management capability (RMC) level of the public or private partner for an evaluated risk factor can be calculated as (Lu and Lo, 1999):

$$RMC_i = \sum_{i=1}^{5} D_i V = (d_1, d_2, d_3, d_4, d_5) \times (1, 2, 3, 4, 5) \tag{9.11}$$

$$1 \le RMC_i \le 5$$

where, RMC represents *risk management capability* level for a risk factor of a PPP partner i (i = public or private partner); D_i represents the membership function of $RCCI_i$ for the evaluated risk factor; and V is the set of grade alternatives that normalises D_i.

9.3.8 Step 8: Quantify Risk Allocation Proportions – Risk Allocation Decision

The output variables are the RA proportions between the public and private partners according to the input variables $(u_1 - u_7)$ that reflect their RM capabilities. To determine the RA proportions according to each partner‘s RM capability, the RCCI of the public and private partners are expressed as percentage. Gao and Jiang (2008) adopted a similar approach to allocate the risk consequences between the construction client and the contractor. Proportion of risk allocated to the public partner $(\mathrm{P_u})$ is expressed as:

$$P_u = \frac{RCCI_{gov.}}{RCCI_{gov.} + RCCI_{private}} \times 100\% \tag{9.12}$$

And the proportion of risk allocated to the private partner $(\mathrm{P_r})$ is given as:

$$P_r = \frac{RCCI_{private}}{RCCI_{gov.} + RCCI_{private}} \times 100\% \tag{9.13}$$

The output value for the public and private partners ranges in a continuum from 0%, indicating no responsibility for a corresponding partner, through 50%, suggesting equal assumption by both parties, to 100%, denoting full responsibility for a corresponding partner. The sum of the output variable equals 100% for any evaluated risk factor.

9.4 DEMONSTRATION OF THE MODEL

Using data from the third and final round of the Delphi questionnaire survey previously described in Chapter 2 or section 9.3.4, above fuzzy model is applied to allocate the 22 CRFs established in Chapter 8. To show how the fuzzy approach works, one salient risk factor, foreign exchange rate (hereafter called RF1), is chosen for demonstration. Results of remaining risk factors are reported.

9.4.1 Determine Weighting Function Set of the of Input Variables

Recall that the RAC (step 1) were defined as the input variables (section 9.3.2 step 2). Having established the seven input variables (see section 9.3.2), the weighting function of each input variable is obtained through Eq. (9.1). From Table 9.5, given that the total mean value of all the input variables is 39.57, the weighting of, for example, *"Foresee and assess the risk"* (u_1) is normalised and obtained as:

$$w_{u_1} = \frac{M_i}{\sum_{i=1}^{7} M_i} = \frac{6.22}{6.22 + 6.14 + 5.97 + 5.27 + 5.43 + 5.49 + 5.05} = \frac{6.22}{39.57} = 0.157$$

Based on this method, the obtained weighting functions of all the input variables are given in Table 9.5. And the normalised weighting function set (according to Eq. (9.1)) is

$$\sum_{i=1}^{7} w_i = 0.157 + 0.155 + 0.151 + 0.133 + 0.137 + 0.139 + 0.128 = 1$$

Table 9.5 Input variables and their weighting functions

ID	Linguistic input variables (U)	Mean score**	Weighting function (w_i)
u_1	Foresee and assess the risk	6.22	0.157
u_2	Control the chance of risk occurrence	6.14	0.155
u_3	Minimise the loss if risk occurs	5.97	0.151
u_4	Sustain the consequence	5.27	0.133
u_5	Bear the risk at the lowest price	5.43	0.137
u_6	Benefit from bearing risk	5.49	0.139
u_7	Assume and manage the direct loss	5.05	0.128
	Total Mean value (seven input variables)	39.57	$\sum w_i = 1$

**Mean scores for round two of Delphi survey as found in Table 9.2

9.4.2 Set up Expert Teams from the Public and Private Sectors

Based on third round of a Delphi questionnaire survey (described in section 9.3.4), the experts from the public sector (Team A) were asked to independently assess each risk factor against each input variable (u_i) in terms of degree of risk management capability of the government. Experts from the private sector (Team B) were also requested to do the same based on their professional judgment and experience. This exercise helps to determine the MF of each input variable for each risk factor, for both sectors.

9.4.3 Determine the MFs of the Input Variables

The MFs of the input variables for an evaluated risk factor are derived from the collective assessments of experts in each team (refer to section 9.3.4). For RF1, the survey indicated that Team A evaluated u_1 (*foresee and assess risk*) as follows: 0% as ‗very low‘, 20% as ‗low‘, 60% as ‗moderate‘, 20% as ‗high‘, and 0% as ‗very high‘ capability. Hence, the MF of u_1 for RF1 according to Team A is obtained through Eq. (9.3) as:

$$MFu_{1(\mathrm{A})} = \frac{0.00}{\text{very low}} + \frac{0.20}{\text{low}} + \frac{0.60}{\text{moderate}} + \frac{0.20}{\text{high}} + \frac{0.00}{\text{very high}} = \frac{0.00}{1} + \frac{0.20}{2} + \frac{0.60}{3} + \frac{0.20}{4} + \frac{0.00}{5}$$

And it is written through Eq. (9.4) as $MFu_{1(\mathrm{A})} = (0.00, 0.20, 0.60, 0.20, 0.00)$. MFs for the remaining input variables $(u_2 - u_7)$ are determined by the same approach, giving the fuzzy matrix through Eq. (9.5) as:

$$R_{\mathrm{A}} = \begin{vmatrix} MF_{u_1} \\ MF_{u_2} \\ MF_{u_3} \\ MF_{u_4} \\ MF_{u_5} \\ MF_{u_6} \\ MF_{u_7} \end{vmatrix} = \begin{vmatrix} 0.0 & 0.2 & 0.6 & 0.2 & 0.0 \\ 0.0 & 0.2 & 0.2 & 0.4 & 0.2 \\ 0.2 & 0.0 & 0.6 & 0.0 & 0.2 \\ 0.0 & 0.0 & 0.8 & 0.2 & 0.0 \\ 0.0 & 0.0 & 0.6 & 0.2 & 0.2 \\ 0.0 & 0.2 & 0.6 & 0.2 & 0.0 \\ 0.0 & 0.0 & 0.2 & 0.6 & 0.2 \end{vmatrix}$$

Similarly, the MF of u_1 for RF1 according to Team B is derived through Eq. (9.3) and written through Eq. (9.4) as:

$$MFu_{1(\mathrm{B})} = \frac{0.00}{\text{very low}} + \frac{0.20}{\text{low}} + \frac{0.60}{\text{moderate}} + \frac{0.00}{\text{high}} + \frac{0.20}{\text{very high}} = (0.00,\ 0.20,\ 0.60,\ 0.00,\ 0.20)$$

MFs for the remaining input variables are determined by the same approach, giving the fuzzy matrix through Eq. (9.5) as:

$$R_{\mathrm{B}} = \begin{vmatrix} MF_{u_1} \\ MF_{u_2} \\ MF_{u_3} \\ MF_{u_4} \\ MF_{u_5} \\ MF_{u_6} \\ MF_{u_7} \end{vmatrix} = \begin{vmatrix} 0.0 & 0.2 & 0.6 & 0.0 & 0.2 \\ 0.2 & 0.4 & 0.2 & 0.0 & 0.2 \\ 0.0 & 0.4 & 0.4 & 0.0 & 0.2 \\ 0.0 & 0.2 & 0.6 & 0.2 & 0.0 \\ 0.2 & 0.2 & 0.4 & 0.2 & 0.0 \\ 0.0 & 0.0 & 0.6 & 0.2 & 0.2 \\ 0.0 & 0.6 & 0.2 & 0.2 & 0.0 \end{vmatrix}$$

These matrixes are also presented in column 4 of Tables 9.6 and 9.7.

Table 9.6 RCCI of the government for foreign exchange rate (RF1)

ID	Risk allocation criteria (RAC)	Weighting, w_i	MFs of input variables (RAC)	MF of RCCI (government)
u_1	Foresee and assess the risk	0.157	(0.00, 0.20, 0.60, 0.20, 0.00)	
u_2	Control the chance of risk occurrence	0.155	(0.00, 0.20, 0.20, 0.40, 0.20)	
u_3	Minimise the loss if risk occurs	0.151	(0.20, 0.00, 0.60, 0.00, 0.20)	
u_4	Sustain the consequence	0.133	(0.00, 0.00, 0.80, 0.20, 0.00)	(0.03, 0.09, 0.51, 0.25, 0.11)
u_5	Bear the risk at the lowest price	0.137	(0.00, 0.00, 0.60, 0.20, 0.20)	
u_6	Obtain intangible asset (obtain benefit)	0.139	(0.00, 0.20, 0.60, 0.20, 0.00)	
u_7	Assume and manage the direct loss	0.128	(0.00, 0.00, 0.20, 0.60, 0.20)	

Table 9.7 RCCI of the private sector for foreign exchange rate (RF1)

ID	Risk allocation criteria (RAC)	Weighting, w_i	MFs of input variables (RAC)	MF of RCCI (private sector)
u_1	Foresee and assess the risk	0.157	(0.00, 0.20, 0.60, 0.00, 0.20)	
u_2	Control the chance of risk occurrence	0.155	(0.20, 0.40, 0.20, 0.00, 0.20)	
u_3	Minimise the loss if risk occurs	0.151	(0.00, 0.40, 0.40, 0.00, 0.20)	
u_4	Sustain the consequence	0.133	(0.00, 0.20, 0.60, 0.20, 0.00)	(0.06, 0.28, 0.43, 0.11, 0.12)
u_5	Bear the risk at the lowest price	0.137	(0.20, 0.20, 0.40, 0.20, 0.00)	
u_6	Obtain intangible asset (obtain benefit)	0.139	(0.00, 0.00, 0.60, 0.20, 0.20)	
u_7	Assume and manage the direct loss	0.128	(0.00, 0.60, 0.20, 0.20, 0.00)	

9.4.4 Determine the MFs of RCCI of Public and Private Partners

Following above, the MF of RCCI of the public partner for RF1 can be calculated based on the weighting function set obtained (W_i) and the fuzzy matrix (R_{A}) by using the fuzzy composite operations of the $M(\bullet, \oplus)$ method (Eq. (9.9)) as:

$$D_{\mathrm{RCCI_{gov.}}} = W_i \circ R_{\mathrm{A}} = \left(w_{u_1},\ w_{u_2},\ w_{u_3},\ w_{u_4},\ w_{u_5},\ w_{u_6},\ w_{u_7}\right) \times \begin{vmatrix} MF_{u_1} \\ MF_{u_2} \\ MF_{u_3} \\ MF_{u_4} \\ MF_{u_5} \\ MF_{u_6} \\ MF_{u_7} \end{vmatrix}$$

$$D_{\mathrm{RCCI_{gov.}}} = (0.157, 0.155, 0.151, 0.133, 0.137, 0.139, 0.128) \times \begin{vmatrix} 0.0 & 0.2 & 0.6 & 0.2 & 0.0 \\ 0.0 & 0.2 & 0.2 & 0.4 & 0.2 \\ 0.2 & 0.0 & 0.6 & 0.0 & 0.2 \\ 0.0 & 0.0 & 0.8 & 0.2 & 0.0 \\ 0.0 & 0.0 & 0.6 & 0.2 & 0.2 \\ 0.0 & 0.2 & 0.6 & 0.2 & 0.0 \\ 0.0 & 0.0 & 0.2 & 0.6 & 0.2 \end{vmatrix} = (0.03, 0.09, 0.51, 0.25, 0.11)$$

The result is also tabulated in Table 9.6. Using the same procedure, the MF of RCCI of the private partner for RF1can be calculated as (see also Table 9.7):

$$D_{\mathrm{RCCI_{pri.}}} = (0.157, 0.155, 0.151, 0.133, 0.137, 0.139, 0.128) \times \begin{vmatrix} 0.0 & 0.2 & 0.6 & 0.0 & 0.2 \\ 0.2 & 0.4 & 0.2 & 0.0 & 0.2 \\ 0.0 & 0.4 & 0.4 & 0.0 & 0.2 \\ 0.0 & 0.2 & 0.6 & 0.2 & 0.0 \\ 0.2 & 0.2 & 0.4 & 0.2 & 0.0 \\ 0.0 & 0.0 & 0.6 & 0.2 & 0.2 \\ 0.0 & 0.6 & 0.2 & 0.2 & 0.0 \end{vmatrix} = (0.06, 0.28, 0.43, 0.11, 0.12)$$

Using the same approach, MFs of RCCI of the public (government) and private sectors for the remaining risk factors are obtained and reported in Table 9.8.

Table 9.8 MFs of RCCI of public and private sectors

ID	Critical risk factors	Membership functions of Risk Carrying Capacity Index (RCCI)	
		Government	Private sector
RF1	Foreign exchange rate	(0.03, 0.09, 0.51, 0.25, 0.11)	(0.06, 0.28, 0.43, 0.11, 0.12)
RF4	Corruption	(0.06, 0.21, 0.58, 0.06, 0.09)	(0.06, 0.06, 0.65, 0.18, 0.06)
RF10	Water theft	(0.17, 0.26, 0.26, 0.23, 0.09)	(0.09, 0.17, 0.37, 0.29, 0.09)
RF8	Non-payment of bills	(0.03, 0.32, 0.39, 0.12, 0.14)	(0.32, 0.14, 0.40, 0.09, 0.06)
RF3	Political interference	(0.06, 0.09, 0.15, 0.39, 0.32)	(0.32, 0.45, 0.12, 0.09, 0.03)
RF6	High operational costs	(0.40, 0.26, 0.24, 0.08, 0.03)	(0.06, 0.08, 0.14, 0.25, 0.46)
RF13	Pipeline bursts during distribution	(0.19, 0.32, 0.20, 0.22, 0.06)	(0.09, 0.19, 0.23, 0.35, 0.14)
RF19	Lack of PPP experience	(0.00, 0.15, 0.49, 0.25, 0.11)	(0.14, 0.32, 0.49, 0.06, 0.00)
RF7	Inflation rate volatility	(0.11, 0.20, 0.35, 0.20, 0.14)	(0.11, 0.17, 0.35, 0.25, 0.12)
RF14	Construction time and cost overrun	(0.26, 0.42, 0.23, 0.03, 0.05)	(0.03, 0.08, 0.18, 0.34, 0.38)
RF20	Poor contract design	(0.06, 0.09, 0.66, 0.14, 0.06)	(0.00, 0.22, 0.63, 0.09, 0.06)
RF17	Supporting utilities risk	(0.11, 0.08, 0.28, 0.38, 0.15)	(0.09, 0.37, 0.29, 0.14, 0.11)
RF22	Interest rate volatility	(0.03, 0.28, 0.35, 0.34, 0.00)	(0.03, 0.23, 0.29, 0.34, 0.11)
RF2	Political discontent and (early) termination	(0.03, 0.06, 0.26, 0.46, 0.19)	(0.28, 0.47, 0.20, 0.06, 0.00)
RF15	Design and construction deficiencies	(0.44, 0.16, 0.29, 0.08, 0.03)	(0.03, 0.08, 0.23, 0.16, 0.50)
RF18	Conflict between partners	(0.06, 0.00, 0.86, 0.03, 0.06)	(0.00, 0.03, 0.83, 0.09, 0.06)
RF9	Water pricing and tariff review uncertainty	(0.03, 0.00, 0.48, 0.27, 0.22)	(0.25, 0.24, 0.48, 0.00, 0.03)
RF5	Financial and refinancing risk	(0.03, 0.00, 0.48, 0.27, 0.22)	(0.25, 0.24, 0.48, 0.00, 0.03)
RF16	Land acquisition risk	(0.03, 0.03, 0.16, 0.35, 0.43)	(0.45, 0.35, 0.14, 0.03, 0.03)
RF11	Public resistance to PPP	(0.03, 0.18, 0.49, 0.20, 0.11)	(0.16, 0.28, 0.43, 0.09, 0.03)
RF21	Change in government / political opp'tion	(0.00, 0.03, 0.32, 0.34, 0.32)	(0.21, 0.40, 0.34, 0.06, 0.00)
RF12	Insufficient private operator performance	(0.29, 0.34, 0.20, 0.14, 0.03)	(0.08, 0.09, 0.14, 0.37, 0.32)

9.4.5 Quantify RCCI and Risk Management Capability of Public and Private Partners

The obtained MFs of the public $\left(D_{\mathrm{RCCI}_{\mathrm{gov.}}}\right)$ and private $\left(D_{\mathrm{RCCI}_{\mathrm{priv.}}}\right)$ partners (in Table 9.8) are further normalised by considering the constants of the scale intervals by using Eq. (9.10) in order to obtain the RCCI: For RF1, the public partner‘s RCCI is:

$$RCCI_{gov.} = \sum_{i=1}^{5} D_{\mathrm{RCCI}_{\mathrm{gov.}}} \times C^{T} = (0.03, 0.09, 0.51, 0.25, 0.11) \times (0.125, 0.250, 0.500, 0.750, 0.875) = 0.57$$

And its defuzzified risk management capability (RMC) level for RF1 through Eq. (9.11) is also:

$$RMC_{\mathrm{gov.}} = \sum_{i=1}^{5} D_{\mathrm{RCCI}_{\mathrm{gov.}}} \times V = (0.03, 0.09, 0.51, 0.25, 0.11) \times (1, 2, 3, 4, 5) = 3.3\,(\text{moderate})$$

Similarly, the private partner‘s RCCI for RF1 is:

$$RCCI_{private} = \sum_{i=1}^{5} D_{\mathrm{RCCI}_{\mathrm{priv.}}} \times C^{T} = (0.06, 0.28, 0.43, 0.11, 0.12) \times (0.125, 0.250, 0.500, 0.750, 0.875) = 0.48$$

And its defuzzified RMC level for RF1 is calculated through Eq. (9.11):

$$RMC_{private} = \sum_{i=1}^{5} D_{\mathrm{RCCI}_{\mathrm{priv.}}} \times V = (0.06, 0.28, 0.43, 0.11, 0.12) \times (1, 2, 3, 4, 5) = 2.9\,(\text{moderate})$$

The RCCIs and RMCs of both government and private sector for the remaining risk factors are calculated using the same procedure and reported in columns 3 and 4 of Table 9.9, respectively. The scale intervals of the RMC is interpreted as: ‗very low risk management capability‘ (RMC < 1.5); ‗low risk management capability (1.5 ≤ RMC < 2.5); ‗moderate risk management capability‘ (2.5 ≤ RMC < 3.5); ‗high risk management capability (3.5 ≤ RMC < 4.5); and ‗very high risk management capability‘ (RMC ≥ 4.5).

