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Full Length Research Paper

A GIS model for determination of water resources suitability for goats grazing

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Proper use from water resources, especially in arid and semi arid of Iranian rangeland are very important. In this area water is one of a valuable ecosystem component. The study was conducted in Ghareh Aghach watershed region is located, Isfahan province, in central part of Iran. Four criteria's of water quality, water quantity, water distance and livestock information were integrated to water resources suitability for goats grazing. According to the results, water distance and accessibility to water is a most declining factor for suitability. A quality and quantity factor is a no limiting factor in part of study area. The results show that from 7158.69 ha of studied rangelands, 6245.93 ha (87.25%) classified as S_1 class (with no limitation), 810.58 ha (11.32%) classified as S_2 class (with low limitation), and 102.3 ha (1.43%) classified as N class (non suitable). Based up on slope classes, areas that far from water point more than 75% of slope is not suitable and less than 15% are very suitable. Good distribution of water resources increases water suitability and cause better and monotonous utilization of rangeland.

Key words: Water resources suitability, Rangeland, FAO, Goats, GIS, Iran.

INTRODUCTION

Rangeland is the biggest important ecosystem in the world. Rangelands occupy more than 90 million hectare in Iran (Mesdaghi, 2004). They provide a variety of products and services such as soil and water conservation, recreation and tourism, forage for animal, which contribute to human health and welfare. Grazing will continue to be an important process in all Iranian rangelands, regardless of their primary use, and managing grazing will continue to preoccupy landholders and others interested in the sustainable and productive use of rangelands. Unfortunately over grazing pressure due to the increment of human population causes the rangelands degradation (Moghadam, 2001). Many authors have reported changes in rangeland conditions around water points (Arzani and Yousefi, 2006; Arzani et al., 2006; Ayoubi, 2006; Badjian et al., 2007; Javadi et al., 2008; Amiri, 2008). Determining a proper distribution of water point can improve and conserve the potential and rangeland production (King, 1993; Bailey, 2004a, b; Schlecht et al., 2004). Water is a major determinant of livestock distributions. Animals graze from a water point to a distance they can afford depending on the availability of forage and their dependency on water (Sileshi et al., 2003; Bailey, 2004a, b; Schlecht et al., 2004). In this research, detecting of most declining and limiting factors on water suitability and rangeland classification according to suitability for goats grazing was our purposes. In the present study, the main objective is to create a GIS model for producing the water suitability map.

MATERIAL AND METHODS

This study conducted in Isfahan province of Iran. The mean annual precipitation is 358 mm. it has semi-arid climate. The area of Ghareh Aghach watershed is about 8954.8 ha which is located between 51º 45' 53" and 51º 34' 54" eastern latitudes and 31º 30' 28" and 31º 26' 19" northern altitudes (Figure 1).

The maximum and minimum heights of the area are 3810 and 2630 m from the sea level. The mean altitude of the watershed is 2936 m from the sea level. The watershed area is divided in five major hydrologic sections according to its topographic feature. Rainfall in the study area was around average during these years (358 mm recorded at Semirom station in 2007; Figure 2). Long term mean temperature are 10.5°C which classifies the site in semi-arid climatic conditions according to Ambergie (Q = 40.7) and Demartin (Ia = 17.4) categories. There are about 17 different vegetation types

