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RESEARCH PAPER

Evaluation and zoning environmental water security in rural districts of Kermanshah (Iran)

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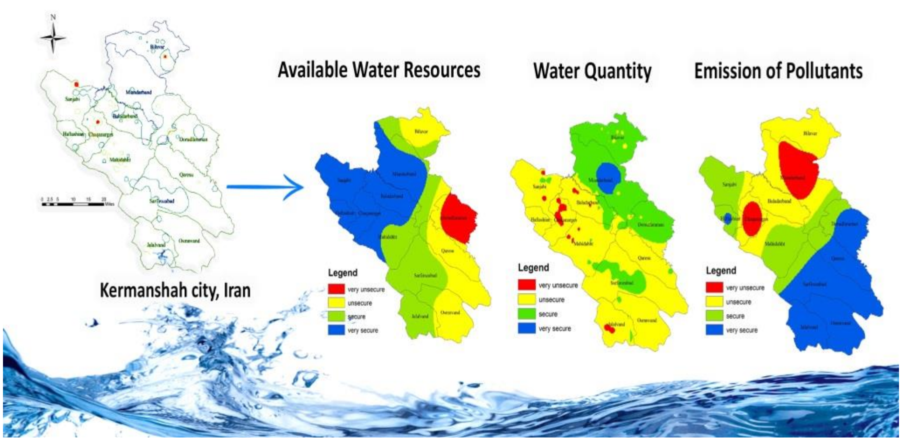
Highlights

- Investigation of water quantity status in rural districts environment of Kermanshah city.
- Investigation of water quality status in rural districts environment of Kermanshah city.
- Creating a basis for balancing the allocation of water between different uses especially the environment.

Graphical Abstract



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Abstract

Water can be considered as one of the most critical environmental factors that, besides intrinsic value, has various environmental impacts. This study aimed at evaluating environmental water security in rural districts of Kermanshah city. In order to assess environmental water security, water quantity, water quality and emission of pollutants were considered. This study was conducted in descriptive and survey method in 2017. The regional water organization database was used to evaluate the dimensions of water quantity and available water resources. Furthermore, the statistical population for evaluating the emission of pollutants was the farmers of the rural districts of Kermanshah, including 34723 people according to the census of 2016. The Morgan table was used to determine the sample size. The statistical population of the research was Farmers in 12 rural districts in Kermanshah city. The software used for data analysis and zonation of the areas was Arc GIS 10.3.1 and SPSS. According to the results, the Miandarband, Sarfirozabad, Jalalvand, Sanjabi and Haftashian districts were very secure compared to other rural districts. Parts of Chaqanarges, Bilavar and Dorudfaraman are in a critical condition regarding environmental water security, which necessitates special attention from the authorities.

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1. Introduction

Water plays a vital role in the transition from the nomadic stage to sedentism and permanent residence in one place. Ease of access to water is a guarantee for life and residence. People are dependent on water as it links them together. In other words, it is impossible to live without water (Amanpur et al., 2014). For this reason, the struggle for scarce water resources has long been at the center of research activities in the fields of economics, politics, psychology, biology, etc. (Akhavan Kazemi and Veici, 2016). As a unique resource, water plays a very important role in human survival. Tensions and conflicts to gain access and control over it have a long history. Regional conflicts over fresh water reserves are expected to increase in the future as the population grows and governments seek to achieve industrialization. This will create a more acute crisis, especially when combined with climate change. The climatic fluctuations resulting from climate change cause frequency and severity of drought or floods, and make it difficult to access freshwater. Moreover, increased temperature causes evaporation from the earth surface (Akhavan Kazemi and Veici, 2016) and lands require more irrigation; Furthermore, an increase in sea and ocean levels and their entry into water resources will change the quality of these waters (Gleick, 1989; Alzoubi et al., 2016; Hooley et al., 1990; Wang et al., 2021; Xu et al., 2021) .

In the postmodern era, security has been influenced by widespread changes in the international system, development of communications, technological advances, and unprecedented proximity of societies (Mohammadi, 2017). The relationship between security and the environment is mutual. The environment encourages human growth and development. Water can be considered as one of the most important environmental factors that, besides intrinsic value, has various environmental impacts. As one of the most important dimensions of water security, environmental water security needs special attention, as it is associated with sustainability. There are a few definitions of Environmental water security. Zakeri et al., (2022) defined environmental water security as the amount of water needed to maintain an ecosystem and its ecology, preserve animals and plants, maintain a sustainable and non-polluting environment and meet the needs of humans and other living organisms by controlling any international threat or conflict (Zakeri et al., 2022). In another definition, environmental water security is considered as management of water sustainability as part of the green economy and rehabilitation of ecosystem services in the river basin (Wang et al., 2018). Many studies have been done on the importance of environmental considerations in the water security (Liu et al., 2016; Burkhard and Müller, 2008; Liang et al., 2010). They evaluated the environmental flow requirements (QQE) and set indicators including water quantity, water quality, frequency-based indicators of selected species, concentration of target elements indicators, the ratio between different classes of organisms' indicators, ecological or process-based strategies' indicators, pollutant-based indicators and sewage disposal.