9.4.6 Quantify Risk Allocation Proportions

For a specific risk factor, the public and the private sector partners exhibit different risk carrying capacities, as demonstrated above, suggesting differences in abilities to foresee and assess risk, minimise risk loss, control risk chance of occurrence, etc. Therefore, as indicated earlier, the RCCI and FRMC are indications of the risk carrying or management capacity of the private or public sector partner in a PPP project. The premise of this thesis is that risk impacts (in monetary terms) should be allocated between the public and private sector participants according to their RCCI, so that both participants truly share in the responsibility for dealing with the risk consequences, and partake in the risk management (Gao and Jiang, 2008). To determine the risk allocation proportions, the RCCI of the public and private sectors are expressed as percentage (Gao and Jiang, 2008; Xu et al., 2010). For instance, proportion of RF1(foreign exchange rate) borne by government is quantified as (Eq. (9.12)):

$$P_u = \frac{RCCI_{gov.}}{RCCI_{gov.} + RCCI_{private}} \times 100\% = \frac{0.57}{0.57 + 0.48} \times 100\% = 54.52\%$$

Using Eq. (9.13), proportion of RF1 allocated to the private partner is:

$$P_r = \frac{RCCI_{private}}{RCCI_{gov.} + RCCI_{private}} \times 100\% = \frac{0.48}{0.57 + 0.48} \times 100\% = 45.58\%$$

Following above approach, the risk allocation proportions for the remaining risk factors are quantified and presented in column 4 under ‗RCCIs and Proportion of risk allocation (%)' in Table 9.9. The model further predicts and compares the capabilities of both parties to manage each risk factor. Thus, the risk capability index directly relates to a risk allocation proportion. The model outputs for the 22 critical risk factors are briefly discussed below.

Table 9.9 Summary of model results

ID	Critical risk factor (CRF)	Risk management capability (RMC) level				RCCIs and Proportion of risk allocation (%)			
		Government		Private sector		Government		Private sector	
		Index	Linguistic	Index	Linguistic	RCCI	%	RCCI	%
RF1	Foreign exchange rate	3.3	moderate	2.9	moderate	0.57	54.42	0.48	45.58
RF4	Corruption	2.9	moderate	3.1	moderate	0.47	47.16	0.53	52.84
RF10	Water theft	2.8	moderate	3.1	moderate	0.46	46.43	0.53	53.57
RF8	Non-payment of bills	3.0	moderate	2.4	low	0.49	55.85	0.39	44.15
RF3	Political interference	3.8	high	2.1	low	0.67	68.98	0.30	31.02
RF6	High operational costs	2.1	low	4.0	high	0.32	31.31	0.69	68.69
RF13	Pipeline bursts during distribution	2.6	moderate	3.3	moderate	0.42	43.21	0.56	56.79
RF19	Lack of PPP experience	3.3	moderate	2.5	moderate	0.57	59.69	0.38	40.31
RF7	Inflation rate volatility	3.0	moderate	3.1	moderate	0.51	49.35	0.52	50.65
RF14	Construction time & cost overrun	2.2	low	3.9	high	0.32	31.63	0.69	68.37
RF20	Poor contract design	3.0	moderate	3.0	moderate	0.51	51.18	0.49	48.82
RF17	Supporting utilities risk	3.4	moderate	2.8	moderate	0.59	56.83	0.45	43.17
RF22	Interest rate	3.0	moderate	3.3	moderate	0.50	47.32	0.56	52.68
RF2	Political discontent and (early) termination	3.7	high	2.0	low	0.66	69.19	0.30	30.81
RF15	Design and construction deficiencies	2.1	low	4.0	high	0.32	31.68	0.70	68.32
RF18	Conflict between partners	2.9	moderate	3.2	moderate	0.47	46.80	0.52	53.20
RF9	Water pricing and tariff review uncertainty	3.7	high	2.3	low	0.64	64.38	0.35	35.62
RF5	Financial and refinancing risk	2.3	low	3.8	high	0.35	34.08	0.67	65.92
RF16	Land acquisition risk	4.1	high	1.8	low	0.73	73.82	0.26	26.18
RF11	Public resistance to PPP	3.2	moderate	2.5	moderate	0.53	56.94	0.40	43.06
RF21	Change in government / political opposition	3.9	high	2.2	low	0.70	67.35	0.34	32.65
RF12	Insufficient private operator performance	2.3	low	3.8	high	0.35	34.59	0.66	65.41

9.5 DISCUSSION OF MODEL OUPUT

This model assumes that the risk allocation proportions would be maintained *ex*-post, through an enforcement system such as contractual provisions. That is, the pre-agreed upon risk-sharing proportions would be well drafted into the contractual clauses and further tied to payment arrangements (Siebert, 1987; Chang, 2012; Norton de Matos, 1996). This means that the risk allocation proportions must be supported by the contractual structure, payment mechanisms and financial risk mitigation tools adopted in the contract. These factors must be combined and integrated into the risk allocation decision to guarantee the achievement of the *ex-ante* risk-sharing proportions of the model (Chang, 2012).

The output of the model is the risk allocation proportion between the public and the private sectors, as presented in Table 9.9. It shows that the impact of *foreign exchange (FX) rate* risk in PPP water projects should be allocated between the government and the private participant by 54.52% and 45.58%, respectively. The model ensures that *FX* risk is shared between both participants in proportions to their abilities to foresee and assess, control, minimise loss of, sustain, bear at least cost, benefit from, and assume and manage the occurrence and consequence (or loss) of the risk. Table 9.8 shows that the parties have moderate risk capabilities to manage *FX* risk. However, the government has a relatively higher index (=3.3) while the private sector has slightly lower capability index (=2.9). This allocation proportions suggests that *FX* risk is (1) not directly in control of government or investor and (2) no partner has a high capability to manage it. Shifting a large proportion of *FX* to an investor may imply charging higher water tariffs, the government therefore should bear a large portion at a lower cost by influencing it through its foreign currency, monetary and fiscal policy interventions (Matsukawa et al., 2003). For instance, in a 25-year water concession between the Municipality of Sofia and Sofijska Voda AD (SV), both parties shared foreign exchange exposure, which prompted the Bulgarian government to create a currency board as a means to reduce exposure and stabilise investment (World Bank, 2006).

On *corruption risk*, the model shows that cost arising from a corrupted PPP deal should be allocated between the government and the private firm by 47.16% and 52.84% as reflected by their capabilities of 2.9 and 3.1, respectively. This allocation emanates from the view that the private sector is more likely to unduly influence the procurement process through bribe offerings, as observed by Hellman et al. (2000) and Hall and Lobina (2007). The contracting authority (or government officials) has a responsibility of ensuring open, transparent, fair and competitive tendering (World Bank, 2006; Li et al., 2005b; Kerf et al., 1998) without requesting or receiving bribes from competing firms (bidders). Private sector firms, on the other hand, must observe the rules of the game and also be mindful of their reputation and the confidence of the marketplace, without offering bribes to or influencing government officials. This allocation contradicts Ke et al.'s (2010a) and Ke et al.'s (2013) findings that corruption risk should be ‗mainly allocated' to the government.

Similarly, the public sector has the least capability (=2.8) to manage *water theft* compared to the private sector (=3.1), although both parties have moderate management capabilities. Therefore, water theft risk is allocated between the government and the private firm by 46.43% and 53.57%, respectively. This comes from a perspective in which the private operator should assume the commercial risk and take steps to detect theft, disconnect illegal connections, and discipline staff who facilitate theft. Conversely, it is the government's responsibility to uphold the law, arrest thieves, and provide effective courts (effective legal system) (Idelovitch and Klas,1995) in which thieves are punished and the operator can claim compensation for very significant losses.

Non-payment of bills risk should be allocated between the contracting authority and the operator in proportions of 55.85% and 44.15%, respectively. This allocation is supported by the Gdansk affermage-lease contract (Poland) in which non-payment by customers was spread between the private firm (Saur Neptun Gdansk, SNG) and the city Government of Gdansk (World Bank, 2006). Here, the government has a moderate capability (=3.0) while the private operator has a low capability (=2.4) to manage and control this risk. Collection of water bills from customers has been a difficult exercise for the private sector in many countries (Dulaimi et al., 2010; Beato and Vives, 1996; Balance and Trémolet, 2005). Ghana is no exception (Ameyaw and Chan, 2013a). The government should assume the legal risk and commit to effecting strict collection policies and legal actions against defaulting customers, especially public institutions, to enable the operator to recover unpaid bills. The operator also has the commercial responsibility of identifying and disconnecting delinquent customers.

Political interference (in tariff setting and adjustment), as discussed in Chapter 8, is directly under the government‘s control and therefore has a high capability (=3.8) to assume this risk in proportion of 68.98%. This stems from the perspective that the government should provide a political commitment to charge economic tariffs and allow justifiable increases to reflect operating costs, through tariff indexation formula or tariff resets. Beato and Vives (1996) supports this allocation, arguing that the government has the power and responsibility to formulate a well-functioning framework that provides the project company with tools to include transitional systems that encourage gradual water tariff increases. The private firm, on the other hand, has a low capability (=2.1), hence assuming a proportion of 31.02%. This suggests that the operating firm has the responsibility to strictly control operating cost, and to provide improved service to merit tariff increases.

High operational cost mainly results from external economic factors such as inflationary pressures, FX rate volatility and poor raw water quality (see Chapter 8). Inefficient management and/or failure to project costs accurately by the private operator may also contribute to high operating costs. The model shows that the operator has a high capability (=4.0) to control such costs through effective cost management measures and is allocated a proportion 68.69% of this risk. The government has low capacity of 2.1 and is allocated a proportion of 31.31%, suggesting that it has the responsibilities to ensure (i) strong macroeconomic policies that reduce significant changes in inflation, FX and interests rates and (ii) timely disclosure of the true state of the economy and public finances to aid the operator to predict future events (Thobani, 1999).

Pipeline bursts risk is allocated between the government and the firm in by 43.21% and 56.79%, respectively. This risk directly falls under the responsibility and control of the operator. Comparatively, the private sector has a moderate capability (=3.3) and technical expertise to detect the causal factors and a financial incentive to resolve the consequences of pipe breaks. In Ghana, experience has shown that the public water utility exhibits both frail capacity and commercial drive (Mugisha, 2007) to tackle pipe bursts and associated losses. The public sector is therefore allocated 43.21% of the risk, as indicated by its capability (=2.6).

The government is allocated a higher proportion of its *lack of PPP experience* by 59.69% (moderate capability =3.3) while the private firm is assigned 40.31%. Once the government decides to engage the private sector in public water infrastructure services delivery, it has a major responsibility to develop its capacity, or engage external experts to complement public sector expertise and assist in the PPP processes (Meng et al., 2011;

Farquharson et al., 2011). Though the private operator has a moderate capability (=2.5) to assume its public partner‘s inexperience, it has some responsibility to devise effective measures to engage an inexperienced contracting authority.

Regarding *inflation risk*, the government and the private sector have moderate capabilities of 3.0 and 3.1 and is allocated by 49.35% and 50.65%, respectively. This allocation is in agreement with contracting practice (Lam et al., 2007) and many previous studies (e.g., Shendy et al., 2011; Ng and Loosemore, 2007; Wang and Tiong, 2000) which highlighted that inflation risk should be shared. The government should bear the political risk portion by allowing total or partial indexing of water tariffs to inflation. Thus, allocating above proportion to government would prompt it to pursue stable macroeconomic policies. The private firm should also bear the remaining portion through measures adopted to maintain value (Shendy et al., 2011).

The model shows that the concessionaire has a considerably high control and capability (=3.9) than its public partner (low capability =2.2) over *construction time and cost overruns*, suggesting that the risk should be allocated in proportions of 68.37% and 31.63%, respectively. Chung et al. (2010) verified that the VfM is associated with efficiency gains from the private sector‘s expertise, who are commercially-driven and flexible in implementing the means to achieve desired outcomes. For example, the PC can transfer the risk to a construction contractor through design–build method (Zou et al., 2008). And the government bearing a small proportion means the possibility of its intervention (Shendy et al., 2011); because the water facility reverts back to the public sector after the concession contract, the government is likely to influence construction procedures and technology, which could result to time and cost overruns. However, where the government makes no such changes, the private entity should fully assume this risk.

Both the public and private partners have a moderate capability to deal with the consequences of *poor contract design*, 3.05 (≈3.0) and 2.98 (≈3.0) and should be allocated by 51.18% and 48.82%, respectively. This risk allocation proportion has some implications. First, given its limited experience in PPP procurement, the Government of Ghana has the major responsibility to engage external advisors during the procurement phase to aid the contract design process, as duly highlighted by previous studies and government guidance (Men et al., 2011; Carrillo et al., 2008; Farquharson et al., 2011; Infrastructure Consortium for Africa, 2009). Second, the bidders have ‗ethical‘ and ‗moral‘ responsibility not to exploit errors in contracts by submitting unrealistic bids, which would likely cost the public in terms of time and money.

Regarding *supporting utilities (electricity/energy)* risk, the government is allocated a large proportion of 56.83% while the private firm is allocated the remainder (43.17%). The government‘s risk management capability is very close to high, with a fuzzy index of 3.4 while the private sector‘s capability is moderate (=2.8). Supporting utilities risk is often assumed by governments as incentive and support to the concessionaire. In the Guangxi Laibin Power project (China), for example, the Guangxi Government provided the concessionaire with power transmission line and start-up electricity (Wang and Tiong, 2000). Augenblick and Custer (1990) noted that the firm may bear part of the cost associated with provision of such utilities under the supply contracts.

Interest rate risk is allocated to the government and concessionaire in proportions of 47.32% and 52.68%, respectively. This allocation strategy generally corroborates with Ke et al. (2010a), but contradicts Wang and Tiong (2000) and Guasch (2004) who noted that interest rate risk should be solely allocated to the private investor. As stated earlier, the government has a political/economic responsibility to pursue stable macroeconomic policies to minimise large changes in floating interest rates (Thobani, 1999), as reflected by its moderate (=3.0) control over the risk. Allocating a larger portion to the concessionaire is, however, supported by the following reasons. The concessionaire (i) has a ‗higher' moderate capability (=3.3) and incentive to manage this risk because it has an option of putting in place hedging facilities, such as interest rate swaps, (ii) is encouraged to limit its exposure to interest rate risk by reducing excessive borrowing, especially in foreign currencies, and (iii) the public (and consumers) is/are cushioned against significant interest rate shocks.

Political discontent and (early) termination risk is directly under the government's control because it relates to government's or government officials' actions, hence the government is allocated a large proportion of 69.19%, indicating that it has a high capability of 3.7 to deal with the risk. Guasch (2004) supports this allocation, arguing that in case of contract termination, adequate compensation to be paid by government. However, the concessionaire, which has little or no influence over government decisions/actions (Chan and Hubbard, 2012), is allocated a small proportion of 30.81%. This implies that the concessionaire, however has a responsibility to provide improved services to customers to win public and political support.

The private partner should bear 68.23% of *design and construction deficiencies*, especially in a water scheme that adopts innovative design and construction approaches. Many previous studies support this risk allocation (Li et al., 2005a; Wang and Tiong, 2000; Arndt, 1998), because the private sector has a high capability (=4.00) and technical expertise and competence to provide innovative design and construction solutions. The PC reserves the responsibility to agree the design and built facility with members of the consortium, regarding specifications, structural integrity, quality of treated water, etc. The government is allocated a small portion of 31.68% as reflected by its low capability index of 2.1. The government has the right, and is likely, to mandate changes to the design at construction phase due to external influences, or changes in service requirements or water policy (Smith, 1999), which could cause design and construction defects.

Conflicts ensuing between the government and the concessionaire are allocated by 46.80% and 53.20%, in response to their capabilities to manage this risk, 2.9 and 3.2, respectively. This implies that both parties have the responsibility for (i) ensuring a clear contract devoid of ambiguities to minimise conflict over its interpretation, (ii) setting up an arbitration committee or panels of experts (clearly provided for in the contract) from the outset and (iii) allowing recourse to the highest local court, or international arbitration to alleviate the concessionaire‘s fears of being mistreated by the local judicial system (Jadresic, 2007; Dulaimi et al., 2010; Thobani, 1999; Wang and Tiong, 2000; Kerf et al., 1998).

Though Ghana has an independent economic regulator (for water and electricity) responsible for water pricing and tariff reviews, its decisions are not always final or enforceable but subject to public and political pressure, as discussed in Chapter 8. This means that the government has considerably more influence and control (high capability =3.7) than the private firm (low capability =2.3) over *water pricing and tariff review risk*. Hence, the government bears 64.38% while the concessionaire assumes a low share of 35.62%. This allocation scheme is likely to bolster investors‘ confidence in the sector.

One key reason for a PPP is attraction of private capital following the government‘s fiscal constraints. Hence, financing and refinancing mainly rests with the private partner (Shendy et al., 2011; Ke et al., 2010a,b). The private firm is believed to have a high capability (=3.8) to secure adequate debt and/or equity required for a project within time at favourable conditions, and is allocated 65.92% of the risk while the government assumes the reminder (34.08%; low capability = 2.3). However, given the high risk perception of water projects in Ghana (Ameyaw and Chan, 2013a), government support/guarantees, such as grants, loan or loan guarantees, equity participation, water purchase agreement, exclusive concession (Freshfields, 1995; Xu et al., 2011), is required to enable the concessionaire to find lenders from the financial market. This allocation strategy reflects what actually happens in practice, as financing risk cannot solely be allocated to the private entity, especially in developing countries.