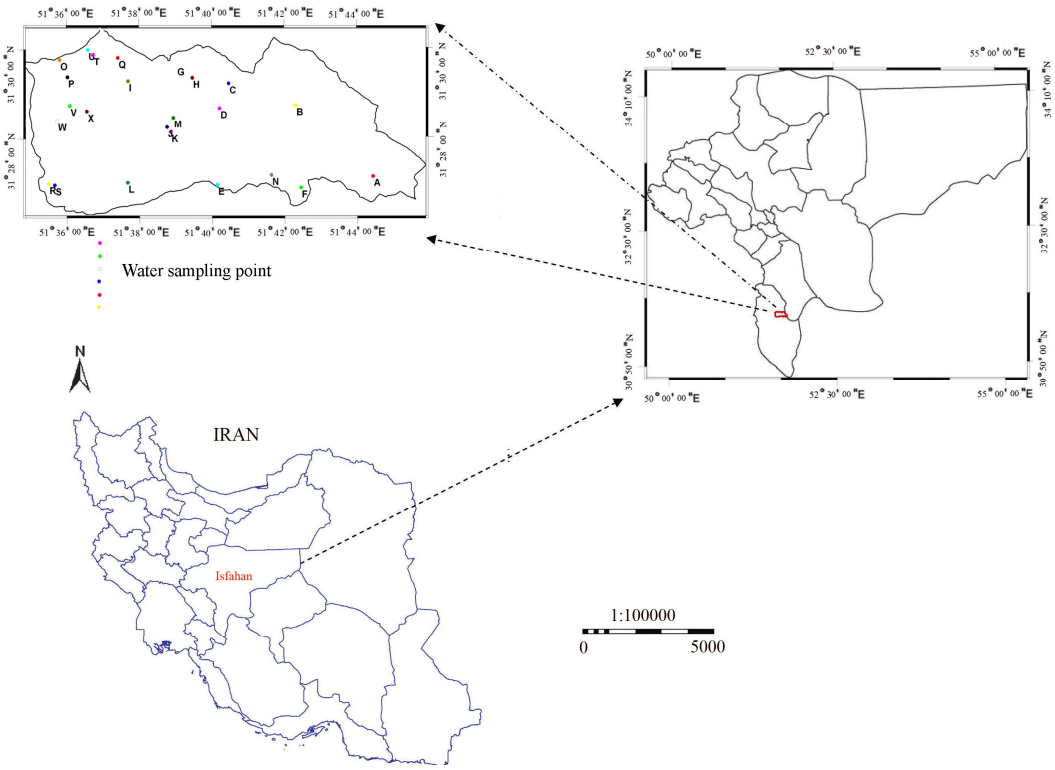

Figure 1. Location of study area within the Ghareh Aghach District.

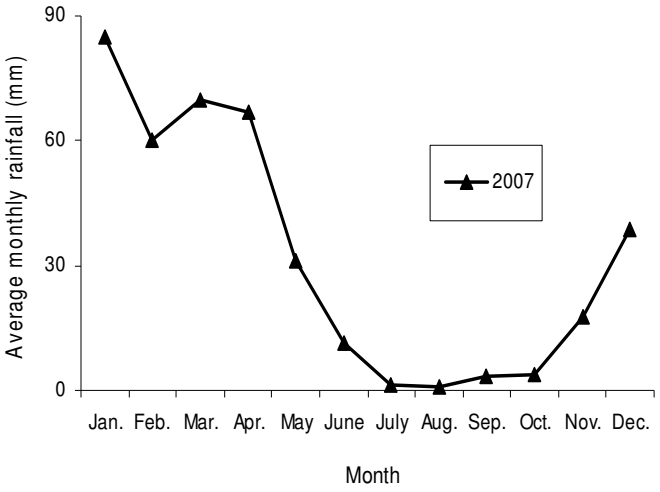

Figure 2. Monthly average rainfall of 2007 recorded at Semirom station within the study area

and four major landscapes of mountainous lands, hilly lands, plateau and gravel lands consisting of nine minor land units (Amiri, 2008).

A goat was an animal grazer in this area. Rangeland often covers by grass, forbs and brush species. To achieve goal study, in the first step a topographic map in 1:25000 scale of the study area was digitalized by ILWIS 3.3 program to provide a contour map. Using the contour map, the slope and aspect maps as well as the digital evaluation model (DEM) of the site were prepared. In the second step the satellite images (e.g., Land sat ETM^{+}), aerial photos of 1:40000 scale and data obtained from the field visits were used to provide with geological, geomorphologic, vegetation cover, peddological and land use maps of the study area.

Method introduced by FAO (1991) used for producing water suitability classification map using ILWIS version 3.3 as a GIS software. Two orders of range suitability for goats grazing were considered: suitable (S) and not suitable (N). Three classes of suitability were determined including high suitable (S_1), moderately suitable (S_2), and marginally suitable (S3). Quantity, quality accessibility of water and livestock information formed water resource model (Figure 3). For creating accessibility of water map, slope map (Figure 5), Location of water in Samman unit (Figure 6) and distance map (Figure 7) were integrated. Quantity of water was evaluated considering grazing capacity and water requirement per animal (Ebrahimi, 2000). Table 1 shows suitability level of distances considering slope classes. Final water suitability model was created by combination of sub-model.

