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ORIGINAL ARTICLE

Using Topography Position Index and Relationship between Land Use AP and Geology for Determination of Quaternary Landform in Zagros Mountain

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ABSTRACT
Study of landforms is important in geomorphology science. Because they provide lands for people who seek shelter, and other opportunities in agriculture and industrial. Landform is one of the most important landscape components in conditions of the Mountain. So in the research used the Zagros Mountain, Iran as case study. Information on land forms are based on digital elevation models (DEM)and field research. The information on other landscape components was taken from existing resources (pedagogical map, forestry typological map). in the research aim is to evaluate the Jennes algorithm for landform classification and their suitability for predictive mapping of agriculture by analysis of spatial relationships between resulting landforms and land use map for determination of areas suitable for agriculture land. Input data for landform classification is digital elevation model (DEM) with resolution of 90 m. we used 5 case study in the Zagros Mountain that consist of Dena, Zardkooh, Oshtorankooh, Shahoo and Grain mountain. After prepared landform classification map for each of sub basin, used land use map to determination landforms suitable for agriculture. The results show that open slope after plain is suitable for agriculture. Also results show that the evaluated method can be helpful in the predictive mapping of agriculture lands. The algorithm of landforms classification proposed by Jennes seem to be the most applicable method. The Jennes's approach uses a multi-scale approach by fitting a quadratic polynomial to a given window size using least squares.
Keywords: *land form classification, land use characteristics, digital elevation model, Jennes algorithms.*

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INTRODUCTION

Landform classification has been used as basic georelief descriptors in soil and vegetation and land use mapping [1] for a relatively long time. Utilization of automated landform classification started in 1990s [2-4].

In the past, geomorphometric properties have been measured by calculating the geometry of the landscape manually that can be time consuming [5, 6]. Recently, advances in computer technology, new spatial analytical methods and the increasing availability of digital elevation data have re-oriented geomorphometry [7,8] and promoted the development of computer algorithms for calculating geomorphometric properties of the Earth`s surface.

Landform units can be carried using various approaches, including automated mapping of landforms [9-12], classification of morphometric parameters, filter techniques, cluster analysis and multivariate statistics [3,13,14].

Several papers document applicability of land form classification and relationship with mapping of land use especially in steep land areas [10, 15].There are new opportunities in this field, resulting from existence of relatively precise global and regional digital elevation models.However, the terms and methods used in different fields of science vary in detail[16, 9].

The aims of in the paper is preparing landform map based on Jennes algorithm and determination of relationship landform classes with mapping land use in the Zagros mountains, Iran. The landforms are classified at two scales (5 and 45 cells) using digital elevation model (DEM)that show in Figure 1:

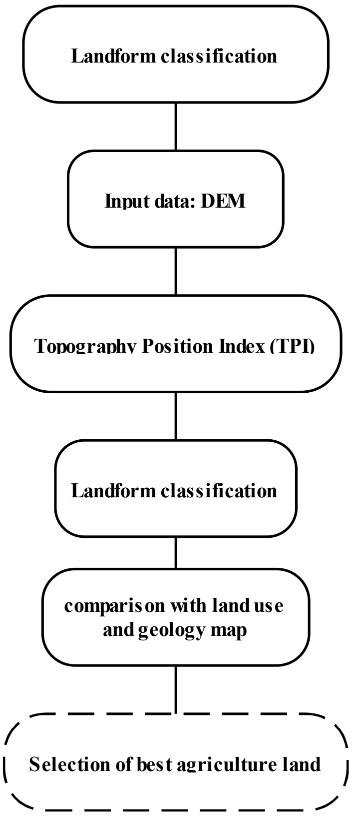


Figure 1. Flowchart of the study area

Digital elevation models (DEMs)

Digital elevation models were include SRTM DEM (90 m resolution). The NASA Shuttle Radar Topographic Mission (SRTM) produced DEM with spatial resolution of 90 m. The DEM downloaded from http://srtm.csi.cgiar.org was used.

MATERIALS AND METHODS

Zagros Mountains are one of the four major mountain ranges in Iran and have a variety of geological phenomena, such as landslides and folding. Iran's main oilfields lie in the foothills of the study area. In addition, it has a variety of landforms, making it suitable for the purposes of this study. The case areas were selected from ten different locations in Zagros Mountains in north east and east (Figure 1).

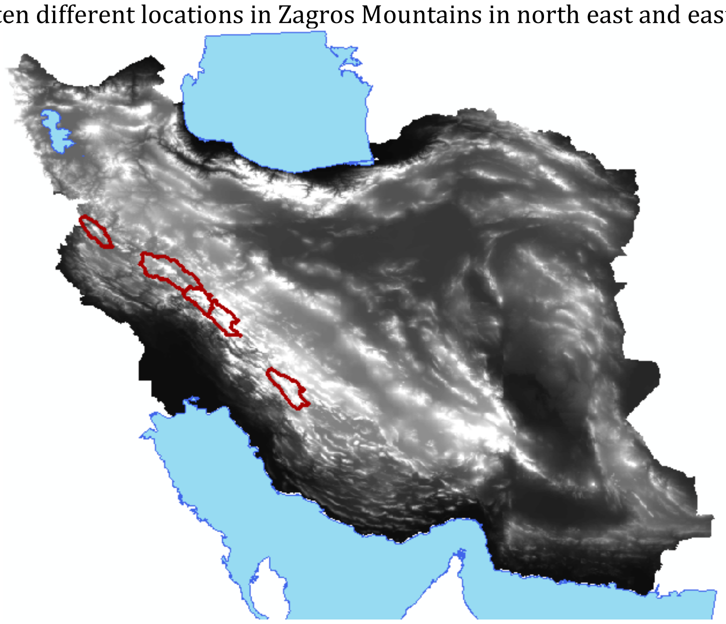
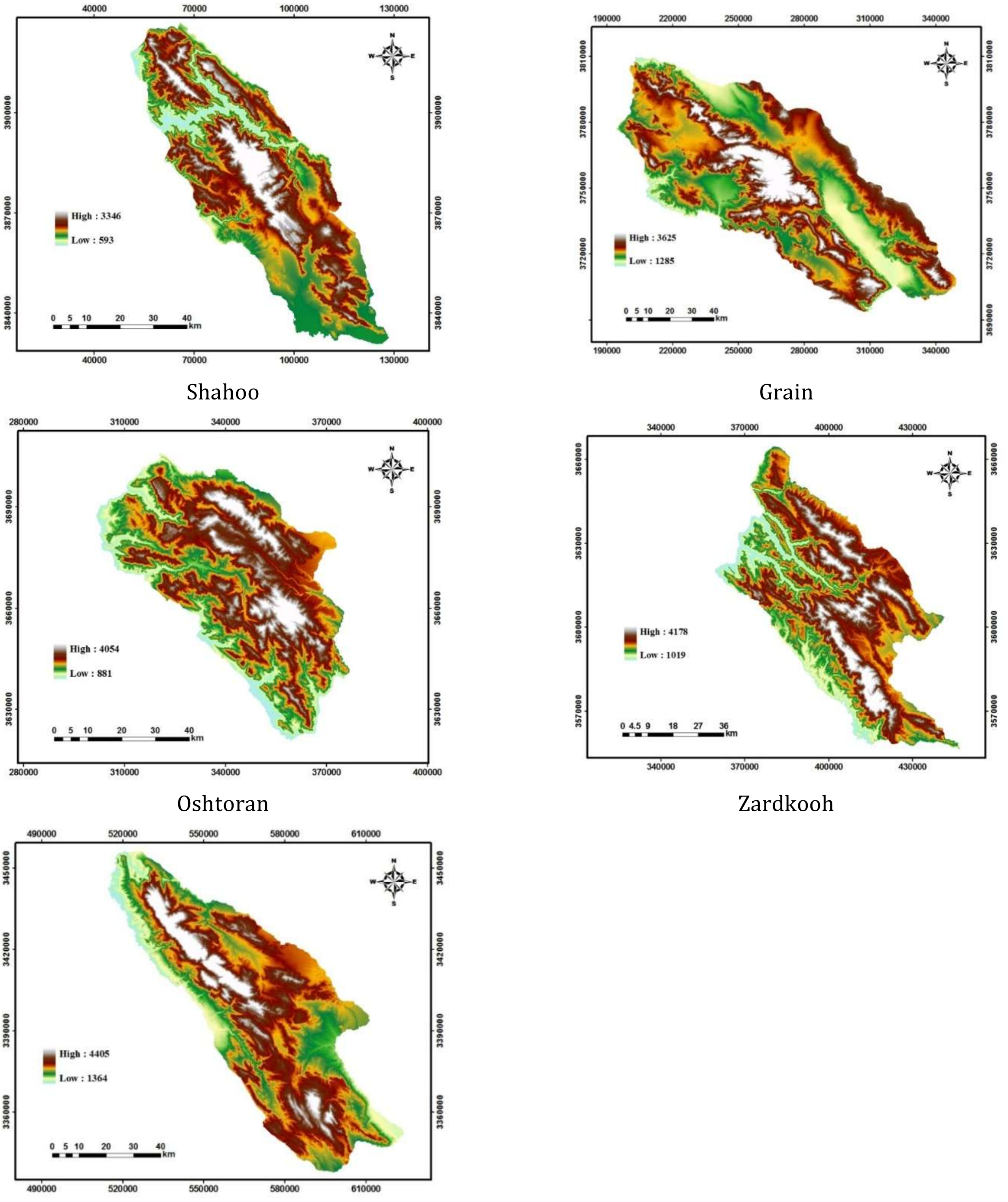


