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A new era for public–private partnership (PPPs) in Egypt's urban water supply projects: risk assessment and operating model

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ABSTRACT

The UN summit entitled "Transforming Our World: Sustainable Development Plan 2030"considered the provision of *clean water and sanitation* (Goal no 6) one of the 17 key goals that the UN is striving to achieve. In this respect, Egypt is considered one of the countries that will suffer from water shortage because of establishing the Grand Ethiopian Renaissance Dam (GERD) and tremendous population growth. This research explores the current state of the water supply sector in Egypt based on the distinctive characteristics and challenges facing the development in this sector. Previous literature has examined the key performance indicators (KPIs) for the water supply sector, (PPPs) approach as an effective tool to promote the water supply sector, China's expertise in water supply by PPPsand summarizing the potential multiple risks associated with water supply projects from the literature reviews. Thereafter, an electronic questionnaire was conducted with multidisciplinary experts to identify optimal models (PPPs), weighted for (PPPs) pillars, and assess the potential risks by the Egyptian economy, and social circumstances in the field of water supply. As such, the findings in this research identify and rank the high potential risks based on the opinion of the experts, and an operating model to promote the (PPPs) projects in the water sector in Egypt was proposed based on the identified risk factors (KPIs) and the (PPPs) agreements.

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KEYWORDS Public-private partnership (PPPs); Egypt; urban water supply projects; risk assessment; operating model

Introduction

Despite huge economic growth in Egypt since 2013, the government struggles to take concrete strides in developing its water and sanitation sector to reduce the gap between demand and supply in the near future, especially with the tremendous population growth increased in the last 5 years [1]. Consequently, massive investments will be required to face this challenge [2].

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In this respect, Egypt allocated $1.471 billion in 2020 for water supply and sanitation management from many funding entities as World Bank and Arab Fund for Economic and Social Development in the form of long-term loans to fill the present deficit in this sector [3], which is not only in water supply for rural areas but also in the continuity of supply, drinking water quality and water treatment and provide new water resources.

From another hand, (PPPs) approach is considered a magic key for financing infrastructure projects. In fact, Egypt has a previous experience with (PPPs) since the 1990's. In 1996 the Egyptian government announced eight projects to be implemented by (PPPs). Marsa Alam international airport, and tahrir garage were actually implemented from this announcement. As well as, from 2009 to 2015, four agreements were contracted by the (PPPs) central unit in the ministry of finance. Only new Cairo and Abo Rawash wastewater treatment plants were executed, while two projects were canceled**[4]**. Theapplication of (PPPs) approach in this era faced a set of obstacles. Forinstance; the absence of a legal frame, unclear operating model, weak risk allocationplan, ineffective time and cost schedule, and unclear biding documents **[5]**.

In this regard the Egyptian government has made conscious efforts in the last 5 years to promote the partnership with the private sector (PPPs) in infrastructure projects to provide alternative funding resources, therefore, reduce the burden on the state budget and minimize government borrowing. In addition, the promotion by the World Bank and International Monetary Fund (IMF) for (PPPs) encouraged the governments to adopt this trend, therefore, crop the benefits of the private sector participation throughout provide experience, improve productivity, enhance operational efficiency, achieve value for money (VFM), extend water supply service, promote science, technology, and innovation (STI) approach, provide capital [6].

Whilst (PPPs) approach has become a common tool for investment in infrastructure projects. Private investment in the public water and sanitation sector is considered modest compared with other sectors, such as transportation, energy and power plants. However, literature observed the prominent role of private investment in the water sector in developed countries, for instance, in the UK and USA water industry [7]. In this vein, a World Bank study in 2008 illustrated the fundamental benefits of private sector participation in terms of quality of service, productivity and expanded coverage [8]. Moreover, despite the effective role of (PPPs) in infrastructure sectors, the private investment in water supply faces a set of financial, managerial and technical challenges, such as the implementation of the risk management plan for the potential risks by the private sector and effective regulatory framework by the public sector [9]. More specifically, the private sector and the public sector must be aware of the huge risks and uncertainties associated with water supply projects. Where it is distinguished by large initial

fixed cost, low rates of return, high operating and maintenance cost, the poor coordination between water plants and local network connections, and externalities not reflected in tariffs [10].

Literature review

Current situation of the water supply sector in Egypt

Egypt encounters a set of challenges to maintain its long-term water security and undermine the sustainability of water, infrastructure, among the most prominent of these challenges are: *First*, the Grand Ethiopian Renaissance Dam (GERD), the share of Nile water will fall by 5bn cu meters per year within the next 6 years to fill the Ethiopian basin. In contrast, Egypt relies on the Nile for 90% of its water supply, and its share of water from the Nile around 55bn cu meters per year has not changed since 1954 [11]. *Second*, tremendous population growth, the current growth rate is 1.85 M person per year, which means the expected population will exceed to be 110 M 2025, and therefore increasing water demand. *Third*, the loss of water in the canals and sub-canals, which is estimated to be 3bn cm per year as a result of water leakage and evaporation. On the other hand, the government during the last 12 years was succeeded to increase the water supply from 89% to 99% in urban areas and from 39% to 93% in rural areas despite the population growth [12].

Therefore, based on analysis of the current situation in Egypt in the water supply sector, the problem facing the current government lies in achieving quality, continuity, optimal utilization of the available water resources, the creation of new resources and technologies and promotion of financing alternatives outside the scope of the state budget, in order to meet the aforementioned challenges.

