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Identifying and Evaluating the Reality of Projects Delivery Systems

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ABSTRACT

The way a project is delivered has a significant impact on project outcomes. Design-build, design-Bid -build represents the most common methods of delivery of wastewater projects in Iraq. Each system comes with its own advantages and disadvantages that suit all different projects and under different circumstances. The purpose of this research is to identify the main and secondary factors affecting the method of delivering wastewater projects and to identify the potential risks of these different methods. The methodology used for identification is by reviewing the general literature and conducting personal interviews for employees working in the planning and implementation of wastewater projects, as well as a questionnaire distributed to 20 projects under implementation in Wasit Governorate / Iraq. The results of this research are summarized by identifying the main and secondary factors according to the relative importance of these factors, where the factors with relative importance less than (65) % were neglected.

1. INTRODUCTION

Infrastructure projects for a large facility are time consuming and usually involve large capital investments. Most issues such as cost overruns and delays tend to be huge depending on the scope of the project. Common criteria for project success are generally cost, time, and quality. It is generally accepted that a project can be considered successful if the project is delivered on time, at appropriate cost and quality standards, and provides owner satisfaction. A construction contract is a fully agreed contract to build an asset or a group of assets that are closely related, in terms of design, technology, function or end use. It is also formulated to provide the services of consultants or contractors [1].

It is also considered a synonym for contract type [2]. There are a variety of PDS that are applied in the construction industry; Including Design-Bid-Build (DBB) and Design-Build (DB), which are traditional types as they have been commonly applied in the construction industry. Other types of contracts such as construction at risk management (CMR), design-build-operate (DBO), design-build-operate-and-maintain (DBOM), design-build-finance-operate (DBFO), complete delivery or program management, build-to-operate (BOT) and build-to-operate (BOOT) contracts.) It has also been invented and applied in many construction projects at a slower pace [3]. PDM also affects stakeholder performance, service quality and communication for the project [4].

The reason for conducting this research is to know and evaluate the reality of the state of the project delivery systems most used in wastewater projects. And the purpose of this research is to focus on the most prominent problems facing sewage projects and the methods of their delivery. In this research, both qualitative and quantitative methods are used. It is qualitative because it assesses a problem by taking the opinions, perspectives and perceptions of professionals about projects that are not delivered with time and budget. It is also quantitative because it attempts to measure the problem by investigating facts and trying to establish relationships using statistical tools.

The importance of this research is to determine the main and secondary factors affecting the delivery methods adopted in wastewater projects. The strategy adopted is of an exploratory and descriptive type. An attempt was made to collect data from relevant specialist experts from consultants and contractors. Some of the previous studies dealt with this subject and their purpose was to try to develop the framework of the project delivery system by identifying the factors that must be taken into consideration and a model was built to help the owner reach a decision on the delivery system that he should adopt [1].

2. PROJECT DELIVERY SYSTEM SELECTION

Selecting a project delivery system means choosing the best way or system to organize the design and construction process, and that is not always an easy or clear decision. The choice of a particular style of PDS will depend on many factors, for example [5]:

1. Ease of design.
2. Degree of design flexibility during construction.
3. Availability of suitable contractors/project managers, and balance sheets of such contractors.
4. Political considerations.
5. Budget constraints vs. performance of completed project.

In many cases, the PDM is chosen simply on basis of the knowledge and experiences of in-house experts and/or guidance from external consultants without a deep exploration of the strengths and weaknesses of each method, or any regard to the influencing success factors and characteristics of each project [6].

If the actual offer (bid) far exceeds estimates, a long redesign, repricing will be required that can lead to increased errors and conflict, and long duration of the project [7-9].

The researcher conducted a personal interview with (owners, contractors, project managers, and engineers) an additional of the literature review to identify the effecting factors on PDS selection, as shown in Table 1.

Table 1. List of selection criteria

Criteria	Sub criteria
	Project cost
	Project time
Project objective	Project quality
	Project safety
	Delivery speed
	Type of project
	Size of project
Owner requirement	Owner capabilities
	Contractor capability and availability
	Time consideration
	Project change orders
	Human resource
	Owner risk
	Owner control and involvement
	Transfer technology
	Owner satisfaction
	Ease of design
External conditions	Contractibility innovation
	Political consideration
	Ensuring confidentially
	Resource availability
	Well define scope
	Knowledge of final cost before starting
	Market

3. FIELD SURVEY

The field survey conducted by two stages, as follows:

1. Open questionnaire stage: through personal interviews see appendix (A) (Table A-2).
2. Closed questionnaire stage: by using questionnaire form see appendix (C).

3.1 Open questionnaire stage

The researcher conducted a personal interview in order to collect data, with engineers who have an experience in managing of construction projects, working in the Wasit sewage Directorate and Wasit Governorate, in addition to other engineers and contractors working in the private Iraqi sector.

General information relating to the interviewees as illustrated in Appendix A, (Table A-1). The main objective of the open questionnaire (interviews) is to take a general idea about project delivery system for wastewater projects and identify the effecting factor on PDS selection. Questions that the researcher discusses them in the interviews were clarify in Appendix (A) (Table A-2).

3.2 Close questionnaire stage

The method of data collection is using by distributed questionnaire forms to the engineers working in both public and private sectors to evaluate and determine the effecting factor on PDS selection. The researcher prepared the questionnaire paragraphs from the literature reviews, and field interviews to prepare the form as shown in Appendix (C).

4. SAMPLE OF RESEARCH

According to purpose of this research, Wasit Sewage Directorate were selected as a population of research. The sampling process was (simple random sampling method), include (20) wastewater projects. The researcher coded the study sample as shown in Appendix B, (Table B-1). Distributed (100) questionnaire forms to engineer's specialists and engineer's experts in the field of construction. (78) Form was received and Table 2 clarify the number of distribution and receive forms.