Figure 2: Digital Eelovation Mountain (DEM) of the study area

The case areas were selected from ten different locations in Zagros Mountains in north east and east that consist of: Shahoo, Grain, Oshtorankooh, Zardkoh, and Dena mountains. The study area is located at 30º 09′ 53′′ to 35º 23′ 07′′ N and 46º 03′ 30′′to 52º 17′ 13′′ E, with area of 1,293.23 km². The locations of the case areas are shown in Figure 3 and Table 1.



Shahoo

Grain

Oshtoran

Zardkooh

Dena

Figure 3. The case study in the research

Table 1. Characteristics of the cases study

Name	Elevation (m)			Slope (°)		
Shahoo	Max: 3345	Min: 598	Mean: 1690	Max: 89.99 º	Min: 0	Mean: 89.93 º
Grain	Max: 3626	Min: 1287	Mean: 1944	Max: 89.99 º	Min: 0	Mean: 89.94 º
Oshtorankooh	Max: 4049	Min: 885	Mean: 2283	Max: 89.99 º	Min: 0	Mean: 89.99 º

Zadkooh	Max: 4174	Min: 1028	Mean: 2523	Max: 89.99 º	Min: 0	Mean: 89.99 º
Dena	Max: 4415	Min: 1365	Mean: 2403	Max: 89.99 º	Min: 0	Mean: 89.98 º

Methods of classification

Estimation of topographic position index (TPI) [17] at different scales (plus slope) can classify the landscape into both slope position (i.e. ridge top, valley bottom, mid-slope, etc.) and a landform category (i.e. steep narrow valleys, gentle valleys, plains, open slopes, etc.). This method was further developed by Weiss [18] and Jenness [4]. Classification of landforms is based on analyses of TPI index at two different scales; therefore it requires 2 values of radius size. A computer version of this method is available as an extension for ArcView [4]. Topographic position index maps with radius size between 50 and 450 m were computed and used for landform classifications.

TPI (Eq. (19)) compares the elevation of each cell in a DEM to the mean elevation of a specified neighborhood around that cell. Mean elevation is subtracted from the elevation value at center.

$$TPI_i = Z_0 - \sum_{n-1} Z_n / n \quad (1)$$

Where;

Z_0= elevation of the model point under evaluation

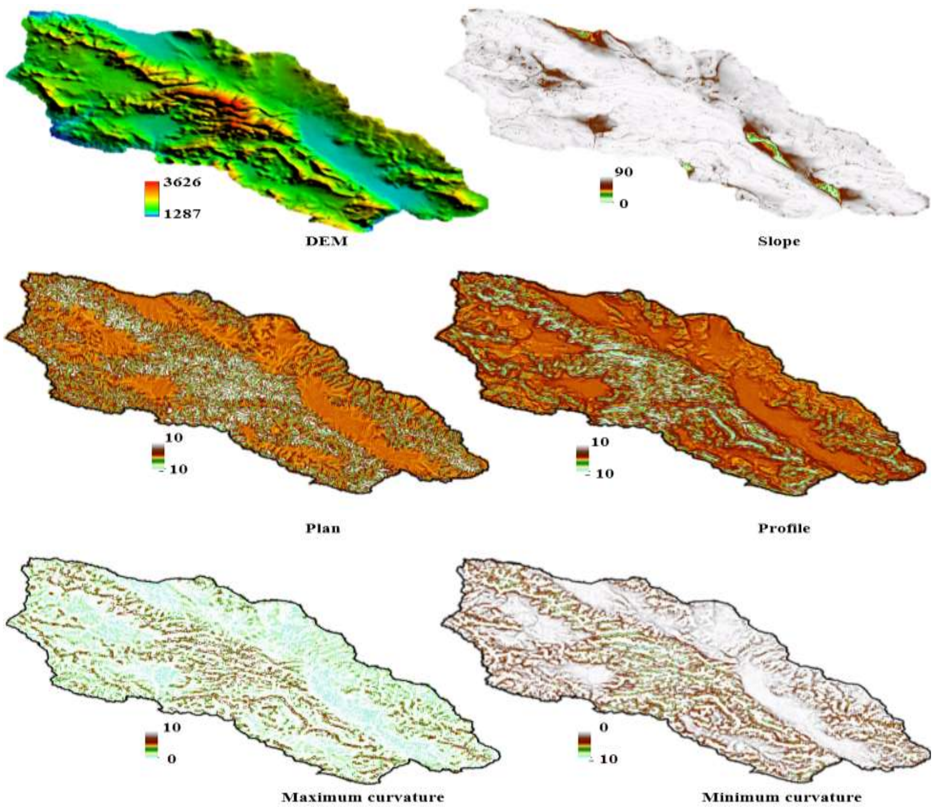
Z_n= elevation of grid

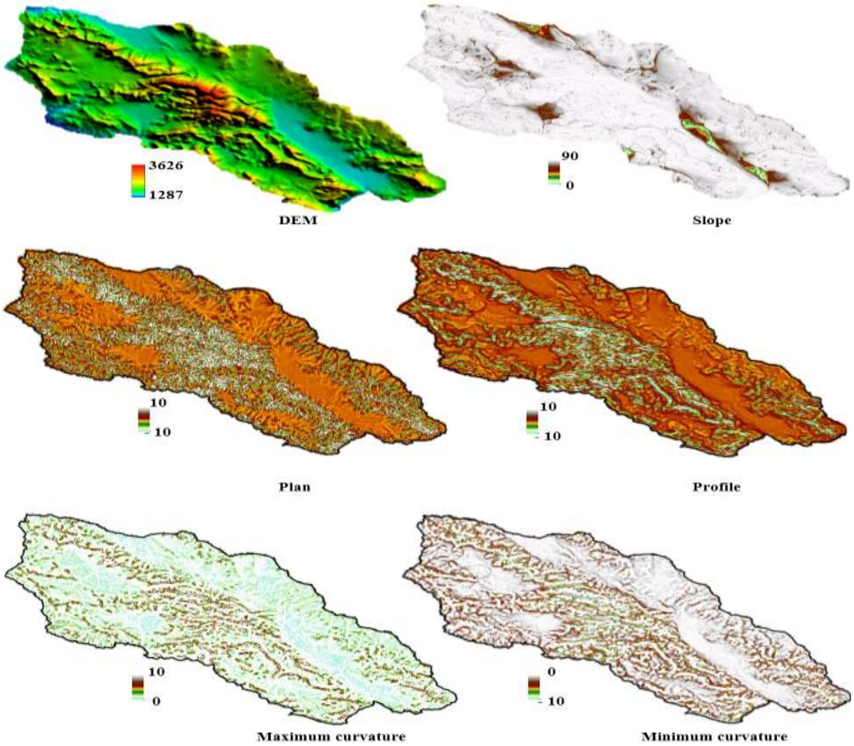
n = the total number of surrounding points employed in the evaluation