Water quality was assessed by laboratory analysis of water in terms of TDS (Total Dissolved Salts), EC and $CaCo_3$ (Table 2) for each water resources. Finally suitability model was created by combination of sub-models for producing water suitability map for goats grazing (Figure 4).

The water need of goats grazing (?) is calculated by the following equation in this model:

(1) lit / kg $^{0.82}$/ day = ? lit/ day a

Were: a = coefficient where determine by local study? = water need for each goats according to weight body (King, 1983). Mean weight body for Torkish Ghashghai goats in this area is about 37 kg. In Iranian rangelands the livestock only can use water in Samman unit.

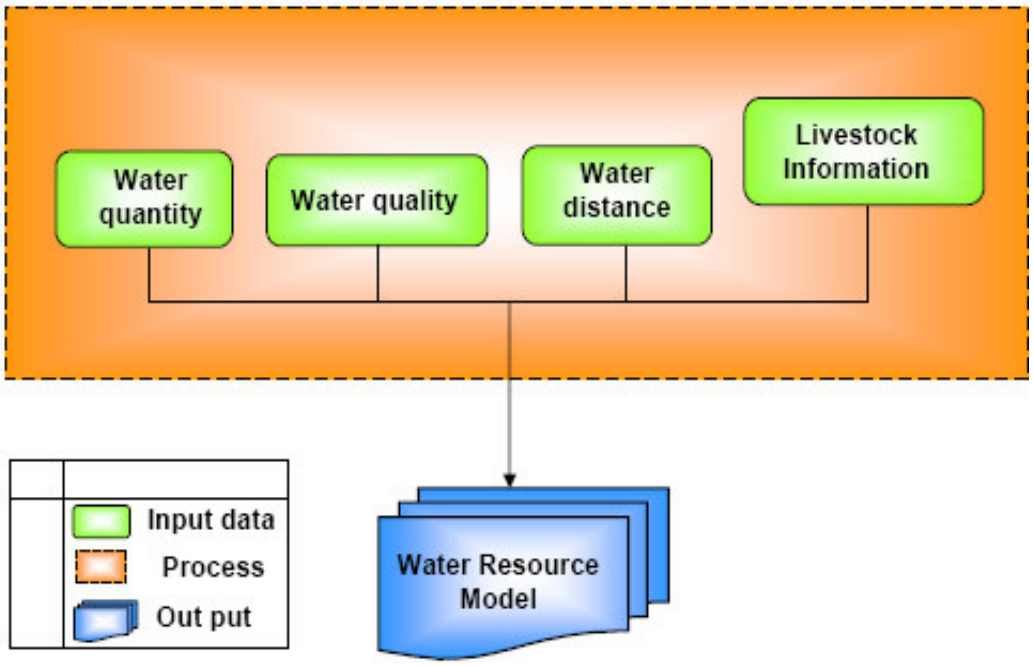

Figure 3. Water resources model.