The literature review revealed that most models and frameworks measure environmental water security at broad scales, i.e. national and international levels. This limits the application of the mentioned frameworks and models at the local level. Therefore, to evaluate the environmental water security at the local level, identifying effective components for measuring water quantity and quality related to the environment seems necessary.

This study aimed at evaluating environmental water security in rural districts of Kermanshah city. Kermanshah Province, west Iran, is a mountainous and semi-humid region exposed to significant environmental water crises due to a high population density and the lack of proper management and comprehensive programs in the water sector (Amanpur et al., 2014). The drought of many pools, springs, wetlands, oak forests and reduced diversity of plant and animal species in the province is a consequence and an evidence for this claim (Mohammadi Ostadkelayeh et al., 2016). This outcome is probable as studies showed that efforts to protect human water are particularly achievable in the short term, but have negative consequences for the environment and, ultimately, for the socio-ecosystems in the long term (Yang et al., 2020).

2. Materials and Methods

This research is a quantitative applied descriptive survey to develop applied knowledge in a particular field. In order to evaluate environmental water security, water quantity, water quality and emission of pollutants were considered. The questionnaire used includes three groups of indicators: the frequency of wells, qanats and dried springs in a given period of water quantity; the frequency of rivers and springs in respect to water sources; and agricultural land pollution after the emission of pollutants. It should be noted that the return rate of the questionnaire was 84.86%. The indicators were selected based on data sets from the database of relevant departments and organizations of the studied districts. The regional water organization database was used to evaluate the dimensions of water quantity and available water resources. Furthermore, the statistical population for evaluating the emission of pollutants was the farmers of the rural districts of Kermanshah, including 34723 people according to the census of 2016. The Morgan table was used to determine the sample size. 380 households were identified and the questionnaire was distributed among them. The multi-stage cluster sampling method was used and the distribution of samples in each district was conducted according to the concentration ratio of the households (Table 1).

The number of samples in each district was determined using the stratified sampling method. Descriptive statistics such as frequency, percentage, mean and standard deviation were used. The software used for data analysis and zonation of the areas was Arc GIS 10.3.1 and SPSS. The analysis process in the GIS included the following steps: First, the Unscaled values of indexes were saved on the Spss16.0 in xls format and were converted to shape files in the Arc GIS so that they can be retrieved in the ArcMap of GIS software. In the next step, using the interpolation technique, the unknown points in each districts were defined by the known points. All shape files were converted to raster layers using the Interpolation command from the Geostatistical Analyst Tools path and the IDW (Inverse Distance Weighted) interpolation. In the next step, to zone the region based on the indicators and dimensions, it was necessary to implement the Reclassify command. Finally, using an Intersect overlap, the overlap of Raster layers was conducted and the overall environmental water security was set commanding Map Algebra from the Spatial Analyst Tools path.

Table 1. The number of rural households, rural districts area and samples Size in 12 rural districts.

Row	Rural District	The number of rural households	Rural districts area (Km2)	Sample Size
1	Dorudfaraman	6183	423	63
2	Qaresu	1829	366	21
3	Bilavar	4979	540	91
4	Sanjabi	2326	441	23
5	Haftashian	440	134	14
6	Sarfirozabad	2999	922	14
7	Chaqanarges	1766	211	36
8	Baladarband	2521	358	30
9	Miandarband	5943	809	39
10	Mahidahht	3334	620	23
11	Jalalvand	1297	346	16
12	Osmnvand	1106	472	10
		34723	5642	380

3. Results and Discussion

In the environmental water quantity dimension, the frequency of dried wells, qanats and springs over 5 years, and the level of water in the wells were studied (Table 2). The average level of piezometers in the studied rural districts was reported in Table 2. This table Shows the frequency of wells and qanats in studied areas and frequency of dried wells and qanats over 5 years (Bard and Barry, 2000; Sharma and Singhvi, 2017).

Table 2. frequency of wells and qanats in studied areas, frequency of dried wells and qanats over 5 years and the average level of piezometers.

Rural District	F.W.	F.W.D. Over 5 years	P.W.D. Over 5 years *	F.Q.	F.Q.D. Over 5 years	P.Q.D. Over 5 years	A.L.P.
Dorudfaraman	433	89	20.55	14	11	78.57	17.76
Qaresu	381	34	8.92	52	32	61.54	16.53
Bilavar	428	68	15.88	87	32	36.78	30.52
Sanjabi	485	21	4.33	0	0	0.00	21.34
Haftashian	0	0	0.00	0	0	0.00	22.30
Sarfirozabad	390	80	20.51	11	2	18.88	5.62
Chaqanarges	406	62	15.27	0	0	0.00	32.19
Baladarband	803	98	12.20	0	0	0.00	27.57
Miandarband	2594	419	16.15	0	0	0.00	6.85
Mahidahht	568	34	5.98	5	2	40.00	26.88
Jalalvand	4	2	50.00	0	0	0.00	29.65
Osmnvand	0	0	0.00	2	1	50.00	19.23

* Dried wells are those that have been reported dry for five consecutive years without seasonal flow. F.W: Frequency of Wells, F.W.D: Frequency of Wells Dried, P.W.D: Percentage of Wells Dried, F.Q: Frequency of Qanats, F.Q.D: Frequency of Qanats Dried, P.Q.D: Percentage of Qanats Dried, A.L.P: Average Level of Piezometers.