In conjunction, the government has taken conscious efforts through the Ministry of Investment and International Cooperation to tackle this issue represented in:

- Providing US$ 1.4 Billion for water supply sector and wastewater management in 2020 international financial institutions [13],
- Supporting a range of reinforcements to expand a new generation of (PPPs) that can accelerate the implementation of the UN SDG 6: clean water and sanitation and UN SDG 13: partnerships for the goals to accomplish solidarity (to promote local and global cooperation).

In this regard, the Ministry of Housing, Utilities, and Urban Communities (MHUUC) has opened 58 desalination plants with a production capacity 440,000 cu meters per day. Further, 39 desalination plants are being under

construction, when complete, it will add 67,100 cmd, and at the end of this program, Egypt's desalination capacity will be 1.8 million cmd [14].

Chain of water supply sector

The chain of water supply can be divided into four stages [15]:

- *Water collection and storage*: it refers to collecting raw water from the sources whether from surface water (rivers, lakes) or from underground and storing it in built tanks. This stage may require energy usage and legal licenses.
- *Water treatment*: throughout, adding chemical additives to the raw water to be drinkable, this process consists of four steps screening, clarification, filtration and disinfection. In fact, the cost of treatment depends on the percentage of the pollution in the water source and the degree of the required treatment, normally, it costs 32% of the operational costs.
- *Water transmission and distribution*: this stage involves conveying the treated water from the production source to the consumers through a supply network, this stage requires massive investments and contains high multiple risks.
- *Customer (end-user) connection to the network*: it includes consumer connection with the main network, metering, and bill collection. Product quality, efficiency and tariffs to achieve customer satisfaction are considered the key to success for investment at this stage.

Key performance indicators (KPIs) for water supply sector

KPI can be used to measure the performance of the water supply utilities, the level of public health protection and customer satisfaction during the agreement period especially in the profit models. Thus, providing a real and comprehensive assessment of the project productivity and efficiency to the decision-makers during the agreement. The KPIs that reflect this regard can be summarized as such [16–18].

- Water quality;
- Water quantity;
- Operational efficiency;
- Network coverage;
- Labor productivity;
- Tariffs/Cost;
- Billing and collection practice;
- Percentage of state subsidies;
- Network efficiency (supply duration).

Public–Private partnership (PPPs) in infrastructure projects

The challenges that face countries in implementing infrastructure projects and the solutions that could be provided by (PPPs) inspired the author to

Table 1. Definitions of (PPPs).

Authority/Author	Definition
Canadian Council	A cooperative venture between the public and private sectors, based on the experience of each partner that best meets public needs through the appropriate allocation of resources, risks and rewards.
Congress of the United States	Arrangements that are intended to motivate private parties to achieve those outcomes more efficiently by combining project stages (and sometimes private financing) in a way that transfers risk to the private party.
World Bank	The partnership between the government and the private sector through cooperation between governmental entities such as local authorities and central governments with private companies in many areas such as health, education and infrastructure, and the degree of partnership varies in terms of responsibility and authority.
UNCITRAL	contractual arrangement between a public-sector agency and a private sector concern whereby resources and risks are shared for the delivery of a public service or development of public infrastructure.
IOB [21]	(PPPs) is process of expansion of the market to provide service for citizens and create new society nature relations. As such, it is not only technical but also ideological.
[22]	A legally binding agreement among a private company (typically referred to as a concessionaire) and public entity, where the partners agree to share some portion of rewards and risks inherent in an infrastructure project.

continue arguing this trend. In addition, the previous studies might imply that (PPPs) are becoming more important to the infrastructure industry at large [19]. In recent years, (PPPs) have been adopted extensively by the country's governments around the world to leverage private capital and management expertise skills [20]. The definition of (PPPs) has been discussed by a group of authorities and authors specialized in economics and finance, such as the World Bank, and as illustrated in Table 1.

There was a clear consensus from practitioners and academicians that (PPPs) is direct cooperation between three parties, private sector and public sector to provide public service to the third party (citizens), through a balanced contract or agreement that shares risks and rewards between the three parties, thereby achieving a win–win relationship.

1.2.1. (PPPs) models in water supply sector

By the end of the last decade, public water systems in developing countries suffer from quality, access and misapplication of subsidies. In addition, countries were encountering severe shortages of water supply to citizens as a result of the low productivity of the public sector utilities and the weak management of the operational process [23]. In response, the governments turned to the private sector to address these failures by transferring all of its assets or operations to private hands, as illustrated in Figure 1. In general, the level of private sector involvement scope can be associated with providing services without depending on the public facility resources for full private operation and ownership of the public facilities. More specifically, there are various spectrums of (PPPs) models that are classified according to the nature

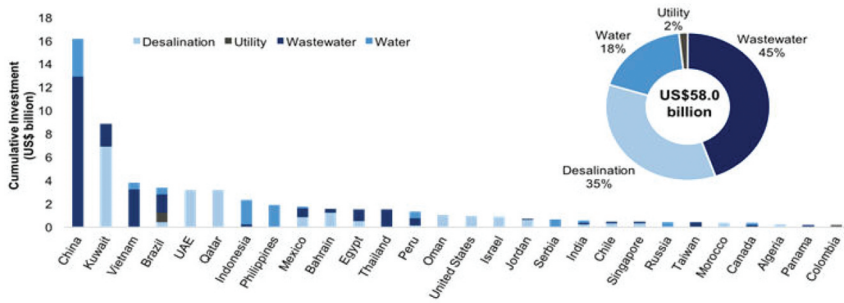

Figure 1. Private sector investment in water and sanitation to 2020. **Source**: https://ppp.worldbank.org/public-private-partnership/agreements

of partnership and based on the allocation of resources, risks and rewards [24]. Diverse types of (PPPs) have been implemented to develop water supply projects as illustrated in Table 2, in the early years of (PPPs) applications, the built, operate and transfer (BOT) has been a common tool for participation among public and private sector.