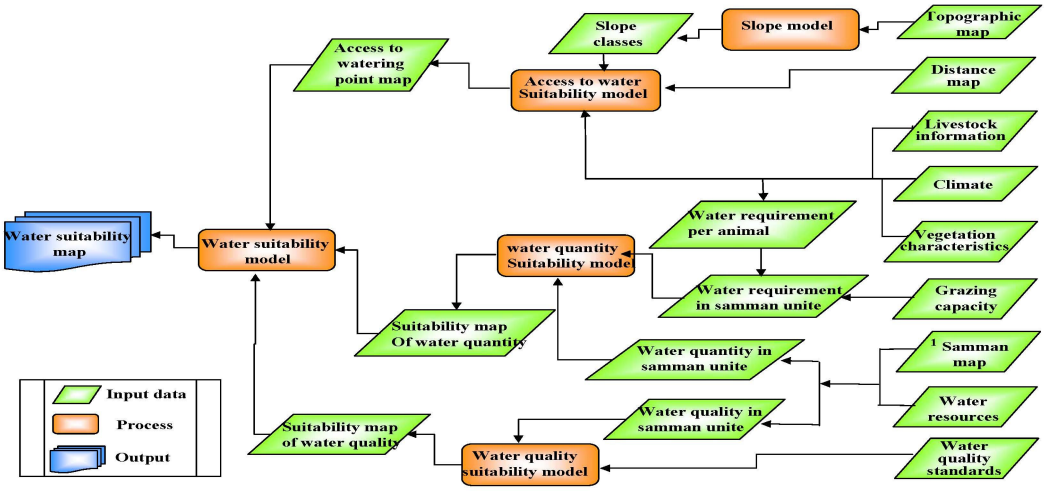

Figure 4. Model for classification of water resources suitability.

RESULTS AND DISCUSSION

Although Iran is the second largest country in the Middle East, it has limited natural resources such as fertile soil and water, resulting in limited opportunities to expand and/or intensify arable farming (Sheidaei and Nemati, 1978). Extensive animal husbandry, on the other hand, including nomadic, transhumant and sedentary forms, is widespread over the rangelands of the country. As the main rangeland enterprise in this study area was sheep grazing, a Geographic Information System (GIS) model was created to determining the suitability of the range land for this purpose. Nevertheless, many rangelands are capable of producing more than one product (Stoddart et al., 1975) which may form the basis of future studies. For management of Ghareh Aghach rangeland, a Geographic Information System (GIS) model was created to deter-mining the most limiting factors on water suitability for goats grazing.

Results showed that in terms of water resources dis-tance, 87.25% of the Ghareh Aghach Range contained S_1, 11.32% classified as S_2 and 1.43% located in N orders (Figure 8). Most of area in suitable classes in slope classes less than 15%. The areas that located far less than 40% of

Table 1. Water resource distance (meter) and its suitable classes.

Slope class / (%) Suitability class	0 - 15	15 - 45	45- 75	>75
S_1	0-3400	0-3000	0-1000	N
S_2	3400-5000	3000-4800	1000-3600	N
S_3	5000-6400	4800-6000	3600-4100	N
N	>6400	>6000	>4100	N

Table 2. Water quality for goats and its suitable classes (Bagley et al., 1997).

Suitability class	S_1	S_2	S_3	N
TDS (mil/lit)	<5000	5000-7000	7000-10000	>10000
EC (mmohs/lit)	<5800	5800-16500	16500-25000	>25000
$Caco_3$ (me/lit)	<60	61-120	121-180	>180

Table 3. Percentage of water distance for goats grazing according to slope classes.

Suitability classes / (%)Slope classes	S_1	S_2	S_3	N
0-15	54.1	-	-	-
15-40	24.98	-	-	-
40-75	8.17	11.32	-	-
>75	-	-	-	1.43
Total	87.25	11.32	-	1.43

slope classes are not limited (Table 3). In terms of quantity of water, suitability class was S_1. Potable water capacity in Ghareh Aghach Range was 2797632 lit/year. Also, goat's water need (according grazing capacity) estimated 19556 lit/year that shows water quantity is not a limiting factor in these areas. Results showed all of water point, suitable in terms of water quality (Table 4) and classified as S_1 Suitability classes.

Integration of three sub-models of quality, quantity and water distance showed that 87.25% (6254.93 ha) of Ghareh Aghach rangelands are in S_1 suitability class, 11.32% (810.58 ha), 18.8 (26720.5 ha) and 1.43% (102.3 ha) percentages are in S_2 and N classes order respectively (Figure 4). GIS facilitated integration of information layers within and between models (Bailey, 2004a, b; Mfitumukiza, 2004; Ayoubi, 2006; Badjian et al., 2007).

Most important declining factor was limitation of accessibility to water. Similar problem was reported by Mfitumukiza (2004) and Arzani and Yousefi (2006). For reason, they stated high slope is a limitation factor. But in Ghareh Aghach, slope factor was not a limiting factor. Because most of areas (54.1%) had less than 15% slope. bad distribution of water points in large area (142642 ha) and dig well near each other by pastoralist cause to part of rangeland lose its suitability for camel grazing. The results of this study show that for monotonous utilization and improve range suitability, as considering goats walking; water points should be far from each other 6 km. There was no limitation in terms of water quantity in the area. This is similar to finding of Arzani et al. (2006). There was no limitation about water quality. Pashne well and Tolombe well had high TDS (>10000 mgl^{-1}). These are not potable and do not introduce to the model, then water suitability declined for Ghareh Aghach Rangeland.

