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ORIGINAL ARTICLE

Investigation of Soil Degradation Using Glasod Model by Photomorphic Working Units

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Shahram Omidvari, Davood Nikkami, Mohammad Hassan Masihabady, Rahman Barzegar, Omid Alizadeh, Kourosh Ordookhani; Investigation of Soil Degradation Using Glasod Model by Photomorphic Working Units

ABSTRACT

Yearly in the world significant levels of valuable lands have become degradation and lapses exploitation of space in effective of management weaknesses. Degradation of soil is including of every loss of soil yielding power or loss of soil nutrients needed plant by erosion. In this study, for investigating soil quality degradation and map preparation, were selected the Honam sub-basin with 140 km^2, located in the south of Alashtar in the Lorestan province in Iran. This sub-basin is one of the most important regions of production in agriculture and animal husbandry unit, and it is one of the critical sub-basins in the Karkheh River basin. Using of interpretation of ETM+ satellite images (Photomorphic units) the area of study was divided in homogeneous units of soil degradation and was known as a working unit. Per working unit, soil samples were prepared and were determined the properties of organic carbon, total nitrogen, phosphorus and available potassium, bulk density and micronutrient including iron, zinc, manganese and copper. For each of the soil properties in the soil working units, soil degradation index calculated and using GLASOD model was determined type, cause, degree, extent and severity of degradation in each working unit and soil degradation map prepared. Accuracy of map degradation was evaluated in Photomorphic units, using the ground control points and by Wilcox and paired comparisons tests. The results showed that available phosphorus in -70.49 percentages has the highest degradation index of soil. Based on that, the accuracy of degradation maps of soil in the Photomorphic units was estimated in 73.9 percentages. The results showed that there is no significant difference between the degree of fertility degradation of ground control points and Photomorphic units in both of tests.

Key words: Glasod, soil degradation, photomorphic units,Honam sub-basin

Introduction

Land and soil degradation assessments have recently become more fashionable responding to environmental concerns in countries that have claimed its significant adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life. Productivity impacts

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of land degradation are due to a decline in land quality on site, where degradation occurs and off site, where sediments are deposited. Land and soil degradation affects on sustainability or the ability of the land to continue to produce indefinitely, resilience or that quality of a resource that makes it sustainable or resistant to degradation, and carrying capacity or the number of people and animals the land can normally support without being significantly stressed. Land degradation can be affected by several factors, e.g. poor land management; inadequate technology; overpopulation; poverty; and decisions of social and political structures.

The terms land degradation and desertification has a close relationship and several attempts to define and describe them have been made. [12,4,10] Desertification was redefined by [12] in the sense of considering it as "the land degradation in arid, semiarid and dry-semi-humid areas resulting mainly from adverse human impact". The term land includes land and local water resources, the land surface and its natural vegetation. It is important to notice that this definition, attributes the causes of land degradation to natural processes and human activities are introduced as another factor.

Land degradation can be defined from another perspective. [4], as "alterations to all aspects of the natural (or biophysical) environment by human actions, to the detriment of vegetation, soils, landforms, water (surface and subsurface) and ecosystems". In this definition, the natural conditions of the area are not considered as factors that can threat land degradation and the human activities are the main responsible factors for the development of this phenomenon.

Desertification affects all dry land zones over the five continents. [11] Almost 900 million people suffer currently the consequences of desertification in the world, and over 5 billion ha (equal to one quarter of the emerged land) are affected by these processes. In total, 98 countries (including 18 developed countries) have some land area affected by desertification.

The problem of land degradation in the world was studied initially at a world scale by an initiative of the United Nations Environmental Program (UNEP) and the International Soil Reference and Information Center (ISRIC). The study was developed from a soil resource perspective and as a human-induced phenomenon. The project was entitled: Global Assessment of Soil Degradation (GLASOD) and the objective was to produce a 1:10 M world map on the status of human-induced soil degradation. [10]

To protect the land from further degradation and make the mitigation measures effective, it is essential to know the spatial distribution of the areas susceptible to degradation and assess hazard severity. Techniques to evaluate land degradation range from simple methods for hazard assessment [2,6] to sophisticated models for estimating soil losses [1,9,7,8] and for simulation modeling and hazard prediction. [3,13,5,14] Results from advanced modeling are often impressive but also difficult to interpret. A general problem for applying such models is data availability. Frequently, missing data have to be generated on the basis of assumptions, including pedotransfer functions. It is essential to devise a method for hazard zonation, which can be applied in a data-poor environment.

