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Application of Water Poverty Index (WPI) in Special Analysis of Water Stress in Kurdistan Region-Iraq

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Abstract

Kurdistan region-Iraq can be considered the richest area in the MENA for water availability per capita. However, water management, economic situation, sustainability and utilisation of water are controversial. Water Poverty Index (WPI) is a holistic tool to find the link between socio-economic development, livelihood, water availability, and water management. In addition, it is an effective method for comparison between different regions and countries. In this work, depending on available data of Kurdistan region-Iraq, and literature review, 14 elements (indicators) has been used to extract WPI score of the study area. The WPI has been used to find water utilisation, and water stress level in Kurdistan region. Then, the result of this work has been compared with WPI scores in some countries in the MENA. The work has shown that the WPI score of the study area is 52. The work has found that, although water availability per person/year in Kurdistan region is more than all countries in the MENA, WPI score of the study area is lower than its neighbours like Iran, and Turkey. The low scores of Kurdistan region regarding WPI are because of many factors like variation of water income, mismanagement of water resources and water use.

Keywords: Economy, Kurdistan Region, Sanitation, Water Management, Water Poverty Index (WPI), Water Resources, and Water Use.

Introduction

Water Poverty Index WPI is a sophisticated multi-disciplinary tool to evaluate and analyse the water-related and it uses for management and planning purposes. It has been introduced by Sullivan (2002) basing on hydrological modeling works (Craswell et al., 2007; & Anju et al., 2017).

There are many definitions of this tool. Craswell et al., (2007) define WPI as a holistic indicator to find the link between livelihood and availability, generally, it is used for water management. Whereas Anju et al., (2017) believe Water poverty index (WPI) is a transparent, open and sample tool to attract the decision-makers and poor people to participate in water management and its development and it is used to evaluate the water situation in a specific area. Farolfi, (2011) claims, WPI is tool can link water availability with socioeconomic variables.

However, some claim WPI is a tool, purely, uses in water management. The WPI can be described as great water management tool relevance in policy-making chiefly in resources allocation and processes of prioritization (Shalamzari, and Zhang, 2018). In addition, Koirala et al., (2020) claim, Water Poverty Index (WPI) is an interdisciplinary tool to evaluate water stress and scarcity, linking the general socio-economic drivers of poverty problem with physical estimates of water availability. In fact, WPI is a tool to link water with general socio-economic development in a specific area. It is used for general development planning purposes in a particular area.

There is a strong link between water poverty and development. Koirala et al., (2020) believes, poverty and water interface is strongly interlinked, accessing to adequate water is a highly relevant issue while addressing the poverty problem. Adds that it is impossible to eradicate the poverty problem without suitable allocation and access to water (Koirala et al., 2020).

The ability to adapt WPI for different scales is one of the important advantages of this tool. For example, some scholars proposed a watershed-based WPI and successfully piloted (Shalamzari, and Zhang, 2018), others proposed the national and regional level as a case study. Shalamzari, and Zhang, (2018) have classified WPI a severe (WPI <48), high (48–56), medium (56–62), medium-low (62–68) and low (WPI >68) (Shalamzari, and Zhang, 2018). Whereas some scholars use other classifications such as numbering (Mlote et al., 2002; & Lawrence et al., 2003). The index score should be between 1 and 100. So, this tool can be used to evaluate the water-related issues in Kurdistan region-Iraq and the MENA, and rank the countries basing on water-socioeconomic development.

The aim of this work is to give an outlook on an application of the WPI indicator to extract the water stress level of Kurdistan region, and then a comparison between Kurdistan region-Iraq and some countries in the MENA. In this work, firstly, the meaning of WPI, and the purposes of using this tool has been explained. After that, WPI score of the study area has been extracted, and finally, the results of this work will be compared with previous works results about the MENA

Purposes of using WPI

Generally, this tool is to find the link between water availability, its uses, and socio-economic development in a specific area. Lawrence et al, (2003) explain the main purpose of using the Water Poverty Index (WPI) is to indicate an interdisciplinary measure that links welfare of household with availability and reliability of water and indicates of water scarcity. In addition, it is a planning indicator. Moreover, the WPI is a first pass at trying to introduce an international measure for comparing performance in the water-related sectors in the world (Craswell et al., 2007). WPI can be used to identify and evaluate poverty in relation to water resources availability (Mlote et al., 2002)

Furthermore, it uses to evaluate and analyse the statue in an area in order to deal with the future planning process. It is giving direction to allocation of resources and managerial policy (Lawrence et al., 2003). Performance Indicators are an important tool for evaluating processes of achievement, particularly for planning purposes. Sullivan et al,(2002) have developed this index to consider all the aspects involved with the management of water, it is basing on five elements which are Resource- R, Access A, Capacity C, Use U, and finally Environment E. (Sullivan, 2002; & Anju et al., 2017).

