Sustainability Assessment of Water Resources in Ain al-Tamr district / Karbala – Iraq

Fadhil M. Al- Mohammed

Kerbala Technical Institute, Al-Furat Al-Awsat Technical University, 56001, Karbala, Iraq

dr.fadeelmohamad@atu.edu.iq

Abstract. The sustainability and development of water resources is a matter of utmost importance, especially for the countries of the Middle East that are threatened by water scarcity such as Iraq due to the different social, political and economic conditions. The importance of studying the sustainability of water resources for different regions, especially those far from water sources, to achieve a water balance between supply and demand and to ensure the provision of water resources and a safe environment for future generations. For the purpose of studying the subject of sustainability, the studies have come up with a proposal and adoption of many indicators that can be applied in all regions. In this paper, the Canadian Water Sustainability Index CWSI proposed by the policy research initiative PRI was used and applied in the Ain al-Tamr region, which is located in the southwest of the holy city of Karbala /Iraq and which is completely fed by groundwater. All data required to calculate the values of the five CWSI components (i.e. resources, infrastructure, ecosystem health, human health, and capacity) were collected according to the PRI assessment method. The weights of CWSI components were determined using a pair-wise comparison method. The results showed that the value of CWSI for the study area was 55.331. It is possible to apply this method to study sustainability after determining the weights of the components. This study can also be repeated in other Iraqi communities.

Keywords. sustainability, pair-wise, Ain al-Tamr, CWSI, PRI.

INTRODUCTION

Water is one of the most important natural resources, as it is the indispensable source of life for any society. Water represents the basis of economic and social development, as it is the cornerstone of every civilization and development. There are many governmental and public institutions that have been interested in studying the issue of water security in addition to identifying its social, economic and environmental effects [1]. Many countries have re-established the policy of managing their water resources and resorted to some methods aimed at developing water due to its scarcity and increased demand for it.

In many cases, the mismanagement of water by various bodies and institutions leads to a growing problem of water scarcity and scarcity in many areas, which prompted researchers and experts to search for modern methods that ensure efficient water management.

Water is one of the important and necessary resources for the continuation of life of organisms, as the increase in the number of scientific research and specialized studies in the field of water resources came as a result of the great interest in the subject of water resources. Therefore, the issue of water sustainability has become a priority for many researchers for the purpose of finding solutions to the problem of water scarcity and for the purpose of reducing water depletion.

There are many definitions of the concept of sustainable development. The closest definition of sustainable development is the exploitation and rationalization of the use of water resources available now, with an emphasis on ensuring the preservation of the rights of future generations from those resources. There are four dimensions of sustainable development: economic, social, environmental and administrative [2].

Gleick [3] mentioned that in the twentieth century, water policies in many countries were characterized by the establishment of infrastructure in the form of water channels, dams, treatment plants and pipelines networks, in order to meet the water demand of different sectors. Many regions still suffer from unresolved water resource problems, as it is imperative to reach more efficient water management methods and apply technology to protect the environment.

Jalal et al. [4] used the Canadian water sustainability index CWSI for Ahwaz District in Iran. The results showed that Weights were calculated using the pair-wise method. The results of the research showed that the application of the CWIS index as a tool for assessing sustainability, gave satisfactory results for the case of the study and it is possible to apply the same method to other regions in Iran.

Alamin et al. [5] studied sustainable water management in AL-wahat region in Libya. The researchers concluded that there are many obstacles facing the achievement of sustainability for the study area, which are Improper practices of irrigation and drainage systems, the problem is not clear, Pollution caused by oil companies, and Poor communication and cooperation between water users and suppliers. The researchers also concluded that problems related to sustainable water use are more serious in arid regions due to the hydrological specificity of the water distribution systems in those regions.

The Iraq Energy Institute (IEI) [6] presented a report on the sustainability of water resources in Iraq, with the participation of many academics and experts. Where the report focused on the study of alternative sources of water, the legal framework for managing water resources, the relationship between energy and water, and the basic role of engineering and technology in water management. The report concluded that there are a number of obstacles to the implementation of the integrated management of water resources in Iraq, namely the lack of confidence, historical conflicts and great differences in the laws adopted for the riparian countries of the Tigris and Euphrates rivers, and the different strategic of those countries regarding the use and distribution of water.