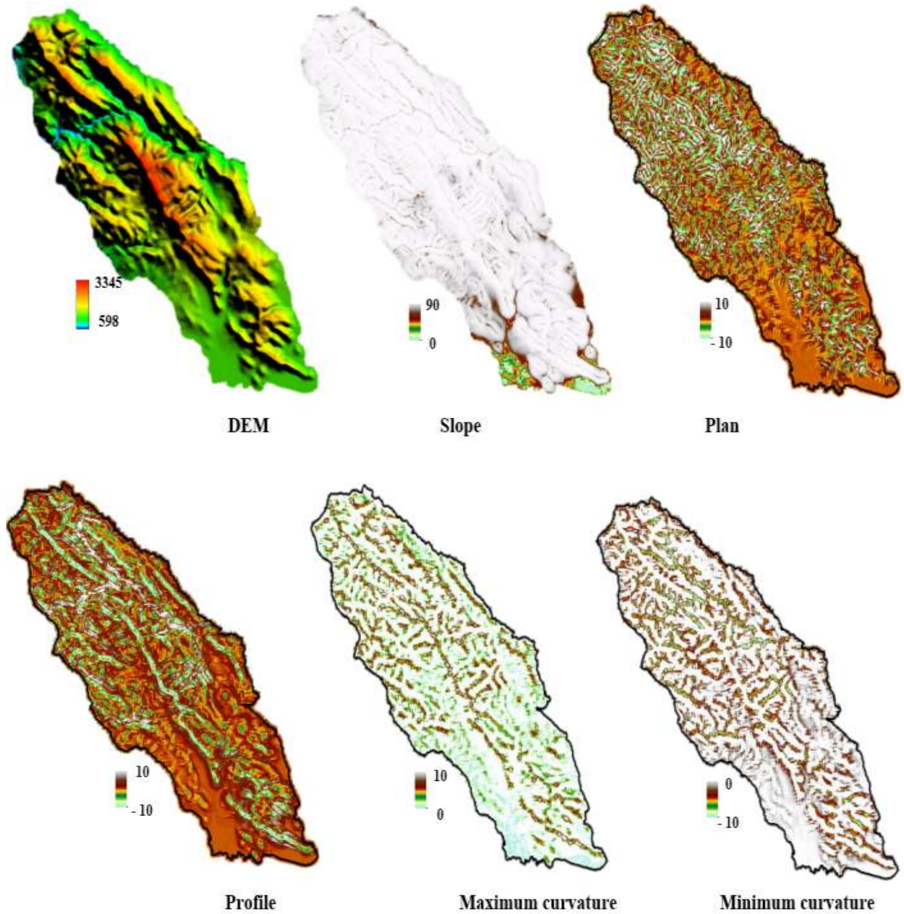
Combining TPI at small and large scales allows a variety of nested landforms to be distinguished. The exact breakpoints among classes can be manually chosen to optimize the classification for a particular landscape. As in slope position classifications, additional topographic metrics, such as variances of elevation, slope, or aspect within the neighborhoods, may help delineate landforms more accurately [18].

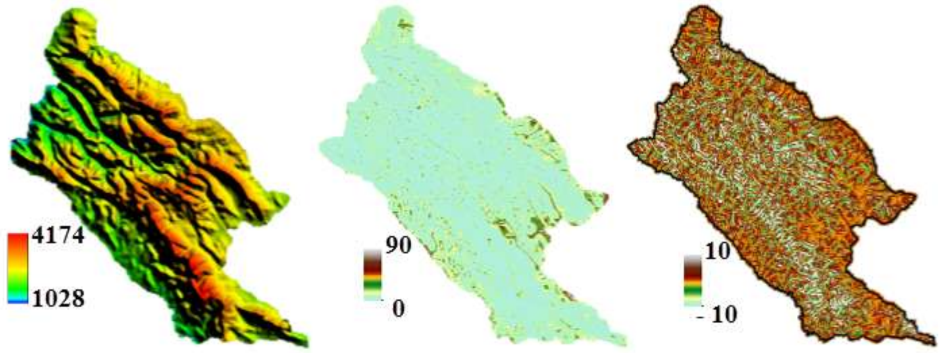
RESULTS

Different values of input parameters (slope, curvature, plan, profile, elevation) (Figure 4) used for preparing landform classification.

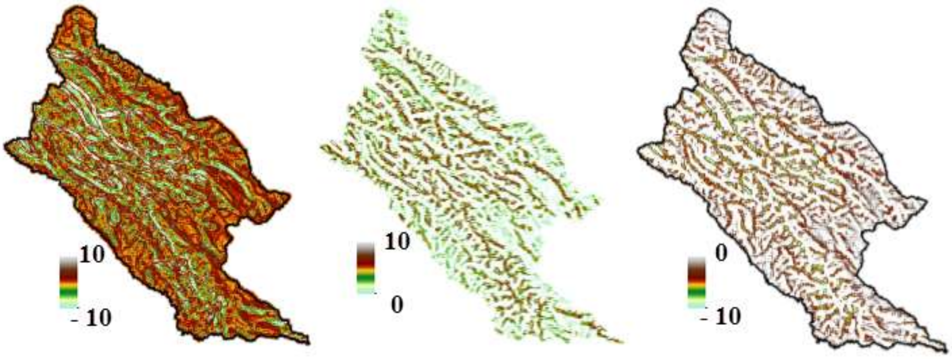



3626
1287
DEM
90
0
Slope
10
- 10
Plan
10
- 10
Profile
10
0
Maximum curvature
0
- 10
Minimum curvature

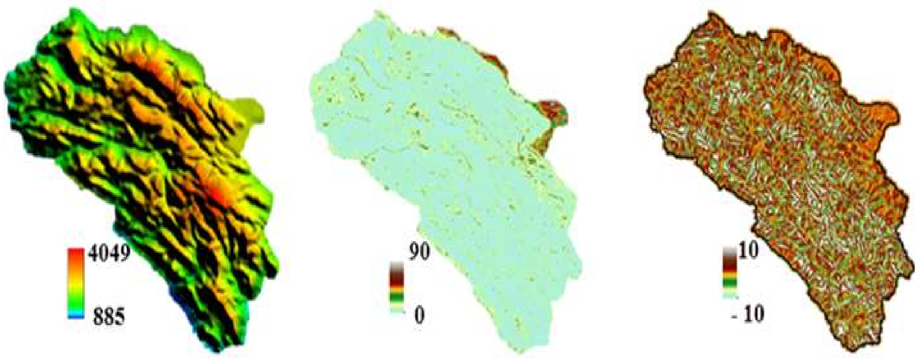

3345
598
DEM
90
0
Slope
10
- 10
Plan
10
- 10
Profile
10
0
Maximum curvature
0
- 10
Minimum curvature



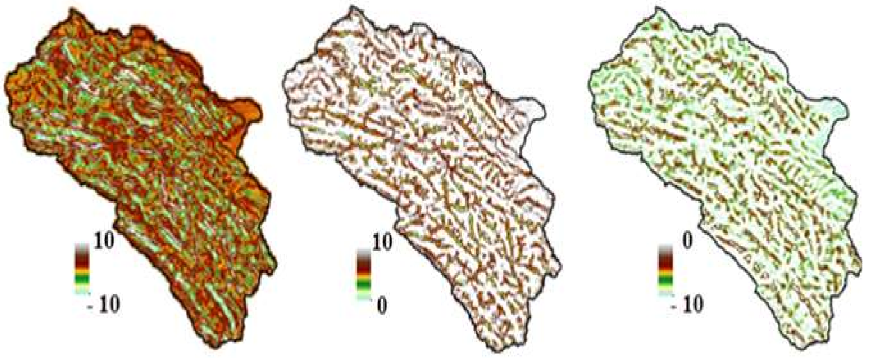
DEM Slope Plan



Profile Maximum curvature Minimum curvature



DEM (m) Slope (degree) Plan (1/m)



Profile (1/m) Maximum curvature (1/m) Minimum curvature (1/m)