.The sub-indicators (elements) of this tool which are (Water resources, Access of water and sanitation, Using of water, Human development index and Environmental protection level) are correlated with socioeconomic development, water availability and natural environment of the specific area. Fo example, clean water and sanitation have been set as a one of the United Nations 2030 Agenda for Sustainable Development explicitly (SDGs) (Koirala et al., 2020).

This tool can be used everywhere around the world. It makes it possible to rank regions, and countries taking into account the economic and physical factors associated with water scarcity (Lawrence et al., 2003). For example, this indicator can be used to compare two or more countries and regions (Mlote et al., 2002). It is international comparison tool (Koirala et al., 2020). In addition, it can be used to compare different parts of one country.

Furthermore, Farolfi, (2011) uses this tool to find water scarcity in the south of Africa. While, Craswell et al., (2007) used this method to evaluate water stress and security in Tanzania, Sri

Lanka and South Africa. Koirala et al., (2020) used WPI tool to evaluate water stress and security in Koshi River Basin, Nepal. In addition, Shalamzari, and Zhang, (2018) has determined 41 as aWPI score of Province of Golestan in the North of Iran.

Materials and Methods

Study Area

Kurdistan Region-Iraq is an autonomous territory, situated in the north of Iraq. See Figure 1. The size of Kurdistan region-Iraq is about 41,000 square kilometers (KRG, 2019). It is bigger than the Netherlands. It mainly covered by the mountains in the North East and North.

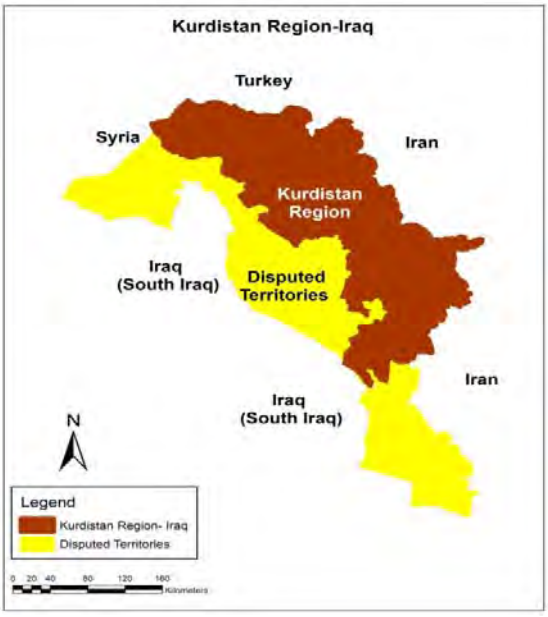

Figure 1. Map of Kurdistan Region of Iraq

The climate condition of the majority of Kurdistan Region is, mainly, semi-arid continental: dry and hot in summer, in contrast, it is cold and wet in winter and spring. The average temperature of the region is between 13.5c and 21.56 in Penjuen (in the mountain area) and Erbil (in the Plain area), respectively (GDOM, 2019). The average annual rainfall is 633MM. It increases in the North and the North East areas to get 1308MM/Y in Mergasor in the mountain area (GDOM, 2019).The total size of population the region is 6.03 million people (KRSO, 2015). KRSO, believes, each year 137,000 people adds to the Kurdistan region population (KRSO, 2015). Kurdistan region has an important amount of available water which is 30 BM3 (Hawrami, 2014) but because of significant mismanagement the value and importance of the water resources reduce.

Elements of WPI

It is important to note that, WPI covers too many floors. It consists of five main elements which are water resource, water and sanitation services, human, and economic development, and Environmental situation (Sullivan, 2002; & Anju et al., 2017). However, different sub-elements (indicators) can be used according to data availability, local conditions of the specific area, and the aim of the work. For example, if we use this tool for comparison between two or more countries, we should use wider elements and data. See table 1.