A GIS method can provide better information and easier integration of various information layers to support model of water suitability assessment. It is found that GIS is to be a useful technique to provide greater flexibility and accuracy for water suitability assessment. This way is supported by Banai (1989, 1993).

Table 4. Ghareh Aghach water resources quality and quantity.

No.	Water code	Samman name	Water yield (lit/s)			The results of water quality												Suitability class of water quality
			Q min	Q max	Q mean	pH	Ec/25°c $\frac{mi.mhos}{Cm}$	T.D.S mgL^{-1}	%Na	Cl^{-} meL^{-1}	Co_3^{2-} meL^{-1}	Hco_3^{2-} meL^{-1}	So_4^{2-} meL^{-1}	Ca^{2+} meL^{-1}	Mg^{2+} meL^{-1}	K^{+} meL^{-1}	S.A.Rz	
1	A	Takhte soltan	3.48	4.1	3.79	7.8	315	203	3.00	3.51	0.00	193.5	5.25	62.25	2.59	0.38	0.07	S1
2	B	Tange tir	5.8	13.38	9.59	7.2	366	238	2.00	3.54	0.00	244.04	0.48	70.14	6.08	0.39	0.07	S1
3	C	Tange tir	0.35	1.8	1.08	7.2	366	238	2.00	3.54	0.00	244.04	0.48	70.14	6.08	0.39	0.07	S1
4	D	Tange tir	0.18	1.41	0.79	7.2	366	238	2.00	3.54	0.00	244.04	0.48	70.14	6.08	0.39	0.07	S1
5	E	Reismelek	0.2	0.35	0.27	7.8	230	150	12.00	3.54	0.00	134.22	10.08	34.06	6.08	0.39	0.28	S1
6	F	Takhte soltan	0.1	3.54	1.82	7.8	314	204	3.00	3.54	0.00	195.23	5.28	62.12	2.43	0.39	0.07	S1
7	G	Chat mohammad	0.32	1.1	0.71	7.6	387	252	6.9	7.09	0.00	189.12	43.6	54.2	14.6	0.39	0.21	S1
8	H	Chat mohammad	0.7	1.2	0.95	7.6	387	252	6.9	7.09	0.00	189.12	43.6	54.2	14.6	0.39	0.21	S1
9	I	Ghoen chaman	0.94	1.31	1.12	7.3	388	252	7.00	7.09	0.00	189.12	43.7	54.1	14.59	0.39	0.21	S1
10	J	ketivar	0.15	1.3	0.72	7.9	374	343	4.9	7.08	0.00	225.6	10.0	60.12	10.94	4.6	0.39	S1
11	K	ketivar	0.5	1.5	0.71	374	343	4.9	7.08	0.00	0.00	225.6	10.0	60.12	10.94	4.6	0.39	S1
12	L	Reis malek	0.52	1.2	0.86	7.8	230	150	12.00	3.54	0.00	134.21	10.0	34.0	6.02	0.38	0.28	S1
13	M	ketivar	0.65	1.12	0.88	7.9	373	343	4.9	7.08	0.00	225.7	10.08	60.12	10.94	4.6	0.39	S_1
14	N	Takhte soltan	0.12	0.65	0.38	7.8	313	204	2.9	3.51	0.00	194.8	5.35	61.8	2.52	0.37	0.08	S_1
15	O	Delig dash	0.94	1.12	1.03	7.3	387	353	7.00	7.0	0.00	188.9	43.5	54.3	14.7	0.36	0.22	S_1
16	P	Ghoyein chaman	0.2	0.35	0.27	7.26	386	251	7.01	7.03	0.00	189.12	43.2	53.8	14.49	0.33	0.2	S_1
17	Q	Ghoyein chaman	1.0	1.3	1.15	7.31	387	253	7.00	7.00	0.00	188.9	43.5	54.3	14.7	0.36	0.22	S_1
18	R	Mergh aligholi	0.3	1.5	0.75	7.8	315	204	3.00	3.54	0.00	195.2	5.28	62.12	3.43	0.39	0.21	S_1
19	S	Mergh aligholi	0.86	2.2	1.53	7.8	315	204	3.00	3.54	0.00	195.2	5.28	62.12	3.43	0.39	0.21	S_1
20	T	Ghoyein chaman	0.6	2.4	1.5	7.2	386	251	7.01	7.03	0.00	189.12	43.2	53.8	14.49	0.33	0.22	S_1
21	U	Ghoyein chaman	0.18	1.4	0.79	7.2	386	251	7.01	7.03	0.00	189.12	43.2	53.8	14.49	0.33	0.22	S_1
22	V	Ghare aghach	0.12	0.68	0.4	8.00	374	343	5.00	7.09	0.00	225.7	10.08	60.12	10.94	4.6	0.39	S_1
23	W	Khar gari	0.14	0.91	0.52	7.3	387	353	7.00	7.00	0.00	188.9	43.5	54.3	14.7	0.36	0.22	S_1
24	X	Dareh jeiran	0.11	0.85	0.48	7.9	373	343	4.9	7.08	0.00	225.7	10.08	60.12	10.94	4.6	0.39	S_1