Recently, partnership in the water sector has primarily relied on the private sector to improve the maintenance and operation, and few of the partnerships have implicated private financing. The regular period for operation and maintenance contracts is between eight to 10 years, and it is long enough for the private sector to recoup its expenses [25,26].

From an overarching perspective (DBO, DBOM and DPFO/M) models can facilitate comprehensive planning for both the government and the private sector, where the partners will be involved in all the project phases starting from design, construction, operation and maintenance. Thus, it will be easy to

Table 2. (PPPs) models in the water supply sector.

	Model	Description of Model
Group (B)	**BOT**	Build, Operate and Transfer
	BOT	Build, Own and Transfer
	BOO	Build, Own and Operate
	BOOT	Build, Own, Operate and Transfer
	BLT	Build, Lease and Transfer
	BRT	Build, Rent and Transfer
	BT	Build and Transfer
	BTO	Build, Transfer and Operate
	BOR	Build, Operate and Renewal of concession
Group (D)	**DBO**	Design, Build, Operate
	DBOM	Design, Build, Operate and Maintain
	DBMF	Design, Build, Manage and Finance
	DBFO/M	Design, Build, Finance and Operate/Maintain
Group (R)	**MOT**	Modernize, Own or Operate and Transfer
	ROO	Rehabilitate, Own and Operate
	ROT	Rehabilitate, Own and Transfer
	O&M	Operate and maintain

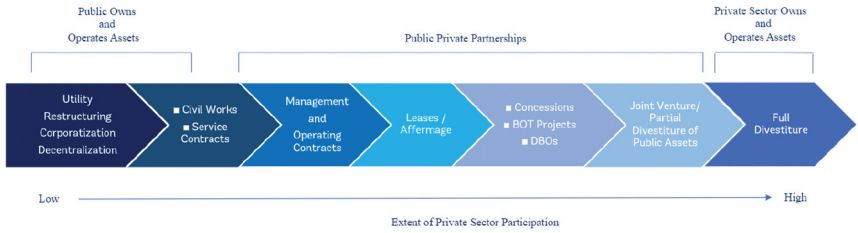

Figure 2. The types of the (PPPs) agreements.

formulate the financial capital, contract period, potential risks and expected profits, in other words, these models can be defined as 'Revenue Models' [27]. Nevertheless, the selection of each model should be based on the specific purpose of the agreement and which will be the emphasis.

It is noteworthy that concession, lease contract, management and joint venture contract are the four types of PPPs contracts or arrangements, which inherently depend on the tariffs to cover the investment cost and the potential risks related to the contract type as illustrated in Figure 2.

The water supply by (PPPs) distinctive characteristics and investment challenges in Egypt

Water is a vital human need as well as is essential and non-substitutable, therefore, there are political considerations that restrict private investment in this sector and makes its role very sensitive, and more specifically, many distinctive characteristics and challenges complicate the implementation of (PPPs) as follows [28–30]:

- The ratio of fixed asset to the expected revenue (tariff) 10:1 which mean lower rate of return against, for instance, 4:1 in the electricity sector,
- In the developing countries, irregular collection of the bills and keeping the tariff below the actual cost, which leads to the payback for the investment, are between 15 and 30 years, also
- The weak solvency of the local banks and lacking their experience in financing these types of projects that hinders the investment in this sector,
- The public water systems have unique objectives due to it considered a national security, therefore, achieving economic efficiency, environmental protection, affordability, especially for the poor, and prevent monopoly are the key drivers to success (PPPs) in this sector,
- Water has been critical to ensure health status and achieve sustainable development (economical, environmental, social) pillars; thus, countries have developed operating standards, emergency response planning and tight regulations to protect their citizens.

- Due to the nature of urbanization in developing countries and as a result of the existence of small and unplanned urban, rural communities, the localization of the water networks in these communities encounter numerous financial, construction and operational challenges,
- The institutional system of the water sector includes a wide base of stakeholders with diverse interests, conflict roles and individual, nationa-land international belongs that increase the potential significant risks in this sector,
- Irregular and poor maintenance during the operational process poses a threat to the sector productivity as a result of high-water losses in the network, thus, lower revenue and failure in the investment.

Water supply by (PPPs) key pillars

In order to achieve effective participation, *six* pillars are required to ensure the success of the projects as illustrated in Table 3 and as such: healthy investment environment, transparent procurement, economic viability, financial package, risk management and governance. The effectiveness and weight of each pillar may differ according to the (PPPs) model [31–33].

Case study: China expertise in water supply by PPPs

Although Egypt and China, confront many common challenges, especially water scarcity, rapid urbanization and environmental degradation, there is a significant gap in the ability of Egypt government to attract private participation in water services, whereas, the private participation reached 350 projects in 2018 in China versus 3 projects in Egypt, despite the similar development needs [34].