Table 1. Example of using of sub-elements by different scholars and this work

(Shalamzari, and Zhang 2018)	(Lawrence, Meigh, and Sullivan, 2003)	(Koirala et al., 2020)	(Farolfi, 2011)	This paper
Resource R				
Per-capita annual water	internal Freshwater Flows	Per capita annual water resources (m3/year)	Internal 50% of external water	Internal 50% of external per cap in CM
-Precipitation Coefficient of Variation (CV)	External Inflows Population	Coefficient of variation of rainfall (CV)		Coefficient of variation of rainfall (CV)
Access Ai				
Population having piped water supply	% population with access to clean water	% population with access to clean water	% of the population with access to safe water	% population with access to clean water
% of the population with improved sanitation	% population with access to sanitation	% population with access to sanitation (A2)	% population with access to sanitation	% of the population with improved sanitation
	% population with access to irrigation adjusted by per capita water resource		Proportion of internal water for arable land	
Capacity C				
Literacy Rate	Education	Literacy rate	Education	Literacy rate
% of the population with access to electricity	Under-five mortality rates	Ratio of Adult Economically Active Population Engaged in Non-agriculture to agriculture	Rate of the population with access to electricity	Life expectancy
-% of households receiving a pension, or/and wages	PPP per capita income	GDP index	GDP per Cap	GDP – CAP
% of the population with access to health centers	Enrolment rates Gini coefficients of income distribution		Gini coefficients of income distribution	

			under-5 mortality rate (per 1000 live births).	
			Life expectance	
Use U				
Domestic water consumption rate	domestic water use in liters per day	Households (HHs) having sufficient domestic water	domestic water use per capita (m3/cap/yr)	Domestic
The rate of irrigated area to the total cultivated lands	share of water use by industry and agriculture adjusted by the sector's share of GDP	HHs having sufficient water for agricultural use Information System (KBIS) (days/year) (U3)	Industrial water use per capita (m3/cap/yr)	Industrial water use per capita (m3/cap/yr)
Livestock water use		Ratio of irrigated to cultivated area	Households (HHs) industrial water use per capita (m3/cap/yr)	
Agricultural water use expressed			Agricultural water use per capita (m3/cap/yr).	
Environment E				
Risk of desertification	Environmental regulation and management	% of area with natural vegetation	% of land area under protected status	% of area with natural vegetation
Risk of erosion		Fertilizer used per hectare	fertilizer consumption per hectare of arable land	Fertilizer used per hectare
Risk of flooding	water quality, water stress (pollution), biodiversity		Mortality rate attributed to unsafe water, sanitation (per 100,000 population)	Pesticide

It is clear each scholar has used different sub-elements (indicators) within the same elements. In fact, for the elements of Resources, Environment and access similar sub-elements have been used; the differences are, mainly, within elements of capacity and use. However, according to the available data, and the purposes of my work, which is to find the water stress and security in Kurdistan region-Iraq in comparison with some countries in the MENA, I have used fourteen elements (indicators) and equations. See table 2.

Table 2. Elements of WPI of this work*

Resources R		**Sub-elements**	**Statue**	**No**	**Equation**
	R1	Internal 50% of external per cap in CM (R1)	+	1	$R1 = \frac{Wr - \min(Wr)}{\max(Wr) - \min(Wr)} \times 100$ R1= internal water+(external water/2)=
	R2	Coefficient of variation of rainfall (CV)	_	2	A- Mean of (annual rainfall) ➡ SD ➡ (CV) % = $\frac{SD}{Mean)} \times 100$ = B- R2 = [1 − (Xi/30)] × 100
Access A	A1	% population with access to clean water	+	3	$A1 = \frac{P}{TP} \times 100$
	A2	% of the population with improved sanitation	+	4	$A2 = \frac{p}{tp} \times 100$
Capacity C	C1	Literacy rate	+	5	$C1 = \frac{LP}{TP} \times 100$
	C2	Rate of the population with access to electricity	+	6	$C2 = \frac{La - minLa}{\max La - \min La} \times 100$
	C3	GDP – CAP	+	7	$C3 = \frac{GDP - \min(GDP)}{\max(GDP) - \min(GDP)} \times 100$
	C5	under-5 mortality rate (per 1000 live births).	_	8	$C4 = 1 - (\frac{Mor - \min(Mor)}{\max(Mor) - \min(Mor)}) \times 100$
	C6	Life expectancy	+	9	$C5 = \frac{Lx - \min(Lx)}{\max(Lx) - \min(Lx)} \times 100$
USE U	U1	domestic water use in liters per day	+	10	$U1 = \frac{Wud - \min(Wud)}{\max((Wud) - \min((Wud)} \times 100$
	U2	Industrial water use per capita (m3/cap/yr)	+	11	$U2 = \frac{Wui - \min(Wui)}{\max((Wui) - \min((Wui)} \times 100$
Environment E	E1	% of area with natural vegetation	+	12	$E1 = \frac{Xvi}{Xai} \times 100$
	E2	Fertilizer used per hectare	_	13	$E2 = 1 - (\frac{Efu - \min(Efu)}{\max(Efu) - \min(Efu)}) \times 100$
	E3	Mortality rate attributed to unsafe water, sanitation (per 100,000 population)	_	14	$E2 = 1 - (\frac{(MRUW - \min((MRUW)}{\max(MRUW - \min((MRUW)}) \times 100$

