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Optimal management of water and wastewater industry projects

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Abstract

Water is now an important issue in the world, and the effective development of water resources and optimal management of industrial projects are essential for sustainable growth. Limitations and crises of water and wastewater companies in the supply and optimal exploitation of water resources and wastewater disposal require strategic planning and management, thereby increasing the competitive advantages of human societies. Given the importance of optimal management of water and wastewater industry projects, the present research sought to detect and introduce indices and criteria, which affected the optimal management of this industry based on certain models (Porter Diamond Model, Porter's Five Forces, and PESTEL), by examining and analyzing political, economic, and socio-cultural trends and using the results of interpretation and analysis of trends. To this end, the experts in the water and wastewater industry, as well as the managers working in this industry were surveyed. Based on experts' opinions, the results of the certain criteria after screening were finally converted into 22 out of 95 criteria using the fuzzy Delphi technique, and then the 22 criteria selected by the experts were reviewed and any of them with the potential to be quantified and their trends could be examined, were selected and quantified. Finally, the results introduced 12 indices in three categories: economic indices (similar in all industries), specialized indices of water and wastewater, and cultural-educational indices. The Gross Domestic Product (GDP), the complexity of the supply chain of the water and wastewater industry, and cultural infrastructures (Intellectual maturity, management attitude, education, corruption, and population) were respectively representatives of the indices.

Keywords: effective indices, optimal management, economy, culture, water and wastewater industry projects
2020 MSC: 90B0, 90B50

Introduction

The lower level of sustainability and the increasing pace of environmental changes in economic, political, social, and technological fields at the international, regional, and national levels have increased complexity, enhanced anomalies, decreased the predictability of the business environment, and increased the intensity of rivalry in the relevant layers

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of the levels [16]. Full reliance on classical and traditional methods, which are mainly based on creating the best possible adaptation between the relatively sustainable and predictable conditions of the external environment and internal characteristics of the business environment, cannot merely provide survival and development of organizations. Furthermore, reflecting the increase in unsustainability, complexity, uncertainty, and unpredictability of the organization's external environment increases the complexity of managing the internal environment and the unsustainability of resources and programs within organizations in the current situation. Under such circumstances, the need for a tool to detect the appropriate and efficient strategy for dealing with unexpected changes in the environment is essential for the survival of organizations and, if possible, their development. In the Environmental School of thought, the results of the analysis of environmental trends are used as the main factors in formulating strategy and future forecasting, and thus the analysis of economic, political, social, cultural, and technological trends in the environment of each organization is the main factor in the emergence of strategy in that organization [16].

Numerous factors are effective in the performance of water and wastewater sector projects. For example, the average annual water consumption is 96 billion cubic meters, and the threshold level of water scarcity is 53 billion m^3 in Iran. In other words, the average annual water consumption is 80% higher than the threshold level in Iran. Furthermore, Iran's renewable water resources are 89 billion m^3, meaning that the average annual water consumption is 8% more than the total renewable water resources in Iran [17]. According to the United Nations forecast, the average water reserves will increase by 8.3% in the world from 2000 to 2040, but the average population of the world will grow by 55% in such years. That is 6.7 times higher. The ratio of water consumption to the reserve of renewable resources is over 70% and more than 3 times higher than the global average in the Middle East/North Africa (MENA) region. In other words, these areas consume more than 70% of their available surface and underground water and mainly have water stress (The U.N.W water Dev. Report 2021). Therefore, the highest economic loss caused by climatic changes based on the water crisis occurs in the Middle East/North Africa region in a way that if this water crisis is not resolved, about two-thirds of the region (71%) will suffer from poverty and its consequences, including health and education problems. Therefore, the water crisis should be considered a serious problem in the coming years.

The water consumption trend in various industrial, agricultural, and domestic sectors in the coming years also indicates that global agricultural water consumption is expected to decrease in the next 30 years and give its place to other sectors such as industrial or domestic consumption. In 2020, agriculture accounted for about 69% of the annual water consumption in the world, but it has the lowest contribution to the national gross domestic product in Iran (12%). The industry sector is the second largest water consumer, accounting for approximately 19% of global water extraction. Drinking water includes the remaining 12% of freshwater consumption [17]. The process of allocating the national construction budget to the water and wastewater sector over the past years indicates the importance of this sector of the national construction and infrastructure projects [12]. Given the importance of the water industry, which plays a key role in reaching economic, social, and environmental goals at the national and international levels, and the fact that water is simultaneously a commodity, a basic natural resource, and a tool for fulfilling basic human needs, water and wastewater projects have received a higher priority than other infrastructural sectors, including road construction and transportation in Iran.

Therefore, the present research sought to investigate and analyze the political, economic, technological, and socio-cultural trends at the national, regional, and international levels of infrastructural projects of the water and wastewater industry in Iran, and thus determined and introduced indices and criteria affecting the optimal management of water and wastewater industry projects using the results of interpretation and analysis of the existing trends.

Research background

Masoudi [11] provided a sociological analysis of social participation in designing and implementing the urban wastewater collection and treatment network. Dabbagh and Alinejad [2] reported the increasing competitive advantages with strategic planning in water and wastewater companies (case study: West Azerbaijan Water and Wastewater Company). Davoudabadi and Shalpoush [4] sought to identify the lost economic opportunities of projects in the process of completing the water and wastewater industry with an approach to economic techniques during 2000-2014. Farajpour et al. [6] identified and ranked the obstacles to the implementation of strategic plans in the water and wastewater companies of cities and towns west of Tehran with an approach to the fuzzy network analysis process. Rousta and Keshavarzi [15] studied the effects of water economy models on optimal water consumption. Goli et al. [7] evaluated the productivity of paddy water resources in northern Iran using a SWOT analysis. Qureshi [14] examined the challenges and prospects of using treated wastewater to manage water scarcity crises in the Persian Gulf Cooperation Council (GCC) Countries. Ahn et al. [1] examined the social benefits of implementing and upgrading sewage treatment plants. Sumiarsih et al. [20] analyzed the strategic sustainable management of the water transmission

system in Indonesia using SWOT and QSPM matrices. Nagara et al. [13] analyzed solutions for water scarcity using the SWOT matrix in Asian and African countries.

Research methods

The present study had a basic type in terms of purpose. Since the desk and field methods such as questionnaires were used in the research, the research was descriptive-survey based on the nature and the data collection method.