In Table 3, the percentage of wells and qanats that had water for 5 years was calculated and compared to total Unscaled indexes values. According to the table, the environmental water quantity component is calculated from the average of two indices (Pahl-Wostl et al., 2013).

Table 3. The percent of wells and qanats that had water for 5 years.

Rural District	**The percent of wells that had water for 5 years** (Unscaled)	**The percent of qanats that had water for 5 years** (Unscaled)	**water quantity (Mean)**
Dorudfaraman	0.93	0.28	0.60
Qaresu	1.06	0.50	0.78
Bilavar	0.98	0.83	0.90
Sanjabi	1.11	1.31	1.21
Haftashian	1.16	1.31	1.24
Sarfirozabad	0.93	1.07	0.99
Chaqanarges	0.99	1.31	1.15
Baladarband	1.02	1.31	1.17
Miandarband	0.98	1.31	1.14
Mahidahht	1.10	0.79	0.94
Jalalvand	0.58	1.31	0.95
Osmnvand	1.16	0.66	0.91

In order to evaluate available water resources, the frequency of rivers was evaluated using physiographic and evolving Drainage basin methods. Moreover, the number of available springs was considered as another indicator of available water resources. Results are reported in Table 4. Table 5, shows the Unscaled values of available water indicators and available water resources values in each studied district (Wilson, 2004).

Pollution from agricultural lands, mainly fertilizers and pesticides, was evaluated to calculate the pollution emission factor. Table 6 shows the amount of nitrogen fertilizer of farm lands. Average nitrogen fertilizer consumption per unit area was higher in Miandarband, Chaqanarges and Bilavar compared to other districts. This value was lower in the Jalalvand, Haftashian and Dorudfaraman than in other districts.

Table 4. Frequency of available rivers and available springs.

Rural District	Frequency of available springs	Frequency of available rivers (Calculation by physiographic method and Watershed development)		
		Grade1	Grade2	Grade3
Dorudfaraman	2	0	12*	1
Qaresu	0	0	8	0
Bilavar	0	10	2	0
Sanjabi	5	4	1	0
Haftashian	0	1	0	0
Sarfirozabad	0	4	0	1
Chaqanarges	2	0	1	0
Baladarband	1	0	2	0
Miandarband	13	1	4	1
Mahidahht	3	6	1	0
Jalalvand	1	0	3	0
Osmnvand	1	0	3	1

* Branches are from different rivers and sometimes boundaries.

Table 5. Unscaled values of available rivers and springs and available water resources values in each studied districts.

Rural District	Frequency of available rivers (Unscaled)			available springs (Unscaled)	available water resources (Mean)
	Grade1	Grade2	Grade3		
Dorudfaraman	0.00	3.89	3.03	0.86	1.95
Qaresu	0.00	2.59	0.00	0.00	0.65
Bilavar	4.61	0.65	0.00	0.00	1.31
Sanjabi	1.84	0.32	0.00	2.15	1.08
Haftashian	0.46	0.00	0.00	0.00	0.12
Sarfirozabad	1.84	0.00	3.03	0.00	1.22
Chaqanarges	0.00	0.32	0.00	0.86	0.29

For zoning the studied areas, after transferring information to the GIS and implementing the interpolation technique, the zoning was done for each of the components and dimensions in four classes ("very secure", "secure", "unsecure" and "very unsecure") with the same variation range. Fig. 1 shows the condition of studied districts on the average surface water level. The blue corresponds to points with a high groundwater level, that is, the water level in the wells of these areas is about 0 to 17 meters from the surface. The red indicates points with a very low groundwater level (more than about 50 meters from the surface). Fig. 2 to 5 show the conditions of the Kermanshah rural districts in terms of environmental water security and its components. In all figures, zones with very unsecure (red), unsecure (yellow), secure (green) and very secure (blue) conditions are shown. According to Fig. 2, the Qaresu and Bilavar districts are in a completely unsecure condition in terms of water availability. Fig. 3 also illustrates the critical condition of water quantity in the ecology of the Chaqanarges, Baladarband, Sanjabi, Mahidasht and Jalalvand districts. According to Fig. 4, regarding emissions of pollutants in the environment, Chaqanarges is red and Baladarband is in a warning condition. In general, regarding environmental water security, parts of the Chaqanarges, bilavar and Dorudfaraman are in critical and warning conditions (Fig. 5). Pollution from agricultural lands, mainly fertilizers and pesticides, was evaluated to calculate the pollution emission factor. Table 6 shows the amount of nitrogen fertilizer of farm lands. Average nitrogen fertilizer consumption per unit area was higher in Miandarband, Chaqanarges and Bilavar compared to other districts. This value was lower in the Jalalvand, Haftashian and Dorudfaraman than in other districts. Table 7 shows the amount of phosphorus fertilizer used in the agricultural lands. The average amount of phosphorus fertilizer per unit area was higher in the Miandarband, Chaqanarges and Bilavar compared to other districts. This rate was lower in Osmanvand, Haftashian and Drood Faraman.