Materials and methods

Study area

The study area is located in Honam, one of the sub-basins of Karkheh river basin, in the north of Lorestan province, Iran (Fig. 1). The 140 km^2 watershed lies between 33°44 51″–33°51 47″ N and 48°12 30″–48°28 45″ E. The annual precipitation is 560 mm which most of it falls during the months of December to March in the form of snow. The average temperature is 10 °C, with the Min. and Max. of 4 and 22 °C.

In this study, To evaluate of soil quality degradation and its mapping, the case study were isolated to homogeneity units of soil degradation using interpretation of satellite images and were identified as working units. In the working units creating are assumed which are homogeneous in the soil degradation. These units were controlled and investigated in the field operations and in the actual ground conditions. During the field operations was evaluated the soil sampling and analysis of laboratory results using the calculating of soil degradation indexes and soil quality degradation in the studies area. According to the field studies, soil samples and GLASOD Model user guide for soil degradation mapping were prepared degradation maps of soil in the working units. Field operations were performed aimed at field observations, determining the types and causes of soil degradation for preparing of degradation maps of soil. Also for soil samples taking in the working units and send to the laboratory were performed the analysis of soil quality characteristics such as organic carbon, total nitrogen, phosphorus and potassium, bulk density, pH and micro elements iron, zinc, manganese and copper.

In this method, soil degradation is classified according to three classes of water erosion (in three degrees of low, moderate and high), wind erosion (in three degrees of low, moderate and high), salinity (in four degrees of low, moderate, high and very high) and decline in nutrition (in four degrees of low, moderate, high and very high).

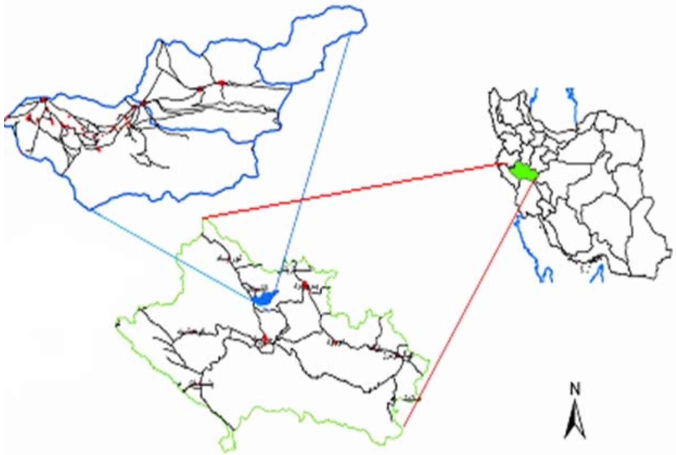

Fig. 1: The location of study area in Iran map

Soil Degradation Index (SDI) are calculated by equation (1) :

$$SDI = \left[\left(\frac{D}{ND}\right)100\right] - 100 \quad (1)$$

Where *SDI* is the percent of soil degradation index of each soil parameter, *D* is the amount of that parameter in soil sample, and *ND* is the upper limit of that parameter in each land type. For example, soil degradation index of organic carbon in working unit 1 is calculated based on *D*=1.13, ND=2.85, so *SDI*=-60.35.

For prepared the degradation maps of soil in GLASOD method, these factors are important; type, causes, degree, rate, extent and degradation history. One type of degradation comes obtain per working unit, which using of field visits and soil sampling delivers one equation and eventually will provide the degradations maps of soil. To evaluate the accuracy of this map were used of ground control points and the statistically comparison were performed using two Wilcox and paired comparisons tests.