There was a strong consensus of the authors that the (PPPs) experience in China has been successful due to five reasons; solid organizational forms, linking local business with international technological expertise, strong multi-level political support, aligned policy and legal framework, tariff reforms and dynamic pricing policy through tariff liberalization, which allowing the investors to receive a reasonable rate of return [35].

(PPPs) contracts in China were characterized by diversity, it was not limited to BOT but, *cooperative joint venture (CJV) and equity joint venture (EJV) models* were adopted, wherein the investors can enter into partnership directly with municipal governments. In 2004, China introduced a set of measures, which are considered the magic keys to promote (PPPs) approach in the water sector, foreign investment, and industrial guidance catalog was released that promote the participation in large and medium-sized water projects, and the Chinese banks could be allowed to fund the water (PPPs) projects instead of foreign loans. Further, rationalization of water tariff was implemented as an initiative to protect water resources and encourage water saving.

Table 3. (PPPs) key pillars in the water supply sector.

	Investment environment					Procurement			
	Government support	(PPPs) guidelines	Legal framework	Regulatory framework	Public perspective	Project identification	Tendering	Contract negotiations	Concession period
Group (B)			***				***		
Group (D)			***				***		
Group (R)			**				*		

	Economic viability					Financial package				
	Financial capability	Financial feasibility	Revenue	Tariff	Evaluation technique	Capital structure	Capital investment	Financial source	Payment method	Dept interest
Group (B)			***					***		
Group (D)			***					***		
Group (R)			**					***		

	Risk management							
	Risk identification					Risk analysis	Risk evaluation	Risk allocation
	Financial	Political	Market	Environmental	Social			
Group (B)					***			
Group (D)					***			
Group (R)					*			

	Governance				
	Citizen's participation	Smart governmental regulations	Optimize use of resources	Civil society participation	Using environmental tools
Group (B)			***		
Group (D)			***		
Group (R)			**		

Source: By the author
*** = very effective, ** = effective, * = less effective

In combination with rationalization of water tariff and forbidding the fixed return, equity joint venture (EJV) model became the favorable contractual tool for the foreign investors, the municipal government contributes with the existing assets and the project company provides funds, both partners share the operation process, and profits and losses are distributed according to each partner's equity.

After 2016, the domestic companies become involved in (PPPs) projects, specialty in operation and shared the foreign companies in bidding, their knowledge of actual demand and local culture of the Chinese society enabled them to relieve the projects potential risks, overcome the fund gaps and technology, therefore, it wins more than 98% of the contracts [36]. Although the success of (PPPs) in the water sector in China, there were weak points emerged as:

- Weakness of creditable regulatory mechanisms,
- The overlapping roles and responsibilities between the involved ministries,
- The municipalities do not have the power to regulate their water companies,
- The lack of transparency in production and operation cost,
- The strong bias of the local officials toward foreign investments.

Risk factors related to water supply by (PPPs) in Egypt

In fact, the high risks associated with the water sector, a few authors focused on it. Therefore, this section may contribute to filling the research gap in the water supply sector. Previous studies have indicated that the most frequent risks come within the context of constructional and political groups. More specifically, investment in the water supply sector includes high multiple risks compared with other infrastructure sectors; thus, identification, evaluation and allocation of these risks are considered the main vehicle to succeed the investment in this sector through risk mitigation and reduction. In this respect, this section of the study strives to discuss the multiple potential risks concerning the water supply chain, the implementation process, and the potential contractual relations between the private and the public sectors through three steps as such:

- Risk identification: identifying risk factors (risk registers) associated with projects (classification and categorization),
- Risk evaluation: determining the probability of occurrence and impact,
- Risk allocation: sharing risks between project stakeholders.

Further, due to this sector sensitivity and the nature of the product or service by (PPPs) projects, this condition led to inability to propose a single risk register by the researchers to be applied in (PPPs) risk evaluation process. Even so, the author sought to summarize the risk categories from the literature reviews in *five* categories as [37,38]:

- Category (a) – (enterprise) – including general risks, country risks, project-specific risks,
- Category (b) – (economic) – including macro-risk, meso-risk, micro-risk,
- Category (c) – (sustainability) – including commercial, political, legal, financial, social, market, environmental,
- Category (d) – (project lifecycle) – including (planning-design-contracting-construction-operation-maintenance),
- Category (e) – source of origin (project stakeholders) – including government (public sector), developer (private sector), consultants, contractor/s, customer, media.

In addition, and regarding risks identification, categorization and allocation. The author identified the potential risks with respect to the water sector in (**35**) risks based on the previous studies in China, India, Ghana and as the adopted from literature review [39–46]. In addition, the study calculated the overall frequency of each risk that was repeated among these categories and calculated the total number of risks under each category and subcategory as summarized in Table 4.

Method

The main objectives of this study are to assess the potential risks in the water supply sector through (PPPs) in Egypt. Also, proposing an operating model for promoting private investment in it. Accordingly, encourage the private sector to achieve the best outcomes at a reasonable cost in a short time with acceptable quality. By ensuring the facility's longer-term performance, and therefore guarantees profit and capital return. From this point of view, the research was divided into three sections as discussed below and as illustrated in Figure 3.