Like supporting utilities, *land acquisition* risk is often taken by the government as a governmental support to the private sector. The government has the experience and resources to deal with this risk, and possesses legal powers (*expropriation, compulsory purchase or takings*) (Lindsay, 2012; Li et al., 2005b) to compulsorily acquire land for a project of public interest. An example is the Nungua SWRO BOOT project (section 3.6.3) in which the government secured land through direct negotiation or compulsory acquisition (see Chapter 8). In the Laibin B power project, the Guangxi Government assumed the responsibility for the delivery of the site and access roads and completion of preliminary contract works (Wang and Tiong, 2000). In this study, the model allocated 73.82% of the risk to the government, which has a high capability (=4.1). The private firm has a low capability (=1.8) and is allocated 26.18%, implying that it has to reimburse the public water utility (GWCL) fully the cost of the land through the water purchase agreement, as in the case of the Nungua SWRO project. This allocation scheme mitigates construction time delay.

Public resistance to PPP is shared between the government and private entity by 56.94%

and 43.06%, in proportions to their moderate capabilities to manage the risk, 3.2 and 2.5, respectively. This allocation scheme implies that both parties have a shared responsibility to communicate and articulate the potential value (e.g., improved services) of the water project through private participation to the public. The government, however has the major responsibility, because public resentment is more a governance risk (Barraqué, 2003), and governments have a vested interest and resources in reducing public repulsion (Chung et al., 2010). The concessionaire also must adopt ‗corporate citizenship models' (Chung et al., 2010) by making the project part of served communities, which helps to win public support.

National Treasury (2004) and Li et al. (2005a) suggested that it is sensible for the government to assume *change in government and political opposition* risk, because it is less risk-averse and is best able to determine and influence its decisions (Medda, 2007). This supports the finding that the government has a high capability (=3.9) to control its political and/or economic decisions and actions while an investor has a low (=2.2) control. For example, a newly-elected government may initiate changes in contractual or legal frameworks which directly and expressly affects the concessionaire (Guasch, 2004). The government is therefore allocated a large proportion of 67.35% while the private firm is allocated 32.65%. This allocation implies that the investor has an obligation to ensure that the deal entered into is fair, transparent, sound and ensures VfM for the public client, in order to make it difficult for future governments to oppose. Moreover, above allocations are supported by Medda (2007) who argued that risks (e.g., change in government and political opposition) arising from government actions or decisions are ‗mainly allocated to the public sector, around 70%' (pg. 215).

The private firm is engaged due to its perceived ability to offer innovative solutions in designing and constructing new pipe network or water treatment plant, and reforming ill-performing public utility. Hence, a large proportion of 65.14% of *operator performance risk* is allocated to the private sector, as reflected by its high risk management capability (=3.8). To bid for a project, the private firm has a duty to assess its competencies against the demands and requirements of the public client. The public partner also has a low capability (2.3) and therefore bears 34.59% of this risk. By PPP, both sectors bring together their core skills/competencies to a project, which suggests that the public sector has a responsibility to support the project company, such as creation of supportive operating and legal environment (Freshfields, 1995; Infrastructure Consortium for Africa, 2009), apart from selecting a strong consortium (Jefferies et al., 2002; UNIDO, 1996).

9.6 VALIDATION OF THE STUDY

Validation is the final and an important stage of a research cycle to assess the quality and credibility of the research output(s) (Yang et al., 2010; Lucko and Rojas, 2010). However, the challenge with the process of validation is that there is no established procedure to identify the specific validation techniques, statistical tests, etc., to use in the validation process (Sargent, 1991). Law (2007) therefore emphasised that validation always depends on the specific purpose of the research study.

Validation is concerned with doing the right things (Lucko and Rojas, 2010). Thus, it seeks to ensure that each stage of the adopted research methodology strictly adheres to the highest standards of quality in order to produce credible and quality results acceptable by users or industry practitioners. According to Botten et al. (1989) cited in Yeung (2007), validation measures usability, adequacy, precision, accuracy, etc. of a system. And the purpose of validation is to ensure improvement in the credibility of the outcomes /

performance of a study or a system (Carson, 2002). Lucko and Rojas (2010) described six types of validation in construction engineering and management research as (i) internal validity, (ii) external validity, (iii) face validity, (iv) content validity, (vi) construct validity, and (v) criterion validity. This study considers the first five validation processes, based on two sets of questionnaire.

The processes for assessing research validity can be grouped into qualitative and quantitative (Yang et al., 2010; O‘Keefe et al., 1987). Qualitative approaches lend themselves to opinion-based data that are in the form of words and ideas rather than numbers, and examples include face validation, content validation, etc. (Roschke, 1994). Quantitative approaches, on the other hand, apply research designs that entail numerical or statistical and objective data that can be used to test hypothesised relationships among variables, including paired *t* tests and Hotelling‘s one sample T^2 test (Yang et al., 2010; Roschke, 1994). This study adopted a qualitative method of validation because the identified critical success factors and critical risk factors and the proposed models are associated with abstract constructs that are difficult to assess quantitatively. As a result, collecting opinion-based data against prescribed evaluation criteria seem more appropriate.

Two sets of questionnaire survey were conducted to test the quality and credibility of the research output and to assess the suitability of the proposed risk allocation model for risk allocation decision-making in PPP agreements. Email-based questionnaire survey was adopted because it is less costly in terms of money and time, and permits a researcher to directly communicate with target respondents (Andrew et al., 2003). The survey period lasted for approximately three weeks, with the two sets of questionnaire (see Appendix 6) targeting different set of experts. Questionnaire _A‘ contained questions for validating the established critical success factors and critical risk factors, in which seven industry practitioners participated in this surveyed validation of the findings. The choice of the industry respondents was based on their (i) expert knowledge of and direct involvement in implementation and risk management of PPP water supply projects, (ii) many years of industry experience, and (iii) non-involvement in any aspect of the research study. The panel of industry practitioners comprised managing directors, professors, a finance lead, a senior water specialist and a lead economist from different professional and socio-economic backgrounds (Table 9.10).

Questionnaire ‗B' contained questions for validating the proposed risk allocation model. The expert respondents were people who have (1) expert knowledge in risk allocation and risk allocation modelling (Balci, 1989), (2) authored books and peer-reviewed papers on the subject (Hallowell and Gambatese, 2010), and (3) not contributed to any aspect of the model development. Table 9.10 shows that the seven expert panelists are academics with many years of hands-on industry experience. The academic and industry backgrounds helped the expert respondents to (a) understand the quantitative model and (b) be able to assess its suitability for practical application. The expert panel comprised professors and PhD holders. For each questionnaire, a brief background of the research and description of its methods and key findings were provided (see Appendix 6), and the respondents were asked to choose an appropriate score for each validation question based on a five-point Likert scale (1 = poor, 2 = average, 3 = good, 4 = very good, and 5 = excellent). The outcomes of the validation surveys are presented in the following sub-sections.

Table 9.10 Background of experts for the validation

Expert	Organisation	Position	Primary role	Industry experience (yrs.)
Expert respondents for Questionnaire A (CRFs and CSFs)				
TT	Triche and Associates	Director	Private	35
CM	University of Paris	Full Professor	Public	20
CJ	Donga University	Associate Professor	Academic	13
JJ	JJ Consult	Managing Director	Private	35
DJ	IADB	Lead Economist	Public sector	35
IU	Deloitte, South Africa	Capital Project Corporate Finance Lead	Private	15
PM	World Bank	Senior Water Specialist	Public sector	20
Expert respondents for Questionnaire B (Risk allocation model)				
PL	Hong Kong Polytechnic University	Associate Professor	Academic	30
DC	Hong Kong Polytechnic University	Associate Professor	Academic	3
AW	Institute for Human Settlements	Research Professor	Public sector	15
WS	Tsinghua University	Professor	Academic/Public	18
JY	Hong Kong Baptist University	Lecturer	Academic	10
YK	The University of Newcastle	Lecturer	Academic	9
BL	Indian Institute of Technology, Guwahati	Assistant Professor	Academic	10

NB: Academics have industry experience; IADB – Inter-American Development Bank

9.6.1 Critical Success Factors (CSFs)

For CSFs, four validation questions, Table 9.11, were assessed. These questions fall under three types of validation; face (questions *a* and *b*), content (question *c*) and external (question *d*) validity.

According to Lucko and Rojas (2010), face validity refers to a subjective non-statistical approach that collects opinion-based data from experts regarding the validity of a study. A study is said to have face validity if the experts looking at the finding (e.g., a list of success factors) agree that it represents to a greater extent what happens in practice. An effective way to establish face validity is to involve domain experts *a priori*, during, *a posteriori* or throughout the study (Lucko and Rojas, 2010). The results show that both questions *a* and *b* have *'very good'* face validity scores of 4.14 (Table 9.11), as assessed by the expert respondents.

Content validity is also a non-statistical process that determines whether content of a study fairly represents reality (Locko and Rojas, 2010). Here, its primary focus is the extent to which the 14 CSFs can contribute to project success, if rightly put together and provided continual attention, or the extent to which they are representative (Babbie, 1990) of the factors that enhance the success of water PPP projects in practice (question c in Table 9.11). The respondents' evaluations showed that the CSFs have a *'very good'* content validity with a mean score of 4.00.

Table 9.11 Validation results of the CSFs

No.	Validation question/aspect	Mean score[a]
a	Are the 14 critical success factors (CSFs) relevant or critical to the success of water PPPs in developing countries?	4.14
b	Do the 14 CSFs reflect those encountered in successful PPP water supply projects in practice?	4.14
c	Can the CSFs contribute to the success of water PPPs if rightly put together and provided special and continual management attention?	4.00
d	Are the importance rankings of the CSFs reasonable?	3.71

a: 1 – poor and 5 – excellent

External validity focuses on generalisability of research findings for purposes of prediction (Leedy and Ormrod, 2001). Thus, it questions whether conclusions drawn from the research sample can be generalised to that population. One of the means to ensure external validity is careful selection of the research subjects to ensure representativeness (Lucko and Rojas, 2010). For this study, in determining whether the importance rankings of the 14 CSFs are reasonable or not, the expert respondents assessments indicate that the factors have a *'very good*' external validity with a mean index of 3.71 (question *d* in Table 9.11). This means that the CSFs can be generalised, especially in the context of water PPPs in developing countries. In this study, though the sample size of 41 experts is small, they were carefully selected from private and public sector institutions with direct involvement and sufficient knowledge in the water industry and water PPPs to ensure adequate representation.

9.6.2 Critical Risk Factors (CRFs)

Four areas (Table 9.12) were also assessed under the CRFs category. Overall, the questionnaire was used to test the criticality and relevance of the identified risk factors. Similarly, these questions fall under three types of validation; face (questions *a* and *b*), content (question *c*) and external (question *d*) validity.

Table 9.12 Validation results of the CRFs

No.	Validation question/aspect	Mean score[a]
a	Are the 22 critical risk factors (CRFs) critical to water PPPs in developing countries?	4.00
b	Do the CRFs reflect those encountered in PPP water supply project in practice?	3.86
c	Can the CRFs contribute to the failure of PPP water supply projects if poorly identified and managed?	4.14
d	Are the probability and severity rankings of the CRFs reasonable?	3.43

a: 1 – poor and 5 – excellent

With respect to the criticality of the CRFs in water PPPs in developing countries, Table 9.12, shows that this validation aspect received a very high agreement from the experts, with a mean score of 4.00 (*'very good'*). This implies that the established factors are very significant and deserve more attention in developing countries. Regarding whether the CRFs reflect those encountered in real water PPP projects (question *c*), the expert respondents again showed a high level of agreement with a mean score of 3.86. This suggests the CRFs, to a greater degree, reflect the significant risk factors encountered in practice, and indicates a very good face validity. Following above two validation areas, the experts further showed a high degree of agreement that the identified CRFs can cause a project to fail if they are poorly identified and managed. The level of consensus is very high with a mean score of 4.14, reinforcing the criticality and relevance of the factors. On the probability and severity rankings of the CRFs (question *d*), the experts showed a moderate (3.43) level of agreement. This may be regarded as significant, given that all the seven experts have diverse experiences and that some could have expected certain factors to be highly, moderately or lowly ranked. The argument is that certain risk factors may be ranked higher in certain countries and lower in other regions.

9.6.3 Fuzzy Quantitative Risk Allocation Decision Model

Seven areas (Table 9.13) about the proposed risk allocation model and its outcomes were assessed through Questionnaire B. Overall, the questionnaire sought to test the practicality, applicability and suitability of the proposed model for risk allocation decision-making in PPP agreements. The procedure and summary and demonstration of the model were first presented to the experts. After going through these, they were requested to rate seven aspects of the model in a questionnaire format.

Table 9.13 Validation results of the risk allocation model

No.	Validation question/aspect	Mean score[a]
a	Are the input variables (risk allocation principles) appropriate such that they reflect the risk management capability of a public/private partner?	4.57
b	Are the importance rankings of the input variables reasonable?	4.57
c	Are the risk allocation proportions (model outputs) reasonable and practical in a typical PPP water supply project in a developing country?	3.71
d	Is the FSE risk allocation model practical and applicable enough to enable PPP practitioners to apply it to support risk allocation decision-making?	3.86
e	Is the FSE risk allocation model easy to understand and use by practitioners?	3.43
f	Are the steps involved in applying the model logical such that the model can be replicated by researchers/practitioners	4.71
g	Overall suitability to be adopted in practice for risk allocation decision-making in PPP (water supply) agreements	3.71

a: 1 – poor and 5 – excellent

These areas fall under four types of validity; construct (question *a*), external (questions *b, c,* and *g*), face (question *d*), and internal (questions *e* and *f*) validity. Lucko and Rojas (2010) noted that construct validity seeks to ensure that a research measures what it is intended to measure. Internal validity relates to causality and ‗is preoccupied with the derivability of relations within data' (Leedy and Ormrod, 2001 cited in Lucko and Rojas, 2010). The authors explained that establishing a true causality is challenging in construction research, given that a number of studies are performed in real-life environments where numerous unpredictable variables interact with one another.

Regarding the appropriateness of the risk allocation criteria (RAC) in defining the risk management capability of the public or private partner (question *a*), the experts showed an ‗excellent‘ level of consensus, as demonstrated by a mean score of 4.57. This means that the RAC adopted in developing the model are comprehensive and relevant. Similarly, the importance rankings of the RAC (question *b*) received an ‗excellent‘ mean score of 4.57 from the experts. This suggests that the rankings of the RAC are very reasonable and can be generalised and used across projects. The reasonability and practicality of the risk allocation proportions (model outputs) (question *c*) was assessed to have a ‗very high‘ mean score of 3.71. Though this indicates that the risk sharing proportions are, in general satisfactory in the context of developing countries, however, a mean index below 4.00 could suggest room for improvement. Moreover, most of the risk factors are better shared on a project-by-project basis. The practicability and applicability of the model for use by industry practitioners (question *d*) received a high mean score of 3.86, suggesting the experts have a ‗very good‘ agreement and confidence about the potential of the proposed model, and it could be adopted by practitioners to support risk allocation decision-making.

The ease of understanding and using the model (question *e*) by industry practitioners received a ‗good‘ level of agreement from the experts with a mean score of 3.43. A possible reason for the low agreement from some experts may be the numerous mathematical formulae and equations involved in applying the model. Some of the respondents who did not understand these formulae and equations assigned low scores. One respondent recommended that a computerised system could be developed to save the practitioners the time and energy of having to understand the mathematics behind the model. With respect to replicability of the model (question *f*), Table 9.13 shows that this validation aspect received the highest level of agreement from the experts with a mean score of 4.71 (‗excellent'). This indicates that most of the experts are more confident that the steps in applying the model are logical and thus can be replicated by both researchers and practitioners in other PPP infrastructure projects. This finding further suggests that the overall research design is logical and appropriate. On overall suitability of the proposed model to be adopted in practice to support risk allocation decision-making (question *g*), the experts demonstrated a ‗very good' level of agreement with a mean score of 3.71. This suggests that the experts are confident about the potential of the proposed model and many see this as good step in the right direction. On the other hand, a mean score below 4.00 or 5.00 could hint the need for further improvement, such as developing a computerised model to save time and energy in its application, as previously indicated.

9.6.4 Additional Feedback From the Experts on the Model

Apart from the quantified outcomes, the expert respondents were provided the opportunity to provide additional comments on the risk allocation model. Some of them provided general qualitative feedback – limitations and suggestions – for improving the model. Some general concerns or limitations of the findings include:

1. Partial sharing of risks in PPP agreements could add significant additional legal and political risks to projects; and
2. The proposed model could be difficult to apply in practice as it may not be easily understood by some industry practitioners, and some risks such as political risks may be difficult to quantify in monetary terms.

Despite above limitations or concerns, this research and the proposed risk allocation model has identified some significant concepts in the area of risk allocation and management in

PPP procurement. Some major issues are:

1. The idea to convert experts‘ opinion into fuzzy numbers is more appropriate and makes the risk allocation process practical, systematic and more objective;
2. The risk allocation matrix is appropriate for most of the identified risk factors; and
3. The suggested methodology and model may suit project-specific needs that are addressed based on a specific context, while taking into account the significant risk factors and local political, legal, economic and social conditions.

General suggestions and recommendations were also provided by the experts to help improve the proposed model:

1. There is a need to address how the risk-sharing proportions can be translated into contractual arrangements to make them operational;
2. A computerized system needs to be developed in order to enhance the practicality and ease of use of the proposed risk allocation model;
3. Risks relating to construction, operation and financing should be wholly allocated to the private sector while others such as land acquisition and local politics should be fully assigned to the public sector; and
4. To allocate the risks in proportions, there is a need to ‗value‘ the financial impact of each one, as what matters is the overall financial balance. Of course, determining the monetary value of each risk factor is a key assumption in this model.

9.7 CHAPTER SUMMARY AND CONTRIBUTION

The context- and sector-specific nature of PPP project risks requires a robust contract strategy that allocates critical risk factors between a host government and a private entity according to accepted risk allocation principles. This chapter proposes a quantitative risk allocation decision model, which has been applied to PPP water supply infrastructure projects, by drawing on the fuzzy set theory and acceptable risk allocation criteria based on professional and experiential knowledge of PPP experts. The fuzzy set theory approach is capable of incorporating and transforming imprecise and vague linguistic RAC and expert knowledge into the decision support system.

The output variable of the fuzzy model is the risk allocation proportions between the government and private partner according to their abilities to manage significant risks associated with such projects. The output value for the public and private partners ranges in a continuum from 0%, indicating no responsibility for a corresponding partner, through 50%, suggesting equal assumption by both parties, to 100%, denoting full responsibility for a corresponding partner. The sum of the output variable equals 100% for any evaluated risk factor.