Table 6. Nitrogen consumption in the arable lands of the studied districts.

Rural District	No fertilizer		1-50 (kg/ha)		50-100 (kg/ha)		100-150 (kg/ha)		150-200 (kg/ha)		More than 200 (kg/ha)		Mean (kg/ha)	Rank *
	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent		
Dorudfaraman	11	20.80	6	11.30	30	56.60	6	11.30	0	0.00	0	0.00	79.24	3
Qaresu	4	23.50	0	0.00	8	47.10	5	29.40	0	0.00	0	0.00	91.27	3
Bilavar	11	16.90	2	3.10	7	10.80	6	9.20	12	18.50	27	41.50	197.69	1
Sanjabi	2	8.70	6	26.10	13	56.50	0	0.00	0	0.00	2	8.70	95.65	3
Haftashian	8	57.10	1	7.10	3	21.40	0	0.00	1	7.10	1	7.10	67.85	3
Sarfirozabad	0	0.00	4	28.60	5	35.70	1	7.10	1	7.10	3	21.40	132.14	2
Chaqanarges	0	0.00	0	0.00	9	28.10	7	21.90	8	25.00	8	25.00	204.68	1
Baladarband	1	3.70	2	7.40	8	29.60	5	18.50	2	7.40	9	33.30	156.29	1
Miandarband	0	0.00	0	0.00	0	0.00	0	0.00	7	21.90	25	78.10	293.75	1
Mahidahht	6	26.10	0	0.00	6	26.10	5	21.70	2	8.70	4	17.40	141.30	2
Jalalvand	8	50.00	3	18.80	2	12.50	1	6.20	1	6.20	1	6.20	62.50	3
Osmnvand	4	40.00	3	30.00	0	0.00	0	0.00	0	0.00	3	30.00	140.00	2

* Ranking: Rank 1= More than 150 (kg/ha); Rank 2= 100-150 (kg/ha); Rank 3= 50-100 (kg /a); Rank 4= 0-50 (kg/ha).

Table 7. phosphorus consumption in the arable lands of the studied districts.

Rural District	No fertilizer		1-50 (kg/ha)		50-100 (kg/ha)		100-150 (kg/ha)		150-200 (kg/ha)		More than 200 (kg/ha)		Mean (kg/ha)	Rank *
	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent		
Dorudfaraman	11	20.80	37	69.80	5	9.40	0	0.00	0	0.00	0	0.00	42.90	4
Qaresu	4	23.50	0	0.00	11	64.70	2	11.80	0	0.00	0	0.00	44.11	4
Bilavar	11	17.50	9	14.30	18	28.60	11	17.50	4	6.30	10	15.90	138.09	2
Sanjabi	2	8.70	19	82.60	2	8.70	0	0.00	0	0.00	0	0.00	50.00	4
Haftashian	9	64.30	3	21.40	1	7.10	0	0.00	0	0.00	1	7.10	35.71	4
Sarfirozabad	0	0.00	8	57.10	4	28.60	2	14.30	0	0.00	0	0.00	76.78	3
Chaqanarges	0	0.00	0	0.00	9	28.10	3	9.40	16	50.00	4	12.50	192.18	1
Baladarband	1	3.70	6	22.20	4	14.80	11	40.70	5	18.50	0	0.00	115.96	2
Miandarband	0	0.00	0	0.00	0	0.00	15	46.90	11	34.40	6	18.80	195.31	1
Mahidahht	4	17.40	1	4.30	10	43.50	6	26.10	2	8.70	0	0.00	102.17	2
Jalalvand	9	56.20	3	18.80	2	12.50	1	6.20	1	6.20	0	0.00	43.75	4
Osmnvand	6	40.00	3	30.00	0	0.00	0	0.00	0	0.00	3	30.00	140.00	4

Table 8 shows the amount of potassium fertilizer used in the agricultural lands. The average consumption of potassium fertilizer per unit area in Chaqanarges, Miandarband and Bilavar was higher than other districts. The average consumption of potassium fertilizer in Osmanvand and Sarfirozabad was zero. Table 9 shows the amount of pesticides used in agricultural lands. Average consumption of pesticides per unit area was higher in Chaqanarges, Miandarband and Qaresu compared to other areas. The average consumption of potassium fertilizers was lower in Sarfirozabad, Jalalvand and Baladarband compared to other areas (Shamsoddini and Shahraki, 2013).

Table 8. potassium consumption in the arable lands of the studied districts.