Research tool

In the present study, 95 basic criteria were detected based on the reference models and were given to experts in water and wastewater and managers working in the water and wastewater industry in structured questionnaires. The experts' opinions, who determined the effectiveness of each criterion in 10 levels, were analyzed using a 7-point Likert scale. The results of the criteria were converted from 95 to 33 criteria after screening by the Fuzzy Delphi technique. The final list of effective criteria in the improvement of the management of water and wastewater industry projects selected by the experts in this industry was also extracted. A total of 33 criteria, which affected the improvement of managing water and wastewater industry projects selected by experts, were then re-sent to the experts, and 22 out of 33 criteria were selected. These 22 criteria were examined by the experts and each one, which could be quantified and examined in terms of their trends, was selected and quantified.

Furthermore, the criteria extracted from previous studies were examined and summarized in interviews with 10 experts, and the criteria, upon which all experts agreed to measure the research concept, were utilized.

This study used the Fuzzy Delphi Method (FDM) as a valid method. Kaufmann and Gupta [9] introduced the use of the fuzzy Delphi technique for forecasting. The structure of triangular fuzzy numbers is in a way that it is very suitable for the Delphi method forecast. In the method, which is used to predict the time, price, and other quantities, experts are asked to provide their forecasts based on the minimum, maximum, and most probable values. Therefore, there is no need to provide a clear and absolute value. The fuzzy Delphi technique algorithm for forecasting is as follows:

Each expert's forecast is first presented as a triangular fuzzy number:

$$A_i = (l_i, m_i, u_i)$$

A fuzzy average is used to aggregate the forecasts:

$$A_{\text{AVE}} = \left(\frac{\Sigma l}{n}, \frac{\Sigma m}{n}, \frac{\Sigma u}{n} \right)$$

The difference between each expert's opinion and the average opinion is calculated and presented again to the relevant expert.

$$A_{\text{AVE}} - A_i = \left(\frac{\Sigma l}{n} - l_i, \frac{\Sigma m}{n} - m_i, \frac{\Sigma u}{n} - u_i \right)$$

Experts' opinions are re-collected and the new fuzzy average is calculated.

$$B_{\text{AVE}} = \left(\frac{\Sigma l}{n}, \frac{\Sigma m}{n}, \frac{\Sigma u}{n} \right)$$

The difference between each expert's opinion and the average opinion is calculated and the Delphi cycle is repeated. This process stops when the consecutive averages, $Aave$, $Bave$, $Cave$, ... are clearly close to each other.

The present research examined reference models in the field of detecting determinants of the environment of an industry and determining indices, which affected business performance, and also collected quantitative data on political, economic, social, environmental, cultural, and technological factors which affected the water and wastewater industry, and identified the relationships between the factors that were extracted from the reference models. Finally, it identified and introduced determining indices of performance of water and wastewater industry projects with a similar trend and pattern by experts in the water and wastewater industry in 3 categories, namely economic indices (common in all industries), specialized water and wastewater indices, and cultural-educational indices.

This research used the fuzzy Delphi technique as a decision-making model along with the criteria, which were selected after the following steps, to ensure the validity of the results.

The criteria extracted from previous studies were also examined in face-to-face interviews with experts, and the steps progressed until the target criteria for the experts were similar and were limited to a specific number. According to the content validity index of each one, those in the range of index acceptance were selected. Furthermore, the importance coefficient of each was calculated as the average of experts' opinions. It should be noted that the importance coefficients were in the parametric model and a company can revise them according to the current conditions and priorities.

Findings

According to the literature review and research in this field, dimensions and criteria were selected to evaluate the competitiveness of an industry in Iran according to the factors determined in the models (Porter Diamond Model, Porter's Five Forces, and PESTEL). The criteria and indices of their subgroups were collected in a table and were given to experts and specialists in this industry to determine the effect of each on the optimal management and progression of water and wastewater industry projects. The table of indices as a questionnaire was scored through several specialized interviews with the government (water and wastewater sector), research colleagues, and managers of the water and wastewater industry to detect the effective factors in the performance of infrastructural projects, especially water and wastewater projects. Table 2 presents the list of indices extracted from the reference models.

Table 1: List of indices extracted from reference models

Model	Index	Number	Sub-index
Porter Diamond Model	Internal factors	1	The level of resource allocation (The level of factors that are involved in an industry, including the number of employees, the level of capital, land, technology, and management)
		2	The level of investment or available capital (Funds provided to achieve business goals of the industry's activists)
		3	Technologies (Key technologies needed for industry development)
		4	Workforce (Talents and expert R&D forces familiar with advanced technology)
		5	The land demand level (the level of necessary land to set up the equipment of an industry's projects)
	Demand conditions	6	Market size (The market growth capacity of projects of an industry in the future)
		7	Environmental pressure (Evaluation of environmental effects and owners' resistance)
		8	Substitution effect (The effect of the development of projects of an industry on the level and model of consumption of applicants of the same industry)
		9	Technology Transfer (Allowing users to implement and use technologies)
		10	Mastery over market demand trends (Possibility of identifying determinants of demand level by active companies)

The results of experts' opinions in the questionnaires were analyzed according to the fuzzy Delphi technique. The effectiveness of the criteria was analyzed based on the opinions of 10 experts at 10 levels. Table 3 presents the results.

The results of the selected criteria were changed from 95 criteria to 33 criteria after screening by the fuzzy Delphi technique as presented in Table 4. A total of 33 out of 95 criteria were accepted.

Experts are those who have high levels of knowledge and skills about a specific field or metacognitive knowledge on that field. These people have an exceptionally high level of performance in a specific task or in a specific field.

The table of the above indices as a questionnaire was given to water and environment experts according to characteristics such as age, education level, relevant work experience, current professional position/status, and mastery over the research field/topic.

Table 2: List of indices extracted from reference models

	Related and supporting industries	11	Competitiveness of the investment industry (Competitive abilities, reflected by the projects of an industry in comparison with the same industry in other countries)
		12	Industry chain related to the water and wastewater industry (Coordination, interaction, and cooperation between upstream, intermediate, and downstream sectors of an industry)
		13	The effect of industrial clustering (Competitive, but interdependent and mutually beneficial relationships between suppliers)
		14	Development of production equipment technology (Production equipment technologies that lead to higher efficiency and productivity of projects in an industry)
	Strategy, structure, and rivalry	15	Management attitude (The level of support and participation of senior managers)
		16	The level of competitiveness of the company (Comprehensive ability of companies to create value for customers)
		17	Alliance of inter-industry strategy (Alliance of different industries, including a set of common interests)
		18	Research and development of technology and innovation capabilities (The level of research and development in the field of technology and the level of innovation of manufactured products in the industry)
		19	Vertical integration capability (Using investment, integration, acquisition, diversification, and other methods to integrate activities in different stages of the production chain in an industry)
	Government	20	Facilitating rules and regulations (Legislation by the government to help develop the industry)
		21	Preferred policies (Subsidies and preferential tax rates imposed by the government to encourage industrial development)
		22	Preferential loans for key industries (Loans provided by banks to upgrade technology)
	Chance, opportunity, and unforeseen events	23	Industry benefits (Complete industry chain, including engineers and technical staff)
		24	Industry challenges (Bad market conditions, political environments, and competitive pressures)
		25	Future development trends (or undeveloped trends that need further improvement in terms of efficiency and cost)
		26	Price reduction (The increasing popularity of projects in an industry decreases costs and improves efficiency)
		27	Increasing job opportunities (increasing local development and social welfare)
Porter's Five Forces	The threat of new competitors	28	Innovation of new products and services (The products should not be almost identical or similar. Innovation not only brings new customers to the market but also gives old customers a reason to buy the company's products)
		29	Saving in the scale (Saving in the scale can be easily achieved to reduce the fixed cost per unit)
		30	Customer loyalty (Customer switching costs decrease if customer loyalty is low)
		31	The level of capital required to enter (Low capital is necessary to enter the market)
		32	Access to distribution channels
		33	Capacity building and spending on research and development (New competitors are less likely to enter a dynamic and up-to-date industry)
		34	Creating an efficient supply chain (with multiple suppliers)