Furthermore, for any evaluated risk event, the model is able to predict individual partner‘s risk management capability level. Possible value $V = \{1, 2, 3, 4, 5\}$, representing a five-point grading system of risk management ability, ranging from 1, referring to *very low* ability by the government or private party, via 3, denoting *moderate* risk management capability, to 5, meaning *very high* capability to handle an evaluated risk event.

The outcome of this study makes a major contribution to PPP practice and construction engineering and management literature by providing a model to aid public and private decision-makers to arrive at a fair risk allocation decision, with the following merits. (i) It introduces a systematic and practical model to support decision-makers in risk allocation practice rather than a crude approach based on preferences and biases of decision-makers. (ii) Though the risk allocations for the 22 risk factors in this study specifically stem from an empirical study conducted in Ghana, developing and emerging countries with mature/budding water PPP markets could use the results to guide their decision-making. The water industries in these countries share similar characteristics and PPP challenges (Bayliss, 2003) like Ghana, hence the applicability of the results reported herein.

Moreover, the validation results of the study show that the CSFs, the CRFs and the risk allocation model are all relevant according to the validation aspects/areas. This suggests that the results of this study would be valuable in the hands of practitioners and policy-makers interested in using PPPs to develop water and other infrastructure projects.

The current model is limited to risk allocation between the direct participants – government and private firm. Further development of the model could focus on including other stakeholders such as customers and lenders, expanding the expert panel sizes, adding more or adjusting the RAC to suit specific projects, and evaluating emerging, significant risk factors.

The following chapter concludes the thesis by presenting a review of the research objectives and conclusions and addressing the contribution of the research to knowledge and practice, limitations and recommendations for future research work.

Chapter 10: Conclusions and Recommendations

The final chapter of a thesis summarises the main findings of the research. It often also includes comments on limitations of the study, future work, how the findings will help both the academic field and the wider community.

This chapter is very effective partly because the writer includes the following:

Structure

Introduction	Section 10.1
⇩	
Review of Research Objectives and Conclusions	Section 10.2
⇩	
Value and Recommendations of the Study	Section 10.3
⇩	
Limitations	Section 10.4
⇩	
Recommendation for Future Research	Section 10.5

Content

- Summarises key ideas included in the chapter in the introduction (e.g. Section 10.1)
- Gives an overview of the chapter (e.g. Section 10.1, paragraph 1, sentence 3)
- Restates the research gap (e.g. Section 10.1, paragraph 1, sentence 5)
- Restates the main aims of the thesis (e.g. Section 10.1, paragraph 2)
- States contribution the thesis has made (e.g. Section 10.2, paragraph 2)
- Makes recommendations based on the model developed (e.g. Section 10.3, paragraph 1)
- Discusses limitations (e.g. Section 10.4)
- Acknowledges limitations but outlines how the problem is mitigated, e.g. *having stated this*, (e.g. Section 10.4, paragraph 2, sentence 3)
- Outlines need for further research (e.g. Section 10.5)

Language

- Uses positive language to highlight the study's contribution, e.g. *unique characteristics* (e.g. Section 10.2, paragraph 2, sentence 1) and *major contribution* (e.g. Section 10.3, paragraph 1, sentence 1)
- Uses objective language to report findings, e.g. *It is observed* (e.g. Section 10.2, Objective 2, paragraph 2, sentence 2)
- Uses tentative language to describe findings, e.g. *is likely to* (e.g. Section 10.3, paragraph 1, sentence 3)
- Uses strong summary sentences at the end of longer paragraphs (e.g. Section 10.3, paragraph 2, final sentence)

<u>To consider</u>

In general, this chapter is effective. However, it could be improved in the following aspects.

Avoid giving too much detail in the final chapter. It is better just to summarize the main findings, avoid including background (e.g. Section 10.2, paragraph 3).

Use vertical lists if the list of reasons is long (e.g. Section 10.2, Objective 2, paragraph 1).

Finish with a short final paragraph restating the importance of the research and how it is hoped that the findings will benefit theoretically and/or practically in the future.

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

10.1 INTRODUCTION

The preceding chapters present various aspects of the research. Chapter 1 introduces the overall research, Chapter 2 discusses methodological issues, Chapters 3, 4 and 6 present literature review on various areas, and Chapters 7, 8 and 9 report on empirical research on various topics. The current chapter summarises the research study, draws conclusions and implications of the findings, and addresses its significance, limitations and recommends areas for further research. Numerous academic and institutional research studies into risk, risk assessment, risk allocation and risk management; and drivers and success factors of PPP have been carried within the construction and project management disciplines over the past two decades. However, very few empirical studies have focused on developing reliable and practical risk assessment and risk allocation models for PPP water supply infrastructure projects, particularly for developing countries. It is therefore difficult for practitioners to objectively evaluate, and allocate the significant risk factors associated with water supply projects, and to determine the factors that significantly influence the success of these projects.

The overall aim of this research is to advance understanding of risks, and to develop a reliable and practical risk allocation model to guide risk allocation decision-making in PPP water supply projects in Ghana. To achieve this aim, the following objectives were formulated:

1. To investigate the water sector‘s characteristics and risk environment, and PPP models and trends within the water industry;
2. To investigate PPP drivers, practice and experience in the water industry of Ghana;

3. To identify and evaluate critical success factors (CSFs) for PPP water supply projects, and to model the impact of the CSFs on successful implementation of PPP projects in Ghana;
4. To identify and evaluate PPP water supply project risk factors and to develop a risk assessment model (RAM) for PPP water projects;
5. To determine the most important risk allocation criteria (RAC) in PPP; and
6. To develop a quantitative risk allocation decision-making model (QRADM) for PPP water supply projects.

10.2 REVIEW OF RESEARCH OBJECTIVES AND CONCLUSIONS

Objective 1: To investigate the water sector's characteristics and risk environment, and PPP models and trends within the water industry

A comprehensive literature review was conducted in Chapter 4 to explore the unique characteristics and risk environment of the water supply sector and the common PPP modalities as well as current trends in developed and developing countries. Through this objective, this thesis seeks to enhance understanding of readers why the water sector is regarded as ‗risky and hardest' to finance. The value chain of the water sector has four main components: (i) raw water abstraction and storage, (ii) water treatment, (iii) treated water transmission and distribution, and (iv) customer interface. Depending on a chosen PPP modality, all or specific functions can be assigned to a private sector.

This study established five key, unique characteristics of the water sector, which differentiate it from other infrastructure sectors and further explain the high risk perception of the sector. These are (1) high capital intensity and huge sunk costs; (2) multiple and conflicting public policy objectives; (3) highly fragmented sector with diverse institutional setups; (4) high asset condition uncertainty; and (5) numerous sector performance indicators.

PPP modalities in the water sector can broadly be classified under two categories: service-based and finance-based models, which exploit private management expertise and capital, respectively. Therefore, based on the extent of private participation, the forms of PPP for water projects vary, with popular models being service contracts, management contracts, affermage-leases, water concessions, joint-ventures, BOT and its variants, and hybrid modalities. Overall, the 1990s experience and lessons indicate that PPP activities in the water sector are evolving across countries, where governments and investors explore modalities that reflect local capacities, local conditions and risks, and political, social and economic contexts.

In developing countries, greenfield and concession contracts are the most popular and important in terms of numbers and share of private investment, while management and lease contracts are relatively popular but account for very little private investment. East Asia and Pacific are regions with the greatest share of projects and investment, followed by Lattin America and Caribbean while Sub-Saharan Africa has the least share of private investment (Marin and Izaguirre, 2006; World Bank PPP database[9]).

In developed countries, divestiture is popular in England and Wales; DBO and operation and maintenance contracts are common in the USA; concession and lease contracting are common in France and Czech Republic; and BOTs are typical of Ireland (Palaniappan et al., 2006).

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[9]World Bank Infrastructure Database (http://ppi.worldbank.org/explore/ppi_exploreSector.aspx?sectorID=4)

In developed countries, PPP seeks to refresh aging water supply (and wastewater) infrastructure and to develop new water systems that satisfy emerging strict environmental requirements (Palaniappan et al., 2006), while in developing countries, government seek private participation to resolve inefficient public water utilities and to build new water supply systems (treatment plants and pipe networks) (Nickson and Vargas, 2002; Haarmeyer and Mody, 1998; Nickson, 1998; Rivera, 1996).

Objective 2: To investigate PPP drivers, practice and experience in the water industry of Ghana

For a good understanding of PPP water practices, a review of the drivers (reasons) for adopting PPP, in response to the challenges (characteristics) of the local water sector, was conducted in Chapter 3. The review drew on government policy documents and previous sector studies, and discussed the key drivers from public sector perspective, because the decision to adopt a PPP is reliant on a government‘s policy and political decision. The review concluded that the main drivers are (1) inadequate public funding, (2) need for improved management and efficiency, (3) growing water demand, (4) poor water asset condition and lack of repair, (5) low coverage rate and high non-revenue water levels, and (6) low labour productivity and quality.

In Ghana‘s water PPP practice, this study observed some emerging trends in the water sector, based on previous and operating projects, as follows: (i) dominance of management contracts, (ii) growing water PPP in small-towns with (iii) domestic operators, (iv) public funding remains a challenge, (v) management contracts between public utilities, and (vi) PPP water projects are donor-driven. It is observed that these emerging trends reflect experiences in many countries, particularly developing economies.

Overall, Ghana has a limited experience in PPP procurement and practice. The literature suggests that the process was slowed by strong public resistance in the late 1990s and early 2000s. The review showed that ambitious projects were reversed by this public resistance. However, continued efforts are being made to attract more private participation to the troubled sector.

Objective 3: To identify and evaluate critical success factors (CSFs) for PPP water projects, and to model the impact of the CSFs on successful implementation of PPP projects in Ghana

Ensuring a successful PPP project requires existence of certain success factors. Fourteen CSFs were qualitatively extracted from local projects and extant literature, and were further subject to expert evaluation through Delphi questionnaire survey. The results (Chapter 7) showed that a PPP water supply project is associated a number of success factors, including an ‗extremely important‘ factor: government (political) commitment, and 13 ‗very important‘ factors (in order): adequate financing, public acceptance/support, strong and competent private partner, effective regulatory and legal structures, strong and competent public partner, national PPP policy and unit, strong commitment from project partners, local capacity building for utility staff, quality water asset and workforce, competitive tendering, internal coordination within government, flexible contracts with fair risk allocations, and profitable water supply projects.

PCFA was conducted to establish the underlying constructs of the 14 CSFs. Five-factor solutions were obtained as Factor 1: Commitment of the partners; Factor 2: Strength of the consortium; Factor 3: Asset quality and social support; Factor 4: Political environment; and Factor 5: National PPP Unit.

A FSE method was applied to model the impact of the CSFs on PPP project success. The proposed model showed that the OSI of the five CSFGs of PPP water projects is 6.10, suggesting that, collectively, the factors are *'very important',* and if well combined and given adequate attention would improve the chances of successful implementation of PPP water supply projects in Ghana. *Political environment* (index = 6.20; rank = 1) is the most critical factor group affecting project success, followed by *asset quality and social support* (index = 6.18; rank = 2); *national PPP unit* (index = 6.17; rank = 3); *strength of the consortium* (index = 6.07; rank = 4); and *commitment of the partners* (index = 5.94; rank = 5). These five factor groups could serve as a means by which project participants optimise the likelihood of successful implementation of PPP water projects. The fuzzy model can be applied to objectively and reliably select the most CSFs for projects by adding new factors or removing less important factors.

Objective 4: To identify and evaluate PPP water supply project risk factors and to develop a risk assessment model (RAM) for PPP water projects

A systematic, qualitative approach was applied to identify relevant risk factors to PPP water supply projects. A 40-risk factor list was established through literature survey, analyses of water projects that were accessed from academic and institutional literatures, and expert review.

These risk factors were subjectively categorised into two. The first category is according to risk sources (‗source taxonomy') as: (1) Political; (2) Financial; (3) Regulatory, Legal and Contractual; (4) Market/revenue; (5) Social; (6) Technical and Operational; (7) Design and

Construction; (8) Relationship; (9) Water resources issues; (10) Natural issues. The second category is based on the lifecycle phase at which each risk factor is likely to occur as: (i) bid preparation; (ii) operator selection to contract signing; (iii) project implementation; (iv) management / operation; and (v) transfer.

The 40 risk factors were formulated into Delphi questionnaire in order to numerically evaluate the probability of occurrence and severity of each risk factor. The aim here is to determine which of the factors typically reflect the country and sector conditions of Ghana.

Risk significance and impact analyses and computed normalised values (≥ 0.50) in Chapter 8 indicated that there are 22 CRFs on PPP water supply projects in Ghana, that deserve private investors‘ and the government‘s attention and require rigorous assessment. Therefore, analyses in chapters 8 and 9 focused on the 22 CRFs. The first 19 risk factors have a ‗high impact‘, while the remaining three have a ‗moderate impact‘ (but close to the ‗high‘ level), on PPP water supply projects.

The 22 CRFs were theoretically classified in three principal factors as: PRF1 – Financial and commercial risk, PRF2 – Legal and socio-political risk, and PRF3 – Technical risk. These factor groups served as the input variables for the fuzzy risk assessment model.

FSE method was applied to determine the overall risk level (or index) of PPP water supply projects in Ghana. The FSE model showed that the overall risk index of these projects is ‗high‘ with an index of 4.78, implying that water supply projects are risky to both the government and private investors. This is underlined by the three principal risk factors. The model, overall, confirmed that PRF1 – Financial and commercial risk (index = 4.909, rank = 1) is the top PRF, followed by PRF2 – Legal and socio-political risk (index = 4.724, rank = 2), and PRF3 – Technical risk (index = 4.672, rank = 3). All the PRFs have ‗high impact‘

on PPP water supply projects. The proposed model does not only evaluate the most pronounced risks in PPP water projects but could also aids investors to compare and select the less risky project.

Objective 5: To determine the most important risk allocation criteria (RAC) in PPP

Following their establishment in Chapter 8, the 22 CRFs were allocated in Chapter 9. PPP projects are believed to achieve VfM through optimal risk allocation between the direct project participants. However, efficient risk allocation is supported by appropriate determinants of risk allocation that guide the decision-making process. Nine RAC, from the literature, were adopted and evaluated numerically through a two-round Delphi survey in order to determine their significance. The mean scores of the RAC ranged between 4.76 and 6.22, indicating that all the factors are important. Consequently, seven factors scored mean values above 5.00, between 5.05 (‗high') and 6.22 (‗very high'), and were selected for modelling the risk allocation decision-making process.

Objective 6: To develop a quantitative risk allocation decision-making model (QRADM) for PPP water supply projects

Each CRF was evaluated against each risk allocation criterion by two expert teams from the private and public sectors. The FSE method was applied to introduce a fuzzy quantitative risk allocation decision model in PPP (water supply) infrastructure projects. The output variable of the model is the risk allocation proportions between the public client and the private entity, according to their capabilities to manage the evaluated risk factors. Thus, for an evaluated risk, the model calculates quantitatively individual partner's risk management capability, based on a five-point scale: from 1, refers to *very low* capability, through 3, indicating *moderate* risk management capability, to 5, denoting *very high* management capability by the government or private party. The sum of risk allocation proportions for both parties for any evaluated risk is 100%. That is, the output value for the public or private partner ranges in a continuum from 0%, suggesting no assumption for a corresponding party, via 50%, denoting equal responsibility by both parties, to 100%, meaning a complete assumption for a corresponding party.

A party has a major responsibility if it is allocated a proportion ≥ 50%, for a given risk factor. Overall, the government is allocated 11 risk factors with proportions greater than 50%, including: foreign exchange rate, non-payment of bills, political interference, lack of PPP experience, political discontent and (early) termination, public resistance to PPP, land acquisition, change in government and political opposition, water pricing and tariff review uncertainty, etc. These factors relate to government policies and political decisions. The private sector also has 11 risk factors with major responsibility, including: water theft, corruption, high operational costs, interest rate, construction time and cost overrun, financing and refinancing, insufficient performance, design and construction deficiencies, pipe bursts during distribution, etc, which are mostly project-related issues. A private consortium has technical expertise and financial incentives to control these risks better than the public client.

The introduced systematic and practical model could aid decision-makers in risk allocation practice rather than a crude approach based on preferences and biases of decision-makers. The approach presents the risk allocation decision-making as a ‗negotiation‘ process to establish each party‘s capabilities to manage a set of risk factors.

10.3 VALUE AND RECOMMENDATIONS OF THE STUDY

This study makes a major contribution to the construction management literature and to the PPP water industry by reporting results that would be impactful and valuable to decision-makers in Ghana and other countries. First, the study has established the key drivers and CSFs for PPP water supply projects, which are believed to wield a strong influence on PPP decision-making and successful implementation. The obtained CSF list is likely to trigger policy development towards PPP practice in Ghana, because these findings have wider implications for legal and regulatory systems, public capacity, financing, public procurement, and politics. Moreover, using the introduced modelling approach, PPP project decision-makers in public and private organisations can properly establish the important success factors and also determine how important a role the CSFs will play in ensuring success the of a project. Following the established CSFs, the following recommendations are made.

Political commitment is indispensable in any PPP programme. However, given scanty projects in the water and other infrastructure sectors to constitute a PPP programme, the Government of Ghana can demonstrate its high-level political commitment by establishing a consistent and clear legal framework and creating an infrastructure investment framework (Infrastructure Consortium for Africa, 2009). A clear legal framework is necessary given that PPP relies on well-designed contracts that are enforceable, and reduces investment uncertainties for private investors. Legal frameworks that have proven successful in markets with successful PPP programmes may be adapted to suit local circumstances. Such a legal framework should clarify pertinent issues such as investors‘ and lenders‘ rights, resolution of contractual disputes, forms of government support for certain risks, use of expatriate personnel and repatriation of profits for foreign investors, contract changes and compensation mechanisms, etc. A well-prepared government investment plan is an optimal means to present to the private sector the government‘s infrastructure investment approach, as it indicates a flow of future projects and helps potential private investors to appreciate the general environment of individual projects and how they fit together (Infrastructure Consortium for Africa, 2009).