Results and discussion

Soil degradation index in the Photomorphic units

Table 1 shows the results of soil degradation index in the photomorphic units. The highest and lowest degradation index of organic carbon was obtained respectively in 71 and 40 units in -66.82 and -10.77 percent. This indicated that due to rich vegetation and human interference in the 40 unit, there is low of organic carbon degradation in this area, and geological formation situation and lack of appropriate vegetation in the 71 unit vice versa, has causes of large degradation of organic carbon in this unit. Degradation index of organic carbon is more than -50 in 30 units. 44 and 40 units respectively with -64.80 and -6.80 percentage have highest and lowest degradation index of total nitrogen in the sub-basin. The highest and lowest degradation index of available Phosphorus is observed in 2 and 40 units respectively with -70.49 and -11.34 amounts of percent. 40 and 59 units have the lowest and highest degradation index of available potassium in -6.67 and -43.30 percent respectively. Iron Degradation index varied from -13.73 to -58.08 percent which were observed in the 49 and 58 units respectively. The lowest and highest on degradation index of Zinc were obtained in -10.87 and -60.87 percent respectively in 49 and 57 units. most indexes of Manganese and Copper were observed in -42.86 and -60.95 percent respectively in 8 and 44 units. The 40 and 32 units respectively have the lowest index of Manganese and Copper degradation in the case study in -6.67 and -12.38 percent.

Soil degradation ID in the Photomorphic units

Fig 2 shows the results of degradation map and soil degradation ID by GLASOD model in the photomorphic units. There are four major degradations types includes; water erosion by soil depth reduces (Wt), water erosion by shape changing and materials moving (Wd), chemical degradation by reduction of organic matter or nutrients or In other words, degradation of soil fertility (Cn), and physical degradation on bulk density or density of soil factor (Pc). Based on offered ID the degradation because is the loss of trees and vegetation, excessive livestock grazing and wrong agricultural activities by farmers. In the sub-basin is observed several degrees of degradation of soil. 29 units have severity of degradation 4 and 28, 15 and 2 units have severity of degradation respectively, 3, 2 and 1.