Table 2. Distributed of questionnaire form

Project ID	No. of Distributed	No. of Received	% Of Response
P1	5	4	80
P2	5	4	80
P3	5	3	60
P4	5	5	100
P5	5	4	80
P6	5	3	60
P7	5	4	80
P8	5	5	100
P9	5	3	60
P10	5	4	80
P11	5	5	100
P12	5	4	80
P13	5	4	80
P14	5	3	60
P15	5	3	60
P16	5	5	100
P17	5	5	100
P18	5	4	80
P19	5	3	60
P20	5	3	60
Total	100	78	78%

The response rate was 78% it is good and acceptable ratio and it can be relied upon in the accounts as research sample.

5. RELIABILITY

The reliability of questionnaire, means the questionnaire gives a same result when re-applying on the same sample and conditions, in other hand means stability in the results that do not change when redistributing during certain periods of time, Eq. (1) shows the Cronbach alpha.

$$\alpha = N.C - V + (N-1).C \quad (1)$$

where:

α: Cronbach alpha

N: Number of items.

C: Average covariance between item-pairs.

V: Average variance.

SPSS program version 20 applied to found the value of Cronbach's Alpha (α) as shown in Tables 3, 4 Cronbach's Alpha equal to (0.800) that indicate the questionnaire is reliable and the same result will be obtained if the questionnaire repeated, and there is statistically significant coefficient.

Table 3. Case processing summary

Cases	N	%
Valid	78	96.3
Excluded[a]	3	3.7
Total	81	100.0

Table 4. Reliability Statistics by SPSS program

Cronbach's Alpha	N of Items
.800	60

6. STATISTICAL ANALYSIS OF THE QUESTIONNAIRE ITEMS

Below is the statistical analysis of the questionnaire items:

6.1 First section: General information

General information includes the following, as shown in Figures 1 and 2.

6.1.1 Project name

The research sample consist of (20) wastewater projects, the detail of these projects was described in Appendix (B).

6.1.2 Work sector

More than half of study sample represented public sector is (55.1%), only public and private sector included in this research.

6.1.3 Academic certification

A half of research sample have a B.Sc. degree is (53.8%), master degree is (37.2%), Ph.D. degree is (7.7%), and diploma degree is (1.3%).

6.1.4 Engineering specialty

It is absorbed that the engineering disciplines were distributed by (52.5%) to civil engineers, (32%) to mechanical engineers, then (12.8%) to electrical engineers, while the other specialized take (2.5%).

6.1.5 Functional degree

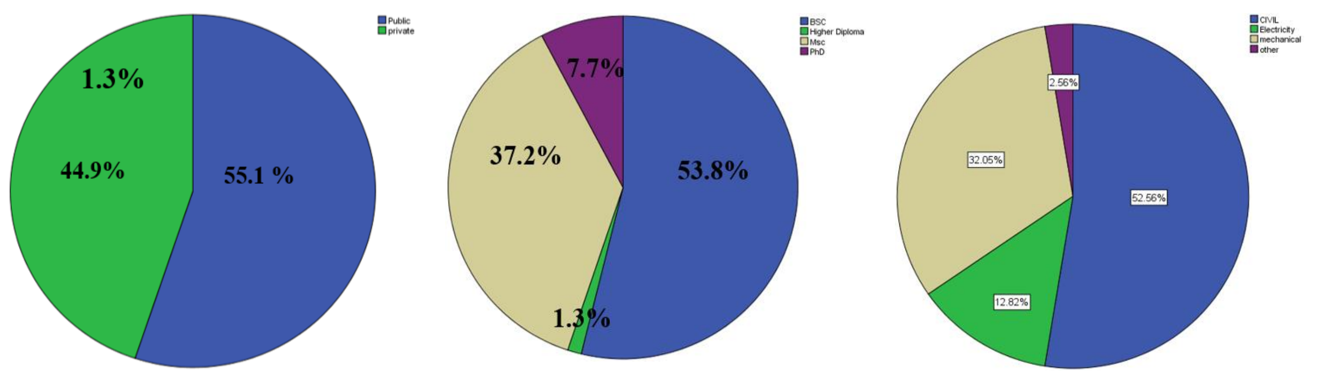
The research sample include many of functional degree, senior engineer degree is (29.5%), and chief engineer is (20.5%), then engineer degree is (11.5%), while assistant chief engineer and chief engineer take same proportion is (20.5%).

6.1.6 Functional position

It is observed that the functional position of supervisor engineer is (28.2%), and projects manager is (20.5%), both company managers and resident engineers are (17.9%), while the less proportion to planning and estimation engineer by (2.6%), (1.3%) respectively.

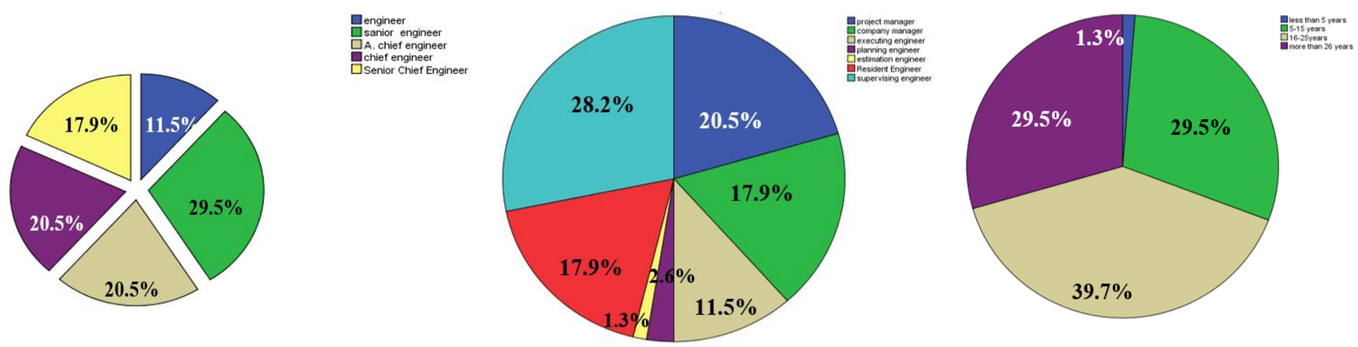
6.1.7 Years of experience

The years of experience of research sample from (16-25 years) was (39.7%), and range between (5-15 years) and more than (25 years) was (29.5%) respectively, while years of experience less than (5 years) less than (1.3%). this indicated that research sample have high level of experience in wastewater projects.