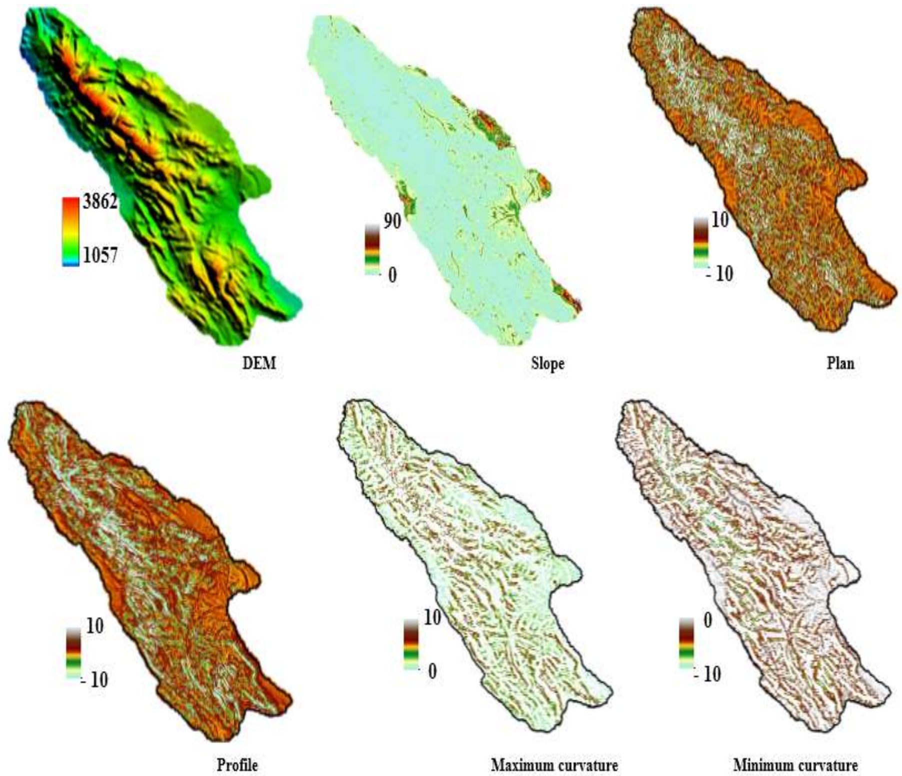
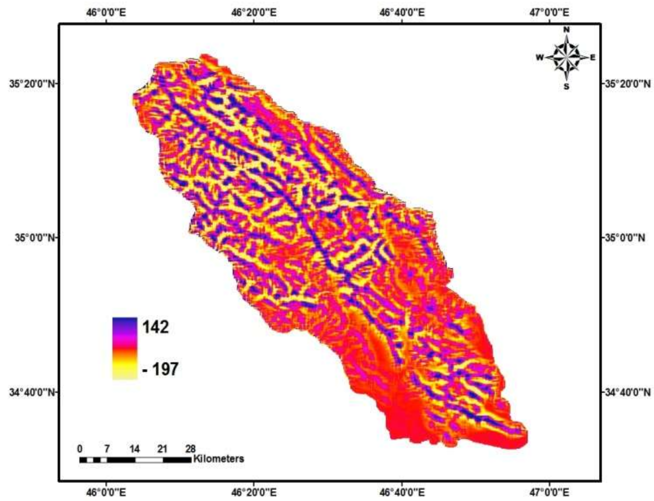


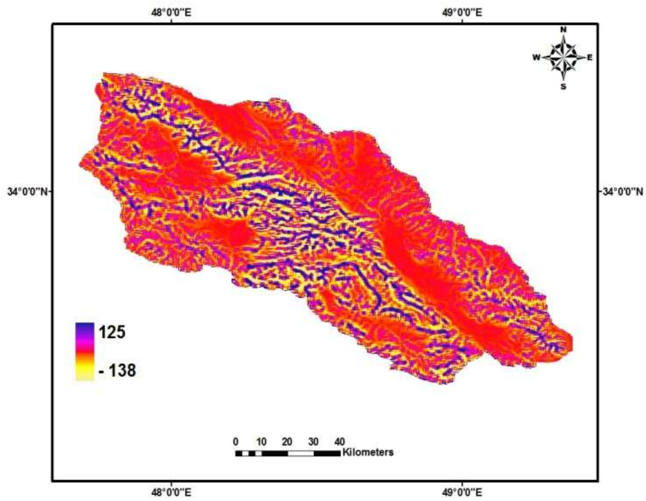
Figure 4. Input data for landform classification

For landform classification via Jennes algorithm, first of all prepared TPI map for each cases that show in Figure 5.

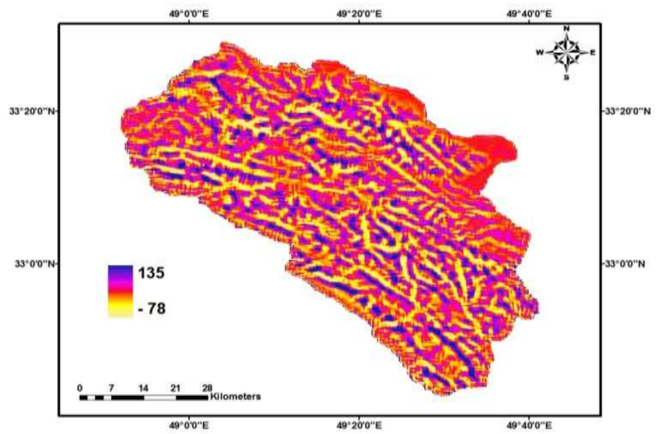
According to Figure 5, minimum and maximum TPI is -205 (red) and +172 (blue) for Zardkooh Mountain. The results show that the most concavity and convexity is in Zardkooh Mountain. Based on the TPI values the deepest valleys and most elevated areas are located in Zardkooh Mountain.



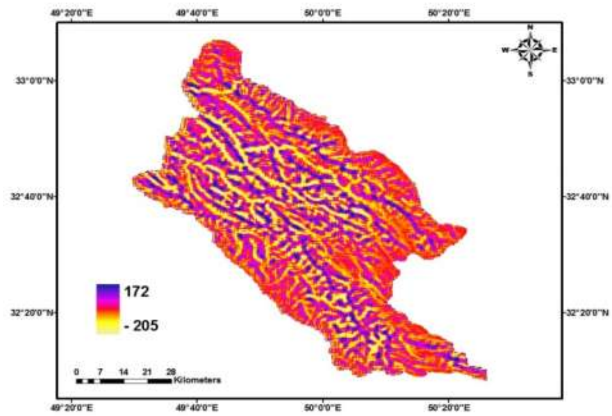
shahoo mountain



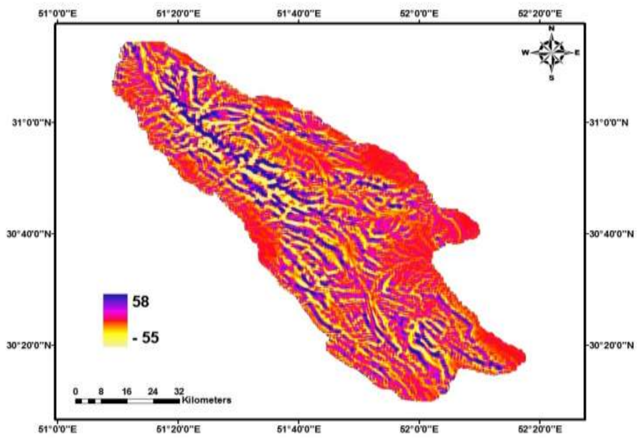
Grain mountain



Oshtorankooh mountain



Zardkooh mountain

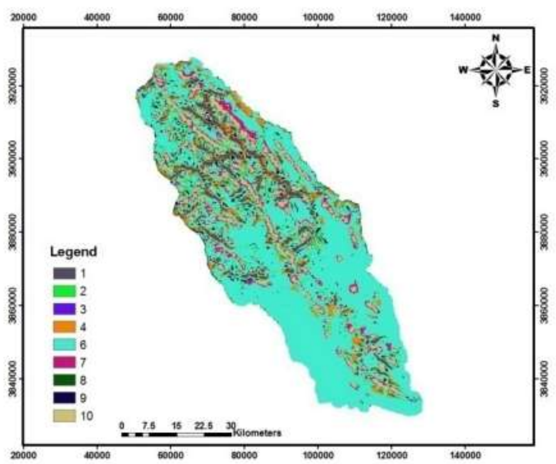


Dena mountain

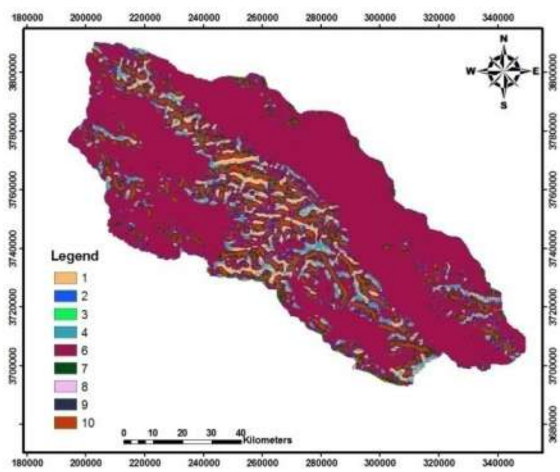
Figure 5. TPI value for the study area

After prepare TPI map for each of the cases study, the landform classification map were created (Figre 6 and Table 2).