United nations –ESCWA [7] presented a report on integrated water management in the Arab region. The report emphasized that the implementation of integrated water resources management provides a comprehensive solution to meet the water requirements of the various sectors. Where the report included the areas of integrated management of water resources and ways to manage and use them in a sustainable, equitable and effective manner. The report indicated that there are many challenges in the water sector facing the Arab countries, namely, Difficulty providing water needs, inefficient use of water, increased demand, population growth and climate change, weak interest and awareness of water problems, and the importance of water in social and economic development.

Haijiao et al. [8] studied the subject of conducting a water resource sustainability assessment for Beijing city from 2008 to 2018. In that study, a system of indicators based on the water footprint and the (drive: pressure: state: impact: response) ,(DPSIR) model was applied simultaneously to collect all the economic and social factors affecting the sustainability of water resource systems. The researchers concluded that the main effects affecting the water resource systems continue to increase, and they are represented in the economic and social factors. The results also showed that the water resources system in Beijing city was sensitive to rainfall. Whereas, the DPSIR indicators showed the same fluctuation trend with precipitation. In addition, the results showed that the indicator affecting the sustainability of water in Beijing is the transfer of water transported from the south to the northern project.

A. Pires [9] studied the overall assessment of the performance of indicators related to water management and use against criteria for the sustainability of water resources. To carry out the research, 170 indicators related to water management and use were identified. The indicators were evaluated by a panel of experts based on the four criteria of sustainability: environmental, economic, social and institutional. An evaluation matrix that included all indicators using the DPSIR model was used. The results showed that there are twenty-four dimensional indicators (meaning that they correspond to all four sustainability criteria), fifty-nine indicators are two-dimensional, eighty-six one-dimensional indicators (in this case, the indicator meets one of the sustainability criteria), and it was found that there is one indicator that does not meet any of those criteria.

Lilya B. .S [10] studied what is known as the issue of "integrated water resources management", which has been recognized globally and adopted as the most important approach that provides a just and lasting solution to limited water resources, which contributes to reducing poverty rates, raising growth levels and thus contributing to food security and achieving the desired goal of sustainable development. It was concluded from the study that the global water crisis and the consequent serious problems faced by many regions, especially developing countries, are more of a crisis of inequity than a crisis of natural scarcity. Therefore, the integrated management approach intervenes and calls for the need to change the irrational ways of managing water resources, which are far from the logic of social justice, to propose a new alternative based on the idea of sustainability in production and treatment, and sustainability in consumption.

Ehsan Q. et al. [11] studied the subject of assessing the water resources sustainability in Khorasan governarate in Iran. The results of the research showed that there are statistical differences in the productivity of the same crops throughout the governorate, as the reason for this is due to the different climatic conditions. The researchers also concluded that, from the point of view of sustainability, the import of fruits and grains is of great importance due to the high total virtual water and not only because of high consumption in the governorate.

This research aims to study and evaluate water sustainability in the Ain Al-Tamr province in Iraq using the Canadian Water Sustainability Index.

CANADIAN WATER SUSTAINABILITY INDEX CWSI

The Canadian Water Sustainability Index provides a visualization of the future of water in a given region for researchers and practitioners in the field of water management [12]. The CWSI consists of five main components: infrastructure, resources, ecosystem health, human health, and capacity [4].The Index was developed by the Policy Research Initiative PRI as it provides a measure of the well-being of society in relation to fresh water [13]. The application of the indicator requires integrating a set of data on water into a unified assessment framework and it consists of fifteen sub-indicators as shown in Table (1). The indicators and components allow the exploration of specific freshwater themes and issues. When sub-indicators are compiled for a specific area, it is possible to provide comprehensive societal information that reflects the nature of integrated water management for that area.

TABLE 1. The framework of the Canadian water sustainability index (Anne Morin,2006).