(a) Work Sector (b) Academic Certification (c) Engineering Specialty

Figure 1. General information



(a) Functional Degree (b) Functional Position (c) Years of Experience

Figure 2. Other general information

6.2 Second section (risk effecting on projects delivery system)

Statistical process is adopted in analysis and evaluation of the responses, as following.

First: Arithmetic mean (AM), it describes the evaluation of the questionnaire answers and an additional the rate used in the analysis of each item of questionnaire axes, depend on Eq. (2).

$$AM = \left[\frac{\sum(WV * Fi)}{N}\right] \quad (2)$$

where:

AM: Arithmetic mean (weighted average for answer).

WV: (weight value), see Table 5.

Fi: Frequency of responses.

N: Total number of respondents.

In order to compute (M) a hypothetical weight value (WV) was adopted to each of the five range classes for answers. Table 5 shows the Five-point Likert scale.

Table 5. Weight value of descriptive frequency

Weight value (WV)	Interval	Deference	Descriptive frequency
1	1.00 - 1.79	0.79	Not effective
2	1.80 - 2.59	0.79	Little effective
3	2.60 - 3.39	0.79	Middle
4	3.40 - 4.19	0.79	Effective
5	4.20 – 5.00	0.8	Very effective

The analysis and evaluation of each item of questionnaire based on median of weight value, that represent the mean value of (1-5) was (m=3). Weighted average analysis for each item of the questionnaire was amended, accordingly approached the limits above, as follows:

1. When (M<3), the assessment of delivery system is (poor), and degree of development required is (must).

2. When (3≤M≤4), the assessment of delivery system is (middle), and degree of development is (wanted).

3. When (M>4), the assessment of delivery system is (good), and degree of development is (desired).

Second: Conformance ratio (CR), it used in the assessment each of axis in the project delivery system, Eq. (3) applied to determine the (CR) [10].

$$Cr = \frac{M}{Xmax} \quad (3)$$

where:

Cr: conformance ratio for axis

M: Arithmetic mean (weighted average of the item)

X max: the highest degree of values and occupies the top tire of the value of the answer center = 4.6

In order to determine lower limit and upper limit track the following rule:

Lower limit = 3/ 4.6 = 0.65

Upper limit = 4/4.6 = 0.85

Assessment of axes are computed according to the following:

If **(Cr < 0.65)**, the degree of application of the axis is **(Poor)**, and the degree of development is **(Must).**

1. If **(0.65≤ Cr≤0.85),** the degree of application of the axis is **(Middle),** and the degree of development is **(Wanted)**.

2. If **(Cr> 0.85),** the degree of application of the axis is **(Good),** and the degree of development is **(Desired)**.

6.2.1 First axis (legal and administration risks)

The researcher analysis the legal and administration risks and determine the frequency, arithmetic mean and degree of impact as shown in Table 6.

From above result the researcher investigate the reality of the application of the most importance practices for the Project delivery system as shown in Table 7.

The result above describes the axes of legal and administration risks, which include the most important practices that should be applied to achieve PDS according to legal and administration aspects. This section divided the aspect in to three axes: planning, dispute and claims, and contract management, via the analysis and responses evaluation of each axis can determine the conformance ratios (Cr) that were 0.66, 0.82, 0.81 (In the same above order of the axes), Which reflects the negligence of the practices application in the project delivery system, which will reflect negatively on the project as a whole. These results refer to **(Wanted)** degree of development required, as shown in Figure 3. As a result, the (Cr) of analysis and evaluation of legal and administration aspect was 0.76, which refers to **(Middle)** degree of evaluation.

Table 6. Degree of Impact for legal and administration risk

Code	Risk	Observed Frequency					AM	Degree of impact
		NE	LE	M	E	VE		
	Planning							
X1	Delayed approval of the general budget	0	0	9	55	14	4.06	Effective
X2	Lack of projects funding comparing with require	17	44	15	2	0	2.03	Little effective
	Dispute and claims							
X3	Inaccuracy evaluating of companies and give them inconsistent rating with the actual capabilities	0	0	2	40	36	4.44	Very effective
X4	Delay of dispute solves between owners and contractors	0	0	5	55	18	4.17	Effective
X5	Inaccuracy of contracts between contractors	6	21	40	9	2	2.74	Middle
	Contract management							
X6	Fragmentation of big projects	3	4	9	48	14	3.85	Effective
X7	Length of time period for the follow procedures of mention tender	2	5	15	40	16	3.81	Effective
X8	Sale of contract to subcontractors	0	5	30	32	11	3.63	Effective

Table 7. Evaluation of each axis in the legal and administration risk

No.	Axes of legal and administration risk	AM	Cr	Degree of application	Degree of development
1	Planning	3.04	0.66	Middle	Wanted
2	Dispute and claims	3.78	0.82	Middle	Wanted
3	Contract management	3.76	0.81	Middle	Wanted

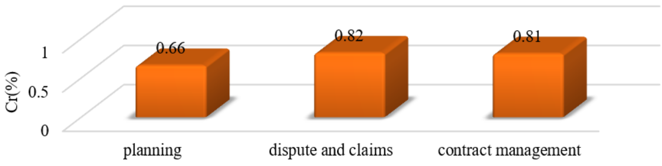


Figure 3. Conformance ratio of legal and administration risks

The Figure 3 includes conformance ratio for each axis, and results shows a decries in the degree of evaluation.

6.2.2 Second axis (financial risk)

This aspect consists of two axes (financial management and cost management), researcher conducted analysis and assessment for responses and determine the frequency, arithmetic mean and degree of impact for financial aspect of PDS, as shown in Table 8.

After analysis and evaluation, the degree of impact from Table 8, the researcher investigates the reality of application of the most important practices for the PDS. Table 9 Illustrate the evaluation for each axis in financial risk.