*local data has been obtained from GDODR (2019); GDOWR (2019); Hawrami, (2014); KRG, (2019); KRSO, (2015), GDOM,(2019); Nasser, (1984); & World Bank. (2019)
International level data has been obtained from Eurostat, (2017); FAO, (2020); UNDP, (2018); &World Bank, (2019)

According to the available data and the purposes of my work I have chosen those fourteen elements. In addition, I have chosen and adapted the equations with the elements. So, basing on 14 sub-elements within 5 main elements of WPI this work is trying to extract WPI score of Kurdistan region.

Methodology

I have chosen the sub-elements (indicators) and equations according to available data and the suitability of the equation for the Kurdistan condition regarding the socio-economic condition and physical situation of the region.

First: Resources R

1- (R1) Internal water+ 50% of external water resources (per cap in CM)

$$R1 = \frac{Wr - \min(Wr)}{\max(Wr) - \min(Wr)} \times 100$$

R1= internal water + (external water/2)=

Where (Wr) is the normalized available water in Kurdistan region per cap/year, min (Wr) is the lowest level of water availability per person in the world, max (Wr) is the highest water availability per cap/ year.

***I have used data of 2014, because data of the other countries for the same element are for the year of 2014.**

2- Coefficient of variation of rainfall (CV)

A- Mean of (annual rainfall) ➡ SD ➡ (CV) %= $\frac{SD}{\text{Mean)}} \times 100$ = xi

B- R2 = [1 − (Xi/30)] × 100

Where (Xi, CV) represent the normalized Coefficient of variation of rainfall (water income) Coefficient of variation of rainfall (CV), 30 has been determined as a maximum level. To calculate the rainfall variability of Kurdistan region-Iraq, available data on rainfall 1975-2015 has been based for all the study area (obtained from GDOM, 2019).

Second: Access A

3- % population with access to clean water

$$A1 = \frac{P}{TP} \times 100$$

Where (A1) refers to the normalized score for the "Access" component, (P) is the rate of the population with access to safe and clean drinking water, and (Tp) is the total population of the Kurdistan region- Iraq.

4- % population with access to sanitation services

$$A2 = \frac{p}{tp} \times 100$$

Where (A2) refers to the normalized score for the "Access" component, (P) is the rate of the population with access to improved sanitation services, and (tp) is the total population of the Kurdistan region- Iraq.

Third: Capacity C

5- Literacy rate

$$C1 = \frac{LP}{TP} \times 100$$

Where (C1) refers to the normalized score for the "education" component, (LP) is the rate of the Literacy population, and (Tp) is the total population of the Kurdistan region- Iraq.

6- *Access to electricity*

$$C2 = \frac{La - minLa}{\max La - \text{minLa}} \times 100$$

Where (La) is the rate of Kurdistan population with access to electricity, (Min La) is the lowest rate of population with access to electricity in the world; (la max) is the highest rate of the population that has electricity in the world.

7- *GDP per cap/year*

$$C3 = \frac{\text{GDP}* - \min(\text{GDP})}{\max(\text{GDP}) - \min(\text{GDP})} \times 100$$

Where (GDP) is the share of GDP per capita in Kurdistan region, (Min GDP) is the lowest GDP per capita in the world, (max GDP) is the highest GDP per capita in the world.