	Component	**Indicator**	**Indicator description**
CWSI	Resource	Availability	This indicator means the volume of renewable fresh water per person
		Supply	The effect of seasonal changes on poor supply or depletion of groundwater
		Demand	Determining the demand for water use based on the data of the distribution institutions
	Ecosystem Health	Stress	The amount of water lost from ecosystem
		Quality	The value of the quality of water resources related to the maintenance of aquatic life
		Native Fish	Health of local fish species of economic and cultural importance to society
	Infrastructure	Demand	The time required to exceed the capacity of wastewater and water services as a result of population growth
		Condition	The general condition of the sewage network pipes and their impact on network losses
		Treatment	The degree of treatment for sewage
	Human Health	Access	The volume of drinking water that can be reached per person
		Reliability	Number of days of delayed services for each person
		Impact	The total number of infections with waterborne diseases
	Capacity	Financial	The community's financial capacity that enables it to manage water resources
		Education	The human potential of community members to manage and address local water issues
		Training	The level of training for workers in the water sector

The final CWSI value for all components were calculated according to the following equation [4]:

$$CWSI = \frac{\sum_{i=1}^{n} w_i . X_i}{w_i} \tag{1}$$

where

X_i = the component i of the index for a particular community,

W_i = the weight for the component.

The value of the CWSI will be between 0 and 100, where numbers close to 100 indicate the best sustainability of water resources. The accuracy of the results for the indicator depends on the accuracy of the data collected for a particular population.

COMPONENT WEIGHTS AND MATRIX CONSISTENCY

According to what was stated in Equation 1, for calculating the value of the CWSI, it is necessary to determine the weights of its components as shown in Table 1. To determine the values of the weights, the pair-wise comparison matrix was used as shown in the following steps.

1. Arranging the matrix of CWIS components as shown in Table 2. Where the symbols Res., Eco. H., Infra., H.H., Cap. refer to resource, ecosystem health, infrastructure, human health, and capacity respectively.
2. Determining the strength and importance of the relationship between the components of the CWSI using a numerical scale that includes numbers from one to nine. The significance was determined with the help of three experts as shown in Tables from 2 to 4.
3. Calculating the geometric mean of the results of the experts' work and approved for completing the matrix as shown in Table 5, Part-1.
4. Calculating the CWIS components weights as shown in Table 5, Part-2.
5. Calculating consistency index CI. The CI value is calculated from the following formula [14]:

$$CI = \frac{\lambda_{max} - N}{N-1} \quad (2)$$

where

λ_{max} = max. eigenvalue in the pair-wise matrix,

N = number of components.

6. Calculating consistency ratio CR using the function (MMULT) that exists within the EXCEL system as shown in Table 5, Part-3. The CR can be calculated from the equation below [14]:

$$CR = \frac{CI}{RI} \quad (3)$$

where RI is a random index. This index is chosen from Saaty Table [15], since its value in this research is 1.12, which is the value corresponding to the number of variables in the research, which is 5. For the purpose of accepting matrix consistency, Satty (1980) suggested that the CR value should be less than 0.1.

TABLE 2. Evaluating the relationship between CWSI components/ first scientific expert

Components	Res.	Eco. H.	Infra.	H. H.	Cap.
Res.	1.00	7.00	0.90	5.00	0.80
Eco. H.	0.14	1.00	0.80	0.20	0.20
Infra.	1.11	1.25	1.00	0.20	4.00
H. H.	0.20	5.00	5.00	1.00	8.00
Cap.	1.25	5.00	0.25	1.00	1.00

TABLE 3. Evaluating the relationship between CWSI components/ 2-nd scientific expert

Component	Res.	Eco. H.	Infra.	H. H.	Cap.
Res.	1.00	9.00	0.70	8.00	0.33
Eco. H.	0.11	1.00	0.20	0.33	0.20
Infra.	1.43	5.00	1.00	0.40	3.00
H. H.	0.13	3.00	2.50	1.00	6.00
Cap.	3.03	5.00	0.33	1.00	1.00

TABLE 4. Evaluating the relationship between CWSI components/ 3-rd scientific expert

Components	Res.	Eco. H.	Infra.	H. H.	Cap.
Res.	1.00	6.00	0.80	6.00	0.40
Eco. H.	0.17	1.00	0.60	0.70	0.33

Infra.	1.25	1.67	1.00	0.80	2.00
H. H.	0.17	1.43	1.25	1.00	5.00
Cap.	2.50	3.03	0.50	1.00	1.00

TABLE 5. The geometric mean, weights, consistency ratio.