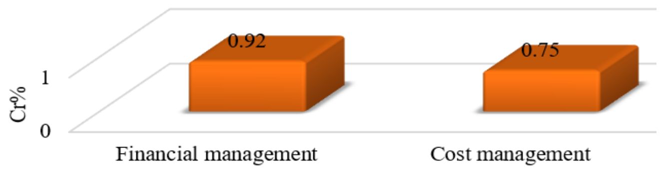


Figure 4. Conformance ratio of financial risk

From result above the researched concluded the financial risk involves two axes (financial management and cost management) that evaluation most important practices that should be applied to achieve PDS. Researcher conducted analysis and responses evaluation of each axis and can determine the conformance ratios (Cr) that were 0.92 and 0.75 (In the same above order of the axes), which reflects the negligence of the practices application in the project delivery system, which will reflect negatively on the project as a whole. These results refer to **(Wanted and desired)** degree of development required, as shown in Figure 4. Also the (Cr) was 0.83, which indicate the **(Middle)** degree of evaluation.

The Figure 4 describes the conformance ratio (Cr) for each axis, the result shows the decrease in the degree of evaluation.

6.2.3 Third axes (technical risk)

Technical risk consists of three axes (technical experience, tools and techniques and Staff training and rehabilitation), researcher conducted analysis and evaluation for responses and determine the frequency, arithmetic mean and degree of impact for as shown in Table 10.

The researcher investigates the reality of the application of the most important practices for the PDS under technical risk.

From result above the researched concluded the technical risk involves the axes (technical experience, tools and techniques, and staff training and rehabilitation) that evaluation most important practices that should be applied to achieve PDS.

Researcher conducted analysis and responses evaluation for each axis and determine the conformance ratios (Cr) that were 0.80, 0.53 and 0.82 (In the same above order of the axes), which reflects the negligence of the practices application in the project delivery system, which will reflect negatively on the project as a whole. These results refer to **(wanted and must)** degree of development required, as shown in Figure 5. As a result, the (Cr) of analysis and evaluation of technical aspect was 0.72, which refers to **(Middle)** degree of evaluation as shown in Table 11.

The Figure 5 describes the (Cr) for each axis, the result shows the decrease in the degree of evaluation. The researcher enables to clarify the degree of application of project delivery system, as shown in the Table 12.

From the Table 12, the researcher identify a weakness in project delivery, system for wastewater projects, where the degree of application 76%, 84% and 72% respectively, Figure 6 shows the results of importance of specific procedures for the PDS at each axis.

Table 8. Degree of impact for financial risk

Code	Risk	Observe frequency					AM	Degree of impact
		NE	LE	M	E	VE		
	Financial management							
Y1	Length of time period for funding procedures to the directorates.	0	1	7	54	16	4.09	Effective
Y2	Inadequate the allocation with current reality.	0	0	5	37	36	4.40	Very effective
Y3	Lack of project funding.	0	1	9	36	32	4.27	Very effective
	Cost management							
Y4	Contract awarded to foreign companies with process that differ from the used payment method.	0	17	60	1	0	2.79	Middle
Y5	Lake of funds allocated to the investment curriculum from the stat general budget.	0	0	8	47	23	4.19	Effective

Table 9. Evaluation of each axis in the financial risk

No.	Axes of financial risk	AM	Cr	Degree of application	Degree of development
1	Financial management	4.25	0.92	Good	Desired
2	Cost management	3.49	0.75	Middle	Wanted

Table 10. Degree of impact for technical risk

Code	Risk	NE	LE	M	E	VE	AM	Degree of impact
	Technical experience							
Z1	inability of some directorate to create designs for wastewater projects,	0	7	65	5	1	3.00	Middle
Z2	Lack of experience of owner team.	0	0	13	61	4	3.88	Effective
Z3	Weakness of experience for most consultant bearue.	0	0	5	45	28	4.29	Very effective
	Tools and techniques							
Z4	Weakness of the ability of local companies and the obsolescence of work methods of work and technology used by them	3	58	11	2	4	2.31	Middle
Z5	lack of financial and efficiency for companies usually in wastewater projects.	6	33	28	9	2	2.59	Little effective
	Staff training and rehabilitation							
Z6	Lack of feasibility studies.	0	4	19	48	7	3.74	Effective
Z7	Weakness of monitoring and supervision procedures in wastewater projects	0	4	34	28	12	3.62	Effective
Z8	Inaccuracy of plans and drawings preparation lead to issue change order.	1	2	11	44	20	4.03	Effective

Table 11. Evaluation of each axis in the technical risk

No.	Axes of technical risk	AM	Cr	Degree of application	Degree of development
1	Technical experience	3.72	0.80	Middle	Wanted
2	Tools and techniques	2.45	0.53	Poor	Must
3	Staff training and rehabilitation	3.79	0.82	Middle	Wanted

Table 12. Degree of application of PDS

No.	Project delivery system	AM	Cr	Degree of application	Degree of development
1	Legal and administration	3.52	0.76	Middle	Wanted
2	Financial risk	3.87	0.84	Middle	Wanted
3	Technical risk	3.32	0.72	Middle	Wanted

To achieve the second objective of this paper, the researcher was identified and diagnose the failure causes on each aspect of project delivery system, the researcher adopted **Fishbone Diagrams technique,** which was created by Professor Kaoru Ishikawa, a major of quality management issues, in 1960s. Also, the diagrams are called as Ishikawa Diagrams or Fishbone Diagrams [11].

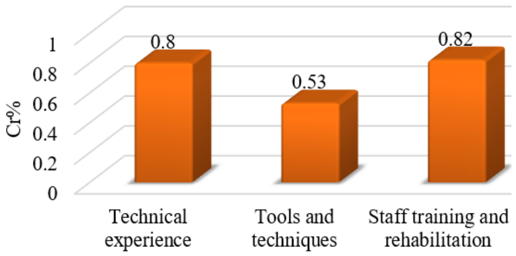


Figure 5. Conformance ratio of technical risk axis

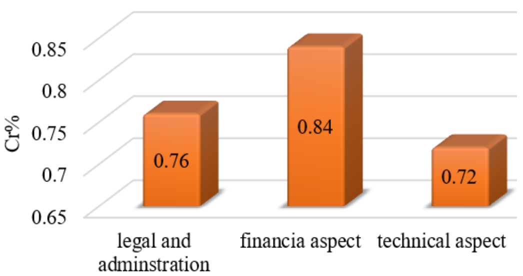


Figure 6. Conformance ratio of project delivery system

A cause-and-effect diagram Clearfield a structured concept for the potential problem causes. This technique helps to enhance risk solving efforts by recognizing categories of factors causing the problems. The following steps are used to determine potential reasons causing failure in legal and administration risk [12].