The first section

Desk-based research and by using the inductive method, the research argues the current situation for the water supply sector in Egypt through the distinctive characteristics and challenges that face the development in this sector and key performance indicators (KPIs) for the water supply sector. We then discuss the (PPPs) approach, identifying alternative models for implementing and its key success pillars, in addition, investigate China's experience

Table 4. Risks identification, categorization and allocation.

		Risk Categories												
		Category (a)			Category (b)			Category (c)						
		Enterprise			Economic			Sustainability						
		General risks	Country risks	project-specific risks	Macro-risk	Meso-risk	Micro-risk	Commercial	Political	Legal	Financial	Social	Environmental	Market
1	Governmental disruption		*		*				*					
2	Breach of contract			*	*			*		*				
3	Political instability		*		*				*					
4	Government corruption		*			*				*				
5	Poor performance			*		*						*		*
6	Lack of transparency	*			*							*		
7	Expropriation of assets		*				*		*					
8	Political interference	*			*				*					*
9	Weak regulatory regime	*				*				*				
10	High operational cost			*	*			*			*			*
11	Weak site infrastructure		*	*			*				*			
12	Low water consumption (demand)		*	*	*			*				*		*
13	Tariff and profitability		*	*	*			*				*		*
14	No risk allocation mechanism			*	*			*	*	*	*	*	*	*
15	Weak capacity of partners			*		*		*			*			*
16	Inexperience in (PPPs)	*		*	*					*				*
17	Unbalanced (PPPs) model			*	*						*			*
18	Public opposition		*		*				*					

Table 4. (Continued).

	Risk Categories												
	Category (a)			Category (b)			Category (c)						
	Enterprise			Economic			Sustainability						
	General risks	Country risks	project-specific risks	Macro-risk	Meso-risk	Micro-risk	Commercial	Political	Legal	Financial	Social	Environmental	Market
19 Environmental impact	*				*				*			*	
20 Transfer failure			*		*				*				
21 Renewal cost overrun			*		*					*		*	
22 High technology cost	*			*						*		*	
23 Weak public participation	*			*				*			*		
24 Poor asset condition			*		*								
25 Using environmental tools	*				*					*		*	
26 Technology transfer			*		*		*						*
27 Rife of information		*			*		*						*
28 Weak role of law		*		*				*	*				
29 Administrative capacity weakness		*	*										
30 High maintenance cost			*	*			*			*			*
31 Construction cost overrun			*	*			*			*			*
32 Construction time delay			*	*			*			*			*
33 Currency exchange fluctuation		*		*						*			*
34 Contract variation			*		*					*			
35 Private investor change			*	*						*			
Total NO. of risks for each subcategory	**8**	**12**	**20**	**20**	**12**	**2**	**11**	**8**	**8**	**14**	**6**	**5**	**15**
Total NO. of risks for each category		**40**			**34**					**67**			

(*Continued*)

Table 4. (Continued).

		Category (d)						Category (e)							
		Project life cycle						Source of origin(Project stakeholders)							
		Plan-ning	Desi-gn	Contra-cting	Cons-truction	Oper-ation	Main-tenance	Government (public sector)	Developer (Private sector)	Consultants	Contractor/s	Customer	NGO	Media	Total frequency
1	Governmental disruption	*						*							**5**
2	Breach of contract			*				*	*	*					**8**
3	Political instability	*						*							**5**
4	Government corruption	*						*							**5**
5	Poor performance					*	*		*	*	*	*			**10**
6	Lack of transparency			*					*						**5**
7	Expropriation of assets					*	*		*						**6**
8	Political interference	*						*							**6**
9	Weak regulatory regime				*	*	*	*					*	*	**9**
10	High operational cost	*				*	*		*		*				**10**
11	Weak site infrastructure	*			*				*		*				**8**
12	Low water consumption (demand)			*		*			*			*			**10**
13	Tariff and profitability			*		*			*			*			**10**
14	No risk allocation mechanism	*						*	*		*				**13**
15	Weak capacity of partners	*				*	*	*	*	*					**11**
16	Inexperience in (PPPs)	*				*	*	*	*						**10**
17	Unbalanced (PPPs) model	*				*	*	*	*		*				**10**
18	Public opposition	*											*		**5**
19	Environmental impact	*	*			*			*	*	*				**10**
20	Transfer failure					*	*		*	*	*				**8**
21	Renewal cost overrun						*		*			*			**7**

	Category (d)						Category (e)							
	Project life cycle						Source of origin(Project stakeholders)							
	Plan-ning	Desi-gn	Contra-cting	Cons-truction	Oper-ation	Main-tenance	Government (public sector)	Developer (Private sector)	Consultants	Contractor/s	Customer	NGO	Media	Total frequency
22 High technology cost	*	*		*				*	*	*				**10**
23 Weak public participation	*										*	*		**7**
24 Poor asset condition				*	*	*	*	*	*					**8**
25 Using environmental tools	*	*					*		*					**8**
26 Technology transfer			*				*							**6**
27 Rife of information									*					**5**
28 Weak role of law	*		*				*	*						**8**
29 Administrative capacity weakness	*	*	*	*	*	*	*	*		*	*			**12**
30 High maintenance cost	*					*		*		*	*			**10**
31 Construction cost overrun	*			*				*		*				**9**
32 Construction time delay	*			*				*		*				**9**
33 Currency exchange fluctuation	*				*	*		*		*	*			**10**
34 Contract variation	*	*			*	*	*	*	*	*				**11**
35 Private investor change	*						*							**5**
Total NO. of risks for each subcategory	**23**	**5**	**7**	**7**	**15**	**14**	**17**	**24**	**10**	**14**	**8**	**3**	**1**	
Total NO. of risks for each category				**71**					**77**					

Source: By the author.