Part-1. Calculating the geometric mean of CWSI components								
Components	**Res.**	**Eco. H.**	**Infra.**	**H. H.**	**Cap.**			
Res.	1.00	7.23	0.80	6.21	0.47			
Eco. H.	0.14	1.00	0.46	0.36	0.24			
Infra.	1.26	2.18	1.00	0.40	2.88			
H. H.	0.16	2.78	2.50	1.00	6.21			
Cap.	2.12	4.23	0.35	1.00	1.00			
SUM	4.67	17.42	5.10	8.97	10.81			
Part-2. Calculating the CWSI components weights							Weight	
Res.	0.21	0.41	0.16	0.69	0.04	1.52	0.30	
Eco. H.	0.03	0.06	0.09	0.04	0.02	0.24	0.05	
Infra.	0.27	0.13	0.20	0.04	0.27	0.90	0.18	
H. H.	0.03	0.16	0.49	0.11	0.57	1.37	0.27	
Cap.	0.45	0.24	0.07	0.11	0.09	0.97	0.19	
							1.00	
Part-3. Calculating consistency ratio CR								
Components	Res.	Eco. H.	Infra.	H. H.	Cap.		MMULT	
Res.	1	7	3	1	1	1.521	8.236	1.083
Eco. H.	0.14	1	0.14	0.2	0.2	0.239	1.046	0.876
Infra.	0.33	7	1	1	1	0.902	5.413	1.200
H. H.	1	5	1	1	1	1.370	5.955	0.869
Cap.	1	5	1	1	1	0.968	5.955	1.231
							SUM	5.259
CI =	0.065	RI =	1.12	CR =	0.058	< 0.1		

STUDY AREA

General

The city of Ain Al-Tamr (Shathatha) is located in the southwest of the holy city of Karbala, 67 km away from it. It is one of the ancient cities dating back to 3000 BC. Ain Al-Tamr District is located between latitudes (32˚ 10′ - 32˚ 45′) North, and longitudes (43˚ 15′ - 43˚ 45′) East, elevation 60 m a.m.s.l. [16]. It is located in the center of Iraq in western part of the sedimentary plain and in the east of the western plateau as in Figure (1). Geographically, the region is bordered to the east by the Karbala district center and from the rest of the Anbar governorate, and the northern parts of the region occupy a large part of Lake Al-Razzaza. The area of the study area is 2330km2, that is, it represents 38.8% of the total area of Karbala governorate. The study area is characterized by the lack of rainfall and its fluctuation, as the annual total of rain is 94 mm, as shown in Table 6. Evaporation values vary in the study area throughout the year, with the highest values of evaporation reaching 468.5 mm during the month of July, as shown in the Table 7. Both the amount of rain and evaporation are of great importance in the studies of integrated water management and sustainability.