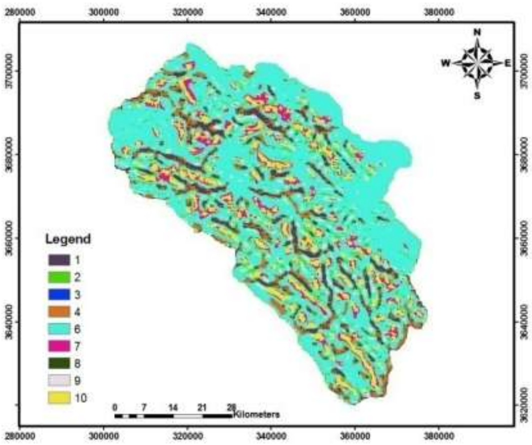
Landform classification maps generated based on the computed TIP values are shown in Figure 6. For this method, the classes consist of canyons/deeply incised streams, midslope drainages/shallow valleys, upland drainages/headwaters, u-shaped valleys, plains small, open slopes, upper slopes/mesas, local ridges/hills in valleys, mid slope ridges/small hills in plains, mountain tops/high ridges. It is observed that, all of cases don't have plain small class, the other cases have 10 classes of landform.



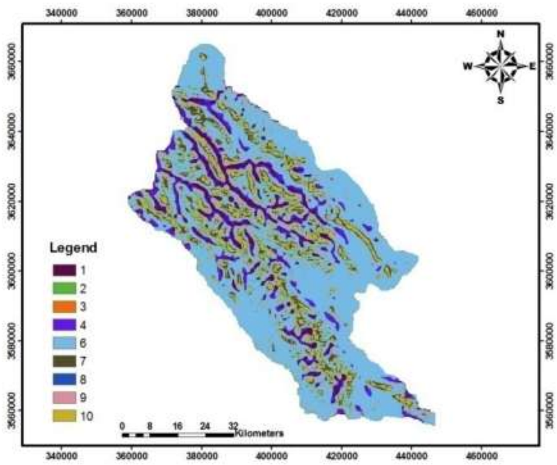
Shahoo mountain



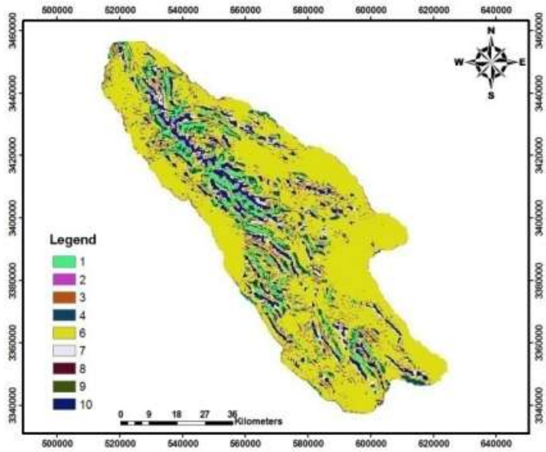
Grain mountain



Oshtorankooh mountain



Zardkooh mountain



Dena mountain

Figure 6. Landform classification map

Table 2. Areas of features for the landform classification maps in Figure 6.

Code	Classes	Shahoo mountains	Grain mountains	Oshtorankooh mountains	Dean mountain
1	Canyons, Deeply Incised Streams	34939	61592	36700	43585
2	Midslope Drainages, Shallow Valleys	21443	46194	24922	37115
3	Upland Drainages, Headwaters	85	2040	47	499
4	U-shaped Valleys	29687	64921	35639	33062
5	Plains Small	0	0	0	0
6	Open Slopes	301151	886425	287089	484737
7	Upper Slopes, Mesas	28870	56421	30409	31160
8	Local Ridges/Hills in Valleys	510	584	463	369
9	Mid slope Ridges, Small Hills in Plains	18995	33166	21190	30844
10	Mountain Tops, High Ridges	46825	97383	47902	62093
Sum		482505	1248726	484361	723464

In order to determination of land suitable for agriculture used land use map in the study area. The land use map show in Figure 7.