Table 1: Soil degradation index results in photomorphic working units

Working unit	Area (ha)	%O.C	TN	P	K	BD	Fe	Zn	Mn	Cu
1	42.3	-60.35	-61.05	-68.03	-34.74	13.04	-48.24	-45.38	-29.87	-43.43
2	1623.8	-64.21	-61.75	-70.49	-42.11	11.59	-50.50	-42.86	-40.26	-57.58
3	79.4	-52.28	-58.25	-61.48	-29.47	4.35	-35.05	-40.34	-28.57	-53.54
4	83.1	-51.93	-47.37	-57.38	-27.37	12.32	-32.43	-36.13	-27.27	-39.39
5	170.5	-58.25	-61.05	-45.08	-35.79	11.59	-29.81	-25.21	-16.88	-35.35
6	601.7	-53.33	-51.23	-48.36	-27.37	11.59	-37.67	-53.78	-38.96	-37.37
7	128.5	-61.40	-58.25	-62.30	-38.95	10.87	-41.19	-45.38	-29.87	-40.40
8	28.7	-52.28	-44.91	-64.75	-37.89	4.35	-33.06	-37.82	-42.86	-56.57
9	249.6	-56.14	-47.72	-55.74	-22.11	11.59	-30.53	-28.57	-33.77	-36.36
10	36.2	-61.75	-58.25	-58.20	-34.74	4.35	-31.53	-36.13	-40.26	-34.34
11	511.9	-60.00	-64.21	-56.56	-38.95	13.04	-50.23	-32.77	-31.17	-55.56
12	337.3	-51.93	-48.07	-54.10	-27.37	13.77	-34.78	-42.86	-37.66	-36.36
13	330.9	-62.46	-57.89	-60.66	-40.00	13.77	-40.56	-57.14	-40.26	-56.57
14	289.2	-51.58	-44.91	-58.20	-31.58	17.39	-43.54	-40.34	-31.17	-33.33
15	365.7	-55.09	-51.23	-47.54	-31.58	12.32	-45.17	-52.10	-28.57	-49.49
16	135.8	-41.40	-46.32	-51.23	-30.53	11.59	-55.01	-58.82	-40.26	-26.26
17	496.7	-45.26	-52.28	-54.10	-22.11	10.87	-43.27	-37.82	-24.68	-33.33
18	331.1	-40.00	-33.68	-53.28	-28.42	10.87	-21.23	-31.09	-16.88	-29.29
19	22.7	-17.54	-30.18	-40.98	-16.84	10.87	-51.76	-29.41	-23.38	-27.27
20	59.9	-56.14	-48.07	-61.48	-34.74	10.14	-43.99	-45.38	-33.77	-54.55
21	145.1	-53.33	-58.25	-62.30	-34.74	16.67	-57.9	-60.50	-35.06	-60.61
22	207.2	-41.75	-47.02	-49.18	-20.00	12.32	-51.22	-47.06	-29.87	-27.27
23	44.9	-51.15	-47.20	-56.70	-34.44	4.58	-50.93	-39.13	-30.67	-54.29
24	431.1	-52.69	-54.00	-48.45	-26.67	10.69	-41.08	-45.22	-30.67	-25.71
25	110.8	-31.15	-34.80	-51.55	-11.11	10.69	-34.09	-20.87	-10.67	-19.05
26	54.8	-19.62	-14.40	-46.39	-7.778	3.82	-51.18	-31.30	-21.33	-20.95
27	94.1	-57.31	-60.00	-51.55	-40.00	11.45	-50.17	-44.35	-29.33	-57.14
28	60.9	-53.46	-52.00	-59.79	-38.89	4.58	-46.13	-27.83	-33.33	-36.19
29	139.9	-52.31	-46.00	-58.76	-30.00	12.21	-40.74	-31.30	-25.33	-26.67
30	82.7	-59.23	-50.40	-63.92	-40.00	3.82	-51.52	-43.48	-34.67	-42.86
31	31.3	-51.54	-46.00	-54.64	-23.33	10.69	-38.97	-41.74	-29.33	-35.24