Having created a PPP unit – PAU – within government is a good step but not enough if it is not staffed with competent professionals with commercial and legal skills and sector expertise who are able to work across government. The unit must also be provided with the necessary resources and political support, capable of playing *supporting* as well as *approval* and *quality control* roles (Infrastructure Consortium for Africa, 2009). This is required of the government, as it seeks to develop a strong PPP programme. A competent and well-resourced PPP unit, investors will be confident of the government‘s seriousness of intent and that the operating framework with government understands the complexity of PPP contracts and is capable the PPP processes successfully.

To ensure successful implementation of a project, the 14 CSFs should be rightly combined and provided sustained management attention. The ideal situation is that project managers should be able to control all the CSFs. However, it is clear that some CSFs are more difficult for project managers to handle than others. The difficult factors relate to government-action (GA), country-specific (CS) and certain project-specific (PS) factors, including government (political) commitment, public acceptance/support, effective regulatory and legal systems, competent public partner, quality water assets, project profitability, *etc*. For instance, good pricing policies and regulatory structures/institutions cannot be implemented overnight and such situations are out of control of the project manager. Hence, the principle is that each CSF should be carefully examined to determine whether or not it can be controlled by the project manager, and to take appropriate action(s) to compensate for the uncontrollable CSFs. For example, if a project is not profitable the government may provide certain revenue generation guarantees. Table 10.1 presents some CSFs that are perceived to be difficult to control (based on project experiences) and the recommended actions to be taken.

Table 10.1 Uncontrollable CSFs and appropriate actions

ID	Critical success factor (CSF)	Action
CSF3	Government (political) commitment	(i) Political risk insurance or guarantee; and (ii) participation of multilateral organisations (e.g., World Bank) and local investor(s)
CSF2	Public acceptance/support	Government may subsidize water tariffs to avoid public resistance or social reaction
CSF6	Effective regulatory and legal structures	(i) Contract out or outsource regulatory functions to a reputable and independent private consortium; (ii) government provides guarantees for legal and regulatory risks outside the private investor‘s control; (iii) a neutral arbitrator, preferably outside the host country, acceptable to both private investor and host government
CSF14	Strong and competent public partner	Engage external professional (legal, financial, technical, etc) advisors to complement public sector expertise
CSF10	Strong commitment from project partners	A well-designed contract with clearly assigned rights and obligations; and (ii) attractive contractual guarantees (those provided by host government and those offered by private investors)
CSF11	Quality water asset and workforce	(i) Government compensation if the existing water assets quality is worse than anticipated; (ii) adopt a less capital-intensive PPP model (e.g. management contract) to learn more about the underlying water assets before moving to a more capital-intensive PPP; and (ii) government‘s readiness to layoff redundant/low-qualified utility workforce through a retrenchment program
CSF9	Profitable water supply projects	Government (i) guarantees a certain minimum rate of return on private investment or (ii) provides revenue generation guarantees (e.g., exclusive rights)
CSF13	Internal coordination within government	Establish a central high-powered and leading authority (e.g., PPP unit) to oversee, if not in charge of PPP projects

Project managers are more likely to focus more on CS CSFs that they are really unable to affect. This is because CS factors often have huge effect on successful delivery of PPP projects. However, because the realisation of the CSFs requires both government and private investors working together, a partnership style approach to the delivery of PPP water projects should be adopted. By this, the government will focus on ensuring CS and certain PS CSFs which are within its control, whilst project managers will concentrate on ensuring most of the PS CSFs.

Second, the study contributes to risk assessment in PPP (water) infrastructure projects by providing a new, ranked 40-factor risk list, extracted 22 CRFs through evaluation by industry experts and theoretically classified them into three critical risk groups. This provides decision-makers with a practical, comprehensive and reliable factor list for developing risk management guidelines. The study also introduces an mathematical risk assessment model that can be applied with appropriate modifications to suit specific projects and contexts by fine-tuning the risk factor list, the MFs of the CRFs/PRFs, and the expert panel size. This model will aid public and private decision-makers to achieve objective rather than subjective risk assessment, assisting them to determine appropriately the most significant risk factors and to determine the overall risk level of a project. Thus, the model is a multi-attribute risk assessment framework designed to aid public clients and private investors to evaluate the risk conditions of PPP in any infrastructure project. For public clients, the model offers a guide to the real risk issues that the public sector (i.e., government) ought to pay attention to in preparing for and attracting more private sector participation in the water sector. It assists in identifying the risk issues that hamper increased private activity in the sector and introduces a framework to evaluate such risk issues. For private participants, the model is a practical tool for evaluating infrastructure projects and to arrive at an investment decision – whether or not to invest in a project due to its risk level. It does highlight the high-risk areas that require attention and effective mitigation measures. It is therefore recommended that

(i) for a specific water supply project, public water authorities should carefully examine the established CRFs to ensure that the project modality suit applicable risk factors. The government may have to provide guarantees to specific risks, such as changes in policy/law or regulatory regime, non-payment and theft risks.

(ii) in the medium and long terms, the government should work towards reducing the risk level of PPP water supply projects. This can be done through sector and institutional reforms, and exploring robust risk mitigation instruments. For example, PURC should be well resourced, given full autonomy, and staffed with competent individuals with utility industry experience. Potential risk mitigation instruments that can be explored to ascertain their applicability in local water projects include political risk insurance, partial credit guarantees, partial risk guarantees, subsidies, credit enhancements, local currency financing, off-take contracts, etc. (Vives et al., 2006).

(iii) private participants (or investors) should focus on the established risk areas for their due diligence. This requires detailed and rigorous risk analysis. As noted by Ward et al. (1991), whatever form of project modality is adopted, there will be a need for conscientious risk analysis and risk management by both public and private contracting parties, as well as a need for a true partnership spirit, to avoid surprises.

Third, the study makes a major contribution to risk allocation decision-making in PPP practice by presenting a fuzzy quantitative risk allocation model (FQRADM) based on the fuzzy set approach, with application to PPP water supply projects. The model provides a practical means by which public and private decision-makers may enter into a decision (or ‗negotiation') over risk allocation. Of course, each infrastructure project risks must be allocated according to the project modality or circumstances. The model is intended to guide and facilitate the risk allocation decision-making process, in order to arrive at valuable outcomes. The FQRADM has the following benefits. (i) It is designed to allocate risks between a public authority and a private entity in proportion to their capability to bear, manage, and control the occurrence and impacts of those risks. By this, the final risk allocation proportions will be more acceptable by both parties with a true partnership spirit. (ii) The results of the model is both in quantitative (risk allocation proportions) and qualitative (risk management capability levels) terms, which could be very impactful and valuable in the hands of public and private participants, by aiding them to develop appropriate risk countermeasures. An underlying premise of this risk allocation decision model is that public benefits in water supply partnerships and successful delivery of water infrastructure services can be maximised if project risks are appropriately allocated between the public water authority and the private party according to their respective risk management capabilities. Risk management capability will only translate to conscientious management of project risks provided it is based a genuine ability to (i) foresee and assess a risk, (ii) control the chance of risk occurrence, (iii) bear the consequences (losses) of a risk eventuating, (iv) sustain and diversify risk consequences, (v) bear the risk at the lowest price, (vi) benefit from undertaking the risk, and (vii) manage and mitigate the risk. In addition, risk management capability should be underpinned by an adequate understanding of project risks and not a need to secure a (long-term) water contract with stable revenue stream (Ward et al., 1991). Appropriate allocation of project risks requires that the involved public and private parties genuinely appreciate and accept risks allocated to them, in order to effectively manage them.

10.4 LIMITATIONS

As with any research study, the current study is not without limitations that decision-makers and readers should be aware of. First, since PPP application, particularly for water supply, in Ghana is limited and evolving, the Delphi questionnaire survey drew on a limited number of industry experts with some experience in the local water sector and PPP procurement. This is due primarily to limited number of projects procured under the PPP procurement route. Hence, our sample was not randomly chosen, but through purposive sampling and semi-snowballing approaches.

The second limitation of the study is that it focuses primarily on the water sector of Ghana. It may be difficult to determine the extent to which the results (success factors, risk factors, risk allocation) generalise to the water, and other infrastructure, sectors in other countries across the world, due to cultural, socio-economic, geographical locations, legal and regulatory differences. Thus, for a water project in a given culture, there may be specific success and risk factors that PPP implementers should add to the established lists. Having stated this, the results can be extrapolated to other countries, especially developing and emerging economies with emerging PPP water markets as supported by the validation results. Moreover, extant literature suggests the water sectors of these countries share common characteristics (Marin, 2009; Bayliss, 2003; Matsukawa et al., 2003; Blumberg, 2013) and are likely to encounter the key risks, and require the CSFs, reported in this study.

Finally, the risk allocation decision model (FQRADM) for PPP water projects is derived based on inputs from industry experts through a Delphi questionnaire survey. This model is not yet tested on a real water supply project, despite its potential to aid risk allocation decision-making as indicated by the validation results.

10.5 RECOMMENDATION FOR FUTURE RESEARCH

Though it is hoped that the outcome of the current study would be useful to practitioners and researchers, there exist avenues for further research into this topic:

i. One unique feature of this research study is that it provides a systematic indication of the most critical success and risk factors for PPP water supply projects based on opinion of experienced industry experts. This achievement is a starting point for future researchers interested in deepening our understanding and knowledge of PPP water project risks and success factors and their variations and significance across time, space and projects (water treatment plants, pipe networks or utility management projects). With these useful findings, future researchers may apply similar methodology and the 40-risk factor and 14-success factor lists to allow for comparison in order to establish differences and similarities in water PPP risk and success factors.

ii. In this study, 22 factors represent high-risk areas in PPP water projects in Ghana. This requires a follow-up empirical research into the following questions: ―Which PPP modalities and risk mitigation measures are feasible and effective in (a) providing water infrastructure projects and (b) mitigating each highly-ranked risk factor? By answering these questions, such a study could propose an analytical framework to guide the choice of feasible PPP modalities that suit local conditions and requirements (i.e., risks) and available risk mitigation tools.

iii. The introduced risk allocation decision model (FQRADM) could be used as a decision support tool in PPP projects. To ascertain its robustness, objectivity, reliability and practicality, a further study should be carried out to test it, preferably on live PPP projects.

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APPENDIX 1

ROUND 1 OF DELPHI QUESTIONNAIRE SURVEY

Dear Sir/Madam,

INVITATION TO PARTICIPATE IN A DOCTOR OF PHILOSOPHY (PhD) RESEARCH INTO RISK MANAGEMENT IN PUBLIC-PRIVATE PARTNERSHIP (PPP) WATER SUPPLY PROJECTS IN GHANA

I write to request your assistance as a practitioner with knowledge in public-private partnerships (PPPs) in Ghana to complete the **attached questionnaire** on a Doctor of Philosophy (PhD) research into ***"Risk Allocation Model for Public-Private Partnerships (PPP) Water Supply Projects in Ghana"***. This is an ongoing research project under the supervision of Professor P.C. Chan, and funded by The Hong Kong Polytechnic University‘s International Postgraduate Scholarship. This survey is part of the above research project that seeks to deepen understanding of **critical risk factors (CRFs) and critical success factors (CSFs)** associated with PPP water supply projects in Ghana. The study aims to develop a **risk allocation model** based on fuzzy synthetic evaluation techniques to inform decision making under PPP arrangements.

This study adopts a **two-round Delphi survey** in order to share with us your experiences and views. This is Round one, and in the final round (i.e., Round two), you will be provided with controlled and anonymous feedback of all invited experts from round one and further be requested to review your opinions/ judgments in view of the consolidated opinions of all experts. The questionnaire is simple, and takes (on average) between 15 and 20 minutes to complete. All responses to the survey will be treated in strict confidence and used solely for academic purposes.

Also, I would be grateful if you could forward the questionnaire to potential practitioner/s who you feel would be able and willing to contribute to this research. If you have any queries, please do not hesitate to contact either Ernest Effah Ameyaw (Tel: +233 (0)26 506 ; and email: myernest2010@ / ernest.ameyaw@), or Professor Albert P.C. Chan (albert.chan@).

Your response will contribute a lot to this research and its further outcomes to water supply management research and practice in Ghana. My supervisor and I are willing and able to share the summary of the research with major stakeholders of Ghana‘s water sector, and anyone who requests for it.

Though this work concerns the water sector, please note that the principles and concepts of PPP remain same.

I would grateful if you are able to return the duly filled questionnaire by **02 April, 2013**. Thanking in anticipation of your kind assistance.

Yours truly,

Ernest Effah Ameyaw, PhD Candidate
Professor Albert P. C. Chan, Associate Dean, Faculty of Construction & Environment
The Hong Kong Polytechnic University, Hong Kong.

Risk allocation model for Public-Private Partnership (PPP) Water Supply Projects in Ghana

Important Instructions:

1. Please, complete the questionnaire and;
2. The completed questionnaire will be collected in person by the research student in **TWO WEEKS (and no later than 11/March/2013)**.
3. Please, provide your telephone number:…………………… and email address: ………………….
4. Please, call 026-506 or email at: ernest.ameyaw@ if you have any queries.

Outline of Questionnaire:

Part One: Defines identified risk factors to guide your judgments regarding risk probability, risk severity, and risk allocation in question 2 of Part Three. **Part Two:** Solicits your background information. **Part Three:** Question 1 – asks you to indicate the importance of risk allocation criteria (RACs) based on a Likert scale. Question 2 – asks you to indicate (a) probability, (b) severity, and (c) allocation of identified risk factors, based on Likert scales. **Part Four:** requests you to rank the importance of critical success factors for water supply PPPs, based on a Likert scale. The use of Likert scales for this survey will make your responses suitable for various statistical analyses.

Part One: Definition of Risk Factors

(Please, you may refer to the definitions, if necessary, when answering Question 2 of Part Three):

No.	Risk factor	Definition
1	Foreign exchange rate	Fluctuation in currency exchange rate, where a water project‘s revenues and costs are denominated in different currencies.
2	Political discontent & early termination	Public sector‘s dissatisfaction with the water operator‘s performance, resulting in early termination of contract by host government.
3	Expropriation/nationaslisation	Due to political, social or economic pressures, host government takes over the water business run by private firm without giving reasonable compensation
4	Political interference	Public sector interferes unreasonably in privatized water facilities/services
5	Corruption	Corrupt public officials demand or water operators offer bribes or unjust rewards in exchange for water contracts
6	Government instability and political violence	Frequent changes in government and acts of civil strife, declared war, insurrection, public disturbances, sabotage, and revolution impact profitability of water projects.
7	Currency convertibility/ transferability risk	A foreign investor‘s inability to exchange/ transfer local currency for foreign currency/ out of the country.
8	Financial and refinancing risk	Poor financial market or unavailability of financial instrument resulting in difficulty of financing/ refinancing
9	High operational costs	Operation cost overruns, more than predicted, resulting from operator‘s responsibility and external *uncontrollable* factors
10	Inflation rate	Unanticipated local inflation rate due to immature local economic and banking systems
11	Climate change risk	Adverse impacts including flood, reduced raw water availability,

No.	Risk factor	Definition
		declining groundwater levels, surge storms, low water quality, and growing water demand.
12	Regulatory risk (weak regulation)	Lack of an effective and independent regulatory system for water PPP contracts
13	Absence of policy & legal frameworks	Absence of potent policy and legal frameworks in support of PPPs and investment financing, generally
14	Non-payment of bills	The consumer/government not being able or willing to pay, due to economic, social, etc reasons
15	Fall in demand	A decline in water demand, for reasons including increased tariffs, poor market appraisals, and over-measured consumption resulting in low revenues, or profits
16	Pricing and tariff review uncertainty	Inadequate tariff design or inflexible adjustment framework leading to insufficient income
17	Unfavourable local/ global economy	Host government‘s inability to meet agreed guarantees, sufficient funding, and unstable demand for water services. A recession of regional/global economic environment impacts the success of water PPPs.
18	Sovereign and contractual risk	Uncertainties that may occur within the operating environment/ in legislation and government policies during the life of a project
19	Water theft	Prevalent water theft from distribution networks by consumers
20	Faulty demand forecasting	Forecasted demand will be inconsistent (i.e., over-estimated) with projections affecting project profitability
21	Public resistance to PPP	Lack of public support resulting in delays in project approval, contract variation, abandonment, etc.
22	Water asset condition uncertainty	Limited knowledge of water infrastructure condition during bidding, which could be worse than expected.
23	Technology risk	The technology adopted not being mature or able to deliver output specifications
24	Insufficient private operator performance during operation	Failure to meet service targets (coverage rate, water quality, service continuity, cost recovery) by private operator.
25	Pipeline failures during distribution	Technical leakage during water transmission/ distribution causing water outages and revenue losses
26	Residual value risk	Underlying water assets on expiration of a concession will fail to be in pre-determined condition for transfer to the public partner
27	Construction time & cost overrun	Longer construction time, and higher construction cost than predicted
28	Design & construction deficiencies	The designed/ constructed water facility fails to satisfy required specifications, resulting in poor service delivery
29	Land acquisition risk	The project land is unavailable, or unable to be occupied at the required time
30	Supporting utilities risk	Supporting utilities (especially electricity) necessary for the construction/ operation of water systems would be unavailable or unreliable
31	Conflict between partners	Conflict (strained relation) engulf water partnerships jeopardizing projects‘ successes
32	Lack of PPP experience	Lack of local expertise and experience to develop and implement water PPPs.
33	Poor contract design	Applying contractual designs with clear weaknesses and irregularities regarding incentives, tariffs, regulation, commitments from partners, risk allocation, choice of PPP model, etc
34	Quasi-commercial risk	Uncertainty over willingness and/or capacity of decentralised governments/ public water utilities to fulfil their contractual obligations as suppliers or purchasers of, for example, bulk water.
35	Procurement risk	Immature procurement systems/ lack of professional advisors resulting in flawed contract designs, legal disputes, and poor project delivery
36	Change in government &	Possibility of a newly-elected government opposing/ abandoning

No.	Risk factor	Definition
	political opposition	PPP schemes, resisting tariff increases, or reversing original agreements.
37	Raw water scarcity	Non-availability of raw water resources
38	Low quality of raw water	Polluted or low quality of raw water resulting in high treatment costs
39	Interest rate	Unexpected local interest rate due to undeveloped economic and banking systems
40	Force majeure	The circumstances that are out of the control of both public/private partners, such as flood, fires, storms, epidemic diseases, war, hostilities and embargo
Some references: Ke et al., 2010; Ameyaw, 2012; Ameyaw and Chan, forthcoming; Wibowo & Mohamed, 2010; Xenidis & Angelides, 2005		

Part Two: General Background Information on Expert

1. Sector category (multiple answers allowed): Public sector☐; Private sector☐; Academic☐;
2. Number of years of (industrial) experience: years;
3. Your position in your organisation:
4. Years of PPP experience/ research:
5. Number of PPP projects you have been involved in (if any):
6. Type of PPP projects you have been involved in (multiple answers allowed): Water concessions ☐; lease/ affermage☐; BOT-type☐; Others

Part Three: Risk Allocation Criteria; and Risk Assessment & Risk Allocation

Question 1: Risk Allocation Criteria (RACs) for Optimal Risk Allocation in PPP Projects

This section consists of criteria for optimal risk allocation, and you can draw on your general experience/ knowledge of PPP procurements. Please, indicate the level of importance of each risk allocation criteria:

1 = not important; 2 = very low importance; 3 = low importance; 4 = Moderate; 5 = important; 6 = very important; 7 = extremely important.