1. Determine the major problem, then write it in a box, and draw an arrow reaching towards it. In this research the major problem is weakness or failure in each aspect for wastewater project delivery system.
2. Diagnose the main factors, then drawing branches of the major arrow to represent the categories that causing the potential failure.
3. The division of the main factors to other sub-causing of those factors.

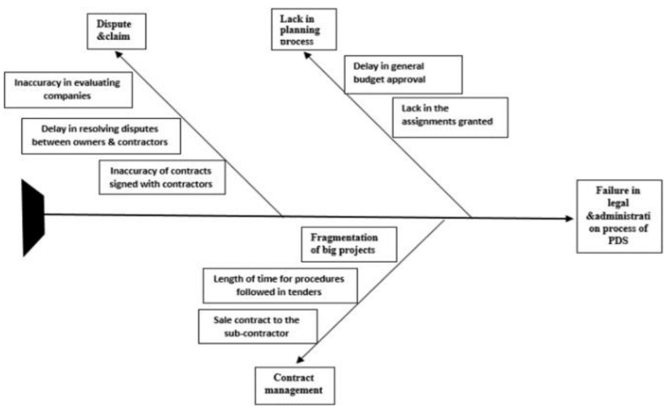


Figure 7. Fishbone diagram for legal and administration risk

In order to identify the causes of weakness or failure in the PDS. Figure 7. represents fish bone diagram of the main problem, which is the failure in the administrative and legal risk of PDS, which depends on three sub reasons , (lack in planning processes, disputes and claims, and weakness in contract management), first reason depends on the following factors (delay in approving the special budget for the projects and the lack of a structure or suitable place for the assignment of projects), while the second reason depends on (inaccuracy in evaluating companies, the delay in resolving disputes between the owner and contractor, and inaccuracy of contracts signed with Contractors), third reason depends on several factors (fragmentation of large projects, length of procedures followed in the bidding stage, sale of the contract to subcontractors).

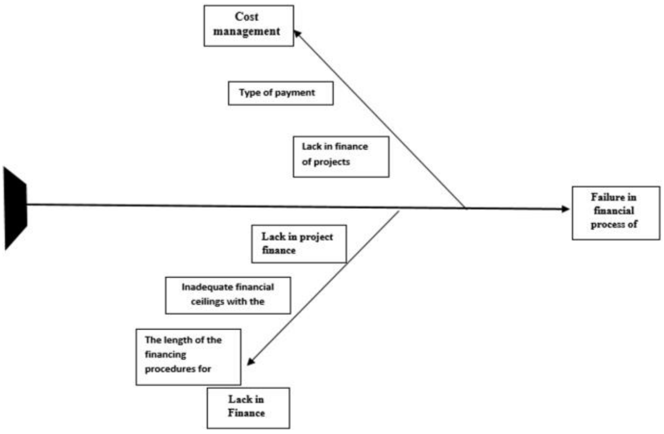


Figure 8. Fishbone diagram for financial risk

Figure 8 shows the failure in the financial operations of the delivery system which depends on several secondary causes (cost management, and financial management). The first reason depends on the following factors (method of payment, lack of project financing), while the second reason depends on financial ceilings that are not appropriate with the current reality, Length of funding procedures for departments affiliated to ministries.

Figure 9 shows the failure in the technical processes of delivery, which depends on the secondary causes (lack of technical expertise, lack of tools and technical techniques, training and rehabilitation of staff), where the first reason depends on the following factors (examination in preparing designs, lack of experience in project implementation).

The shortage in the capabilities of consulting offices) while the second reason relied on (the lack of efficiency of the companies implementing the sewage, the weak ability of companies to work methods. As for the last reason, it depends on the inaccuracy in preparing maps and statements, the lack of supervision and control over the project, the lack of preparation Feasibility studies.

6.3 Third section (factor effecting on PDS selection)

This section consists of three axes (project objective, owner requirement and external condition), each axes include sub-factors that has been affected on PDS selection.

6.3.1 First axes (project objective)

The researcher conducted the analysis and compute the frequency, arithmetic means and degree of impact for project objective factors as shown in Table 13.

Figures 10 and 11 show the degree of impact for the project objective factors, according to the result the researcher can determine the relative importance for each factor as shown in Table 14.