32	33.4	-45.77	-51.20	-36.08	-13.33	3.05	-20.62	-11.30	-10.67	-12.38
33	66.2	-65.77	-58.40	-70.10	-36.67	11.45	-47.81	-44.35	-37.33	-24.76
34	21.5	-54.23	-50.80	-56.70	-28.89	4.58	-31.73	-33.04	-28.00	-36.19
35	97.5	-36.15	-40.00	-21.65	-10.00	3.05	-52.36	-57.39	-32.00	-23.81
36	753.1	-53.85	-56.00	-44.33	-31.11	4.58	-32.41	-31.30	-26.67	-44.76
37	433.1	-42.31	-39.60	-51.55	-17.78	4.58	-31.23	-30.43	-26.67	-17.14
38	21.3	-60.00	-53.60	-58.76	-35.56	4.58	-50.34	-44.35	-37.33	-56.19
39	82.9	-53.46	-46.80	-55.67	-31.11	10.69	-41.75	-38.26	-24.00	-40.95
Working unit	Area(ha)	%O.C	TN	P	K	BD	Fe	Zn	Mn	Cu
40	139.4	-10.77	-6.80	-11.34	-6.67	3.05	-14.39	-13.04	-6.67	-15.24
41	180.5	-63.08	-58.00	-61.86	-36.67	14.50	-41.41	-35.65	-29.33	-50.48
42	245.9	-40.77	-45.60	-55.67	-17.78	11.45	-28.03	-21.74	-26.67	-20.95
43	132.2	-44.23	-43.60	-52.58	-21.11	12.98	-31.14	-51.30	-28.00	-40.00
44	188.7	-60.00	-64.80	-58.76	-42.22	13.74	-51.52	-59.13	-42.67	-60.95
45	399.4	-52.50	-43.18	-46.77	-27.84	3.08	-55.28	-49.28	-37.21	-54.15
46	68.2	-37.92	-46.82	-29.03	-15.46	12.31	-51.94	-44.20	-20.93	-21.95
47	110.2	-32.08	-37.27	-51.61	-17.53	3.85	-46.79	-41.30	-25.58	-34.63
48	192.9	-21.25	-17.27	-54.03	-29.90	6.92	-55.28	-24.64	-11.63	-31.71
49	18.4	-36.67	-51.36	-15.32	-10.31	3.08	-13.73	-10.87	-8.14	-16.10
50	157.9	-61.67	-56.82	-50.81	-31.96	13.08	-46.16	-50.00	-31.40	-39.51
51	231.1	-38.75	-36.82	-41.94	-21.65	3.85	-52.39	-42.75	-27.91	-35.61
52	106.8	-50.42	-53.18	-48.39	-27.84	13.08	-45.35	-47.83	-31.40	-36.59
53	101.8	-52.92	-45.00	-46.77	-30.93	2.31	-51.40	-50.72	-36.05	-33.66
54	73.5	-32.50	-40.00	-54.03	-24.74	12.31	-41.46	-45.65	-26.74	-25.85
55	34.1	-51.25	-42.27	-59.68	-25.77	13.85	-48.51	-42.75	-38.37	-39.51
56	331.1	-51.25	-38.64	-45.16	-21.65	3.08	-53.21	-55.80	-41.86	-40.49
57	181.8	-40.00	-41.82	-53.23	-20.62	12.31	-45.26	-60.87	-30.23	-36.59
58	225.5	-47.50	-52.27	-49.19	-30.93	3.85	-58.08	-51.45	-33.72	-57.07
59	10.4	-59.58	-50.45	-61.29	-43.30	3.85	-49.14	-41.30	-38.37	-31.71
60	16.6	-63.64	-61.50	-59.65	-43.16	13.87	-51.25	-43.57	-30.95	-60.00
61	156.4	-54.55	-52.00	-42.98	-31.58	12.41	-40.29	-36.43	-26.19	-35.24
62	813.3	-52.27	-54.50	-61.40	-34.74	13.87	-48.08	-59.29	-36.90	-52.38
63	85.8	-52.73	-46.00	-55.26	-28.42	13.87	-36.35	-40.00	-26.19	-33.33
64	171.3	-31.36	-47.00	-52.63	-22.11	4.38	-32.21	-20.71	-10.71	-22.86