No.	Criteria for equitable risk allocation in PPPs	Ratings
1	The ability to foresee the probability of risk occurrence and evaluate possible severity of the risk consequence	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
2	The ability to avoid, minimize, monitor, and control the chance of risk occurrence	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
3	The ability to minimize the loss if risk occurs (minimize the severity, extra cost, and delay)	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
4	The ability to sustain the consequences of the risk	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7

5	The ability to bear the risk at the lowest price	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
6	Be able to get reasonable and acceptable premium	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
7	Be able to enhance risk undertaker's credibility, reputation, and efficiency in risk management	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
8	Be able to assume the direct loss	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
9	Risk should be allocated to the party who prefer to assume the risk (risk neutral, risk prone, or risk averse)	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
Reference: Xu et al 2010		

Question 2: The following provides a table of risk factors involved in PPP water supply projects.

(A). Please, indicate an estimated probability (likelihood) of occurrence of each risk factor based on the following scale: **1 = extremely low; 2 = very low; 3 = low; 4 = moderate; 5 = high; 6 = very high; 7 = extremely high probability** of occurrence.

(B). Please, indicate an estimated severity of each risk factor based on the following scale: **1 = extremely low; 2 = very low; 3 = low; 4 = moderate; 5 = high; 6 = very high; 7 = extremely high**

(C). Please, allocate each risk based on the following scale: **1 = public sector takes sole responsibility; 2 = public sector takes major responsibility; 3 = both parties take equal responsibility; 4 = private sector takes major responsibility; 5 = private sector takes sole responsibility.**

Reminder: You may refer to Part One for definitions as may be necessary.

No.	Risk factors	**A:** Probability of occurrence	**B:** Severity of risk factors	**C:** Risk allocation
1	Foreign exchange rate	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
2	Political discontent & early termination	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
3	Expropriation/nationaslisation	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
4	Political interference	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
5	Corruption	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
6	Political violence/ Government instability	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
7	Currency convertibility/ transferability	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
8	Financial and refinancing risk	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
9	High operational costs	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
10	Inflation rate volatility	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
11	Climate change risk	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
12	Regulatory risk (weak regulation)	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
13	Absence of policy & legal frameworks	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
14	Non-payment of bills	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
15	Fall in demand	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5
16	Water pricing and tariff	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5;☐6;☐7	☐1;☐2;☐3;☐4;☐5

No.	Risk factors	**A:** Probability of occurrence	**B:** Severity of risk factors	**C:** Risk allocation
	review uncertainty			
17	Unfavourable local/global economy	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
18	Sovereign and contractual risk	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
19	Water theft	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
20	Faulty demand forecasting	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
21	Public resistance to PPP	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
22	Water asset condition uncertainty	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
23	Technology risk	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
24	Insufficient private operator performance during operation	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
25	Pipeline bursts during distribution	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
26	Residual value risk	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
27	Construction time & cost overrun	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
28	Design & construction deficiencies	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
29	Land acquisition risk	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
30	Supporting utilities risk	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
31	Conflict between partners	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
32	Lack of PPP experience	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
33	Poor contract design	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
34	Change in government & political opposition	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
35	Quasi-commercial risk	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
36	Procurement risk	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
37	Raw water scarcity	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
38	Low quality of raw water	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
39	Interest rate	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5
40	Force majeure	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5;□6;□7	□1;□2;□3;□4;□5

Part Four: Factors Contributing to the Success of Water Supply PPPs

Please, indicate the level of importance of each factor's contribution to successful PPPs in the water supply sector of Ghana: **1 = not important; 2 = very low importance; 3 = low importance; 4 = Moderate; 5 = important; 6 = very important; 7 = extremely important**

No.	Critical success factors (CSFs) for water PPPs	Rating
1	National PPP policy and implementation unit	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
2	Public acceptance/support	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
3	Government (political) commitment	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
4	Adequate financing	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
5	Quality water asset and workforce	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
6	Effective regulatory and legal structures	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
7	Strong and competent private partner	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
8	Profitable water supply projects	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
9	Flexible contracts with fair risk allocations	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
10	Local capacity building for utility staff	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
11	Competitive tendering	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
12	Internal coordination within government	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
13	Strong commitment from project partners	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
14	Strong public partner	☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
Please indicate and rate other success factors (if any)		
1		☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
2		☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
3		☐1; ☐2; ☐3; ☐4; ☐5; ☐6; ☐7
Some references: Meng et al., 2011; Ameyaw, 2012; Li et al. 2005		

-The End-

Thank You for Participating in Round One

Please, the research student will collect the duly filled questionnaire in person within two weeks.

NB: References are available on request.

APPENDIX 2

ROUND 2 OF DELPHI QUESTIONNAIRE SURVEY

Dear Sir/Madam,

We are very grateful for your quality feedback to our Water Public-Private Partnership (PPP) Delphi Survey in Ghana. Please, this is the final round (i.e. Round two) and you are provided with **attached** controlled feedback of all invited experts *(MS word doc.)* and summary of results *(pdf file)* from Round one.

Please, you are further requested to review or reconsider your opinions/ judgments/ scores in view of the consolidated opinions (mean scores) of all experts. Please, note that a **nil entry implies that you are happy with the original score in Round one and no adjustment is necessary.**

Your response will contribute a lot to this research and its further outcomes to water supply management research and practice. My supervisor and I are willing and able to share the summary of the research with anyone who requests for it.

We would be grateful if you are able to respond **within one week from today**. Thanking in anticipation of your kind assistance.

Yours truly,

Ernest Effah Ameyaw, PhD Candidate
Professor Albert P. C. Chan, Associate Dean, Faculty of Construction & Environment
The Hong Kong Polytechnic University, Hong Kong

ROUND TWO: STATISTICAL FEEDBACK OF ALL INVITED EXPERTS AND ADJUSTMENT OF ROUND ONE SCORES

Expert Respondent's Name/ Tel No.: Mr. G. H.

Part 3: Risk Allocation Criteria; and Risk Assessment & Risk Allocation

Question 1: Risk Allocation Criteria (RACs) for Optimal Risk Allocation in PPP Projects

Likert Scale: 1 = not important; 2 = very low importance; 3 = low importance; 4 = Moderate; 5 = important; 6 = very important; 7 = extremely important

***Nil entry implies that you are happy with the original score and no adjustment is necessary**

No.	Criteria for equitable risk allocation in PPPs	Mean score by 37 experts	Your score in Round 1	Your adjusted score in Round 2 (if deemed necessary)*
1	The ability to foresee the probability of risk occurrence and evaluate possible severity of the risk consequence	6.03	6	
2	The ability to avoid, minimize, monitor, and control the chance of risk occurrence	6.05	6	
3	The ability to minimize the loss if risk occurs (minimize the severity, extra cost, and delay)	5.89	5	
4	The ability to sustain the consequences of the risk	5.14	6	
5	The ability to bear the risk at the lowest price	5.38	5	
6	Be able to get reasonable and acceptable premium	4.86	4	
7	Be able to enhance risk undertaker's credibility, reputation, and efficiency in risk management	5.43	5	
8	Be able to assume the direct loss	4.92	5	
9	Risk should be allocated to the party who prefer to assume the risk (risk neutral, risk prone, or risk averse)	4.54	4	

Question 2: Risk Probability of Occurrence (A)

Likert Scale: 1 = extremely low; 2 = very low; 3 = low; 4 = moderate; 5 = high; 6 = very high; 7 = extremely high probability of occurrence.

***Nil entry implies that you are happy with the original score and no adjustment is necessary**

No.	Risk Factors	Mean score by 40 experts	Your score in Round 1	Your adjusted score in Round 2 (if deemed necessary)*
1	Foreign exchange rate	5.43	5	
2	Political discontent & early termination	4.10	4	
3	Expropriation/nationaslisation	3.28	4	
4	Political interference	4.98	3	
5	Corruption	5.13	3	
6	Political violence/ Government instability	3.00	4	
7	Currency convertibility/ transferability	3.60	4	
8	Financial and refinancing risk	4.00	2	
9	High operational costs	4.73	3	
10	Inflation rate volatility	4.65	4	
11	Climate change risk	3.60	2	
12	Regulatory risk (weak regulation)	4.13	4	
13	Absence of policy & legal frameworks	3.38	2	
14	Non-payment of bills	4.95	4	
15	Fall in demand	2.88	3	
16	Water pricing and tariff review uncertainty	4.35	6	
17	Unfavourable local/ global economy	3.95	3	
18	Sovereign and contractual risk	3.73	4	
19	Water theft	5.15	5	
20	Faulty demand forecasting	3.68	3	
21	Public resistance to PPP	4.28	3	
22	Water asset condition uncertainty	3.98	3	
23	Technology risk	3.85	2	
24	Insufficient private operator performance during operation	4.08	3	
25	Pipeline failures during distribution	4.63	4	
26	Residual value risk	4.03	3	
27	Construction time & cost overrun	4.35	3	
28	Design & construction deficiencies	3.95	3	
29	Land acquisition risk	4.30	4	
30	Supporting utilities risk	4.60	5	

31	Conflict between partners	4.33	4	
32	Lack of PPP experience	4.73	3	
33	Poor contract design	4.28	2	
34	Change in government & political opposition	4.20	4	
35	Quasi-commercial risk	3.90	3	
36	Procurement risk	3.78	4	
37	Raw water scarcity	3.08	1	
38	Low quality of raw water	3.80	3	
39	Interest rate	4.28	2	
40	Force majeure	3.53	4	

Question 2: Risk Severity (B)

Likert Scale: 1 = extremely low; 2 = very low; 3 = low; 4 = moderate; 5 = high; 6 = very high; 7 = extremely high

***Nil entry implies that you are happy with the original score and no adjustment is necessary**

No.	Risk Factors	Mean score by 40 experts	Your score in Round 1	Your adjusted score in Round 2 (if deemed necessary)*
1	Foreign exchange rate	5.10	5	
2	Political discontent & early termination	4.68	6	
3	Expropriation/nationaslisation	4.05	6	
4	Political interference	5.25	4	
5	Corruption	5.50	4	
6	Political violence/ Government instability	4.18	4	
7	Currency convertibility/ transferability	4.23	5	
8	Financial and refinancing risk	4.83	6	
9	High operational costs	5.13	5	
10	Inflation rate volatility	4.78	5	
11	Climate change risk	4.08	2	
12	Regulatory risk (weak regulation)	4.58	5	
13	Absence of policy & legal frameworks	4.25	5	
14	Non-payment of bills	5.48	6	
15	Fall in demand	4.30	6	
16	Water pricing and tariff review uncertainty	4.83	5	
17	Unfavourable local/ global economy	4.55	5	
18	Sovereign and contractual risk	4.40	5	
19	Water theft	5.18	4	
20	Faulty demand forecasting	4.35	5	
21	Public resistance to PPP	4.85	5	

22	Water asset condition uncertainty	4.53	5	
23	Technology risk	4.40	4	
24	Insufficient private operator performance during operation	4.70	5	
25	Pipeline failures during distribution	5.10	4	
26	Residual value risk	4.45	4	
27	Construction time & cost overrun	4.70	5	
28	Design & construction deficiencies	4.88	5	
29	Land acquisition risk	4.70	5	
30	Supporting utilities risk	4.78	6	
31	Conflict between partners	4.63	5	
32	Lack of PPP experience	4.98	4	
33	Poor contract design	5.03	6	
34	Change in government & political opposition	4.73	5	
35	Quasi-commercial risk	4.35	6	
36	Procurement risk	4.60	4	
37	Raw water scarcity	4.70	6	
38	Low quality of raw water	4.78	6	
39	Interest rate	4.78	4	
40	Force majeure	4.93	5	

Question 2: Risk Allocation (C)

Likert Scale:1 = public sector takes sole responsibility; 2 = public sector takes major responsibility; 3 = both parties take equal responsibility; 4 = private sector takes major responsibility; 5 = private sector takes sole responsibility.

***Nil entry implies that you are happy with the original score and no adjustment is necessary**

No.	Risk Factors	Mean score by 39 experts	Your score in Round 1	Your adjusted score in Round 2 (if deemed necessary)*
1	Foreign exchange rate	2.56	1	
2	Political discontent & early termination	2.15	2	
3	Expropriation/nationaslisation	2.21	1	
4	Political interference	2.08	2	
5	Corruption	2.97	3	
6	Political violence/ Government instability	1.95	1	
7	Currency convertibility/ transferability	2.56	2	
8	Financial and refinancing risk	3.64	5	
9	High operational costs	3.79	5	
10	Inflation rate volatility	2.77	**1**	
11	Climate change risk	2.90	2	

12	Regulatory risk (weak regulation)	2.05	1	
13	Absence of policy & legal frameworks	2.05	1	
14	Non-payment of bills	2.90	1	
15	Fall in demand	2.82	2	
16	Water pricing and tariff review uncertainty	2.46	1	
17	Unfavourable local/ global economy	2.67	2	
18	Sovereign and contractual risk	2.46	2	
19	Water theft	3.38	2	
20	Faulty demand forecasting	3.15	4	
21	Public resistance to PPP	2.54	3	
22	Water asset condition uncertainty	2.64	2	
23	Technology risk	3.97	5	
24	Insufficient private operator performance during operation	3.64	5	
25	Pipeline failures during distribution	3.10	2	
26	Residual value risk	3.23	4	
27	Construction time & cost overrun	3.56	4	
28	Design & construction deficiencies	3.72	5	
29	Land acquisition risk	1.85	1	
30	Supporting utilities risk	2.72	5	
31	Conflict between partners	3.05	3	
32	Lack of PPP experience	2.64	3	
33	Poor contract design	2.87	3	
34	Change in government & political opposition	2.10	1	
35	Quasi-commercial risk	2.69	1	
36	Procurement risk	2.41	1	
37	Raw water scarcity	2.87	2	
38	Low quality of raw water	2.56	2	
39	Interest rate	2.85	4	
40	Force majeure	2.82	2	

Part 4: Factors Contributing to the Success of Water Supply PPPs in Ghana

Likert Scale: 1 = not important; 2 = very low importance; 3 = low importance; 4 = Moderate; 5 = important; 6 = very important; 7 = extremely important

***Nil entry implies that you are happy with the original score and no adjustment is necessary**

No.	Critical Success Factor (CSF)	Mean score by 41 experts	Your score in Round 1	Your adjusted score in Round 2 (if deemed necessary)*
1	National PPP policy and implementation unit	6.05	6	
2	Public acceptance/support	6.15	5	
3	Government (political) commitment	6.71	7	
4	Adequate financing	6.39	5	
5	Quality water asset and workforce	5.78	5	
6	Effective regulatory and legal structures	6.12	6	
7	Strong and competent private partner	6.22	6	
8	Profitable water supply projects	5.63	6	
9	Flexible contracts with fair risk allocations	5.63	6	
10	Local capacity building for utility staff	5.71	4	
11	Competitive tendering	5.71	3	
12	Internal coordination within government	5.54	6	
13	Strong commitment from project partners	6.07	7	
14	Strong and competent public partner	6.12	7	

-END-

Thank You for Participating in Round Two

APPENDIX 3

ROUND 3 OF DELPHI QUESTIONNAIRE SURVEY

Dear Expert,

We are very grateful for your kind assistance and contribution to our earlier two-round international Delphi survey on Risks on Water Supply PPP projects.

Based on the background information you provided during this survey, we realised that you have rich experience in water, and PPP practice and/or research and you are among the five experts selected for this final phase of the PhD research.

We are humbly seeking your assistance in evaluating the public and private sectors capability to manage a set of risk factors against risk allocation criteria (RAC).

Please, evaluate each risk factor on each risk evaluation criterion based on the following five-point scale:
1 = very low ability;
2 = low ability;
3 = moderate ability;
4 = high ability;
5 = very high ability.

This is final and round three of our earlier Delphi survey, and your response would aid us to develop a risk allocation model to guide the risk allocation decision-making in PPP projects.

Please, acknowledging your busy schedules, **you have 3 weeks (or 21 days) from today within which to respond**. We however will be sending you regular reminders through emails and phone calls. Your contribution will mean a lot to effective risk management for water supply PPP projects.

Please, email me if you have any queries. Thanking in anticipation for your kind assistance.