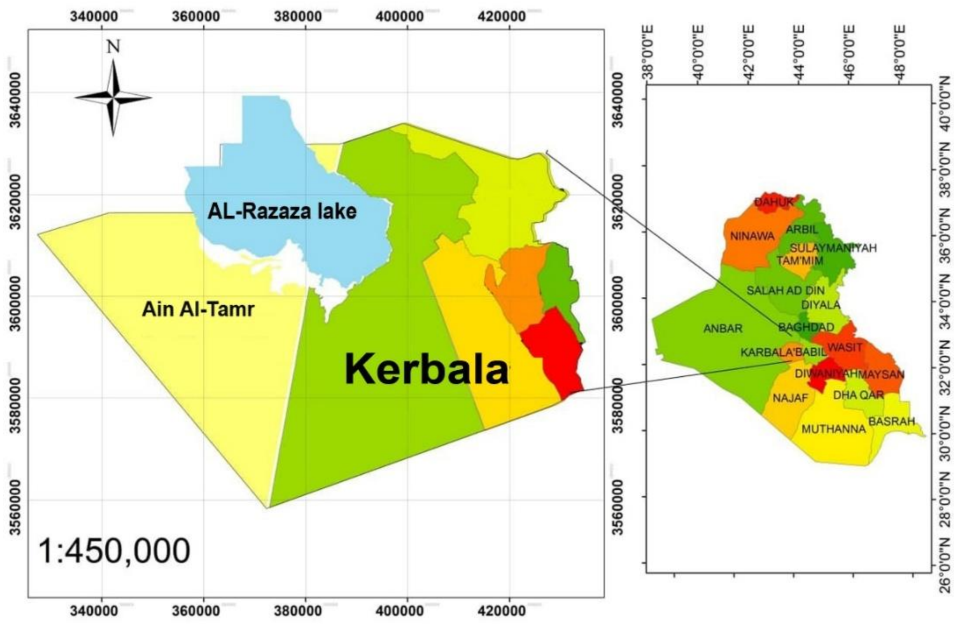

FIGURE 1. Location of Ain Al-Tamr District /Kerbala-Iraq

TABLE 6. Variation of the monthly average rainfall within Ain Al-Tamr District [16]

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall mm	17.3	12.9	15.3	12	3.1	---	---	---	0.3	3.8	14.2	15.1

TABLE 7. Variation of the monthly average evaporation within Ain Al-Tamr [16]

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
evaporation mm	63.6	97.5	172.5	249.3	243.2	430.0	465.8	420.2	314.9	212.4	104.7	65.1

Water resources

The water resources in the study area are represented by temporary surface water and rain, in addition to groundwater represented by springs and wells. There is no permanent surface water in the region. Al-Razzaza Lake is one of the closed and semi-saline lakes. The annual evaporation and rainfall rates in Lake Razzaza are estimated at 2291 and 124 mm, respectively [16]. The researchers found that the salinity of the lake increases in its north to 22,000 ppm, while it decreases in its southern parts to 12,000 ppm. Groundwater represents the main source of water in the Ain Al-Tamr area.

Groundwater appears on the surface of the earth in the form of springs or wells. Springs form when groundwater flows naturally from its bearing layers. The study area is characterized by the presence of four main springs located in the center of the study area, namely, Al-Ain Al-Zarqa, Ain Al-Seeb, Al-Ain Al-Hamra and Al-Ain Al-Khadra, in addition to many secondary springs. The amount of total dissolved salts of the main spring water ranges from 500 to 2500 ppm. According to estimates, the population of Ain al-Tamr area is 48,396 [16]. They live in gatherings and villages around the eyes, wells and water resources.

The study area includes many orchards planted with palm trees, pomegranate and other trees with a total area of 20868 Donum as shown in Table 8. The orchards are irrigated with the water of many springs, most of which dried up after the year 2000 due to the social and political changes that led to the drilling of wells in low areas that affected the water distribution of the study area.

TABLE 8. Agricultural crops irrigated in Ain Al-Tamr District, [16]

Crop type	Area Donum
Wheat	8000
Barley	600
winter crops	2078
summer crops	2190
palm and fruit	8000
total	20868

RESULT AND DISCUSSION

Due to the dependence of the study area mainly on the water of wells and springs, the calculations of estimation CWIS and the 15 sub component that contain the five thematic components (were resource, ecosystem health, infrastructure, human health, capacity) carried out using its data.

The values of all compounds were calculated based on Appendix 1, which was included in the report of the Sustainable Development Team PRI that was completed in 2006 [13], according to the points shown below:

Resource

This component includes three indicators, which are availability, supply, and demand.

First indicator-Availability: Ra

This indicator relates to the amount of renewable water available annually for each individual in units m3/cap/year. The scientist Falkenmark classified the different cases for the availability of different quantities of fresh water, as shown in Table 1.

The amount of water available for each person in the study area is estimated at 456m3/cap/year, so the value of the availability indicator is taken as zero, according to the results of the researcher Falkenmark.

Second indicator-Supply: Rg

This indicator will serve to determine the vulnerability of a community's fresh water supply by considering the diversity of surface water flows or ground water or both. The value of this indicator was calculated according to the formula [13]:

$$R_g = (r + 0.5n)x100 \tag{4}$$

Where

r = Percentage of wells in which water levels rise,

n = Percentage of wells in which water levels do not change.

In this study, the values of r and n were 26% and 37%, respectively. The, the value of supply indicator was 63%.