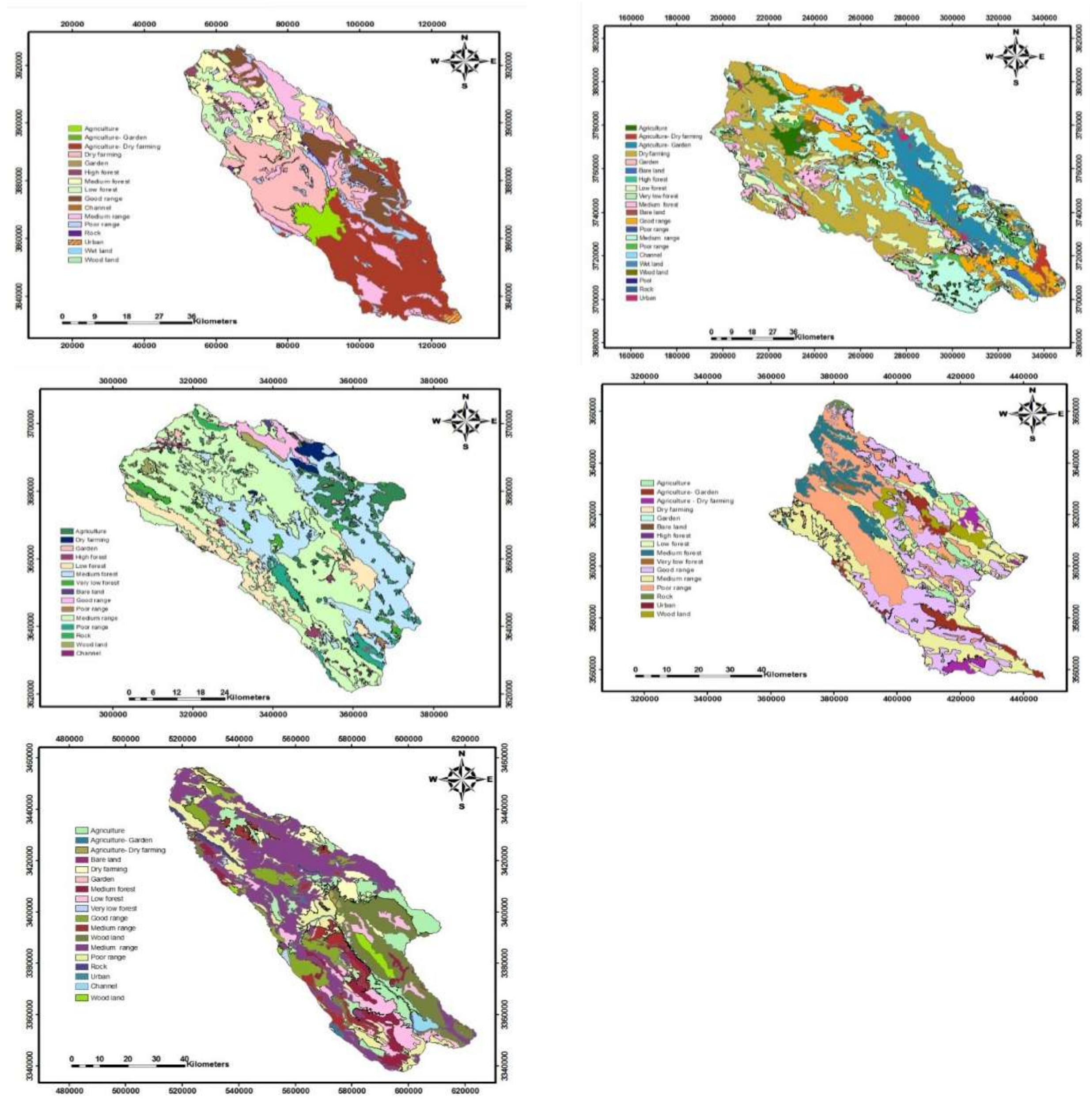
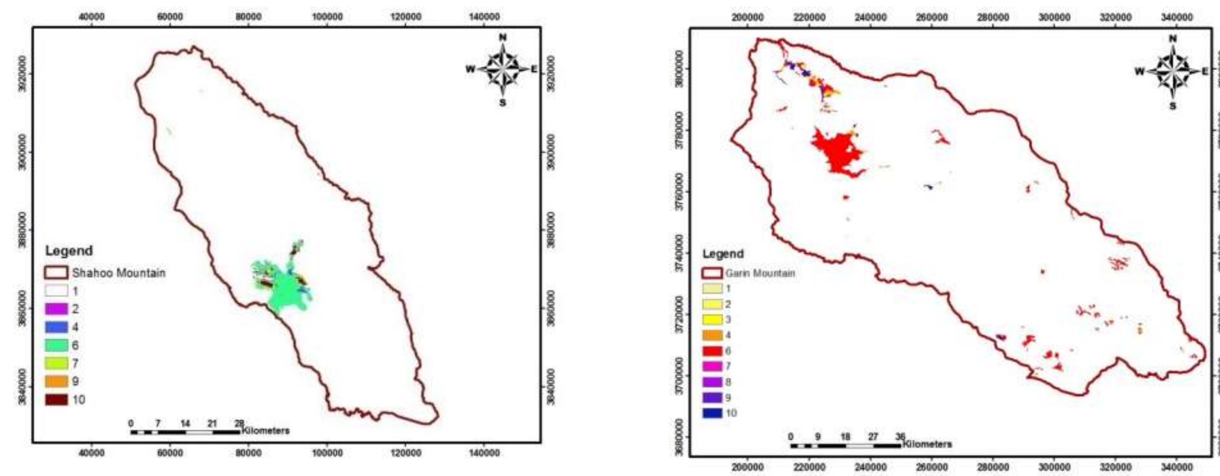
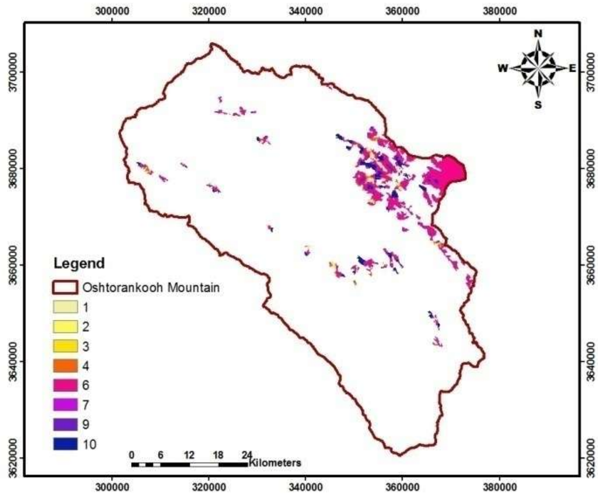


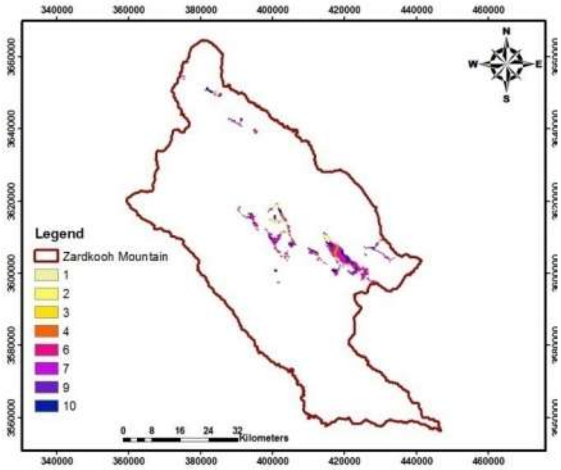
Figure 7. Land use map for the study area

The landform classes that located in agriculture land show in Figure 8, Figure 9 and Table 3.

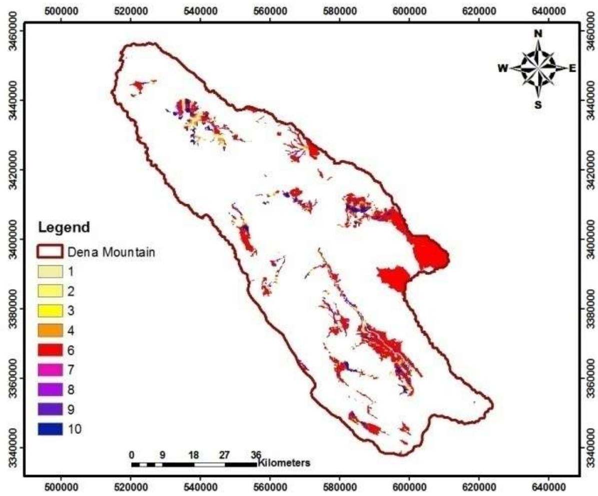


Shahoo Grain





Oshtorankooh Zardkooh

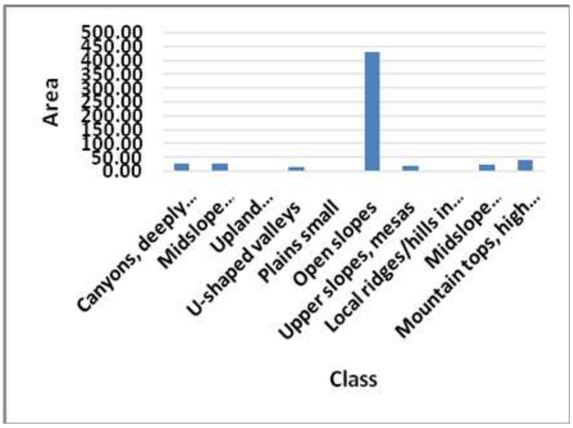


Dena

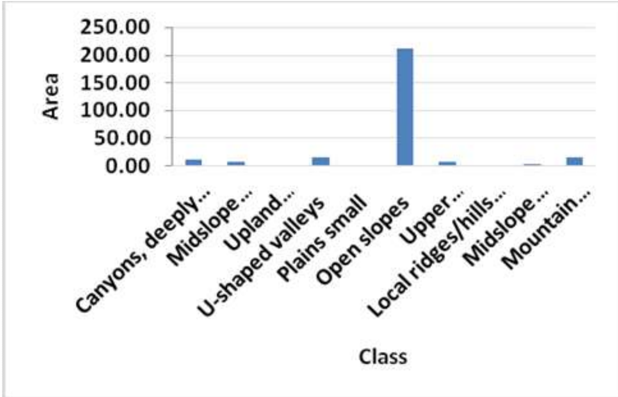
Figure 8. Landform classes that located in agriculture land