Yours truly,

Ernest Effah Ameyaw, PhD Candidate
Professor Albert P. C. Chan, Supervisor, Associate Dean, Faculty of Construction & Environment
The Hong Kong Polytechnic University, Hong Kong

ID	Risk Allocation Criteria (RAC)	Critical Risk Factors (CRFs)													
		Foreign exchange rate	Corruption	Water theft	Non-payment of bills	Political interference	High operational costs	Pipeline failures	Lack of PPP experience	Inflation rate	Construction time & cost overruns	Poor contract design	Unreliable energy supply	Interest rate	Political discontent and (early) termination by
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	The ability to foresee and assess the probability of risk occurrence and evaluate possible severity of the risk consequence														
2	The ability to avoid, minimize, monitor, and control the chance of risk occurrence														
3	The ability to minimize the loss if risk occurs (minimize the severity, extra cost, and delay)														
4	The ability to sustain the consequences of the risk														
5	Be able to enhance risk undertaker's credibility, reputation, and efficiency in risk management														
6	Be able to enhance risk undertaker's credibility, reputation, and efficiency in risk management														
7	Be able to assume the direct loss														

ID	Risk Allocation Criteria (RAC)	Critical Risk Factors (CRFs)							
		Design and construction deficiencies	Conflict between partners	Water pricing and tariff review uncertainty	Financing and refinancing	Land acquisition	Public resistance to PPP	Change in government and political opposition	Insufficient private operator performance
		15	16	17	18	19	20	21	22
1	The ability to foresee and assess the probability of risk occurrence and evaluate possible severity of the risk consequence								
2	The ability to avoid, minimize, monitor, and control the chance of risk occurrence								
3	The ability to minimize the loss if risk occurs (minimize the severity, extra cost, and delay)								
4	The ability to sustain the consequences of the risk								
5	Be able to enhance risk undertaker's credibility, reputation, and efficiency in risk management								
6	Be able to enhance risk undertaker's credibility, reputation, and efficiency in risk management								
7	Be able to assume the direct loss								

APPENDIX 4

SELECTED CONSTRUCTION MANAGEMENT PEER-REVIEWED PAPERS ON DELPHI METHOD

Selected construction management peer-reviewed papers on Delphi method

Study	Experts qualification	No. of rounds (R)	No. of experts in each round	Means of feedback	Measure of consensus	Survey duration	Field / application	Journal
Gunhan and Arditi (2005)	Specific, prequalified	2	R1 (12/17) R2 (10/12)	Median	Standard deviation	Not indicated	International construction	JCEM
Xia et al. (2013)	Specific, prequalified	2	R1 (82/615) R2 (34/82)	Mean	Kendall's Coefficient of Concordance (*W*)	Not specific, about 5 months	Design-build	JCEM
Hallowell and Gambatese (2009a)	Specific, prequalified	3	R1 (15/15) R2 (13/15) R3 (13/15)	Median	Absolute deviation	Not indicated	Safety risk	JCEM
del Cano and de la Cruz (2002)	Specific, not prequalified	1	R1 (20/20)	None indicated	Not indicated	Not indicated	Risk management	JCEM
Iyer and Sagheer (2010)	Specific, not prequalified	2	R1 (4/4) R2 (4/4)	Mean	Mean values	Not indicated	Risk management	JCEM
Xia et al. (2011)	Specific, not prequalified	3	R1 (20/20) R2 (17/20) R3 (17/17)	Mean	Kendall's Coefficient of Concordance (*W*)	Not indicated	Design-build	JCEM
Rajendran and Gambatese (2009)	Specific, prequalified	3	R1 (12/15) R2 (11/12) R3 (11/11)	Mean; Median	Mean score; Range	Not indicated	Construction health and safety	JCEM
Lu (2010)	Not specific	Not indicated	Not indicated	None indicated	Not indicated	Not indicated	Strategic planning	JCEM
Yeung et al. (2010)	Specific, prequalified	2	R1 (34/34) R2 (34/34)	Mean	Kendall's Coefficient of Concordance (*W*)	Not indicated	Risk allocation	JCEM
Hyun et al. (2008)	Specific, prequalified	3	R1–R3 (7)	None indicated	None	Not indicated	Project performance	JCEM
Yasamis-Speroni and Arditi (2012)	Specific, prequalified	2	R1 (6) R2 (6)	Mean	Coefficient of variance (COV)	Not indicated	Quality performance	JCEM
Hallowell and Gambatese (2009b)	Specific, prequalified	3	R1 (13) R2 (13) R3 (13)	Median	Absolute deviation	Not specific, 1month b/n rounds	Safety risk mitigation	JCEM

Selected construction management peer-reviewed papers on Delphi method *(continues)*

Study	Experts qualifications	No. of rounds (R)	No. of experts in each round	Means of feedback	Measure of consensus	Survey duration	Field / application	Journal
Hallowell and Calhoun (2011)	Specific, prequalified	3	R1–R3 (10/13)	Median	Absolute deviation	4 months	Construction safety	JCEM
Yeung et al. (2007)	Specific, prequalified	4	R1 (31/39) R1 (31/31) R1 (31/31) R1 (31/31)	Percentage	Kendall‘s Coefficient of Concordance (*W*)	5 months	Partnering performance indicators	CME
Chan et al. (2001)	Specific, prequalified	4	R1 (10) R2 (10) R3 (8) R4 (8)	Average	Kendall‘s Coefficient of Concordance (*W*)	About 5 months	Procurement systems	CME
Chong et al. (2013)	Specific, not prequalified	2	R1–R2 (12)	None indicated	Mean	Not indicated	Contract administration	JCEM
Arnold and Javernick-Will (2013)	Specific, prequalified	3	R1 (11/11) R2 (11/11) R3 (9/11)	Median	Absolute deviation	Not indicated	Construction project management	JCEM
Ghraibeh (2013)	Specific, prequalified	3	R1–R3 (27)[+]	None indicated	Percentage	Not indicated	Cost management	JCEM
Manoliadis and Nakou (2006)	Specific, prequalified	2	R1 (20) R2 (20)	Mean	None indicated	5 months	Sustainable construction	CME
Gannon and Smith (2011)	Specific, not prequalified	2	R1 (9) R2 (9)	Experts‘ views	None indicated	Not indicated	Public-private partnership (PPP)	CME

[+]The author investigated 2 unique projects with Delphi panelists of 15 and 12.

JCEM: Journal of Construction, Engineering and Management
CME: Construction Management and Economics

APPENDIX 5

FUZZY SYNTHETIC EVALUATION PROJECT RISK / SUCCESS EVALUATION PROCESS

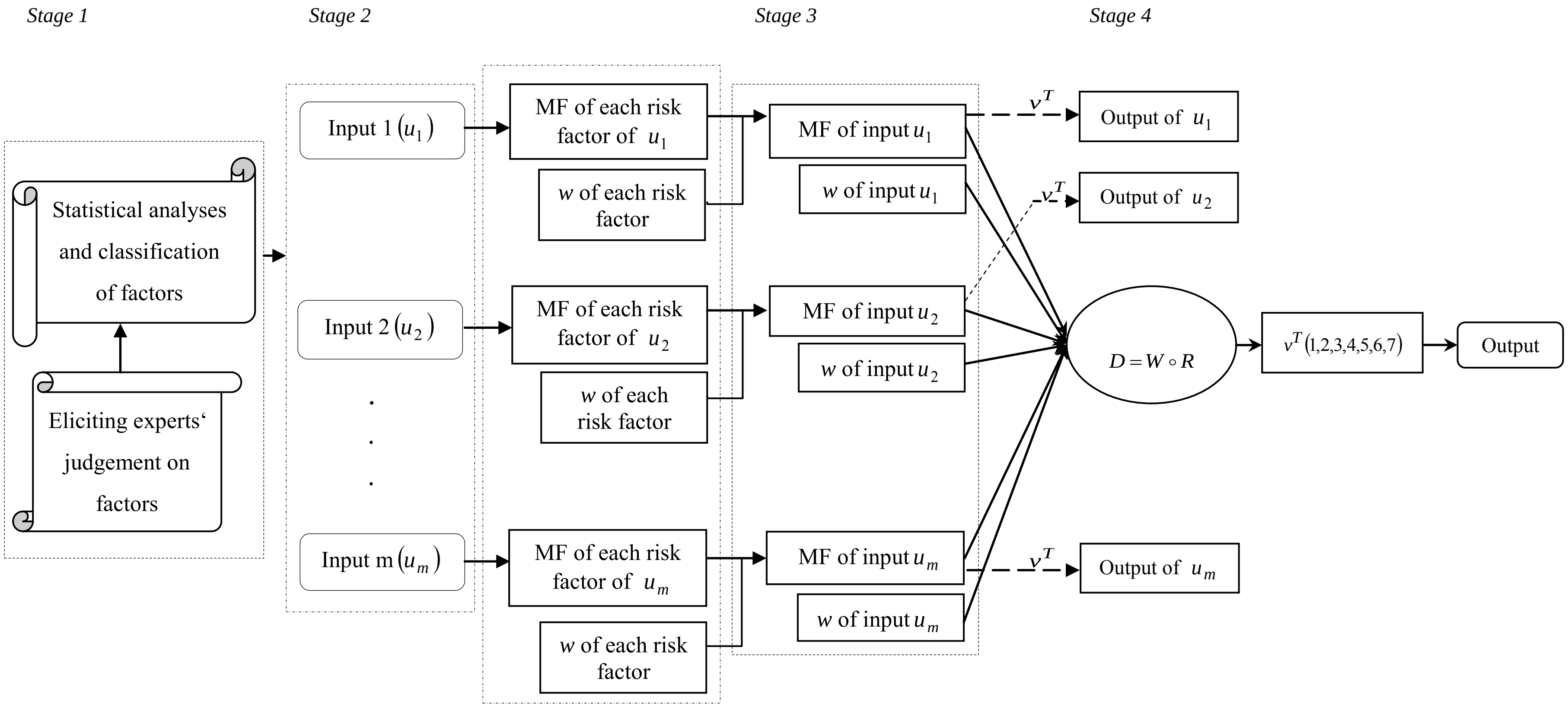


Fig. 5a: FSE project risk/success evaluation process

NB: MF = membership function; w = weighting function

APPENDIX 6

VALIDATION QUESTIONNAIRES FOR THE STUDY

Questionnaire for Validating Critical Risk Factors (CRFs) and Critical success Factors (CSFs) in PPP Water Supply Projects

Purpose of questionnaire

To validate that the set of (i) 23 critical risk factors (CRFs) and (ii) 14 critical success factors (CSFs) in PPP water supply projects is relevant and practical to PPP practice.

Background

These risk factor and success factor lists were established as part of the deliverables of a PhD research study conducted at The Hong Kong Polytechnic University in Hong Kong by Mr. Ameyaw Effah Ernest, under the supervision of Professor Albert P. C. Chan. The overall study aimed at developing a risk allocation model for PPP water supply projects in developing countries, using Ghana as a case study. These CRFs and CSFs were derived following a two-round Delphi questionnaire in Ghana between February and May 2013.

Instructions

This document has 5 pages (1 page of background and 4 pages presenting the risk factors and the success factors in separate tables). After going through the tables, you are kindly requested to respond to questions that aim at validating both factor lists.

Information of expert respondent

Name of organisation/institution:

Position in your organisation:

Primary role: Public sector ☐; Private sector ☐; Academic ☐

Years of professional experience:

Please, your kind assistance in completing this questionnaire is very appreciated. Please kindly return the completed questionnaire (this file) to Mr. Ameyaw Effah Ernest by email: **1190 @ / myernest2010@** within ~~***two weeks***~~ from today, **7 May 2014**.

Thank you in advance for your kind contribution.

Yours truly,

Ameyaw Effah Ernest, PhD Candidate
Professor Albert P. C. Chan, Interim Dean, Faculty of Construction and Environment
The Hong Kong Polytechnic University
Hong Kong

Part A: Critical Risk Factors (CRFs) in PPP Water supply projects

Table 1 Established critical risk factors (CRFs) in PPP water supply projects

ID	Critical Risk Factors	Risk Probability	Risk Severity	Risk Significance Index	Risk impact	Ranking	Normalized values	Risk criticality
RF1	Foreign exchange rate	5.58	5.18	28.90	5.38	1	1.00	High
RF2	Corruption	5.13	5.58	28.63	5.35	2	0.98	High
RF3	Water theft	5.13	5.20	26.68	5.16	3	0.89	High
RF4	Non-payment of bills	4.90	5.38	26.36	5.13	4	0.87	High
RF5	Political interference	5.00	5.15	25.75	5.07	5	0.84	High
RF6	High operational costs	4.70	5.10	23.97	4.90	6	0.75	High
RF7	Pipeline failures during distribution	4.55	5.20	23.66	4.86	7	0.73	High
RF8	Lack of PPP experience	4.68	5.05	23.63	4.86	8	0.73	High
RF9	Inflation rate volatility	4.73	4.88	23.08	4.80	9	0.70	High
RF10	Construction time & cost overrun	4.50	5.03	22.64	4.76	10	0.68	High
RF11	Poor contract design	4.23	5.10	21.57	4.64	11	0.61	High
RF12	Supporting utilities risk	4.50	4.78	21.51	4.64	12	0.61	High
RF13	Interest rate	4.38	4.83	21.16	4.60	13	0.59	High
RF14	Political discontent & early termination	4.28	4.90	20.97	4.58	14	0.58	High
RF15	Design & construction deficiencies	4.05	5.13	20.78	4.56	15	0.57	High
RF16	Conflict between partners	4.38	4.70	20.59	4.54	16	0.56	High
RF17	Water pricing and tariff review uncertainty	4.20	4.88	20.50	4.53	17	0.56	High
RF18	Financial and refinancing risk	4.15	4.93	20.46	4.52	18	0.55	High
RF19	Land acquisition risk	4.25	4.78	20.32	4.51	19	0.55	High
RF20	Public resistance to PPP	4.25	4.75	20.19	4.49	20	0.54	Moderate
RF21	Change in government & political opposition	4.20	4.73	19.87	4.46	21	0.52	Moderate
RF22	Insufficient operator performance	4.05	4.83	19.56	4.42	22	0.51	Moderate
RF23	Regulatory risk (inexpert regulation)	4.03	4.65	18.74	4.33	23	0.50	Moderate
7-point scale		1 = not important and 7 = extremely important						

$$\text{Risk significance index} = (\text{probability} \times \text{severity})$$

$$\text{Risk impact} = (\text{risk significance index})^{0.5}$$

$$N_v = a + (x - A) \times (b - a) / B - A,$$

where, N_v = normalized value of a specific risk factor; a = minimum value (= 0); b = maximum value (= 1); A = minimum mean index of the risk factors; B = maximum mean index of the risk factors; and *x* = mean index of a specific risk factor to be normalized. Risk factors with $N_v \geq 0.50$ are deemed _critical' in this study.

Part B: Critical Success Factors (CSFs) in PPP Water supply projects

Table 2 Established critical success factors (CSFs) in PPP water supply projects

ID	Critical success factor (CSF)	Mean index	Std. deviation	Ranking	Criticality	Cronbach's alpha if item deleted
CSF3	Government (political) commitment	6.80	0.06	1	extremely important	0.813
CSF4	Adequate financing	6.39	0.10	2	very important	0.812
CSF2	Public acceptance/support	6.24	0.13	3	very important	0.818
CSF7	Strong and competent private partner	6.22	0.13	4	very important	0.806
CSF6	Effective regulatory and legal structures	6.20	0.12	5	very important	0.807
CSF14	Strong and competent public partner	6.20	0.16	6	very important	0.805
CSF1	PPP policy and unit	6.17	0.16	7	very important	0.823
CSF10	Strong commitment from project partners	6.15	0.15	8	very important	0.801
CSF5	Capacity building for local utility staff	5.90	0.15	9	very important	0.810
CSF11	Quality water asset and workforce	5.88	0.14	10	very important	0.820
CSF8	Competitive tendering	5.80	0.19	11	very important	0.814
CSF9	Profitable water supply projects	5.78	0.15	12	very important	0.824
CSF12	Flexible contracts with fair risk allocations	5.73	0.12	13	very important	0.808
CSF13	Internal coordination within government	5.66	0.17	14	very important	0.797

VALIDATION QUESTIONNAIRE

Please, respond to separate questions on the CRFs and the CSFs as shown in the following pages.

Questionnaire for Part A: Critical Risk Factors (CRFs) in PPP Water supply projects

1. Choose appropriate score for each validation aspect/question to indicate extent of your satisfaction: **1 – poor; 2 – average; 3 – good; 4 – very good; 5 – excellent**

	Validation Aspects	Evaluation Scale
a	Are the 23 critical risk factors (CRFs) critical in water PPPs in developing countries?	1☐; 2☐; 3☐; 4☐; 5☐
b	Do the 23 CRFs reflect those encountered in PPP water supply project in practice?	1☐; 2☐; 3☐; 4☐; 5☐
c	Can the 23 CRFs contribute to the failure of PPP water supply projects if poorly identified and managed?	1☐; 2☐; 3☐; 4☐; 5☐
d	Are the probability and severity rankings of the risk factors reasonable?	1☐; 2☐; 3☐; 4☐; 5☐

2. Of the 23 CRFs listed in Table 1, which ten contribute most to failure of PPP water projects in developing countries? *(please indicate by providing the IDs of your selected factors in the following table)*

Your top-ten CRFs			
Rank	ID *(e.g. RF2 in Table 1)*	Rank	ID *(e.g. RF2 in Table 1)*
1		6	
2		7	
3		8	
4		9	
5		10	

3. Other general comments (if any):

<u>Questionnaire for Part B: Critical Success Factors (CSFs) in PPP Water supply projects</u>

1. Choose appropriate score for each validation aspect/question to indicate extent of your satisfaction: **1 – poor; 2 – average; 3 – good; 4 – very good; 5 – excellent**

Validation Aspects		**Evaluation Scale**
a	Are the 14 critical success factors (CSFs) relevant or critical to the success of water PPPs in developing countries?	1☐; 2☐; 3☐; 4☐; 5☐
b	Do the 14 CSFs reflect those encountered in successful PPP water supply project in practice?	1☐; 2☐; 3☐; 4☐; 5☐
c	Please, can the 14 CSFs contribute to the success of PPP water supply projects if rightly put together and provided special and continual management attention?	1☐; 2☐; 3☐; 4☐; 5☐
d	Are the importance rankings of the success factors reasonable?	1☐; 2☐; 3☐; 4☐; 5☐

2. Of the 14 CSFs listed in Table 2, which five contribute most to successful PPP water projects? *(please indicate by providing the IDs of your selected factors in the following table)*

Your top-five CSFs	
Rank	ID *(e.g. CSF2 in Table 2)*
1	
2	
3	
4	
5	

3. Other general comments (if any):

The End

Many thanks for your time and participation

Questionnaire for Validating A Risk Allocation Model for Risk Sharing Decision in PPP Projects

<u>Purpose of questionnaire</u>
To validate that the proposed risk allocation model for risk sharing decision in PPP projects is appropriate, objective, easy to understand and use, reliable and practical.

<u>Background</u>
This model was proposed as part of the deliverables of a PhD research study conducted at The Hong Kong Polytechnic University in Hong Kong by Mr. Ameyaw Effah Ernest, under the supervision of Professor Albert P. C. Chan. The overall study aimed at developing a risk allocation model for PPP water supply projects in developing countries, using Ghana as a case study. The model was derived following a three-round Delphi questionnaire survey among water and PPP practitioners (from public and private sectors) in Ghana between February and June 2013.