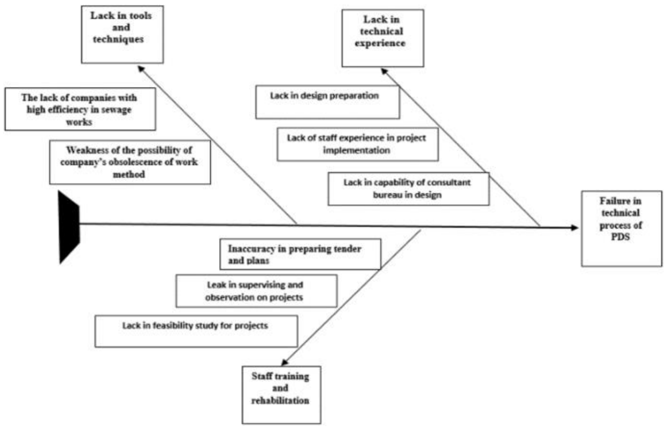


Figure 9. Fishbone diagram for technical risk

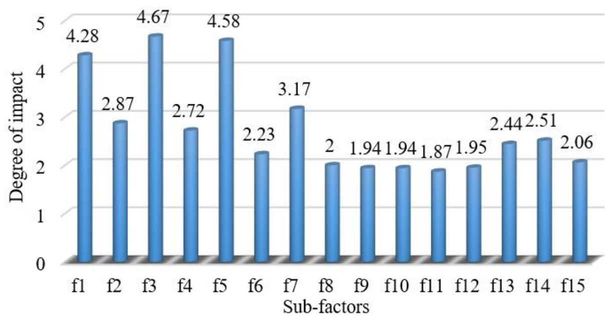


Figure 10. Degree of impact for projects objective factors

Table 13. Degree of impact for project objectives

Code	Sub-factors	Observed Frequency					AM	Degree of impact
		NE	LE	M	E	VE		
f1	Project compieation with specific time.	0	2	10	30	36	4.28	Very effective
f2	Deviation in cost during the implementation phase	1	17	51	9	0	2.87	Middle
f3	Level of quality	0	0	0	26	52	4.67	Very effective
f4	Type of project	1	20	57	0	0	2.72	Middle
f5	Volume of project	0	0	4	25	49	4.58	Very effective
f6	Complete the project with less cost	3	61	9	3	2	2.23	Little effective
f7	Project complexity	3	28	5	37	5	3.17	Middle
f8	Scope of project	9	63	4	1	1	2	Little effective
f9	Flexibility in change order issues	12	61	4	0	1	1.94	Little effective
f10	Innovation	14	57	6	0	1	1.94	Little effective
f11	Contract price	18	54	5	0	1	1.87	Little effective
f12	Cost of maintenance	22	41	13	1	1	1.95	Little effective
f13	Mandatory specifications for the project	5	37	34	1	1	2.44	Little effective
f14	Structural knowledge and specialized machines	5	32	38	2	1	2.51	Little effective
f15	Unclear project parameter	14	51	7	6	0	2.06	Little effective

Table 14. Relative importance and rank of project objective factors

Main factor	Sub-factor	Weight of sub-factor	RI%	Rank
	f1	4.28	104	3rd
	f2	2.87	70	5th
	f3	4.67	113	1st
	f4	2.72	65	Neglects
	f5	4.58	111	2nd
	f6	2.23	54	Neglects
	f7	3.17	77	4th
F	f8	2	49	Neglects
	f9	1.94	47	Neglects
	f10	1.94	47	Neglects
	f11	1.87	45	Neglects
	f12	1.95	47	Neglects
	f13	2.44	59	Neglects
	f14	2.51	61	Neglects
	f15	2.06	50	Neglects

Table 15. Degree of impact for owner requirement

Code	Sub-factors	Observed Frequency					AM	Degree of impact
		NE	LE	M	E	VE		
w1	Frequent disputes and claims between stakeholders	0	0	5	37	36	4.40	Effective
w2	The possibility of the employer to participate in the details of the project	7	55	15	0	1	2.14	Little effective
w3	Taking into account the risks facing the project at all stages	0	0	4	64	10	4.08	Effective
w4	Bid package	8	57	8	5	0	2.13	Little effective
w5	Level of design	7	57	14	0	0	2.09	Little effective
w6	Institution knowledge	7	60	11	0	0	2.05	Little effective
w7	Possibility of execution projects item before design completion	12	55	10	1	0	2.00	Little effective
w8	Project alliancing is not useful for high risk	10	54	13	1	0	2.06	Little effective
w9	Owner requirement for cost predicted	11	31	34	2	0	2.35	Little effective
w10	Owner requirement for price combative	10	51	15	2	0	2.12	Little effective
w11	Experience available for owner team to select PDS	1	47	30	0	0	2.37	Little effective
w12	Bid clarification meeting	46	23	3	5	1	1.62	Not effective
w13	Type of payment	11	51	13	2	1	2.12	Little effective
w14	Technology available for owner team	12	48	15	2	1	2.13	Little effective
w15	Job explanation meeting	48	30	0	0	0	1.38	Not effective
w16	Use modern tools and techniques to select PDS	2	31	43	2	0	2.58	Little effective

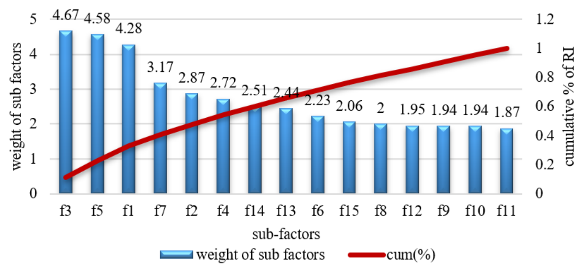


Figure 11. Pareto chart for project objective factors

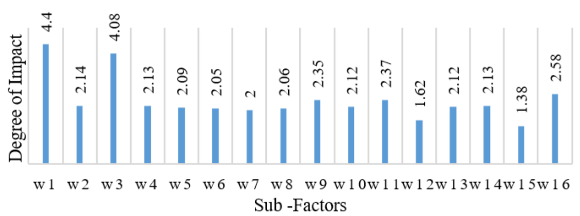


Figure 12. Degree of impact for owner requirement factors

The Pareto chart in the Figure 12 shows the most important factors that affecting on delivery system selection, where the researcher chose the factors that give max relative importance (more than 65%), were represented by **(f3, f5, f1, f7, f2)** Where did you get a percentage **(113%, 111%, 104%, 77%, 70%)** respectively. The researcher neglected factors that give RI less than or equal to 65%.

6.3.2 Second axis (owner requirement)

This axis consists of (16) sub-factors, researcher conducted analysis and determine the most importance factor that effect on PDS selection, as shown in Table 15.

The Figure 12 shows the degree of impact for the owner requirement factors; the researcher can determine the relative importance for each factor as shown in Table 16.