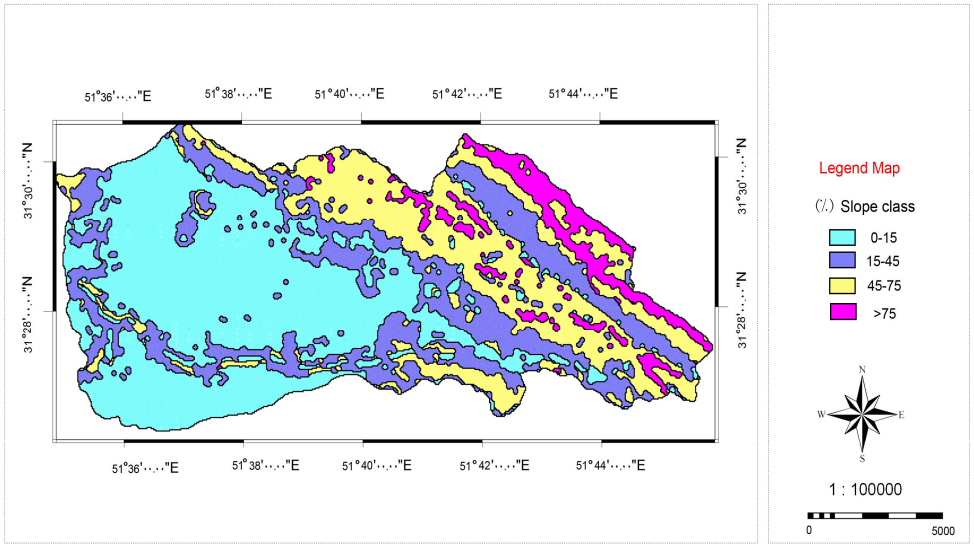

Figure 5. Slope map of Ghareh Aghach Rangeland.