Table 3. Characteristics of landform classes that located in agriculture land

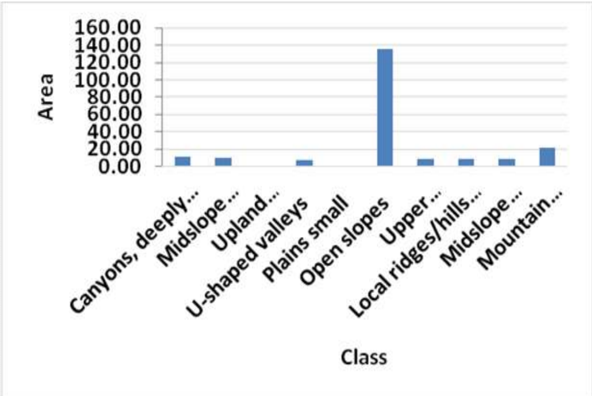
	classes	Dena	Grain	Oshtoran	Shahoo	Zardkooh
1	Canyons, deeply incised streams	31.28	10.86	10.17	6.24	11.61
2	Midslope drainages, shallow valleys	31.37	6.66	8.51	3.16	3.76
3	Upland drainages, headwaters	0.12	0.17	0.04	0.00	0.01
4	U-shaped valleys	18.70	14.85	6.70	5.86	6.14
5	Plains small	0.00	0.00	0.00	0.00	0.00
6	Open slopes	433.36	212.33	135.16	93.35	47.51
7	Upper slopes, mesas	20.43	6.55	8.20	5.94	9.40
8	Local ridges/hills in valleys	0.39	0.02	8.20	0.00	0.00
9	Midslope ridges, small hills in plains	26.43	2.80	7.68	4.20	4.13
10	Mountain tops, high ridges	41.37	14.24	20.74	9.66	14.09



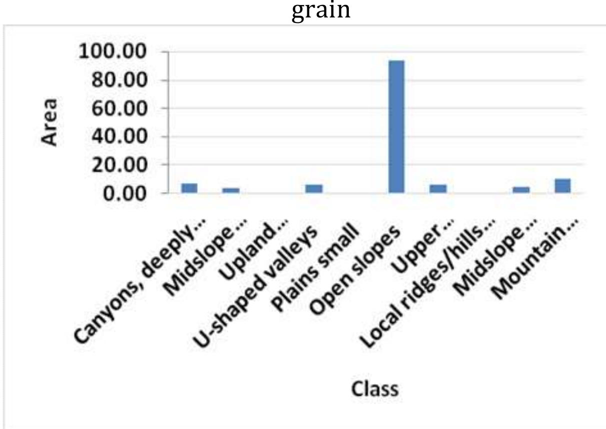
Dena



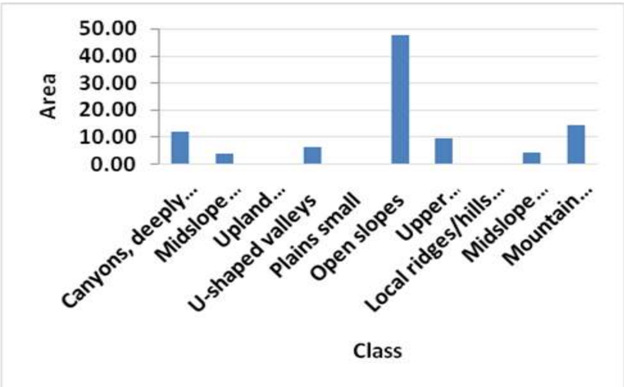
grain



oshtoran



shahoo



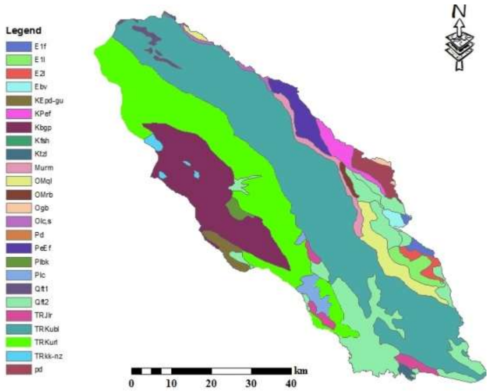
zardkooh

Figure 9. Area of each of classes that located in agriculture land

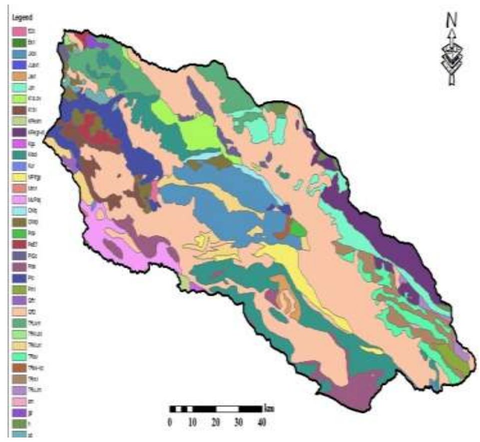
As shown in Figure 9, the open slope has most area on the agriculture land for cases study in Zagros Mountain, Iran. So class of the open slope as a good land for agriculture activities is recognized in the study.

Also the geology maps and relationship with land use and landform maps were prepared for five cases study. The results of the geology maps shown in Figure 10 and Figure 11.

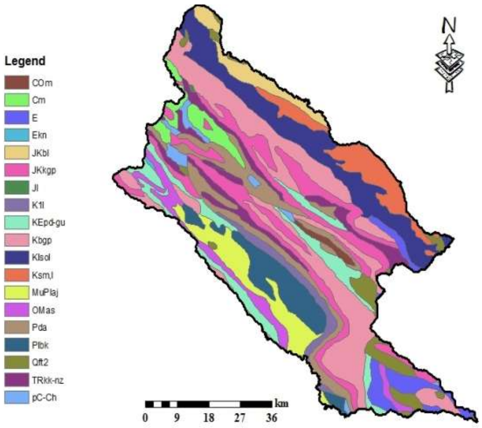
In the Dena Mountain, most geology units are low level piedmont fan and valley terrace deposits and limestone. Also for the Grain Mountain, most geology units area low level piedmont fan and valley terrace deposits and limestone. Most geology units are dolomitic limestone and thick layers of anhydrite in alternation with dolomite in middle part on the Oshtorankooh Mountain and in the Zardkooh Mountain, dolomitic limestone and thick layers of anhydrite in alternation with dolomite in middle part and limestone are more geology units.