Table 16. Relative importance and rank for owner requirement factors

Main factor	Sub-factor	Weight of sub-factor	RI%	Rank
	w1	4.4	117	1st
	w2	2.14	57	Neglects
	w3	4.08	108	2nd
	w4	2.13	57	Neglects
	w5	2.09	56	Neglects
	w6	2.05	54	Neglects
	w7	2.00	53	Neglects
W	w8	2.06	55	Neglects
	w9	2.35	62	Neglects
	w10	2.12	56	Neglects
	w11	2.37	63	Neglects
	w12	1.62	43	Neglects
	w13	2.12	56	Neglects
	w14	2.13	57	Neglects
	w15	1.38	37	Neglects
	w16	2.58	69	3rd

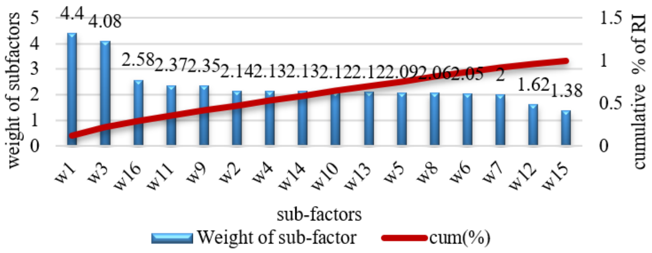


Figure 13. Pareto chart for owner requirement factors

Figure 13 shows the Pareto chart of most important factors that affecting on delivery system selection, where the researcher chose the factors that give max relative importance (more than 65%), were represented by **(w1, w3, and w16)** Where did you get a percentage **(117%, 108%, and 69%)** respectively. The researcher neglected factors that give RI less than or equal to 65%.

6.3.3 Third axis (external conditions)

This axis consists of (8) sub-factors, researcher conducted analysis then determine the most importance factor that effect on PDS selection, as shown in Table 17.

After determine the degree of impact for each factor as describe from Figure 14, the researcher determined the relative important (RI) for each factor as shown in Table 18.

Figure 15 shows the most important factors that affecting on delivery system selection, where the researcher chose the factors that give max relative importance (more than 65%), were represented by **(m7, m2, and m1)** Where did you get a percentage **(109%, 105%, and 103%)** respectively. The researcher neglected factors that give RI less than or equal to 65%.

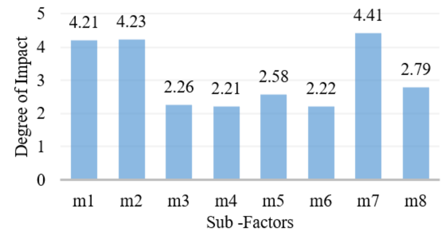


Figure 14. Degree of impact for external condition factors

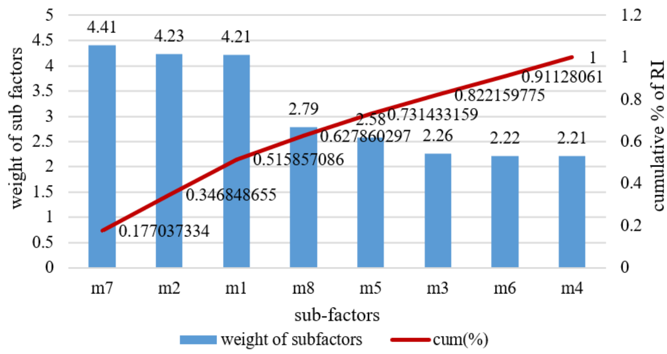


Figure 15. Pareto chart for external conditions factors

Table 17. Degree of impact for external condition factor

Code	Sub-factors	Observed Frequency					AM	Degree of impact
		NE	LE	M	E	VE		
m1	Materials and possibilities available to the contractor	0	0	10	42	26	4.21	Very effective
m2	Unstable market conditions	0	0	4	52	22	4.23	Very effective
m3	Political and security unrest of the country	4	52	20	2	0	2.26	Little effective
m4	Unexpected site conditions	4	56	17	0	1	2.21	Little effective
m5	Issues and decisions taken by the third party (consulting office) to solve work-related problems	2	33	40	2	1	2.58	Little effective
m6	Risks arising from changing the laws and legislative regulations adopted by the government	5	59	8	4	2	2.22	Little effective
m7	International and local funding sources for the project	0	0	8	30	40	4.41	Very effective
m8	The investment climate of the project represented by the factors of attraction and expulsion	7	17	44	5	5	2.79	Middle effective

Table 18. Relative importance and rank of external conditions factors

Main factor	Sub – factors	Weight of sub factors	R.I%	Rank
M	m1	4.21	103	3rd
	m2	4.23	105	2nd
	m3	2.26	53	Neglects
	m4	2.21	52	Neglects
	m5	2.58	60	Neglects
	m6	2.22	53	Neglects
	m7	4.41	109	1st
	m8	2.79	63	Neglects

7. CONCLUSIONS

Given the importance of evaluating the reality of the delivery methods of wastewater projects and identifying the factors that have the greatest impact on those methods, the opinions of specialists in this field were collected and analyzed, it can be concluded that there are several main and secondary factors affecting the project delivery methods. The main factors are three factors: project objectives, owner requirements, and external conditions. These factors included several secondary factors whose relative importance was calculated. The factors that do not exceed their relative importance (65%) were neglected, while the other secondary factors were taken into consideration, as follows:

- The first main factor is the project objectives: It included fifteen secondary factors, only five were taken into consideration, depending on their relative importance. They are (f3, f5, f1, f7, f2) and its relative importance was (113%, 111%, 104%, 77%, 70%) respectively.
- The second main factor is the owner's requirements: it also includes sixteen secondary factors, three were taken into consideration to have the highest relative importance, and these factors are (w1, w3, and w16) and their relative importance (117%, 108%, and 69%) respectively.

- The third main factor is the external conditions: it includes eight secondary factors, three of which have been taken into consideration because they have the highest relative importance. These factors are (m7, m2, and m1) and their relative importance is (109%, 105%, and 103%) respectively.