	Bargaining power of buyers	39	Building a large base of customers (it decreases the bargaining power of buyers)
		40	Product differentiation (It refers to highlighting the features of a product or service that makes it unique and valuable to customers and leads to competitive advantages)
		41	Buyers' knowledge on the relevant product
		42	Customer switching costs (The customers can easily switch their suppliers)
		43	The rapid innovation of new products (it reduces the bargaining power of buyers)
	Threats to products or services	44	Service orientation instead of product orientation
		45	Understanding the customer's main needs instead of what the customer buys
		46	Customer's willingness to diversify and replacement of new products
		47	Higher switching costs for customers
	Rivalry among existing competitors	48	Creating sustainable differentiation (Production of differentiated services or products)
		49	Industry growth (In case of rapid growth, only companies can compete, develop, and survive that can adapt their activities to the growth rate of the industry)
		50	Barriers to market exit (Rivalry in a market where competitors cannot easily leave.)
		51	Cost structure (The ratio of variable to fixed costs)
		52	Creating scale (Scale to an extent that causes difficulty for the entry of competitors and their activities)
		53	Heterogeneity of managers (Waste of resources and lack of consensus)
		54	Cooperation and partnership with competitors (To increase market size, instead of rivalry for small markets)
PESTEL	Political factors	55	Political stability (The existence of a reliable and calm political and social space; continuity in the laws; management, and policies)
		56	National construction budget (Government's budget in the industry infrastructure sector)
		57	Government investment (Government's attitude towards new technology/ Government's budget in the research and development sector of the industry)
		58	War, rebellion, coup, anarchy, and chaos (Threats to the system and society)
		59	Tax policies
		60	Tariffs
		61	Trade restrictions
	Economic factors	62	Sustainability of government investment policies (Monetary/financial policies)
		63	Economic growth
		64	Efficient tax structure
		65	Unemployment (Employment rate)
		66	Inflation
		67	Bank interest rate
		68	Gross domestic product (GDP)
		69	Allocation of budget to infrastructure projects (Funding the projects of this sector)
		70	Foreign investment
		71	Level of liquidity

Social-cultural factors	72	Social understanding and public acceptance (social awareness (awareness of risk and personal perceptions))
	73	Public participation
	74	Health awareness (level of education/knowledge)
	75	Life expectancy (The average number of years when a person is expected to live in a country)
	76	Health status
	77	Gender (Female to male ratio)
	78	Age distribution (The youth to old population)
	79	Population growth rate
Technological factors	80	Compatibility with new technologies (Lack of desire for technology/ desire for traditional methods/ the level of compliance and acceptance of industry stakeholders with modern technology)
	81	Innovation capability (Institutions; human capital and research; infrastructure; market and business complexity; and innovation output indices, including knowledge and technology and creative outputs)
	82	Rate of change in technology (Pace of technological change)
	83	Research and development activities
	84	Access to new and key technology
	85	Dependence of the industry on new technologies (The level of dependence of the progress and development of the relevant industry on technology)
Environmental factors	86	Climatic conditions (Water scarcity/climate)
	87	Natural disasters (Tsunami, tornado, etc.)
	88	Environmental pollution (Pollution of physical and biological components of the earth to the extent that natural environmental processes are adversely affected)
	89	Population growth
Legal factors	90	Rivalry laws in the relevant industry (It enhances or maintains rivalry in the market by regulating the anti-competitive practices of companies)
	91	International treaties
	92	Intellectual property
	93	Industry regulations
	94	Labor and employment laws
	95	Consumer Laws

Table 3: The results of converting experts' scores from 1 to 10 on a 7-point Likert scale

Score	**Fuzzy number**	**Linguistic expressions**
1	$(0, 0, 0.1)$	Extremely Unimportant
2	$(0, 0, 0.1)$	Extremely Unimportant
3	$(0, 0.1, 0.3)$	Very Unimportant
4	$(0.1, 0.3, 0.5)$	Unimportant
5	$(0.3, 0.5, 0.75)$	Moderately Important
6	$(0.5, 0.75, 0.9)$	Important
7	$(0.5, 0.75, 0.9)$	Important
8	$(0.75, 0.9, 1)$	Very Important
9	$(0.75, 0.9, 1)$	Very Important
10	$(0.9, 1, 1)$	Extremely Important

Table 4: The criteria selected after screening by the Fuzzy Delphi technique

Model	Index	Row	Sub-index	Opinion's mean	Crisp value	Result
Porter Diamond Model	**Internal factors**	1	**The level of resource allocation** (The level of factors that are involved in an industry, including the number of employees, the level of capital, land, technology, and management)	$(0.78, 0.92, 0.99)$	0.89	*Accepted*
		2	**The level of investment or available capital** (Funds provided to achieve business goals of the industry's activists)	$(0.74, 0.89, 0.97)$	0.86	*Accepted*
		3	**Workforce** (Talents and expert R&D forces familiar with advanced technology)	$(0.52, 0.73, 0.88)$	0.71	*Accepted*
		4	**The land demand level** (the level of necessary land to set up the equipment of an industry's projects)	$(0.58, 0.75, 0.88)$	0.73	*Accepted*
		5	**Environmental pressure** (Evaluation of environmental effects and owners' resistance)	$(0.53, 0.72, 0.87)$	0.70	*Accepted*
	Related and supporting industries	6	**Industry chain related to the water and wastewater industry** (Coordination, interaction, and cooperation between upstream, intermediate, and downstream sectors of an industry)	$(0.66, 0.85, 0.96)$	0.82	*Accepted*