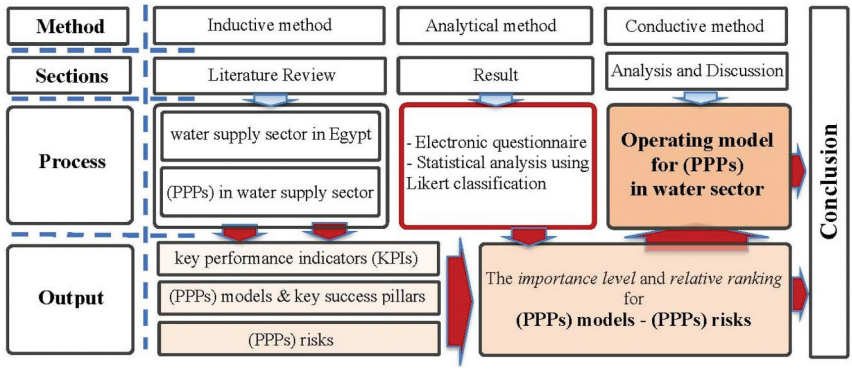

Figure 3. Research methodology. Source: by the author.

in obtaining useful lessons from (PPPs) in water and sanitation projects. Subsequently, summarizing the potential multiple risks associated with water supply projects from the literature reviews in (35) risks.

The second section

From the desk-based research, the author was able to select (25) risks that had frequency more than (6), then recategorized them in three categories as follows: (a) risks related to the chain of water supply, (b) risks related to the implementation process and (c) risks related to potential contractual relations.

A baseline survey (electronic questionnaire) was conducted, it was divided into two parts: the *first*, to evaluate the (PPPs) models and to gain relative weight for each (PPPs), the *second*, to assess the (25) risks regard to the water sector by using a Likert scale. The author conducted the electronic questionnaire with the associate multiple stakeholders (40 experts) to address this issue, including (state governmental officials, urban local body officials, private developers, academic staff, PPPs consultants). Based on the result of the questionnaire, and by using the analytical method, statistical analysis was calculated; starting from calculating the mean value (μ), and Standard Deviation (α) by using (Likert) scale [47], then, concluding the relative importance index (RII). Finally, the research set the importance level and relative ranking (RK) for the (PPPs) models, (PPPs) pillars and the (25) risks as illustrated in Tables 5 and 6.

The third section

An operating model was proposed to improve the four dimensions of the performance (access, operational efficiency, tariffs and quality of service)

Table 5. (PPPs) Model assessment.

	EI	I	A	NI	ENI	μ	α	cv	RII		RK
Group (B)	1	4	5	20	10	2.150	1.001	46.571	0.430	M	4
Group (D)	34	4	1	1	0	4.775	0.620	12.977	0.955	H	1
Group (R)	16	12	7	5	0	3.975	1.050	26.408	0.795	M-H	3
EJV & CJV	27	11	1	1	0	4.600	0.672	14.604	0.920	H	2
The average of coefficient of variance (CV)								**25.11**	CV (between 20–30) = acceptable sample		

Source: By the author

And the Relative Important index as [48]

- RII = 0:0.20 = Importance level (Low = L)
- RII = 0.21:0.40 = Importance level (Medium low = M-L)
- RII = 0.41:0.60 = Importance level (Medium = M)
- RII = 0.61:0.80 = Importance level (Medium high = M-H)
- RII = 0.81:1.00 = Importance level (High = H)

Result

Regarding the statistical analysis of the electronic questionnaire to evaluate the (PPPs) models and potential risks associated with (PPPs) for water projects as illustrated in Tables 5 and 6, and after the verification of the questionnaire via (CV) coefficient. The analysis results determined that Group D (DBO, DBOM and DPFO/M), and EJV & CJV are ranked high (H).

In the same context, seven risk factors are ranked high (H), two risk factors are ranked medium–high (M-H), and one risk factor is ranked medium–low (M-L) under the chain of water supply risk category, also, five risk factors are ranked high (H), one risk factor is ranked medium–high (M-H), under the implementation process risk category; similarly, six risk factors are ranked high (H), two risk factors are ranked medium–high (M-H), and one risk factor is ranked medium–low (M-L) under contractual relation risk category. Finally, 18 risk factors are ranked high (H), five risk factors are ranked medium–high (M-H), and two risk factors are ranked medium–low (M-L) as illustrated in Figure 4.

Analysis and discussion

In order to attract the private sector, an operating model based on risk factor evaluation is required to avoid the potential conflict objectives between profitability and affordability, information asymmetry and monopoly and to achieve full cost recovery, reasonable profit, implement tariff reforms and dynamic pricing and monitor potential risks. Therefore, that yields to improve performance, achieve effective consolidation responsibility, direct efficiency

Table 6. PPP risks evaluation.