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NOMENCLATURE

PDS	project delivery system
NE	Ineffective
LE	Little effect
M	Medium effect
E	Effected
VE	Very effected
AM	Arithmetic mean

APPENDIX

Appendix (A)

Table A-1. Background of interviewer

No.	Work place	Academic qualification	Functional position	Years of experience
1	Wasit Swage Directorate	B.Sc.	Head of planning department	12
2	Wasit Swage Directorate	B.Sc.	Head of design department	23
3	Wasit Swage Directorate	B.Sc.	Head of GIS department	11
4	Wasit Swage Directorate	B.Sc.	Head of execution department	37
5	Wasit Swage Directorate	B.Sc.	Head of operation department	15
6	Wasit Governorate	M.Sc.	Head of planning department	14
7	Wasit Governorate	M.Sc.	Head of projects management	18
8	Taj Al-Nahran company	M.Sc.	Project manager	30
9	Taj Al-Nahran company	B.Sc.	Contractor	35
10	Al – Kut swage project	B.Sc.	Supervisor	27
11	Al – Rumaila & Dabbia sewage project	M.SC.	Resident engineer	13

Table A-2. Main questions discussed in the open questionnaire

No	Questions
1	Are alternative delivery systems used in wastewater projects or a traditional methods used?
2	What are the most commonly used delivery systems in sewage projects?
3	Are the traditional delivery system appropriate to the project conditions?
4	What are the claims resulting from the use of traditional delivery methods?
5	What are the main factors affecting the choice of delivery system in wastewater projects?
6	What are the secondary factors affecting the choice of delivery system in sanitation projects?
7	How do you evaluate the performance of the current delivery system in terms of time, cost and quality?
8	Is there a methodology for managing the project delivery system by the owner team?
9	What are the most commonly used delivery systems for the maintenance of wastewater project?
10	What are the criteria that determine priority in the implementation of wastewater projects?
11	What are the risks affecting the sewage project delivery system? And what are its types?

Appendix (B)

Table B-1. Projects coded

Pro. ID	Project Name	Type of finance
P1	Development of the entrance to Suwaira from the side (Baghdad - Hilla) with a length of 1840 m for the two main corridors and a design width of 46 m in the district of Suwaira (first phase)	Develop regions
P2	Implementation of sewage and rainwater lines with the construction of separate streets in Sheikh Saad district	
P3	Developing part of the Rumaila and Dabbia area in the Kut district	
P4	Implementation of heavy sewage conveying lines from the right side with a sewage station in Kut district	
P5	Implementation of a water network with the implementation of communications works with the development and rehabilitation of the electrical network with the implementation of a rain and heavy water network with the development of scattered streets in the Mardan area in the district of Taj al-Din	
P6	Implementation of a water network with communications works with the rehabilitation of the electrical network with the implementation of a rain and heavy sewage network with paving scattered streets in Al-Ghadeer neighborhood with a total length of about 4300 m.	
P7	Development of Al-Maimoun neighborhood and part of the 150th district in Al-Kut district	
P8	Implementation and rehabilitation of a water network with the implementation of heavy sewage networks, a common station and a payment line with the improvement of the electrical network in the Officers, Jurists, Freedom and Industrial District Street with a length of 21100 m.	
P9	Developing, covering and pouring streets and rehabilitating the gardens of the Al-Hawra neighborhood area, starting from Al-Shirazi Street to Alwa Al-Mawashi Street, including the parallel street to the Dujaili River, from the end of Al-Izza Street to the end of the borders of the Al-Hawra neighborhood area, including Al-Madras Street within the first region, with a total length of 44,000 m.	
P10	Developing, covering and pouring streets and rehabilitating the gardens of Hay al-Jihad area, including the Jamia'a area, the Martyr Daoud area, the carpet area, and part of the neighborhood of al-Shuhada and al-Zahra', with a total length of 20000 m in the city of Kut.	
P11	Completion of the design, supply, implementation and operation of the Numaniyah sewage networks	Investment plan
P12	Design, supply, implementation and operation of Azizia sewage networks	
P13	Supplying and implementing a treatment plant, rain sewage networks, and lifting stations / the first phase of the city of Essaouira (Chinese company CGGC)	
P14	Supplying, implementing, operating and maintaining a treatment plant, rain sewage networks and lifting stations / the first phase of the district (Chinese company CGGC)	
P15	The project of the treatment unit in the district of Al-Aziziya within the list of spare order No. (12) for the internal network, the workshop and the road	
P16	Implementation of a rain and heavy sewage network in Al-Zahraa neighborhood / Jassan district	Social contribution
P17	Implementation of a rain and heavy sewage network in Al-Abbas neighborhood / Jassan district	
P18	Implementation of a rain and heavy sewage network for the northern entrance of Jassan	
P19	Rehabilitation of Tammuz sewage plant (behind the Kut textile)	Operational plan
P20	Rehabilitation of the mechanical group for the main Hoora station	

Appendix (C)

First section

General information

1. Project name:

2. Sector of work: public () private () mixed ()

3. Academic certificate: B.Sc. Degree () Higher Diploma ()Master () PhD ()

4. Engineering spatiality: Civil () Electricity () Mechanical () Architectural () others ()

5. Job rank: Asst . Engineer () Engineer () Senior Engineer () Eng. Chief Engineer () Chief Engineer ()

R. Senior Engineers () Expert ()

6. Position: Project Manager () Company Manager () Executive Engineer () Planning Engineer () Estimation Engineer ()

Resident Engineer () Supervising Engineer for Sanitary Works ()

7. Number of years of experience in sanitation projects:

Less than 5 years () (5-15) years ()

(16-25) years () more than 26 years ()

Second section

A reality survey of the ways of delivering sewage projects

The project delivery system means that all contractual operations between the project parties (stakeholders) from the planning stage to the implementation and maintenance stage. It has several types depending on the nature of the project and its circumstances.

1. What is the delivery system used for this project?

Design - Contract - Build () Design - Build () Direct Execution ()

Accelerated execution () separate master contracts () turnkey ()

Public-Private Partnership () Construction Manager - Risks () Other ()

2. The delivery system contains a set of contracts between stakeholders. What are the most commonly used contracts in this project? (You can choose more than one type)

Unit Price Contract () Lump Amount Contract () Bill of Quantity Contract () Unit Price Contract and Bill of Quantity () Cost Plus Contract () Other ()

3. What is the method of financing the project?

Development of regions () investment plan () operational plan ()

Social Contribution () Loans () Grants ()

4. What are the most commonly used delivery systems for the maintenance of sewage projects?

....And why?