	Strategy, structure, and rivalry	7	**Management attitude** (The level of support and participation of senior managers)	$(0.7, 0.87, 0.96)$	0.84	*Accepted*
	Government	8	**Facilitating rules and regulations** (Legislation by the government to help develop the industry)	$(0.7, 0.84, 0.93)$	0.82	*Accepted*
		9	**Preferred policies** (Subsidies and preferential tax rates imposed by the government to encourage industrial development)	$(0.56, 0.72, 0.84)$	0.70	*Accepted*
		10	**Preferential loans for key industries** (Loans provided by banks to upgrade technology)	$(0.72, 0.86, 0.93)$	0.83	*Accepted*
	Chance, opportunity, and unforeseen events	11	**Industry benefits** (Complete industry chain, including engineers and technical staff)	$(0.58, 0.77, 0.92)$	0.75	*Accepted*
		12	**Industry challenges** (Bad market conditions, political environments, and competitive pressures)	$(0.53, 0.73, 0.87)$	0.71	*Accepted*
Porter's Five Forces	**The threat of new competitors**	13	**Saving in the scale** (Saving in the scale can be easily achieved to reduce the fixed cost per unit)	$(0.52, 0.75, 0.9)$	0.72	*Accepted*
	Bargaining power of suppliers	14	**Creating an efficient supply chain** (with multiple suppliers)	$(0.59, 0.77, 0.88)$	0.74	*Accepted*
		15	**The degree of concentration and specialization of a supplier** (A specialized supplier of a part of a product)	$(0.6, 0.77, 0.89)$	0.75	*Accepted*
	Rivalry among existing competitors	16	**Heterogeneity of managers** (Waste of resources and lack of consensus)	$(0.61, 0.75, 0.86)$	0.74	*Accepted*
PESTEL	**Political factors**	17	**Political stability** (The existence of a reliable and calm political and social space; continuity in the laws; management, and policies)	$(0.55, 0.75, 0.89)$	0.73	*Accepted*
		18	**Government investment** (Government's budget in infrastructures of the industry)	$(0.74, 0.87, 0.95)$	0.85	*Accepted*
		19	**Government investment** (Government's budget in the research and development sector of the industry)	$(0.66, 0.82, 0.92)$	0.8	*Accepted*
		20	**War, rebellion, coup, anarchy, and chaos** (Threats to the system and society)	$(0.58, 0.75, 0.87)$	0.73	*Accepted*
		21	**Tax policies**	$(0.55, 0.72, 0.85)$	0.70	*Accepted*
		22	**Trade restrictions**	$(0.64, 0.79, 0.89)$	0.77	*Accepted*
	Economic factors	23	**Sustainability of government investment policies** (Monetary/financial policies)	$(0.76, 0.89, 0.97)$	0.87	*Accepted*
		24	**Inflation**	$(0.65, 0.8, 0.89)$	0.78	*Accepted*
		25	**Bank interest rate**	$(0.62, 0.8, 0.92)$	0.78	*Accepted*
		26	**Allocation of budget to infrastructure projects** (Funding the projects of this sector)	$(0.8, 0.93, 0.98)$	0.90	*Accepted*
		27	**Foreign investment**	$(0.68, 0.86, 0.96)$	0.83	*Accepted*
		28	**Level of liquidity**	$(0.75, 0.9, 0.99)$	0.88	*Accepted*

Technological factors	29	**Dependence of the industry on new technologies** (The level of dependence of the progress and development of the relevant industry on technology)	(0.55, 0.74, 0.88)	0.72	*Accepted*
Environmental factors	30	**Climatic conditions** (Water scarcity/climate)	(0.64, 0.81, 0.92)	0.79	*Accepted*
	31	**Environmental pollution** (Pollution of physical and biological components of the earth to the extent that natural environmental processes are adversely affected)	(0.64, 0.81, 0.91)	0.78	*Accepted*
	32	**Population growth**	(0.59, 0.78, 0.92)	0.76	*Accepted*
Legal factors	33	**International treaties** (To provide agreements or create restrictions on the progression of water and wastewater industry projects)	(0.53, 0.72, 0.86)	0.70	*Accepted*

A total of 33 criteria that affected the improvement of managing water and wastewater industry projects selected by the experts were sent to them again, and 22 out of 33 criteria were selected in the next stage (Table 5).

Table 5: A total of 22 criteria that affected the improvement of managing water and wastewater industry projects selected by experts

Model	Index	Row	Sub-index	Opinion's mean	Crisp value	Result
Porter Diamond Model	**Internal factors**	1	**The level of resource allocation** (The level of factors that are involved in an industry, including the number of employees, the level of capital, land, technology, and management)	(0.78, 0.92, 0.99)	0.89	*Accepted*
		2	**The level of investment or available capital** (Funds provided to achieve business goals of the industry's activists)	(0.72, 0.88, 0.98)	0.86	*Accepted*
	Related and supporting industries	3	**Industry chain related to the water and wastewater industry** (Coordination, interaction, and cooperation between upstream, intermediate, and downstream sectors of an industry)	(0.66, 0.85, 0.96)	0.82	*Accepted*
	Strategy, structure, and rivalry	4	**Management attitude** (The level of support and participation of senior managers)	(0.6, 0.79, 0.93)	0.77	*Accepted*
	Government	5	**Facilitating rules and regulations** (Legislation by the government to help develop the industry)	(0.59, 0.78, 0.89)	0.75	*Accepted*
		6	**Preferential loans for key industries** (Loans provided by banks to upgrade technology)	(0.66, 0.82, 0.91)	0.79	*Accepted*