***GDP per cap of Kurdistan region of 2011 has been based, the recent years data of GDP of Kurdistan region are not available.**

8- *Under-5 mortality rate (per 1000 live births)*

$$C4 = 1 - (\frac{Mor - \min(Mor)}{\max(Mor) - \min(Mor)}) \times 100$$

Where (Mor) is Under-5 mortality rate (per 1000 live births) in Kurdistan region-Iraq, (max Mor) and (min Mor) are representing the highest and the lowest Under-5 mortality rate (per 1000 live births) in the world.

9- Life expectancy

$$C5 = \frac{Lx - \min(Lx)}{\max(\text{Lx}) - \min(Lx)} \times 100$$

Where (Lx) is life expectancy in Kurdistan region-Iraq, (max Lx) and (min Lx) are representing the highest and the lowest life expectancy in the world**.**

Fourth: USE U

10- Domestic water use per cap

$$U1 = \frac{Wud - \min(Wud)}{\max((Wud) - \min((Wud)} \times 100$$

Where (Wud) is domestic water use per person in CM/Yr, in Kurdistan region-Iraq, (max Wud) and (min Wud) are representing the highest and the lowest domestic water use per person in CM/Yr in the world**.**

11- Rate of water withdraws by Industry sector a year

$$U2 = \frac{Wui - \min(Wui)}{\max((Wui) - \min((Wui)} \times 100$$

Where (Wui) is Industrial water withdraws in % in Kurdistan region-Iraq, (max Wui) and (min Wui) are showing the highest and the lowest rate of Industrial water withdraws in the world**.**

Fives: Environment E

12- % of area with natural vegetation

$$E1 = \frac{Xvi}{\text{Xai}} \times 100$$

Where (Xvi) and (Xai) are space and areas that covered by natural vegetation and forest and the total size of the space and area.

13- Fertilizer used per hectare

$$E2 = 1 - (\frac{Efu - \min(Efu)}{\max(Efu) - \min(Efu)}) \times 100$$

Where (Efu) is the amount of used fertilizer in Kg for one Ha of land in Kurdistan region, while (max (Efu) $and($ min $(Efu$ are the highest and the lowest volume of fertilizer usage in the world.

14- Mortality rate attributed to sanitation, and unsafe water (per 100,000 population)

$$E2 = 1 - (\frac{MRUW - \min(MRUW)}{\max(MRUW) - \min(MRUW)}) \times 100$$

Where ($MRUW$) is the mortality rate attributed to unsafe water, sanitation (per 100,000 population) in Kurdistan region, where max(($MRUW$) and min (($MRUW$ are the highest and lowest volume of fertilizer mortality rate attributed to unsafe water, sanitation (per 100,000 population) in the world.

Results and Discussion

WPI score of Kurdistan region-Iraq

The average score result of WPI in Kurdistan region is 51.94 (52). It can be said that the WPI index of Kurdistan region is at the medium level. Table 3 gives more explanation about Kurdistan's situation.

Table 3. WPI score of Kurdistan region-Iraq

	R	A	C	U	E	WPI of Kurdistan
1(R,A,C,U or E)	32	91	80	30	43	
2(R,A,C,U or E)	17	51	100	7	99.6	
3(R,A,C,U or E)			11		97	
4 (R,A,C,U or E)			78			
5 (R,A,C,U or E)			60			
Average	24.5	71	65.8	18.5	79.9	52

The table explains that the WPI score of Kurdistan region is high regarding 'Access' to clean water, and sanitation services, 'Environment' and 'capacity'. On the other hand, the score is going down, sharply, with Resources of water particularly in "variability in rainfall and water income of rivers". In this field, the score of study area is 24.5. So, the Kurdistan must find a solution to mitigate the impact of the variability of precipitation and its water resources income.

In addition, the use of water is another issue; a large part of water resources in the region is being lost without being used. Moreover, a small portion of water is being used in the industry sector. So, "Use" is recording the lowest score of WPI in Kurdistan region which is, only, 18.5. That means Kurdistan region needs more accurate management and planning for mitigation of precipitation variability and effective use of water resources.