Third indicator-Demand: Rd

The value of the demand Rd can be calculated by applying the equation below:

$$R_d = \left(1 - \frac{a}{T}\right)X100 \tag{5}$$

where

a = volume of water that has been allocated in m^3/year

T = volume of renewable water m^3/year

In this study, the values of a and T were 9600000 and 15300000, respectively. The, the value of supply indicator was 62.7%. Table 9 illustrated the Falkenmark [17] for cases of availability of water requirements.

TABLE 9. Classification of cases of availability of water requirements [17]

Amount of water available m^3/cap/year	state of society
>1700	Water shortage occur locally or irregularly
1000-1700	Water stress occurs clearly and regularly
500-1000	The scarcity of water, despite its limited quantities, is a constraint on economic development, well-being, and human health
<500	Availability of water is the main obstacle to life

Ecosystem health

The health component of the ecosystem on the water resources of the study area was assessed by examining the health of aquatic ecosystems with indicators of ecosystem-oriented stresses (STRESS), the status of aquatic life protection (quality) and the resulting effects on fish.

Fourth indicator-Stress: Es

This indicator aims to show the impact of the types of pressures on the ecosystem. The ecosystem is under stress due to excessive water use and pollution. The value of the demand Es can be calculated by applying the equation below:

$$E_s = \left(\frac{0.4-\frac{c}{T}}{0.4}\right) X100 \quad (6)$$

where a is c volume of water consumed annually in m^3/year.
If c/T >0.4, then Es = 0
If c/T = 0, then Es = 100
For study area, the value of c is 7956000 m^3/year, then Es value is zero.

Fifth indicator-Quality: Eq

WQI was calculated for 27 sites, 15 on lakes, 12 on wells. WQI is measured on a scale from 0 (poor quality) to 100 (excellent quality) so the WQI results can be directly integrated into the CWSI scoring chart. For study area, the value of WQI is 67, then Eq value is67.

Sixth indicator-Fish: Ef

After reviewing the specialized directorates, the data for this indicator is not available.

Infrastructure

This component includes both wastewater infrastructure and water supply networks that serve the community. This component is evaluated by measuring its ability to meet future demand, its condition, and level of treatment.

Seventh indicator-Demand: Id

This indicator indicates the ability of a community's infrastructure to meet future water demand by measuring the number of years before system capacity is reached at 100% (t100). To calculate the value of t_{100}, the formula below is used:

$$t_{d100} = \frac{\log FV - log PV}{\log(1+r)} \quad (7)$$

where
FV=The number of people in the community served by the current system at 100%
PV=Number of people in the community served by the existing water network
r=Population growth rate of the community
The value of the indicator Id is calculated using the equation below:

$$I_d = \frac{t_{100}}{50} x100 \quad (8)$$

If, $t_{100} > 50$, then ID = 100
If, $t_{100} = 0$, then ID = 0
If $50 > t_{100} > 0$, then calculate ID using the above equation

From a review of the documents related to the study area, it was found that the values of the FV, PV, and r are 201895, 113887, and 2.3% respectively. Therefore, the value of the demand indicator Id is 25.17 and Id equal to 50.34.

Eighth indicator-Condition: Ic

This indicator depends on water losses of the system. The percentage of the study area system is 36%. Then the indicator Ic is zero.

Ninth indicator-Treatment:

The treatment indicator is concerned with focusing on the presence of treatment plants for wastewater. Whereas, wastewater treatment is on three levels: primary, secondary and tertiary.
Due to the absence of sewage stations in the study area, the value of the It is zero.

Human Health

The human health component consists of three components that are directly related to the health of the community, which are the amount of drinking water per person (ACCESS), the degree of reliability of the water supply (reliability), and the extent to which the health of citizens is at risk due to the low quality of drinking water (IMPACT).

Tenth indicator-Access:Ha

This indicator is concerned with the volume and quantity of available and potable water for each person as a measure of meeting the basic basic household needs.
Referring to the results of research scientist [12], a volume of 150-250 liters per day will be enough to meet all personal requirements such as cleaning, drinking, bathing, etc. In this study, this criterion will be adopted. Communities will get a score of 100 if they have access to at least 150 liters/day. You will also get a score of zero if the shaking is less than or equal to 50 liters / day. For the present research, the volume of drinking water supplied to the community in the study area was 172 liter/day, so the value of frying will be equal to 100.