	Chance, opportunity, and unforeseen events	7	**Industry benefits** (Complete industry chain, including engineers and technical staff)	(0.57, 0.78, 0.92)	0.75	*Accepted*
	Bargaining power of suppliers	8	**Creating an efficient supply chain** (with multiple suppliers)	(0.63, 0.81, 0.93)	0.79	*Accepted*
	Rivalry among existing competitors	9	**Heterogeneity of managers** (Waste of resources and lack of consensus)	(0.6, 0.77, 0.9)	0.75	*Accepted*
PESTEL	**Political factors**	10	**Political stability** (The existence of a reliable and calm political and social space; continuity in the laws; management, and policies)	(0.52, 0.73, 0.89)	0.71	*Accepted*
		11	**Government investment** (Government's budget for infrastructures of the industry)	(0.76, 0.89, 0.95)	0.86	*Accepted*
		12	**War, rebellion, coup, anarchy, and chaos** (Threats to the system and society)	(0.62, 0.79, 0.91)	0.77	*Accepted*
		13	**Trade restrictions**	(0.59, 0.75, 0.87)	0.73	*Accepted*
	Economic factors	14	**Sustainability of government investment policies** (Monetary/financial policies)	(0.75, 0.89, 0.96)	0.86	*Accepted*
		15	**Inflation**	(0.65, 0.8, 0.89)	0.78	*Accepted*
		16	**Bank interest rate**	(0.64, 0.81, 0.92)	0.79	*Accepted*
		17	**Allocation of budget to infrastructure projects** (Funding the projects of this sector)	(0.82, 0.94, 0.98)	0.91	*Accepted*
		18	**Foreign investment**	(0.72, 0.88, 0.98)	0.86	*Accepted*
		19	**Level of liquidity**	(0.78, 0.92, 0.99)	0.89	*Accepted*
	Environmental factors	20	**Climatic conditions** (Water scarcity/climate)	*(0.67,0.84,0.95)*	*0.82*	*Accepted*
		21	**Environmental pollution** (Pollution of physical and biological components of the earth to the extent that natural environmental processes are adversely affected)	(0.59, 0.78, 0.89)	0.75	*Accepted*
		22	**Population growth**	(0.6, 0.8, 0.94)	0.78	*Accepted*

Thereafter, 22 criteria selected by the experts were examined and each one, which could be quantified and examined in terms of trends, was selected and quantified. Table 6 presents the criteria.

Table 6: Identification of criteria that can be quantified

Row	**Criterion/sub-index**	**The possibility of quantification**
1	The level of resource allocation (The level of factors that are involved in an industry, including the number of employees, the level of capital, land, technology, and management)	-
2	The level of investment or available capital (Funds provided to achieve business goals of the industry's activists)	√
3	Industry chain related to the water and wastewater industry (Coordination, interaction, and cooperation between upstream, intermediate, and downstream sectors of an industry)	√
4	Management attitude (The level of support and participation of senior managers)	-
5	Facilitating rules and regulations (Legislation by the government to help develop the industry)	√
6	Preferential loans for key industries (Loans provided by banks to upgrade technology)	-
7	Industry benefits (Complete industry chain, including engineers and technical staff)	-
8	Creating an efficient supply chain (with multiple suppliers)	√
9	Heterogeneity of managers (Waste of resources and lack of consensus)	√
10	Political stability (The existence of a reliable and calm political and social space; continuity in the laws; management, and policies)	√
11	Government's investment (Government's budget in the industry infrastructure sector)	√
12	War, rebellion, coup, anarchy, and chaos (Threats to the system and society)	-
13	Trade restrictions	-
14	Sustainability of government investment policies (Monetary/financial policies)	√
15	Inflation	√
16	Bank interest rate	√
17	Allocation of budget to infrastructure projects (Funding the projects of this sector)	√
18	Foreign investment	√
19	Level of liquidity	√
20	Climatic conditions (Water scarcity/climate)	√
21	Environmental pollution (Pollution of physical and biological components of the earth to the extent that natural environmental processes are adversely affected)	-
22	Population growth	√

The trends of indices, which could be quantified, were examined those indices with the same trends and patterns were placed in a category. Finally, the indices with similar trends and patterns were placed in three categories, namely economic indices (common in all industries), specialized indices of the water and wastewater domain, and cultural-social indices, as discussed below.

√ Economic indices (applicable in all industries)

- Liquidity

Money stock, liquidity, and the monetary base are monetary variables in the economy. Money stock refers to the number of bills and cash which people and banks have in short-term deposits under one year. The liquidity volume includes the volume of money and quasi-money. Quasi money includes long-term bank deposits. Monetary base or high-powered money refers to money that is produced by the central bank and enters the economic cycle with the support of foreign currency reserves, gold, or other methods. According to the latest statistics of the Deputy of Economic Affairs of Iran Ministry of Economic Affairs and Finance in September 2020, the amount of liquidity was equal to 2895.9 thousand billion Tomans, money stock was 600.7 thousand billion Tomans, quasi money was 2295.2 thousand billion Tomans, and the monetary base was 372.06 thousand billion Tomans in Iran.

The increase in liquidity volume was 36.2% at the end of September 2020 compared to the same volume in the previous year on the same date, while it was 31.3% in 2018 and 23.1% in 2017. (Figure 1)

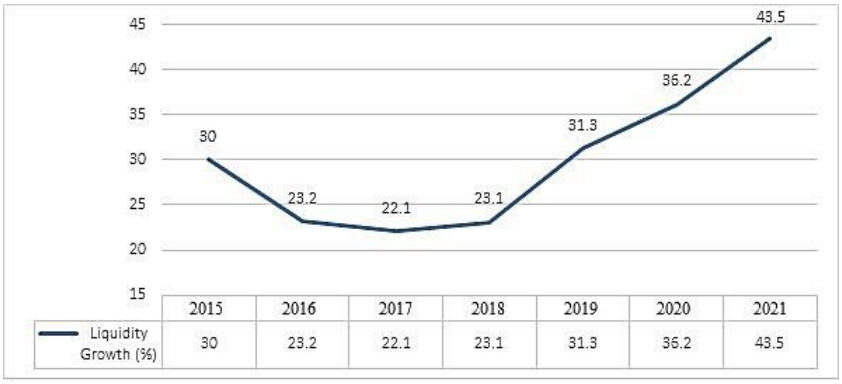

Figure 1: Amount of liquidity growth from 2015 to 2021

- Inflation

According to the World Bank report, Iran's annual inflation showed an increase of 41.3% and 36.9% in 2019 and 2020 respectively due to the recession caused by the recent epidemic and sanctions. Iran's inflation reached 29.3% by the end of 2021, which was 1.9% greater than the previous forecast of this source. Figure 2 shows Iran's inflation status.

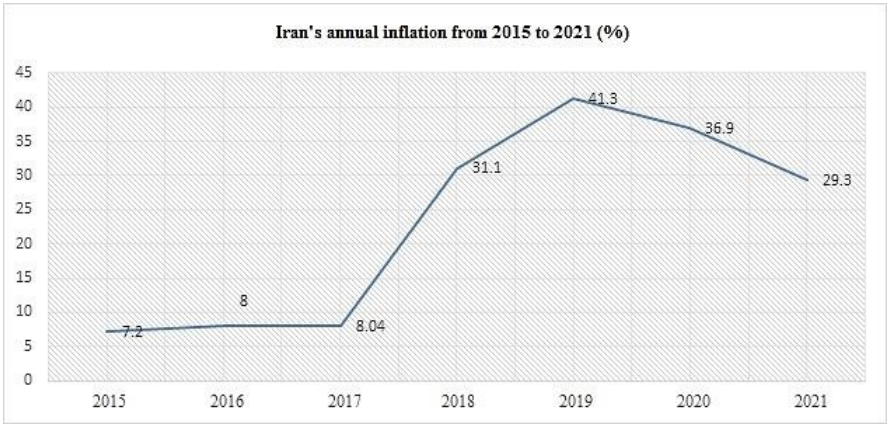

Figure 2: Iran's inflation rate in 2015-2021

World Bank, MPO - Iran Forecast, April 2021 [22]

- **Bank interest rate**

Figure 3 shows the five-year (long-term) bank deposit interest rate and the bank lending rate until 2021 based on the analysis and forecast of the Economist Intelligence Unit (EIU) of Iran's monetary policy according to the current status of liquidity and inflation.