		EI	I	A	NI	ENI	μ	α	CV	RII		RK
a	**Chain of water supply risks**											
1	Weak site infrastructure	0	1	4	10	25	1.525	0.784	51.413	0.305	M-L	9
2	Environmental impact	9	28	2	1	0	4.125	0.607	14.718	0.825	H	4
3	Poor asset condition	19	11	9	1	0	4.200	0.883	21.021	0.840	H	5
4	Using environmental tools	10	26	3	1	0	4.125	0.648	15.708	0.825	H	6
5	Low water consumption (demand)	30	8	2	0	0	4.700	0.564	11.997	0.940	H	3
6	Tariff and profitability	35	3	1	1	0	4.800	0.608	12.659	0.960	H	1
7	No risk allocation mechanism	28	10	1	1	0	4.625	0.667	14.432	0.925	H	4
8	Transfer failure	5	10	20	5	0	3.375	0.868	25.715	0.675	M-H	8
9	High technology cost	6	23	9	2	0	3.825	0.747	19.535	0.765	M-H	7
10	Administrative capacity weakness	30	9	1	0	0	4.725	0.506	10.703	0.945	H	2
b	**Implementation process risks**											
11	Poor performance	12	25	2	1	0	4.200	0.648	15.440	0.840	H	5
12	High operational cost	25	12	3	0	0	4.550	0.639	14.033	0.910	H	3
13	Renewal cost overrun	10	22	3	5	0	3.925	0.917	23.356	0.785	M-H	6
14	High maintenance cost	30	8	1	1	0	4.675	0.656	14.029	0.935	H	2
15	Construction cost overrun	33	5	1	1	0	4.750	0.630	13.272	0.950	H	1
16	Construction time delay	26	10	3	0	1	4.500	0.847	18.829	0.900	H	4
c	**Contractual relations risks**											
17	Breach of contract	36	2	1	1	0	4.825	0.594	12.317	0.965	H	1
18	Weak regulatory regime	20	14	3	3	0	4.275	0.905	21.181	0.855	H	6
19	Weak capacity of partners	15	13	7	5	0	3.950	1.037	26.241	0.790	M-H	7
20	Inexperience in PPPs	32	7	1	0	0	4.775	0.480	10.046	0.955	H	2
21	Weak public participation	3	10	26	1	0	3.375	0.667	19.777	0.675	M-H	8
22	Weak role of law	25	10	2	3	0	4.425	0.903	20.398	0.885	H	5
23	Currency exchange fluctuation	1	1	2	16	20	1.675	0.888	53.034	0.335	M-L	9
24	Contract variation	26	12	2	0	0	4.600	0.591	12.837	0.920	H	4
25	Unbalanced PPP models	32	6	2	0	0	4.750	0.543	11.432	0.950	H	3
The average of coefficient of variance (CV)									**12.103**	CV (between 10 and 20) = very good sample		

Source: By the author.
EI = Extremely important, I = Important, A = Average, NI = Not important, ENI = Extremely not important.

gains and fill the gap between the requirement of (PPPs) projects and the capability of the government officials [49]. In other words, the operating model can address the lack of inability of the government ministries to develop appropriate projects opportunities, and thus improve the capacity building of the government departments to implement (PPPs) projects [50]. More specifically, the operating model can; determine the efficiency indicators to assess the PPPs projects, reduce the influence of the multiple local factors on operating costs and tariff structure and facilitate obtaining performance data on the water services for the current projects, therefore, determining the future trends for the sector. The pivot of the operating model is an independent regulatory agency (IRA) as illustrated in Figure 5, it is responsible to provide acceptance for the new projects, monitoring and controlling the implementation of the projects, and assisting the governmental agencies in preparing project reports and bid documents [51].

In this respect, the operating model for PPPs in the water supply sector must be crafted based on the service performance evaluation, therefore Performance-based contractual agreements and service purchase agreements are the best solution wherein these types of agreements relied on KPIs as a tool for the judgment among the partners [52]. Consequently, the revenue models (DBO, DBOM and DPFO/M) are considered an effective tool where it can:

- Improve service quality and operational efficiency,
- Reduce non-revenue water (NRW) or water losses,
- Achieve an improvement in bill collection,
- Foster financial sustainability and full cost recovery,
- Achieve profits, therefore, increase the incentives for operational efficiency,
- Strengthen the government financial conditions,
- Ensure higher rate implementation in the other infrastructure sectors,
- Minimize the life cycle cost of the project through an integrated model for design, construction and operation.
- Reduce the time for the construction phase,
- Promote technological innovation,
- Mitigate risk probability and impact, especially the risk associated with a reduction in demand,
- Support and develop social and economic government programs.

In contrast and, despite the revenue models proving a success in water sectors, private financing should not be discarded, especially in the advanced developing countries, where medium debts in local currency have become available [53]. Thus, mixed-financing for PPPs projects becomes a viable option through the use of the hybrid model (DBMF). Therefore, a decision