Table 1: Continue

65	65.8	-22.73	-32.00	-43.86	-15.79	2.92	-51.25	-52.14	-30.95	-32.38
66	113.4	-57.27	-48.50	-52.63	-29.47	3.65	-42.31	-57.86	-35.71	-35.24
67	29.9	-52.73	-44.50	-55.26	-32.63	2.92	-40.58	-48.57	-34.52	-35.24
68	46.2	-46.82	-40.50	-52.63	-18.95	12.41	-41.73	-37.14	-28.57	-40.00
69	14.3	-58.18	-48.50	-57.89	-26.32	4.38	-42.12	-46.43	-29.76	-37.14
70	107.2	-52.27	-51.00	-49.12	-29.47	5.11	-39.52	-41.43	-27.38	-30.48
71	46.6	-66.82	-54.00	-60.53	-41.05	13.87	-56.73	-50.00	-42.86	-60.00
72	168.6	-51.36	-53.00	-47.37	-23.16	4.38	-41.54	-42.86	-35.71	-34.29
73	60.8	-55.00	-43.00	-49.12	-25.26	3.65	-53.94	-45.00	-36.90	-36.19
74	173.1	-59.55	-53.00	-61.40	-38.95	13.14	-48.08	-47.14	-34.52	-35.24

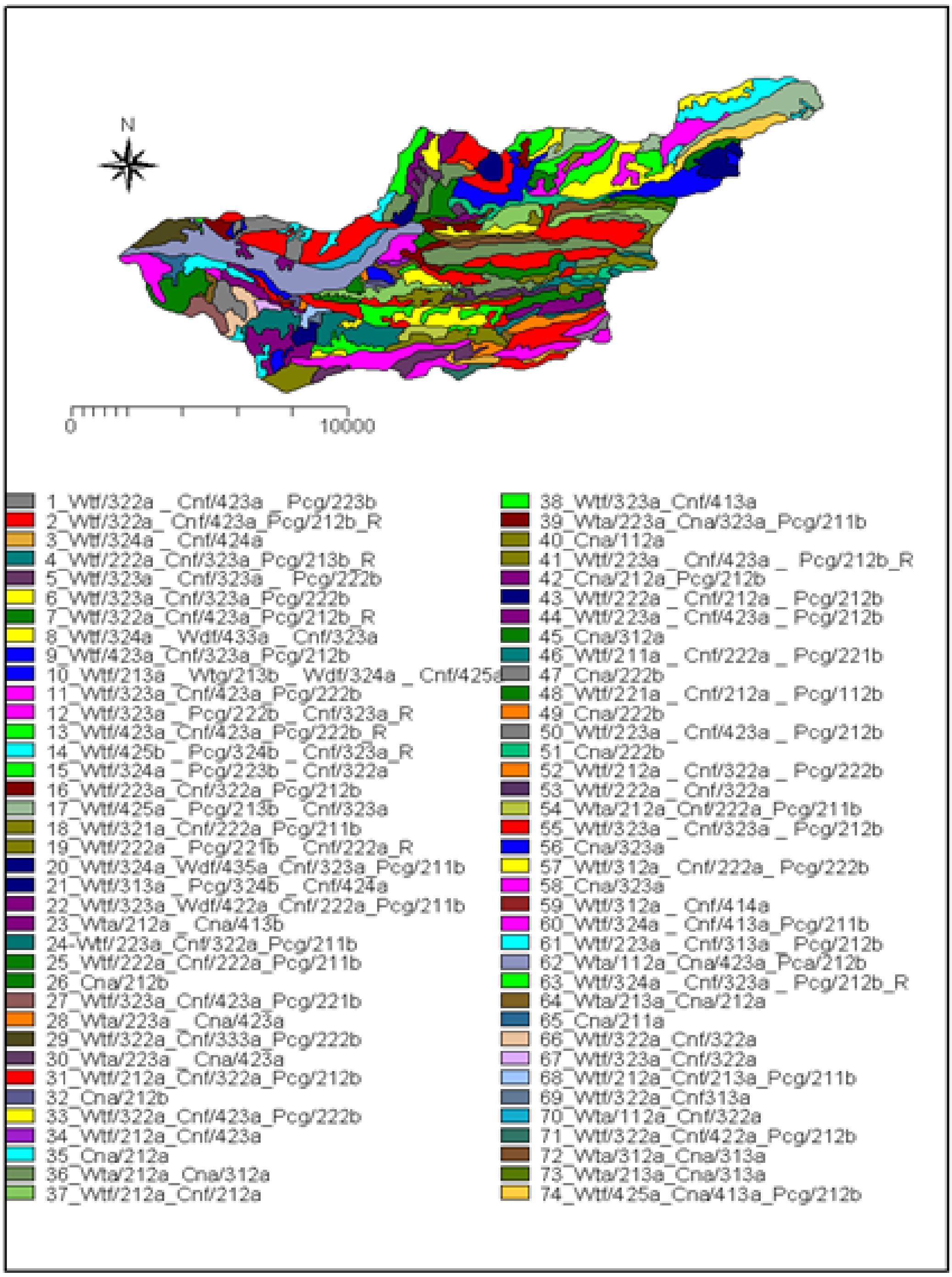

Fig. 2: Soil degradation map by GLASOD model in photomorphic units

The accuracy of soil degradation map in the Photomorphic units

The results showed that the degree of fertility degradation in Photomorphic units and ground control points were similar in 51 points from 69 points and are different in the 18 points. Therefore the accuracy of degradation maps of soil in the interpretation of satellite image units is estimated in 73.9 percentage.

The results showed that the calculated t value in the paired comparisons test is 0.48 and it is less than table t at the five percent level (1.67). Therefore accepted the zero assumption based on not different in the degree of degradation fertility of ground control points and Photomorphic units in five percent levels and there is not significantly different.

Also, results showed that calculated Z-value at the Wilcox test is 0.47 and it is less than of table Z in five percent level (1.96). Therefore accepted the zero assumption based on not different in the degree of degradation fertility of ground control points and Photomorphic units in five percent level and there is not significantly different. The results of degradation map accuracy of soil in the Photomorphic units and statistical tests shows that, this map was close to the ground truth and there is no significant differences with that and could be to use that for evaluate the accuracy and precision of soil degradation maps in the working unit determination methods.

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