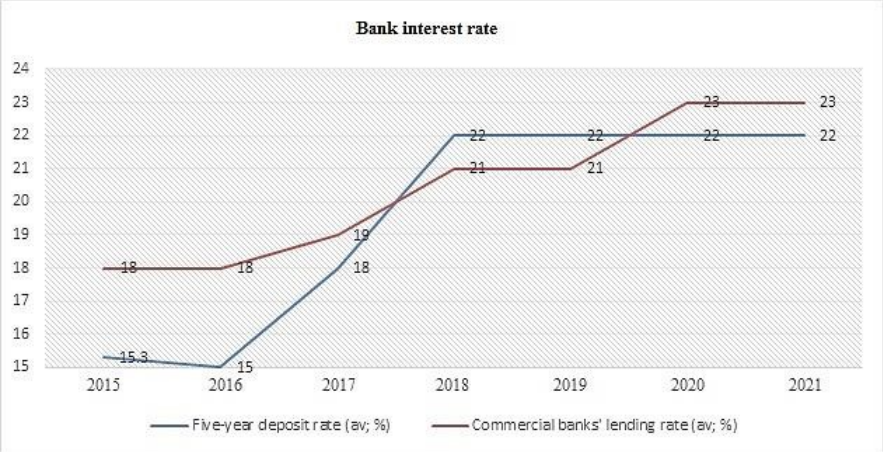

Figure 3: Bank lending rate and long-term deposit interest (five-year) in 2015-2021

- **Foreign investment in various infrastructure sectors of Iran**

Figure 4 shows the rate of foreign investment in different infrastructural sectors of Iran from 2015 to 2021. According to the figure, the trend of this investment increased in different sectors and it reached 1.3 billion dollars in 2021.

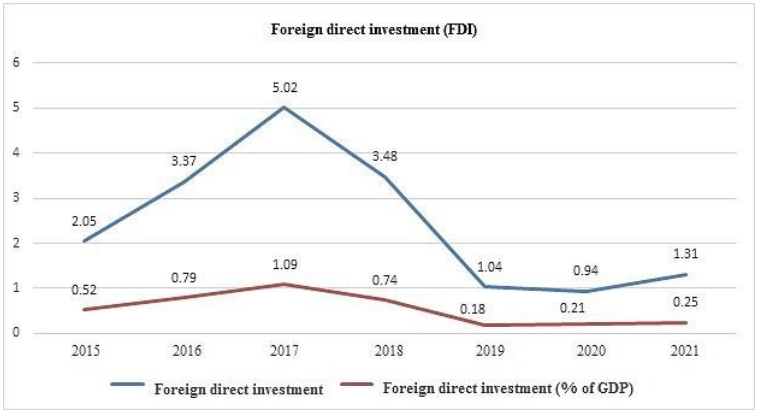

Figure 4: Foreign investment in different infrastructure sectors of Iran from 2015-2021

- **Gross Domestic Product (GDP)**

According to data on the national gross domestic product [3], the average economic growth of Iran was equal to 10.6% from 1959 to 1976 and decreased to -2.4% after the Iranian revolution and the outbreak of the Iran–Iraq War in 1977 to 1988, and it was estimated to be 5% from 1989 to 2011. The average annual economic growth of Iran again decreased to -1.8% in 2012-2015 due to tough financial, banking, and commercial sanctions. After the Joint Comprehensive Plan of Action in 2015, the national economic growth faced a significant increase to an average annual rate of 8.5% from 2016 to 2018

Figure 5 presents the Real GDP Growth Rate from 2015 to 2021 based on the data provided by the World Bank. (International Monetary Fund World Outlook Database)

The GDP index was determined as considered a representative of the group of economic indices (inflation, liquidity, bank interest rate, and foreign investment in different infrastructure sectors of Iran).

[3] World Bank, Global Economic Prospects Report, January 2021, p.94

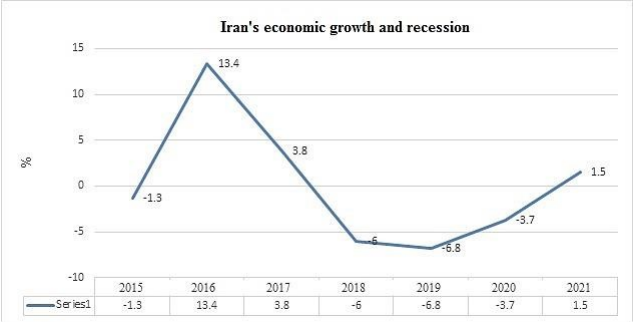

Figure 5: Iran's economic growth and recession from 2015 to 2021

√ **Specialized indices of the water and wastewater industry**

The projects of the water and wastewater sector are significantly important in the national infrastructure sector for reasons such as global and regional exposure to the water crisis. In this regard, the national construction budget and the contribution of the specific water and wastewater sector budget to the construction budget, the water scarcity status, water crisis, and the supply chain of water and wastewater projects were examined and the complexity of the supply chain of water and wastewater projects due to necessity, the importance and need for the implementation of water and wastewater projects, and the emphasis of government in the role of providing vital factors in the implementation of projects in this sector, including the budget and necessary resources, were considered the representatives of the second group.