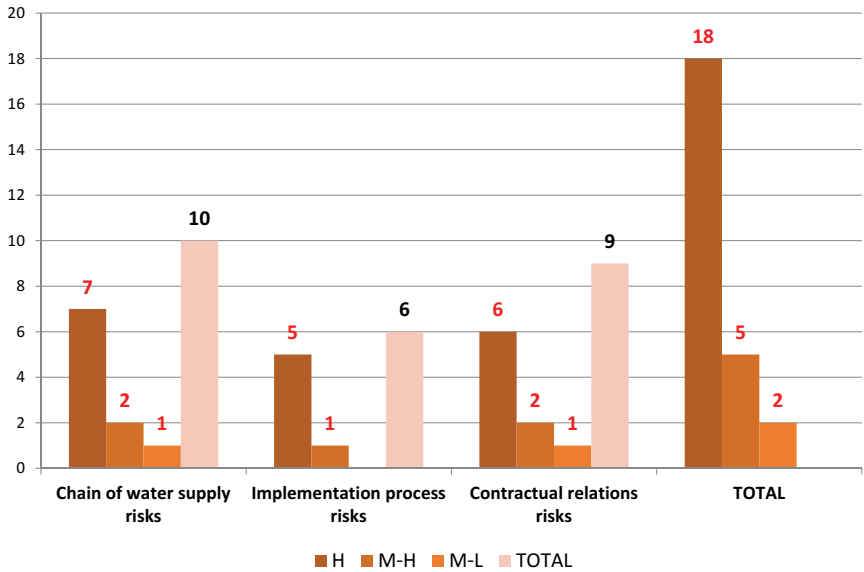

Figure 4. The importance level for the risk factors. Source: by the author.

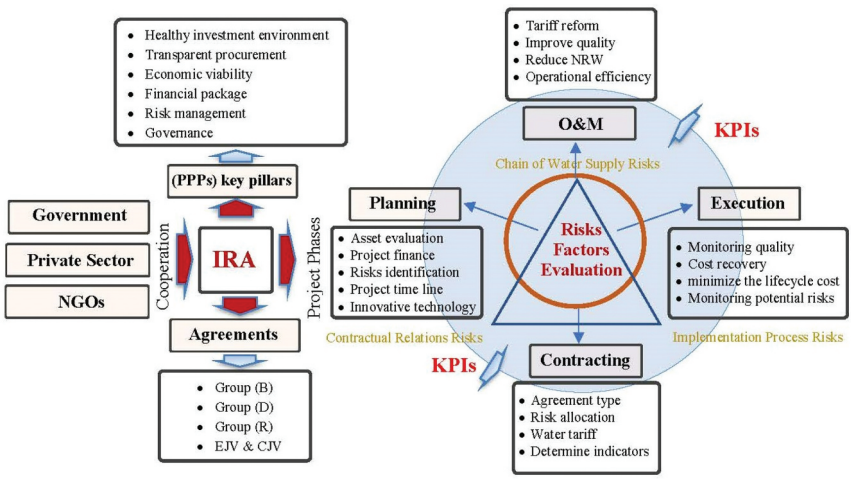

Figure 5. The proposed operating model.

to apply the PPPs model should be relative to the status quo approach to the study population according to their local conditions and needs. Therefore, each model will have different features and outcomes.

It is noteworthy that NGOs and civil society participation play a substantial role in the operating model as intermediaries between the government and the private sector to ensure the actual needs of the society, especially in the social services. In addition, it ensures each partner's contribution is in the ideal field with respect to their expertise, therefore reducing the potential risk for all partners [54].

Conclusion

Generally, PPPs approach can be an effective tool when public aims such as common good and welfare are being achieved for target groups, as well as, the well-designed partnership between the public and private sector is a valid option to turn poor performance in water utilities in developing countries to be sustainable. More specifically, the revenue models (DBO, DBOM, and DPFO/M) are considered the effective tool to apply in the water sector in Egypt according to the experts evaluation, where the analysis result determined that models were ranked high (H). Additionally, the application of (PPPs) key pillars in the water supply sector including a healthy investment environment, transparent procurement, economic viability, financial package, risk management, and governance can ensure the success of these models. Moreover, KPI's for water supply sector is an adequate tool for the Egyptian government to evaluate the (PPPs) models as a result of the shift of the government's role of a producer toward of quality assurer, as well as it allows the government to do its role in a professional and sustainable way.

The potential risks (25 risks) for PPPs projects in the water sector in Egypt have been determined and assessed by the experts. Where, eighteen risk factors are ranked high (H), five risk factors are ranked medium-high (M-H), and two risk factors are ranked medium-low. Therefore, that can enable the investment operator to obtain a reasonable investment return, thereby enhancing service quality and resource utilization efficiency, as well as improving the motivation for the investment. As well as, risk allocation is one of the critical success factors (CSFs) for PPPs projects in water supply sector, where, it enables the stakeholders to gain their goals.

The coordination between the partners through the proposed operating model is the actual key to achieve maximum advantages and benefits. Further, the operating model can be applied to the existing water plants, and to the marketization of new ones. Overall, and despite the diversity in (PPPs) models, it will not solve all the challenges facing the water sector without an operating model for implementing it in a frame of transparency and justice.

It should be recognized that the water supply is a socio-economic activity, and therefore civil society and NGOs are integral part of it, which promote better service performance and future improvement as well as strengthen the

service relations between the stakeholders through ensuring deliver the service to target groups "disadvantaged people".

Finally, to incentivize private investment in the water sector, there is a need to evolve a long-term strategy underpinned by a strong operating model, legal framework, and sound policy to develop trusting partnerships.

Availability of data material

All data generated or analyzed during this study are included in this published article (and its supplementary information files). Note: all questionnaire data and analysis were modified in the methodology.

Ethics approval

The authors confirm that this article is original research and has not been published or presented previously in any journal or conference in any language (in whole or in part).

Consent to Participate and Consent to Publish

The authors declare that they have consent to participate and consent to publish.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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