<u>Instructions</u>
This document contains seven pages. Following on this background, the summary of the model is shown in a flow chart in Fig. 1 (section 1) and briefly described in section 2, while the application and output of the model is summarised in section 3. After going through these sections, you are kindly requested to rate seven aspects by checking appropriate boxes in section 4.

*NB: For more details, you **<u>MAY</u>** refer to attached File 2 (Risk Allocation Model and Demonstration) which first presents and explains the model, and then demonstrates its application using one salient risk factor, Foreign exchange rate (RF1), in a PPP water supply project. This could help you to understand and make sense of the model.*

Your kind assistance in completing this questionnaire will be much appreciated. Kindly return the completed questionnaire (this file) to Mr. Ameyaw Effah Ernest by email: **1190 / myernest2010@** within ***~~two weeks~~*** from today, **7 ~~May~~ <u>2014</u>**.

Thank you in advance for your kind contribution.

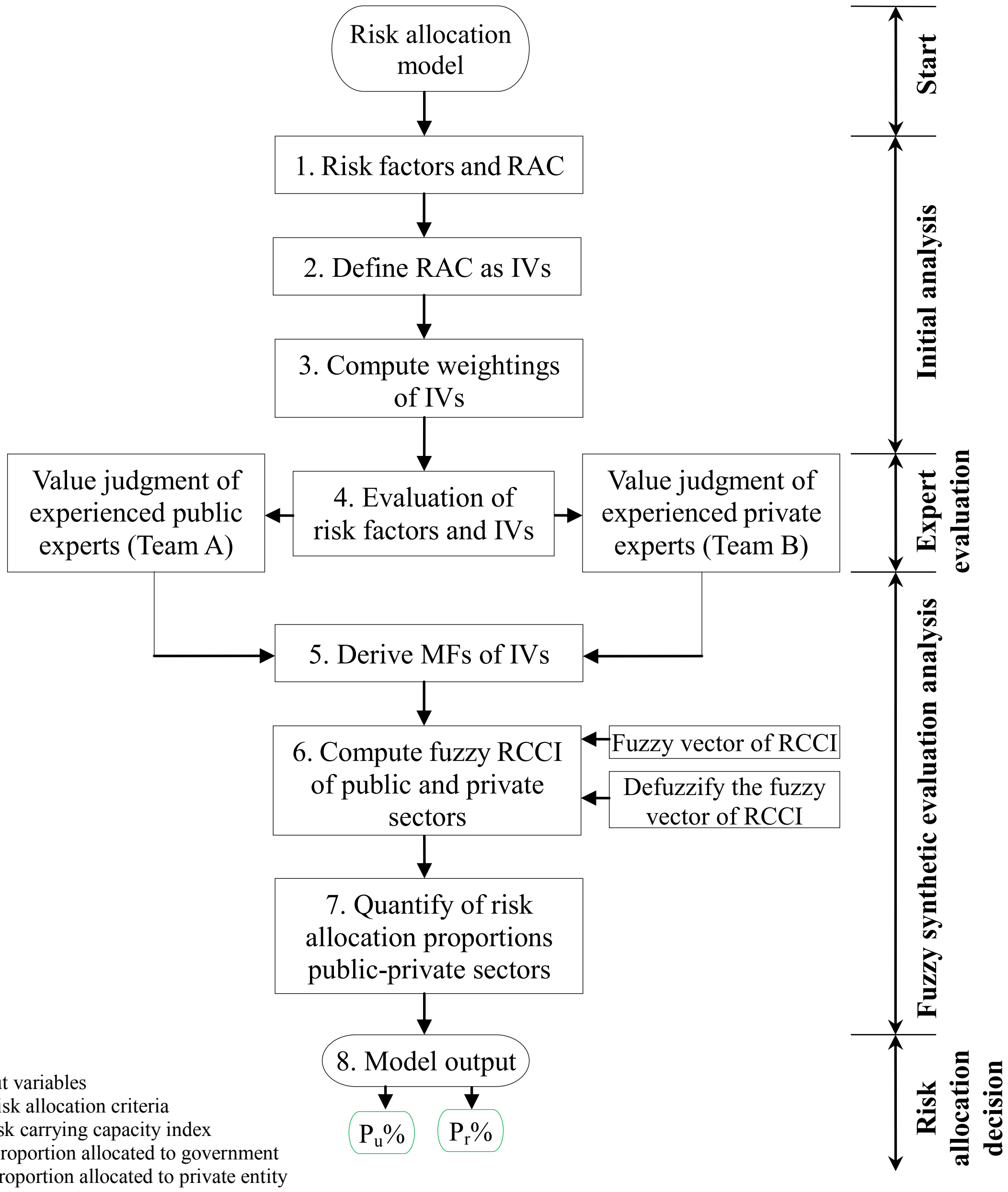
Yours truly,

Ameyaw Effah Ernest, PhD Candidate
Professor Albert P. C. Chan, Interim Dean, Faculty of Construction and Environment
The Hong Kong Polytechnic University
Hong Kong

A Fuzzy Risk Allocation Model

1. Flow chart of the Model

A simple model based on the fuzzy synthetic evaluation (FSE) method (see Wei et al., 2010; Hsiao, 1998) is developed to guide the risk allocation decision-making. The model, Fig. 1, is a step-by-step system in which outputs of preceding steps are fed into following steps, which helps to deal with the imprecise and subjective nature of risk allocation process (Lam et al., 2007) and to handle the simultaneous consideration of the multiple risk allocation criteria and the multiple decision-makers. The procedure in applying the model is summarised in the figure and briefly described below.



Key:
IVs – input variables
RAC – risk allocation criteria
RCCI – risk carrying capacity index
P_u – risk proportion allocated to government
P_r – risk proportion allocated to private entity
MF – membership function

Fig. 1 Fuzzy-based risk allocation decision model

2. Summary of the Model

The first step is to establish the critical risk factors (CRFs) to be allocated and the critical risk allocation criteria (or principles). Here, the adopted risk allocation criteria are defined as the *linguistic input variables* (u_i) and the weighting function (w_i) of each input variable is computed (as shown in Table 1).

Next, two experienced independent expert teams from the public sector (Team A) and private sector (Team B) are set up to evaluate each risk factor against each input variable based on experience in risk allocation in PPP agreements, in terms of the degree of risk management capability of the pubic client and the private entity. The judgements from the experts are based on a defined five-point grading system (or Likert scale) with *linguistic terms* (u_{ij}) that describe the input variables (please refer to Table 2).

Following evaluations by the expert teams, the membership function of each input variable (MF_{u_i}) for an evaluated risk factor is established. These membership functions together form a fuzzy matrix (R_i) of each sector, public and private, for that risk factor. Weighting functions (in Table 1) are then multiplied with the fuzzy matrix and then processed to obtain the membership function of the risk carrying capacity index $(RCCI_i)$ of the public partner, or public partner (please refer to Table 3). It should be noted that the public and private sectors have the same weighting function set but different fuzzy matrices. The RCCI of the public or private partner is underpinned by the derivation of constants (c_i) from intervals of the five-point grading system (or Likert scale) (please refer to last two columns of Table 2). These constants are the same for both sectors, and are based on Lam et al.'s (2007) risk management capability scale. Membership function of RCCI of the public or private partner is further normalised by the constants to arrive at a RCCI (please refer to Table 4), which is an indication of a public client's or private entity's capability to manage/control a particular risk factor and forms the basis for the risk allocation. It should be noted that the public-private sector partners may exhibit different RCCIs, suggesting differences in abilities to foresee and assess risk, minimise risk loss, control risk occurrence, etc (which represent the input variables in Table 1).

The output of the model is the risk allocation proportions between the public and private partners according to the input variables that reflect the partners' risk management capabilities. To determine final risk allocation proportions according to each partner's risk management capability for the evaluated risk factor, the RCCI of the public (P_u) and private (P_r) partners are expressed as percentage (please refer to Table 4). The sum of risk allocation proportions for both parties for any evaluated risk factor is 100%. That is, the output value for the public or private partner ranges in a continuum from 0%, suggesting no assumption for a corresponding party, via 50%, denoting equal responsibility by both parties, to 100%, meaning a complete assumption for a corresponding party. This provides a clear indication to the decision-maker of the overall decision of risk allocation.

Finally, the model may be adopted by practitioners to allocate risks between a public authority and a private entity in proportions to their capability to bear, manage, and control the occurrence and impacts of risks. By this, the final risk allocation proportions will be more acceptable by both parties with a true partnership spirit.

Assumptions of the model include:

1. The members of the expert teams have enough professional and experiential knowledge to evaluate the risk factors and the input variables (i.e., risk allocation criteria) to enable derivation of the membership functions of the input variables.
2. Risk management capability affects cost of risk-bearing and therefore should be a key determinant of risk allocation.
3. The adopted input variables reflect the risk management capability of the public-private partners. In a given project, however, more criteria may be added to those in Table 1.
4. Risk allocation proportions would be maintained *ex-post* through an enforcement system such as contractual provisions/clauses and payment mechanisms.

3. Application and output/results of the Model

In order to demonstrate application of the model, it has been applied to the most complicated of the infrastructure sectors, water supply. Given the political implications, the ‗social tradition' of water, public resistance to PPP in water services, pricing and collection difficulties and other obstacles, the water sector is one of the ‗hardest to finance and one of the riskiest investment for the private sector' (Vives et al., 2006). Above model has been applied to allocate 22 critical risk factors in PPP water supply projects in a developing country, Ghana. For brevity, key inputs and outputs/results of the model (as previously mentioned) are summarised in the following tables. *NB: you **may** refer to File 2 for details and demonstration of the model.*

Table 1 Input variables and their weighting functions

ID	Linguistic input variables (u_i)	Statistical results		
		Mean index	Ranking	Weighting (w_i)
u_1	Foresee and assess the risk	6.22	1	0.157
u_2	Control the chance of risk occurrence	6.14	2	0.155
u_3	Minimise the loss if risk occurs	5.97	3	0.151
u_4	Sustain the consequence of risk	5.27	6	0.133
u_5	Bear the risk at the lowest price	5.43	5	0.137
u_6	Benefit from bearing risk	5.49	4	0.139
u_7	Assume and manage the direct loss	5.05	7	0.128
	Total Mean value	39.57	$\sum w_i = 1$	
	Sample *(n)*	40		
	Overall Cronbach‘s alpha coefficient	0.815		
	7-point scale	1 = not important and 7 = extremely high importance		

In this model and as shown in Table 1, seven risk allocation criteria are used as input variables $(u_1 - u_7)$

Table 2 Grading system/linguistic terms for input variables

Scale/linguistic terms for input variables $(u_1 - u_7)$			Range of RM capability (adopted from Lam et al., 2007)	Constant (c_i)
scale	terms			
1	Very low	u_{i1}	0 – 0.250	0.125 (c_1)
2	Low	u_{i2}	0 – 0.500	0.250 (c_2)
3	Moderate	u_{i3}	0.25 – 0.75	0.500 (c_3)
4	High	u_{i4}	0.50 – 1.00	0.750 (c_4)
5	Very high	u_{i5}	0.75 – 1.00	0.875 (c_5)

RM = risk management
The constants are the averages of the RM scale intervals under ―Range of RM capability” (column 2)

Table 3 Membership functions of RCCI of public and private sectors for evaluated risk factors

ID	Critical risk factors	Membership functions of Risk Carrying Capacity Index (RCCI)	
		Public sector (Government)	Private sector
RF1	Foreign exchange rate	(0.03, 0.09, 0.51, 0.25, 0.11)	(0.06, 0.28, 0.43, 0.11, 0.12)
RF4	Corruption	(0.06, 0.21, 0.58, 0.06, 0.09)	(0.06, 0.06, 0.65, 0.18, 0.06)
RF10	Water theft	(0.17, 0.26, 0.26, 0.23, 0.09)	(0.09, 0.17, 0.37, 0.29, 0.09)
RF8	Non-payment of bills	(0.03, 0.32, 0.39, 0.12, 0.14)	(0.32, 0.14, 0.40, 0.09, 0.06)
RF3	Political interference	(0.06, 0.09, 0.15, 0.39, 0.32)	(0.32, 0.45, 0.12, 0.09, 0.03)
RF6	High operational costs	(0.40, 0.26, 0.24, 0.08, 0.03)	(0.06, 0.08, 0.14, 0.25, 0.46)
RF13	Pipeline bursts during distribution	(0.19, 0.32, 0.20, 0.22, 0.06)	(0.09, 0.19, 0.23, 0.35, 0.14)
RF19	Lack of PPP experience	(0.00, 0.15, 0.49, 0.25, 0.11)	(0.14, 0.32, 0.49, 0.06, 0.00)
RF7	Inflation rate volatility	(0.11, 0.20, 0.35, 0.20, 0.14)	(0.11, 0.17, 0.35, 0.25, 0.12)
RF14	Construction time and cost overrun	(0.26, 0.42, 0.23, 0.03, 0.05)	(0.03, 0.08, 0.18, 0.34, 0.38)
RF20	Poor contract design	(0.06, 0.09, 0.66, 0.14, 0.06)	(0.00, 0.22, 0.63, 0.09, 0.06)
RF17	Supporting utilities risk	(0.11, 0.08, 0.28, 0.38, 0.15)	(0.09, 0.37, 0.29, 0.14, 0.11)
RF22	Interest rate	(0.03, 0.28, 0.35, 0.34, 0.00)	(0.03, 0.23, 0.29, 0.34, 0.11)
RF2	Political discontent and (early) termination	(0.03, 0.06, 0.26, 0.46, 0.19)	(0.28, 0.47, 0.20, 0.06, 0.00)
RF15	Design and construction deficiencies	(0.44, 0.16, 0.29, 0.08, 0.03)	(0.03, 0.08, 0.23, 0.16, 0.50)
RF18	Conflict between partners	(0.06, 0.00, 0.86, 0.03, 0.06)	(0.00, 0.03, 0.83, 0.09, 0.06)
RF9	Water pricing and tariff review uncertainty	(0.03, 0.00, 0.48, 0.27, 0.22)	(0.25, 0.24, 0.48, 0.00, 0.03)
RF5	Financial and refinancing risk	(0.03, 0.00, 0.48, 0.27, 0.22)	(0.25, 0.24, 0.48, 0.00, 0.03)
RF16	Land acquisition risk	(0.03, 0.03, 0.16, 0.35, 0.43)	(0.45, 0.35, 0.14, 0.03, 0.03)
RF11	Public resistance to PPP	(0.03, 0.18, 0.49, 0.20, 0.11)	(0.16, 0.28, 0.43, 0.09, 0.03)
RF21	Change in government/ political opp'tion	(0.00, 0.03, 0.32, 0.34, 0.32)	(0.21, 0.40, 0.34, 0.06, 0.00)
RF12	Insufficient private operator performance	(0.29, 0.34, 0.20, 0.14, 0.03)	(0.08, 0.09, 0.14, 0.37, 0.32)

Table 4 Model output: risk carrying capacity indices (RCCIs) and risk allocation proportions

ID	Critical risk factors (CRFs)	RCCIs and Proportion of risk allocation (%)			
		Government		Private sector	
		RCCI	%	RCCI	%
RF1	Foreign exchange rate	0.57	54.42	0.48	45.58
RF4	Corruption	0.47	47.16	0.53	52.84
RF10	Water theft	0.46	46.43	0.53	53.57
RF8	Non-payment of bills	0.49	55.85	0.39	44.15
RF3	Political interference	0.67	68.98	0.30	31.02
RF6	High operational costs	0.32	31.31	0.69	68.69
RF13	Pipeline bursts during distribution	0.42	43.21	0.56	56.79
RF19	Lack of PPP experience	0.57	59.69	0.38	40.31
RF7	Inflation rate volatility	0.51	49.35	0.52	50.65
RF14	Construction time & cost overrun	0.32	31.63	0.69	68.37
RF20	Poor contract design	0.51	51.18	0.49	48.82
RF17	Supporting utilities risk	0.59	56.83	0.45	43.17
RF22	Interest rate	0.50	47.32	0.56	52.68
RF2	Political discontent and (early) termination	0.66	69.19	0.30	30.81
RF15	Design and construction deficiencies	0.32	31.68	0.70	68.32
RF18	Conflict between partners	0.47	46.80	0.52	53.20
RF9	Water pricing and tariff review uncertainty	0.64	64.38	0.35	35.62
RF5	Financial and refinancing risk	0.35	34.08	0.67	65.92
RF16	Land acquisition risk	0.73	73.82	0.26	26.18
RF11	Public resistance to PPP	0.53	56.94	0.40	43.06
RF21	Change in government / political opposition	0.70	67.35	0.34	32.65
RF12	Insufficient private operator performance	0.35	34.59	0.66	65.41

B. <u>Questionnaire</u>

Please choose appropriate score for each validation aspect/question to indicate extent of your satisfaction: **1 – poor; 2 – average; 3 – good; 4 – very good; 5 – excellent**

Validation Aspects		Evaluation Scale
1	Are the input variables (risk allocation principle) (Table 1) appropriate such that they reflect the risk management capability of a public/private partner?	1☐; 2☐; 3☐; 4☐; 5☐
2	Are the importance rankings of the input variables reasonable?	1☐; 2☐; 3☐; 4☐; 5☐
3	Are the risk allocation proportions (percentages in Table 4) reasonable and practical in a typical PPP water supply project in a developing country?	1☐; 2☐; 3☐; 4☐; 5☐
4	Is the fuzzy synthetic evaluation risk allocation model practical and applicable enough to enable PPP practitioners to apply it to support risk allocation decision-making?	1☐; 2☐; 3☐; 4☐; 5☐
5	Is the fuzzy synthetic evaluation risk allocation model easy to understand and use by practitioners?	1☐; 2☐; 3☐; 4☐; 5☐
6	Are the steps (Fig. 1) involved in applying the model logical such that the model can be replicated by researchers/practitioners?	1☐; 2☐; 3☐; 4☐; 5☐
7	Overall suitability to be adopted in practice for risk allocation decision-making in PPP water agreements	1☐; 2☐; 3☐; 4☐; 5☐

C. Please, provide general comments/suggestions that could help improve the proposed model.

The End

Many thanks for your time and participation

References can be found at: https://www.dropbox.com/s/zp15v1fm8b3ma4s/Reference.docx