- **The national construction budget and the specific budget contribution of the water and wastewater sector to the construction budget**

In the budget bills of 2018, 2019, 2020, and 2021, the budgets allocated to the chapter of water and wastewater resources from the appropriations of capital assets (construction budget) of the same years were 32%, 24, 42%, and 22% respectively. (Figures 6, 7, and 8)

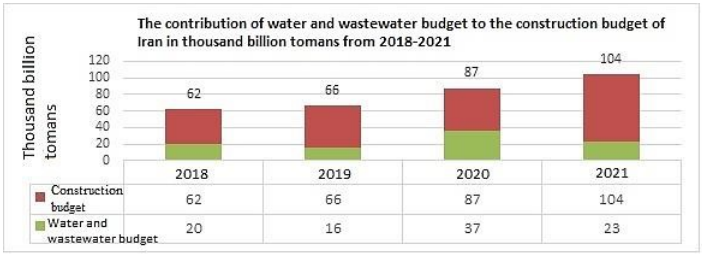

Figure 6: The contribution of water and wastewater budget to the construction budget of Iran in thousand billion tomans in 2018-2021

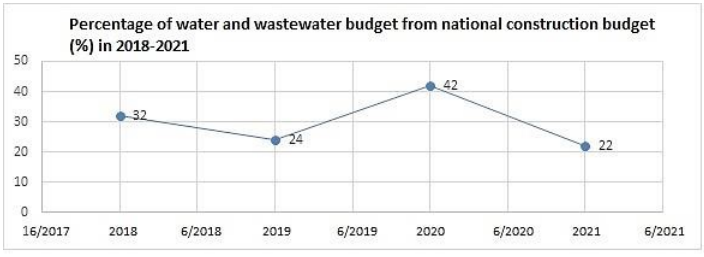

Figure 7: The Percentage of water and wastewater budget from the national construction budget (%) in 2018-2021

- **Water scarcity- Population**

Majlis Research Center

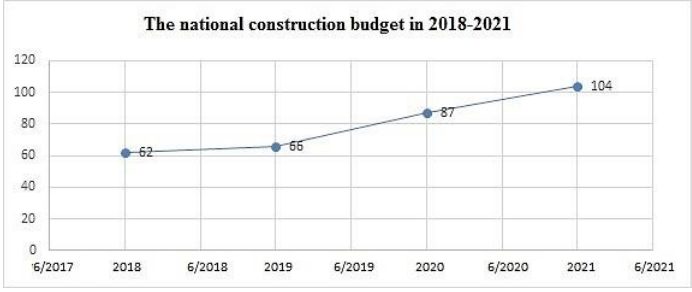

Figure 8: The national construction budget for 2018-2021

The average annual consumption of water is 96 billion m^3, and the threshold level of water scarcity is 53 billion m^3 in Iran. In other words, the average annual water consumption is 80% higher than the threshold level of the country. Iran's renewable water resources are 89 billion m^3, meaning that the average annual water consumption is 8% higher than Iran's total renewable water resources [18].

Figure 9 compares the world population growth with the status of water reserves. According to the United Nations forecast, this difference increases with the passage of time, and the average water reserves will increase by 8.3% in the world from 2000 to 2040, but the average population of the world will grow by 55% in these years, which is 6.7 times higher.

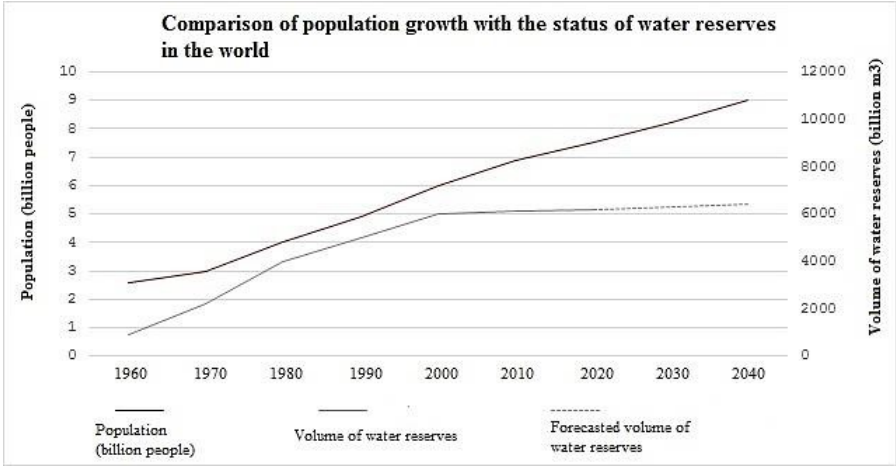

Figure 9: Comparison of population growth with the status of water reserves in the world

- **Supply chain of the water and wastewater industry**

To measure this index, the complexity and uncertainty of different industries were investigated and the complexity score of each industry was determined using the determinants, identification, and comparison of supply chains of the water and wastewater industry with other industries. The final score of complexity and benefits of the supply chain of each industry was obtained according to the mean score of factors of the same industry, which was scored by expert minds in each industry as presented in the following table. The opinions of two expert groups in planning and implementing infrastructure projects were used to complete this index. A score of 1 indicated the least and a score of 5 indicated the greatest complexity and difficulty. The determinants were as follows:

- Identification /exploitability (product/ market capacity)
- Qualitative standard (necessary qualitative standards for implementation of projects)
- Implementation method/ technical complexity/ design knowledge
- Specialized knowledge of suppliers

This research examined water and wastewater, oil and gas/petrochemical, electricity, transportation, construction, and mining industries.

The first group: Kayson Engineering and Contracting Company. The second group: Khatam al-Anbiya Construction Headquarter

- Ability to replace suppliers
- Human resources (Specialized human resources for the implementation of projects in this industry/ access to specialized human resources)

The following table presents the mean results of experts in scoring the determinants of the complexity of the supply chain of each industry.

Table 7: The mean results of experts of both groups

Name of industry	Water and wastewater	Oil and gas/ petrochemical	Electricity	Transportation	Construction	Mine
Mean expert opinion	3.3	3.2	2.7	2.6	1.2	3.1

Given the review of the rate of return on investment in different industries and the mean results of experts in scoring the determinants of the complexity of the supply chain of each industry, the following figure provides a comparison of the supply chain status of the water and wastewater industry with other industries.

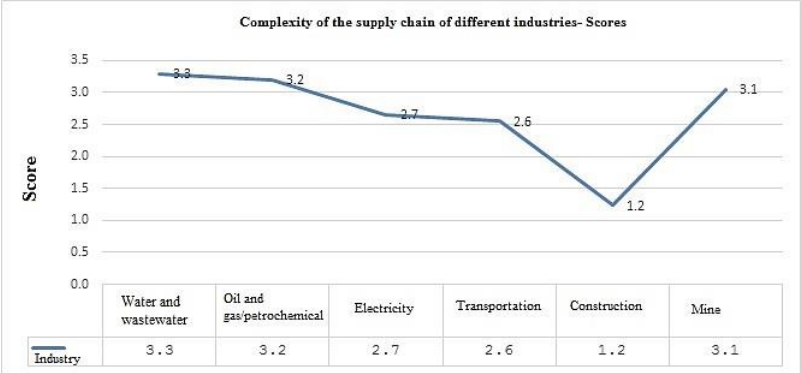

Figure 10: A comparison of the supply chain status of the water and wastewater industry with other industries

√ **Socio-cultural indices**

Social understanding and public acceptance (social awareness (awareness of risk and personal perceptions)), public participation, the level of health awareness, and education/ knowledge levels are among the determinants of the development and success of projects in any industry. In this regard, the present study examined the status of education, the level of political and governance stability, the corruption of executive bodies, and the status of laws and regulations in Iran and considered the education index, which represented the general status of the indices, the representative of the third group.