Rural District	**No fertilizer**		**1-50 (kg/ha)**		**50-100 (kg/ha)**		**100-150 (kg/ha)**		**150-200 (kg/ha)**		**More than 200 (kg/ha)**		**Mean (kg/ha)**	**Rank ***
	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent		
Dorudfaraman	41	77.40	7	13.20	5	9.40	0	0.00	0	0.00	0	0.00	14.62	3
Qaresu	13	76.50	2	11.80	2	11.80	0	0.00	0	0.00	0	0.00	17.64	3
Bilavar	18	29.50	20	32.80	11	18.00	0	0.00	10	16.40	2	3.30	76.22	1
Sanjabi	9	39.10	12	52.20	2	8.70	0	0.00	0	0.00	0	0.00	31.52	2
Haftashian	8	57.10	5	35.70	0	0.00	0	0.00	1	7.10	0	0.00	32.14	2
Sarfirozabad	14	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	4
Chaqanarges	6	18.80	3	9.40	15	46.90	8	25.00	0	0.00	0	0.00	89.06	1
Baladarband	8	29.60	14	51.90	5	18.50	0	0.00	0	0.00	0	0.00	37.00	2
Miandarband	6	18.80	4	12.50	19	59.40	3	9.40	0	0.00	0	0.00	79.68	1
Mahidahht	15	65.20	6	26.10	2	8.70	0	0.00	0	0.00	0	0.00	21.73	3
Jalalvand	9	56.20	0	0.00	2	12.50	5	31.20	0	0.00	0	0.00	15.62	3
Osmnvand	10	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	4

Table 9. Toxin and pesticide consumption in the arable lands of the studied districts.

Rural District	**No fertilizer**		**1-50 (kg/ha)**		**50-100 (kg/ha)**		**100-150 (kg/ha)**		**150-200 (kg/ha)**		**More than 200 (kg/ha)**		**Mean (kg/ha)**	**Rank ***
	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent		
Dorudfaraman	41	77.40	7	13.20	5	9.40	0	0.00	0	0.00	0	0.00	14.62	3
Qaresu	13	76.50	2	11.80	2	11.80	0	0.00	0	0.00	0	0.00	17.64	3
Bilavar	18	29.50	20	32.80	11	18.00	0	0.00	10	16.40	2	3.30	76.22	1
Sanjabi	9	39.10	12	52.20	2	8.70	0	0.00	0	0.00	0	0.00	31.52	2
Haftashian	8	57.10	5	35.70	0	0.00	0	0.00	1	7.10	0	0.00	32.14	2
Sarfirozabad	14	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	4
Chaqanarges	6	18.80	3	9.40	15	46.90	8	25.00	0	0.00	0	0.00	89.06	1
Baladarband	8	29.60	14	51.90	5	18.50	0	0.00	0	0.00	0	0.00	37.00	2
Miandarband	6	18.80	4	12.50	19	59.40	3	9.40	0	0.00	0	0.00	79.68	1
Mahidahht	15	65.20	6	26.10	2	8.70	0	0.00	0	0.00	0	0.00	21.73	3
Jalalvand	9	56.20	0	0.00	2	12.50	5	31.20	0	0.00	0	0.00	15.62	3
Osmnvand	10	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	4

* Ranking: Rank 1= More than 3 (kg/Lit/ha); Rank 2= 2-3 (kg/Lit/ha); Rank 3= 1-2 (kg/Lit/ha); Rank 4= 0-1 (kg/Lit/ha).

Table 10 shows the Unscaled values between the fertilizer and pesticide classes in the studied districts. Averaging these numbers, the amount of emission of pollutants was calculated in the studied areas.

Table 10. Unscaled values of fertilizer and pesticide classes and emission of pollutants in each studied districts.

Rural District	C.N.F.U. (Unscaled)	C.P.F.U. (Unscaled)	C.K.F.U (Unscaled)	C.Pestiside.F.U (Unscaled)	E.P. (Mean)
Dorudfaraman	1.44	1.37	1.24	0.80	1.21
Qaresu	1.44	1.37	1.24	0.80	1.21
Bilavar	0.48	0.68	0.41	1.20	0.69
Sanjabi	1.44	1.37	0.83	0.80	1.11
Haftashian	1.44	1.37	0.83	1.20	1.21
Sarfirozabad	0.96	1.03	1.65	1.60	1.31
Chaqanarges	0.48	0.34	0.41	0.40	0.41
Baladarband	0.48	0.68	0.83	1.20	0.79
Miandarband	0.48	0.34	0.41	0.40	0.41
Mahidahht	0.96	0.68	1.24	1.20	1.02
Jalalvand	1.44	1.37	1.24	1.60	1.41
Osmnvand	0.96	1.37	1.65	0.80	1.19

C.N.F.U: Class of Nitrogen Fertilizer Use, C.P.F.U: Class of Phosphor Fertilizer Use, C.K.F.U: Class of Potassium Fertilizer Use, C.Pestiside.F.U: Class of Pesticide Fertilizer Use, E.P: Emission of Pollutants.