WPI of Kurdistan Region-Iraq and MENA

To give more explanation, it is a good idea to compare Kurdistan region-Iraq WPI with some countries of the MENA which mainly have issues of availability and management of water resources. See figure 2

The figure explains Iran has the highest score of WPI which is greater than 60, Egypt is coming in the second position with under 60, and Turkey is the third with 56.5. In contrast, Yemen has the lowest WPI score which is 44 and in Jordan 46. In Kurdistan region, however, the WPI score is 52.

If we compare Kurdistan WPI score with Iran, we will find that Iran has better water management than Kurdistan region in addition to infrastructure and water allocation in Iran are better than Kurdistan region. Although, water availability per person in Kurdistan region is more than 5500M3 per cap and In Iran is, only, 1700 M3 per cap (Hawrami, 2014), but the WPI score of Iran is higher than Kurdistan region. According to Abu-Qasm, and Al-Maraghi (2018) Iran has about 30BCM/Y of water deficit, but it had implemented a proposed new plan, to reduce water consumption, sufficient using of water in agriculture, limiting of groundwater usage. Whereas Hawrami,

(2014) explains, Kurdistan region has a surplus in water resources. Important mismanagement of water resources and lack of appropriate plan have reduced the value and efficiency of water resources in Kurdistan region-Iraq.

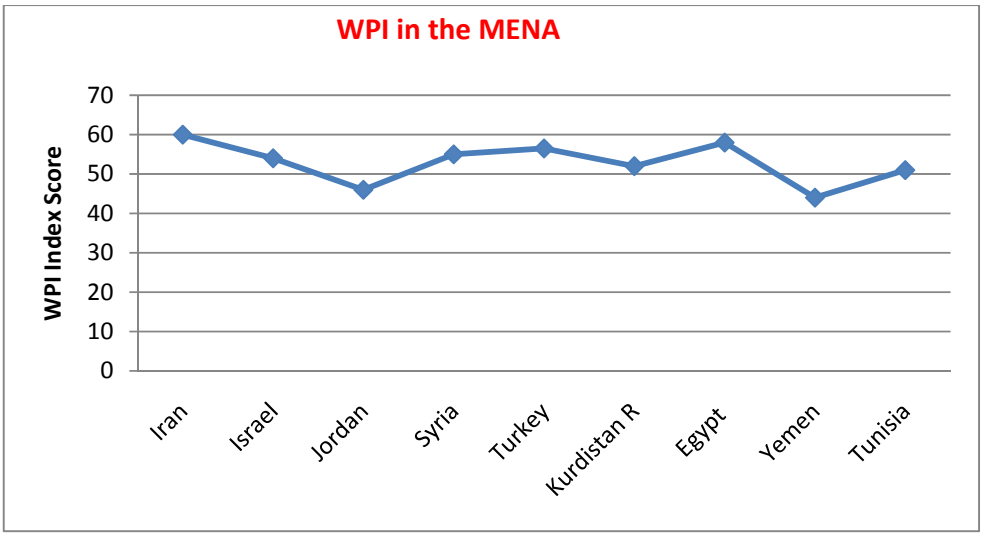

Figure 2. WPI index score of some countries in the MENA, adapted from (Lawrence et al., 2003)

Conclusion

Water Poverty Index WPI is a robust and meaningful tool to find water stress levels and to show water management and general socio-economic development level. The arid regions like the MENA requires more evaluating of water stress and the management of its resources because of the deficit of available water resources and conflicts over water resources. Kurdistan region-Iraq is a unique case; water availability per capita is the highest in the Middle East and North Africa. However, water management, water policy, economic situation, and water infrastructure are not appropriate. The work has found that the average score of WPI of Kurdistan region is 52. The work has explained, 'Environment' has the highest score. Whereas, 'Use', and "Variation of Water Income" have gained the lowest score. Although Kurdistan region has a significant water income it has two downsides, firstly, variation in precipitation (water resources income) is huge, and a remarkable portion of the water income of this region is coming from abroad. Secondly, water management and water use are other faces of the problem. Moreover, the work has explained that the WPI score of Kurdistan region is lower than the WPI score of Iran and Turkey. More works are required, especially, comparison between South Iraq and Kurdistan region-Iraq and between provinces in Kurdistan region.

References

Abu-Qasm, M. & Al-Maraghi, A. (2017). Water crisis in Iran, Directions and Consequences. Journal of Iranian Studies. *International Institute for Iranian Studies*. Available: https://rasanah-iiis.org/wp-content/uploads. Accessed on [2019-03-09].