Eleventh indicator -Reliability:Ha

When the community experiences an interruption in the water delivery service, the water supply will be unreliable. This indicator is concerned with the reliability of water delivery to the community by determining the number of days that the water is cut off.
In this research, no information was available for this indicator.

Twelveth indicator -Impact:Hi

This indicator includes an assessment of the health effects associated with insufficient water quantity and quality. As there are many communicable diseases that accompany the shortage in the quantities of water supply. In this research, no information was available for this indicator.

Capacity

This component is concerned with the administrative capacity of the community and its effectiveness. It looks at the financial capacity (surplus), education, and the number of trainers working in sewage and water treatment plants (training). This component is very important because it determines the socially available economic resources in the community to manage fresh water resources.

Thirteen indicator - Surplus:Cf

For assessing the financial capacity of a community, the local government's per capita surplus (surplus of revenue over expenditure) will be examined in relation to the minimum and upper levels across the country. In this research, no information was available for this indicator.

Fourteenth indicator - Education:Ce

This indicator will consider the educational level of the community. Where the education indicator can help community members to increase analytical, practical and analytical skills that serve the community in an efficient and positive manner in various jobs. Education will provide an important indicator of the human capacity available for the purpose of managing water resources sustainably. , no information was available for this indicator.

Fifteenth indicator - Training:Ct

This indicator includes the capacity of the community regarding the operation of wastewater treatment plants and drinking water purification treatment plants. This is done by reviewing the level of training enjoyed by the station operators. The presence of competently trained operators will ensure the effectiveness and reliability of the water infrastructure. This reflects the safety of the environment and the members of society. No information was available for this indicator.

Table 10 shows the results for all CWSI components and indicators.

TABLE 10. The results of CWSI for Ain Al-Tamr District

Component	Indicator	Code	Score	Component score Wi	Component weight Xi	WixXi
Resource	Availability	Ra	0	41.9	0.30	12.57
	Supply	Rg	63			
	Demand	Rd	62.7			
Ecosystem health	Stress	Es	0	33.5	0.05	1.675
	Quality	Eq	67			
	Fish	Ef	NA			
Infrastructure	Demand	Id	50.34	16.78	0.18	3.02
	Condition	Ic	0			
	Treatment	It	0			
Human health	Access	Ha	100	100	0.27	27
	Reliability	Hr	NA			
	Impact	Hi	NA			
Capacity	Financial	Cf	NA	NA	0.19	
	Education	Ce	NA			
	Training	Ct	NA			

The Canadian Water Sustainability Index (CWSI) was calculated using Equation 1, where its value was 55.331.

CONCLUSION

1. Using the Canadian Sustainability Index is a simple and convenient tool that can be used for the purpose of monitoring and measuring the water sustainability of a given area. Depending on the value of the indicator, studies and challenges facing sustainability can be prepared, and water resources policies can be prepared appropriately for future conditions.
2. Determining the objective of the sustainability study plays a key role in determining the value of the water resources sustainability indicator. According to previous studies and current research, the economic, environmental, social, institutional and political components are the main components for calculating the value of the water resources sustainability index. The weights of the components are determined according to the social, climatic and economic conditions of the study area.
3. There is no local indicator of water sustainability in Iraq. The first attempt to apply the CWSI index to the case study in Iraq-Karbala-Ain al-Tamr was found satisfactory, despite the economic and ethical differences.

4. The CWSI final result for the Ain Al-Tamr-Karbala-Iraq region enhanced the high value of the resource and the low value of the infrastructure component significantly reduced the value of the indicator. In order to overcome this problem, it is necessary to establish treatment plants for wastewater.
5. The use of the pair wise method showed a clear effect in determining the values of the weights of the components of the CWSI indicator

RECOMMENDATION

Based on the results of this research, it is possible to repeat the study of the sustainability of water resources in different regions of Iraq, which facilitates the identification of sustainability obstacles and ensure their application and the development of appropriate policies for water management.

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