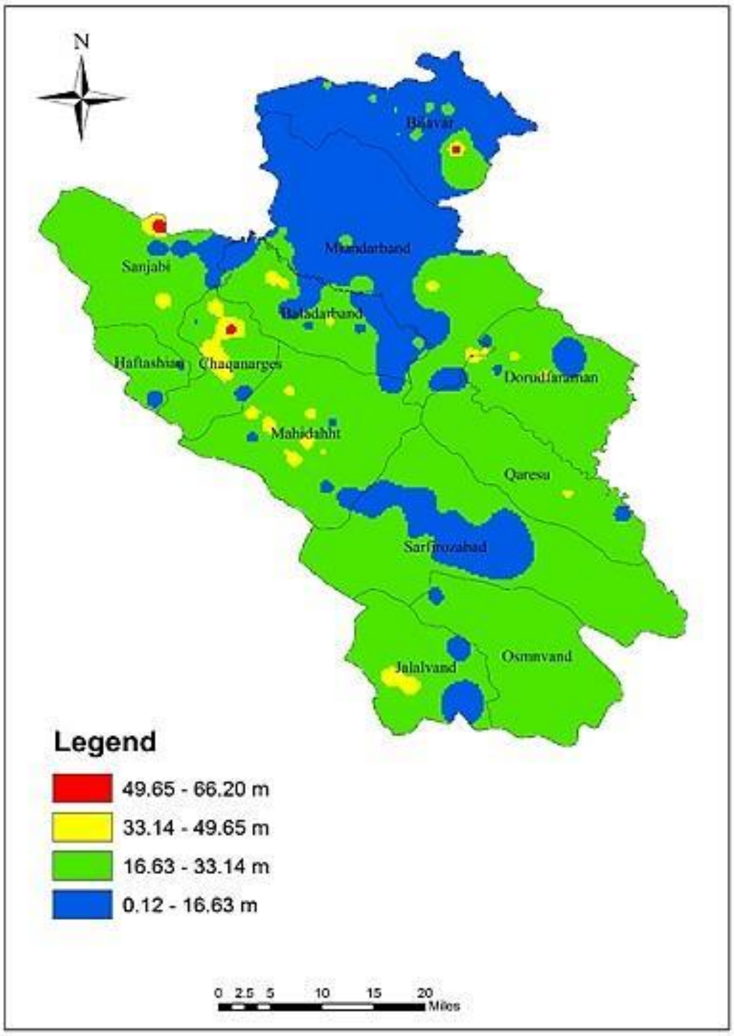

Fig. 1. Status of rural districts of Kermanshah city in terms of piezometers.

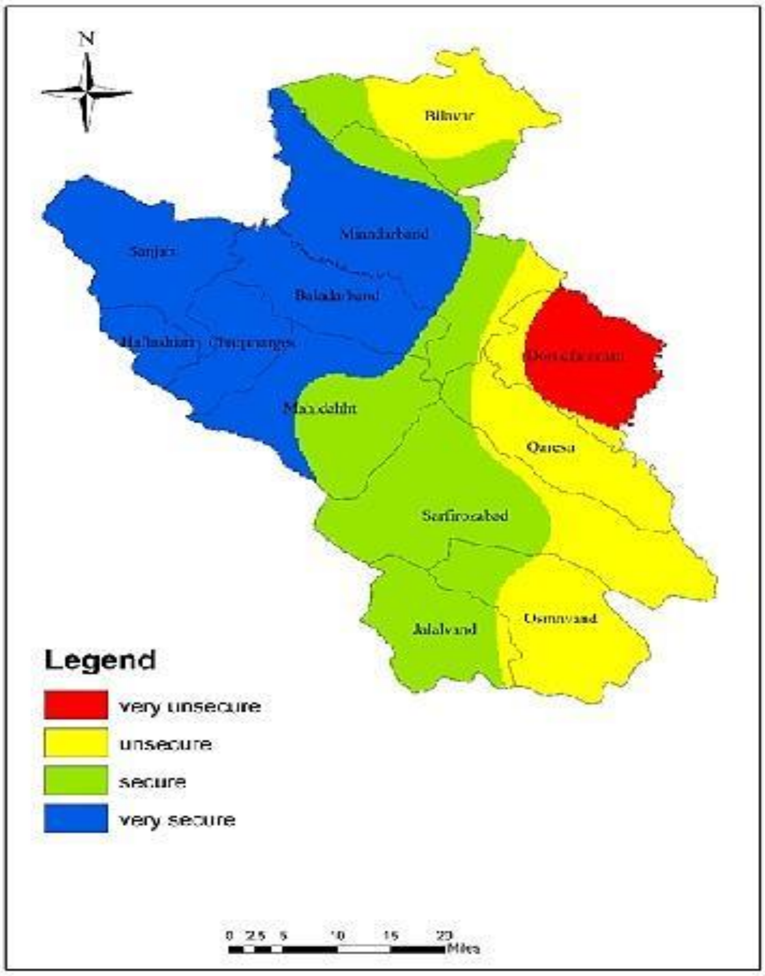

Fig. 2. Status of rural districts of Kermanshah city in terms of available water resources.