- **Education level**

Figure 11 shows the status of education in various cultural and health sectors of Iran in terms of access to educational infrastructures and the budget allocated to this sector in 2015-2021. The lower this rank, the better the status of the educational infrastructure. This ranking is performed annually in comparison with 176 countries.

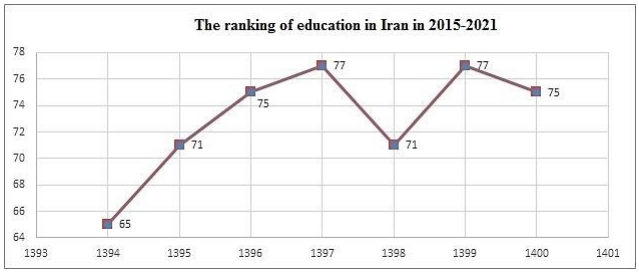

Figure 11: The ranking of education in different sectors of Iran in 2015-2021

- **Political stability, corruption, and enforcement of laws and regulations**

Corruption decreases if the rank is reduced in measuring the relevant index. According to the diagram of levels of political stability, corruption, and enforcement of laws and regulations in Iran, the status of Iran is downward in 2015-2021, indicating a decrease in political stability and the accuracy of laws and regulations. (Figure 12)

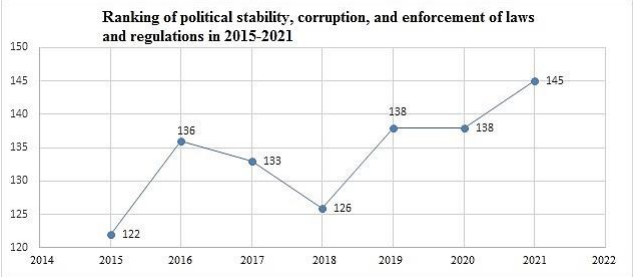

Figure 12: Ranking of political stability, corruption, and enforcement of laws and regulations in 2015-2021

- **Corruption**

Transparency International determines the Corruption Perception Index in 180 countries every year by surveying experts and business activists in those countries. The value of this index ranges from 0 to 100, and the higher the value for a country, the lower corruption is seen there. A 2020 report of this institution provided a comparison of this index for different regions of the world, including Iran, as presented in Table 8.

Table 8: The Corruption Perception Index for different regions of the world

World	43
Western Europe and European Union	66
Sub-Saharan Africa	32
Americans	43
MENA	39
Eastern Europe and Central Asia	36
Asia Pacific	45
Iran	25

In this report, the value of this index was equal to 25 for Iran in 2020 and it was ranked 149 out of 180 countries in terms of the severity of corruption. Figure 13 shows the trend and rank of Iran in terms of this index from 2015 to 2021, indicating the increase in the corruption perception index in recent years.

Figure 13: Index and rank of Iran in terms of corruption

- **Population- The process of population growth and distribution according to the degree of urbanization and rurality**

Figure 14 shows the level of urbanization and rurality from 1956 to 2021. According to the figure, the rate of urbanization was increasing in Iran over the past 50 years and reached 76% in 2021 from 31.4% in 1956. Furthermore,

Statistical Centre of Iran; Examining the trend of changes in the structure and composition of Iran's population- official census of 2016, p. 12

the rural population was decreasing and reached 23% in 2021 from 68.6% in 1956. This trend change indicates the urgent need to increase education and knowledge levels and develop relevant infrastructures for the current population.

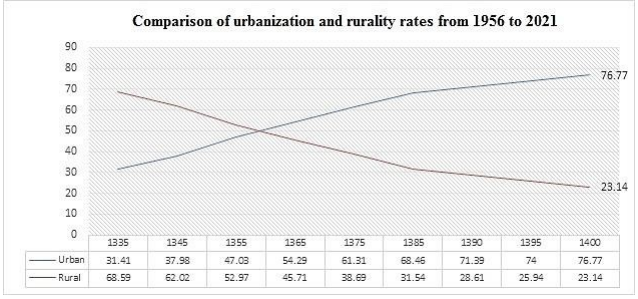

Figure 14: Urbanization and rurality rates

- **The degree of realization of the approved government plan (A comparison of determined and allocated construction budgets in Iran)**

Figure 15 shows the average realization of the construction budget in Iran from 2018 to 2020. The average realization rate of the construction budget was 87.4% in Iran during the last 3 years.

Figure 15: The average rate of realization of the construction budget in Iran from 2018 to 2020

Summary and conclusion

Given the importance of the water industry, which plays a key role in the achievement of national and international environmental, economic, and social objectives, and is also an exchange commodity, a basic natural resource, and a means to fulfill basic human needs, the present study identified the indices and criteria affecting the optimal management of water and wastewater industry projects based on Porter Diamond Model, Porter's Five Forces, and PESTEL models by examining and analyzing the economic, socio-cultural, political, and technological trends at the national, regional, and international levels of infrastructure projects of the water and wastewater industry and according to results of interpretation and analysis of the trends, and classified them into three groups, the economic indices (common to all industries), specialized water and wastewater indices, and cultural-educational indices.

Based on the results, since water is scarce in terms of resources and is not easily available without cost, and its production and distribution are associated with value-added, the optimal management of its projects depends on some important economic indices; hence, the present study introduced indices such as liquidity, inflation, bank interest rate, foreign investment in a variety of infrastructure sectors, and gross domestic product and considered GDP the representative of this group. Therefore, any investment in the water and wastewater industry brings many economic benefits. This result was consistent with the results of research by Dabbagh and Alinejad [2].

The national construction budget and the contribution of the dedicated budget of the water and wastewater sector to the construction budget, current water scarcity compared to the population growth, and the complexity of the supply chain of the water and wastewater industry are also indices that affect the optimal management of water and wastewater industry projects in the category of specialized indices of the water and the wastewater industry. In this regard, the complexity of the supply chain of the water and wastewater industry was introduced as a representative.

Political stability, corruption, the enforcement of laws and regulations, cultural infrastructures (management attitude, intellectual maturity, corruption, education, and population), population-trend of growth, and population

distribution according to the rate of urbanization and rurality, and the degree of realization of plans approved by the government are also socio-cultural indices which affect the optimal management of water and wastewater industry projects. In this regard, cultural infrastructures (management attitude, intellectual maturity, corruption, education, and population) were considered representatives of this group.

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