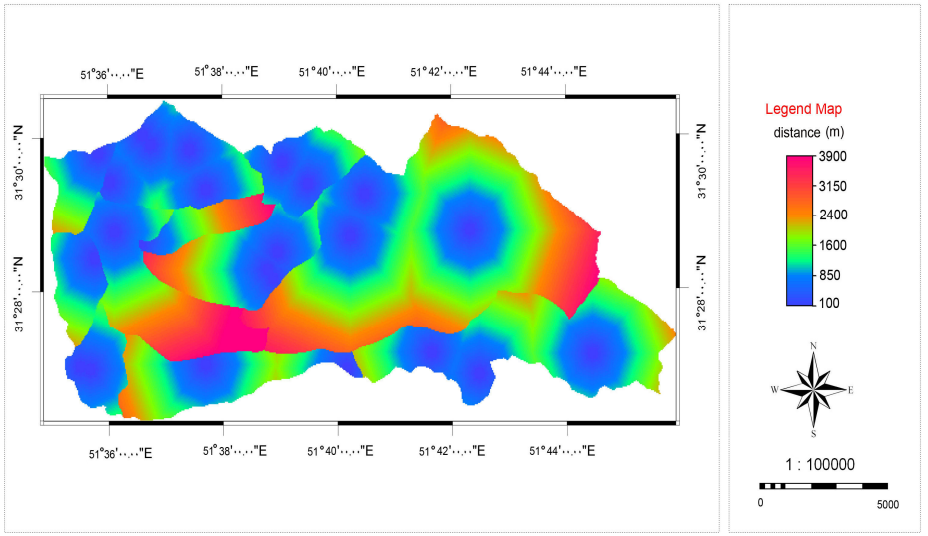

Figure 7. Water point distance map of Ghareh Aghach Rangeland.

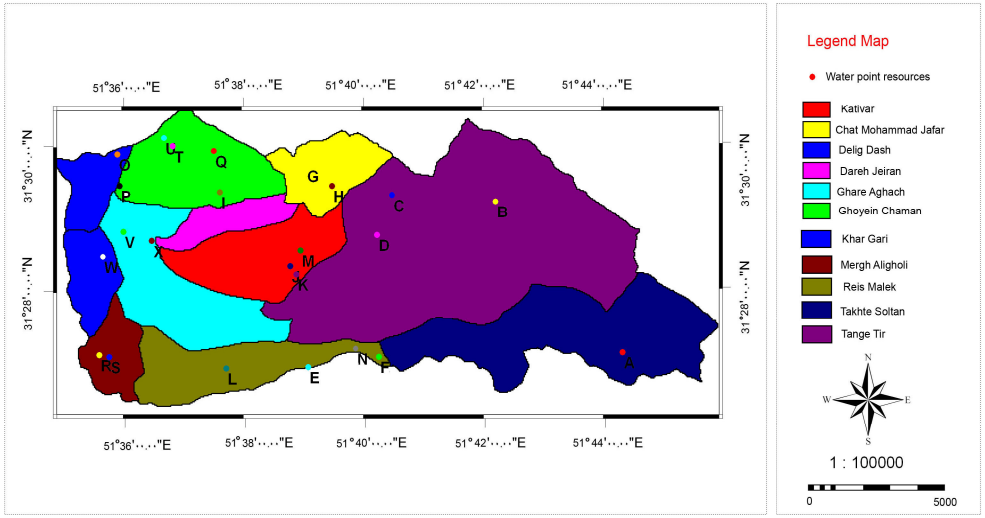

Figure 6. Location of water in Samman unit of Ghareh Aghach Rangeland.

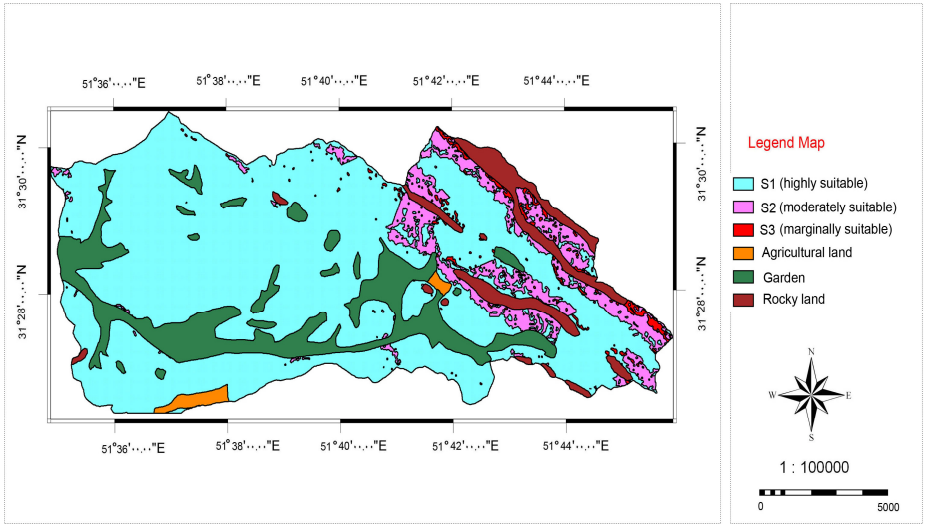

Figure 8. Water suitability map of Ghareh Aghach Rangeland.

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