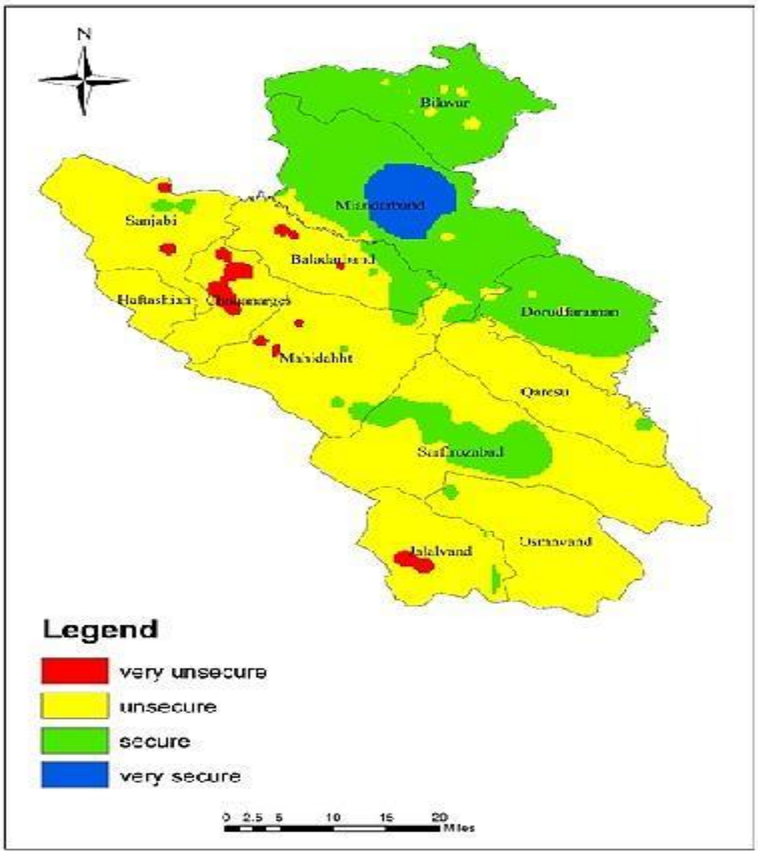

Fig. 3. Status of rural districts of Kermanshah city in terms of water quantity.

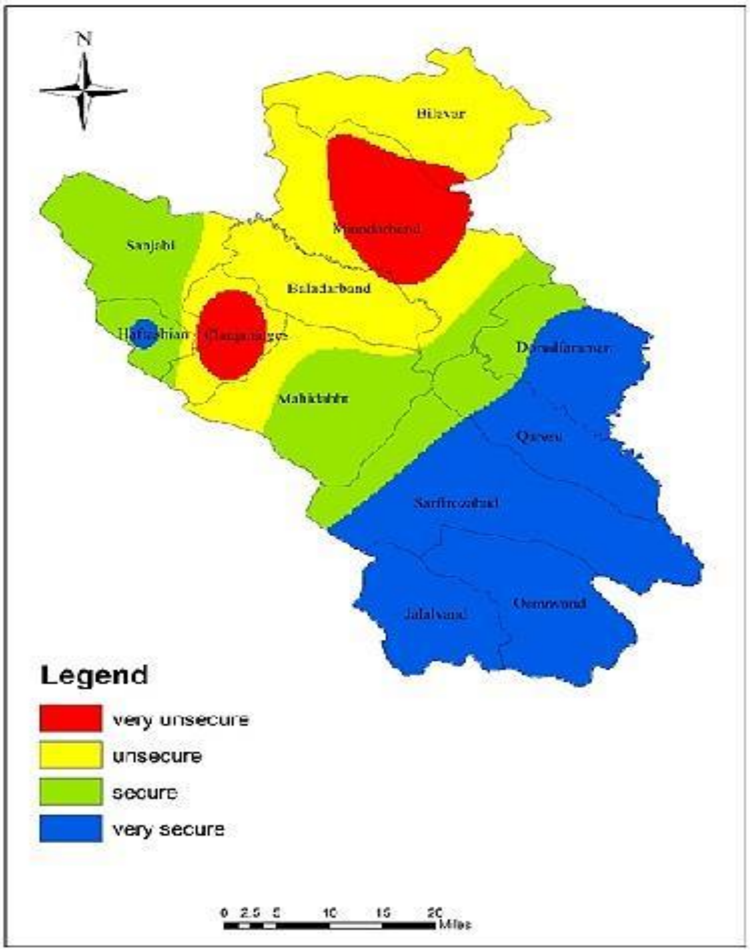

Fig. 4. Status of rural districts of Kermanshah city in terms of emission of pollutants.