Anju, AM., Vicky., SE. & Kumar, PJ. (2017). Water poverty Analysis using Water Poverty Index (WPI) -A critical Review. *International Journal of Environmental Sciences and Natural Resources, 1*(4),1-3.

BBC. (2017). *Iraqi PM urges Kurds to 'cancel' referendum result*. Available: https://www.bbc.com/news/world-middle-east-41413999. Accessed on [2019-04-06].

Craswell, E., Bonnell, M., Bossio, D., Demuth, S. & Giesen, v. (2007). Integrated Assessment of Water Resources and Global Change: A North-South Analysis. *Water resources Management 21*(1).

Eurostat. (2017). *Water use in industry*. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Water_use_in_industry. Accessed on {14 Apr 2020}.

Food and Agriculture Organization of the United Nations FAO. (2020).The state of the World's Forests. Available from: http://www.fao.org/state-of-forests/en/. Accessed on {21-04-2020}.

Farolfi, S. (2011). An Introduction to Water Economics and Governance in South Africa. *International Centre for water Economics and Governance in Africa*. Available: https://agritrop.cirad.fr/561748/1/document_561748.pdf. Accessed on {03-04-2020}.

General Directorate of Metrology of Kurdistan region (GDOM). 2019. Unpublished data.

General Directorate of Water Resources and Irrigation of Kurdistan region (GDOWR). 2019. Unpublished data.

General Directorate of Dams and Reservoirs of Kurdistan region (GDODR)2019. Unpublished data.

Hawrami, K. (2014). Impact of wastewater on Water balance in the Middle East, Kurdistan region as example. In: *International conference on Ecology, Environment and Energy (ICEEE)*, Salahaddin University and Ishik University, Erbil, p325-238.

Koirala, K., Fang, Y., Dahal, N., Zhang, C., Pandey, B. & Shrestha, B. (2020). Application of Water Poverty Index (WPI) in Spatial Analysis of Water Stress in Koshi River Basin, Nepal. *Journal of Ecological Applications.* Available: www.mdpi.com/journal/sustainability. Accessed on [12-04-2020].

Kurdistan Regional Statistics Office KRSO. (2015). *Report of Population Expectation 2009-2021: Department of Planning, Population and Labor Force Office. Special Report.* Available: www.KSRO.net. Accessed on [2019-04-08].

Kurdistan Regional Government KRG. (2019). *The Kurdistan Region in Brief.* Available: http://cabinet.gov.krd/p/page.aspx?l=12&s=050000&r=300&p=210. Accessed on [2019-04-30].

Lawrence ,P., Meigh, J. & Sullivan, C. (2003). The Water Poverty Index: an International Comparison. *Keele Economics Research Papers.* Keele University, Keele, Staffordshire, st5 5bg, uk.

Mlote, S., Sullivan, C., & Meigh, J. (2002). Water Poverty Index: a Tool for Integrated Water Management. *3rd Water Net/Warfsa Symposium 'Water Demand Management for Sustainable Development'*, Dar es Salaam, 30-31 October 2002. Available from: https://pdfs.semanticscholar.org/156d/64b0e5ded2e7336c2692de0ed041c9d4751c.pdf. Accessed on {20-04-2020}.

Nasser, M.(1984). Forests and Forestry in Iraq: Prospects and Limitation. *The Commonwealth Forestry Review.* Available from: https://www.jstor.org/stable/42606437. Accessed on {19-03-2020}

Shalamzari, M., and Zhang, W. (2018). Assessing Water Scarcity Using the Water Poverty Index (WPI) in Golestan Province of Iran. *Journal of water*. Available from: www.mdpi.com/journal/water. Accessed on {13-04-2020}.

Sullivan, CA. (2002). Calculating a water poverty index, *World Development, 30*(7), 1195-1210.

United Nations Development Program UNDP, *Human Development Reports*. [Online] Available from: http://hdr.undp.org/en/data.{Accessed on 13 Apr 2020}

World Bank (2019). *World Bank data.* [Online] Available from: https://data.worldbank.org/indicator/ny.gdp.pcap.cd?end=2011&most_recent_value_desc=false&start=1960 . Accessed on [10 Apr 2020].