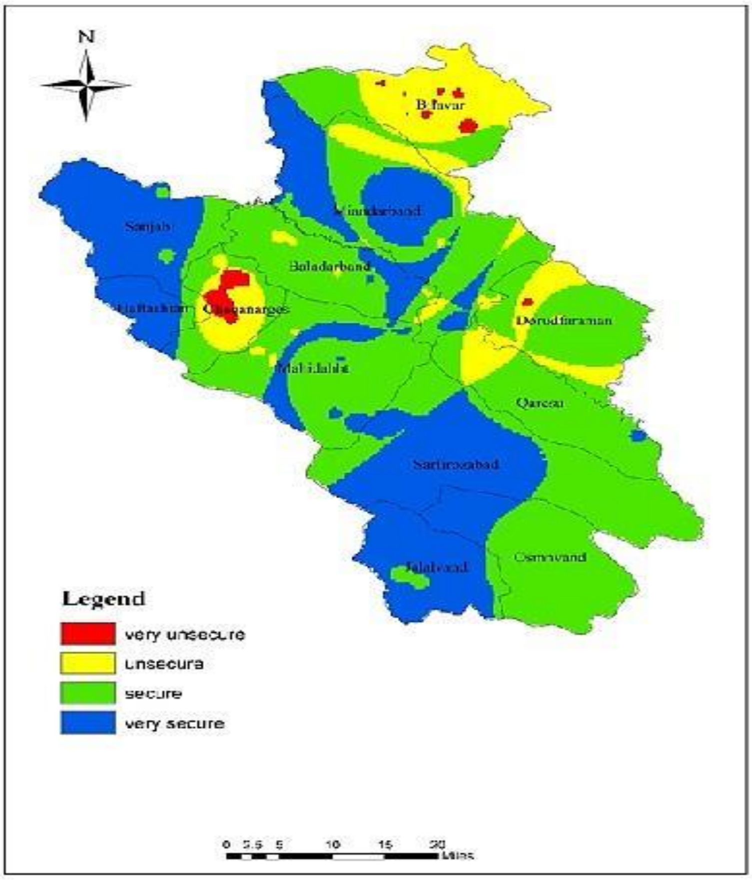

Fig. 5. Status of rural districts of Kermanshah city in terms of environmental water security.

4. Conclusion

Considering the water quantity component in the environment, the statistics of the Kermanshah Regional Water Organization database indicated that no wells have been registered in the Haftashian and Osmanvand districts. Investigating the number of dried wells during the 5-year period showed that the highest drought was in the Miandarband, Baladarband, Dorudfaraman, Sarfirozabad, Bilavar and Chaqanarges districts. Also, the highest qanat drought was in the Bilavar and Qaresu districts. Another indicator of water quantity was the water level of wells. According to the statistics, the average level of underground water was lower in Chaqanarges, Bilavar, Jalalvand, Baladarband, Mahidasht, Haftashian and Sanjabi. In general, the Haftashian, Sanjabi and Baladarband had the highest rank and Dorudfaraman, Qaresu and Bilavar had the lowest rank in water quantity. The results of the available water resources component and, in particular, the frequency indices of available rivers, showed that the Bilavar and Mahidasht have the highest number of level 1 river branches, Dorudfaraman and Qaresu of level 2 river branches, and Miandarband and Sanjabi of level 3 river branches. According to available data, the Miandarband and Sanjabi districts have the highest number of springs. In total, the Miandarband and Dorudfaraman districts were ranked the highest and Haftashian, Baladarband and Chaqanarges had the lowest ranks in available water resources. Agricultural pollution was another indicator used to evaluate environmental water security. Some studies have considered the unreasonable use of chemicals as one of the most important causes of water and environmental pollution. Pesticides and chemical fertilizers are transferred from agricultural land to water sources so about 15% of water pollution is due to the use of these toxins. Agricultural pesticides directly affect water quality.

The third dimension of environmental water security is the pollutant emission factor. In the present study, the pollutant emissions, fertilizer levels and chemical pesticides used in agricultural lands were surveyed by asking the heads of households. Considering the importance of chemical pesticides in the environment, numerous studies have been carried out both inside and outside the country. The results showed that the highest level of nitrogen fertilizer was used in Bilavar, Chaqanarges, Baladarband and Miandarband. The highest levels of phosphorus pesticide have also been reported in Chaqanarges and Miandarband. Furthermore, Bilavar, Chaqanarges and Miandarband had the highest levels of potassium fertilizer consumption. Regarding emissions, the Jalalvand and Sarfirozabad were the most secure and Chaqanarges and Miandarband had the most unsecure conditions among the studied districts.

After the overlap of layers, the water environmental security map showed that the Miandarband, Sarfirozabad, Jalalvand, Sanjabi and Haftashian districts were in a very secure condition compared to other rural districts. Parts of Chaqanarges, Bilavar and Dorudfaraman are in a critical condition regarding environmental water security which necessitates special attention from the authorities. Considering the critical condition of water levels in the wells of Chaqanarges, Bilavar and Sanjabi and the warning condition in Dorudfaraman, Jalalvand, Mahidasht and Baladarband, it is recommended to enforce rules to prevent unauthorized use of wells, control drainage and prevent over-drainage of wells through patrol groups and install smart water meters to control the level of operation with greater sensitivity. Research on the transfer of water from one area to another, especially in Haftashian, Baladarband, Chaqanarges and Jalalvand, which had a lower rank in available water quantity, is necessary. Moreover, training programs provided by agricultural promoters to raise farmers' awareness about the amount and manner of using fertilizers and chemical pesticides are necessary.

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