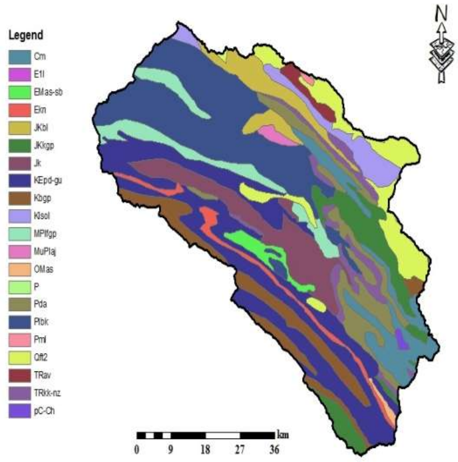
Shahoo mountain



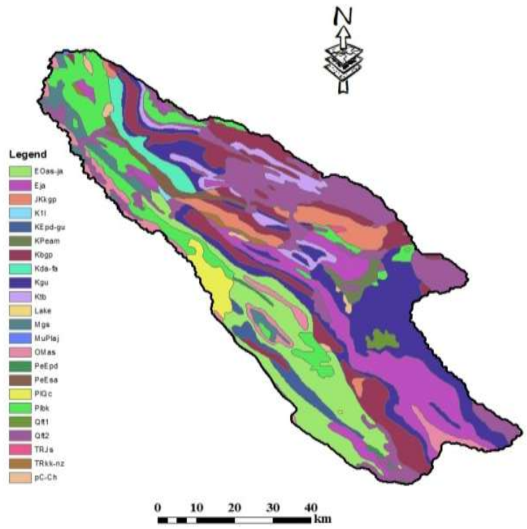
Grain mountain



Zardkooh mountain

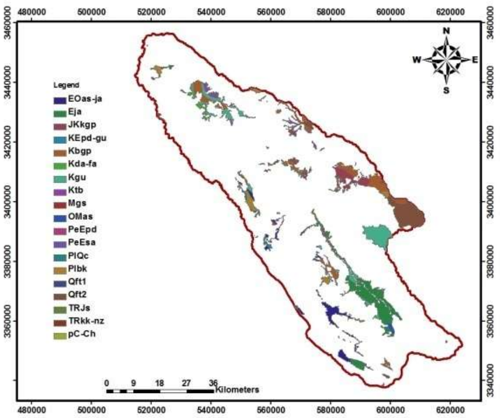


Oshtorankooh mountain

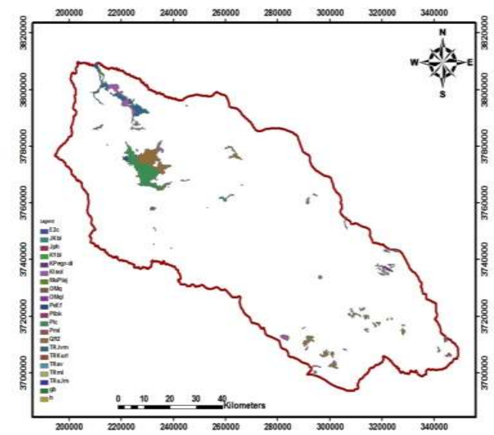


Dena mountain

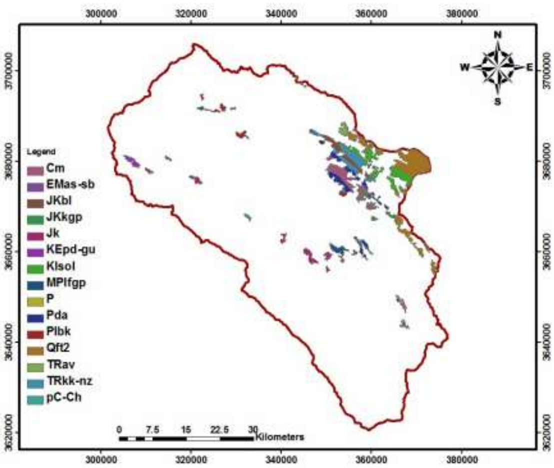
Figure 10. Geology map for the study area



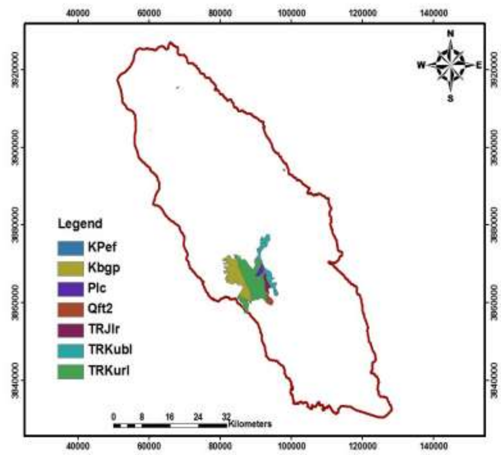
Dena mountain



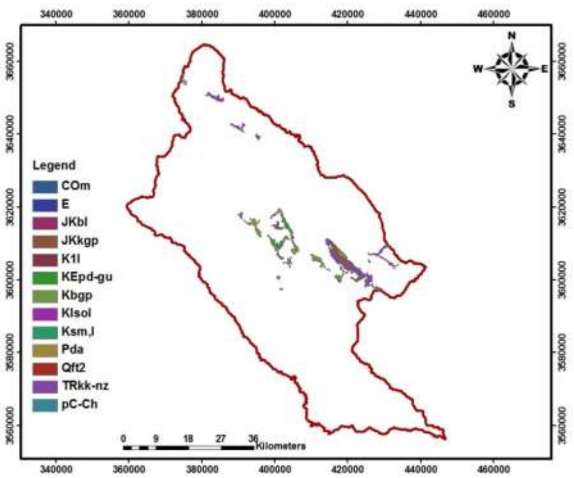
Grain mountain



Oshtorankooh mountain

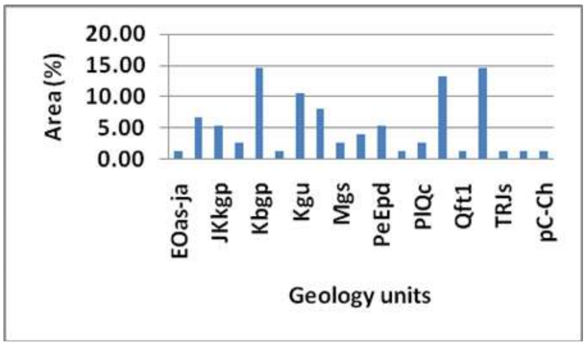


Shahoo mountain

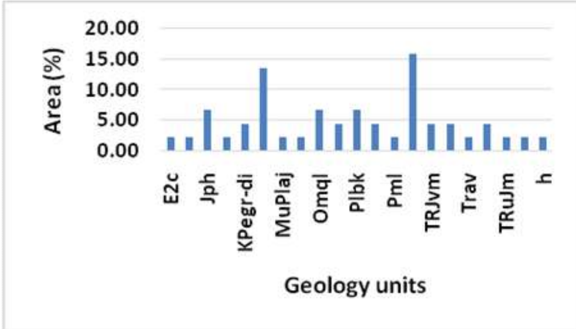


Zardkooh mountain

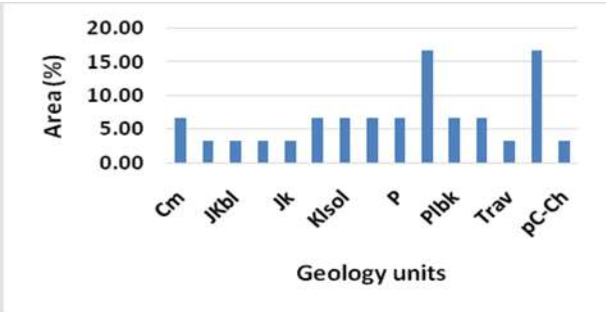
Figure 11. Geology units that located in agriculture land



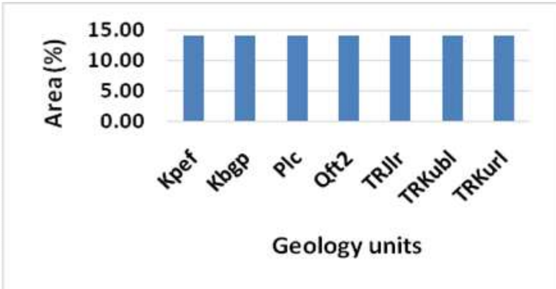
Dena mountain



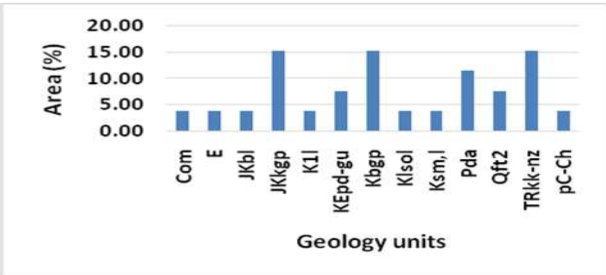
Grain mountain



oshtorankooh



Shahoo mountain



Zardkooh mountain

Figure 12. Area of each of geology unit that located in agriculture land

Table 4. Area of each of geology units for the study area

Dena (%)		Grain (%)		Oshtorankooh (%)		Shahoo (%)		Zardkooh (%)	
EOas-ja	1.33	E2c	2.27	Cm	6.67	Kpef	14.29	Com	3.85
Eja	6.67	JKbl	2.27	EMas-sb	3.33	Kbgp	14.29	E	3.85
JKkgp	5.33	Jph	6.82	JKbl	3.33	Plc	14.29	JKbl	3.85
KEpd-gu	2.67	K1bl	2.27	JKkgp	3.33	Qft2	14.29	JKkgp	15.38
Kbgp	14.67	KPegr-di	4.55	Jk	3.33	TRJlr	14.29	K1l	3.85
Kda-fa	1.33	Klsol	13.64	KEpd-gu	6.67	TRKubl	14.29	KEpd-gu	7.69
Kgu	10.67	MuPlaj	2.27	Klsol	6.67	TRKurl	14.29	Kbgp	15.38
Ktb	8.00	Omq	2.27	MPlfgp	6.67			Klsol	3.85
Mgs	2.67	Omql	6.82	P	6.67			Ksm,l	3.85
Omas	4.00	PeEf	4.55	Pda	16.67			Pda	11.54
PeEpd	5.33	Plbk	6.82	Plbk	6.67			Qft2	7.69
PeEsa	1.33	Plc	4.55	Qft2	6.67			TRkk-nz	15.38
PlQc	2.67	Pml	2.27	Trav	3.33			pC-Ch	3.85
Plbk	13.33	Qft2	15.91	TRkk-nz	16.67				
Qft1	1.33	TRJvm	4.55	pC-Ch	3.33				
Qft2	14.67	TRKurl	4.55						
TRJs	1.33	Trav	2.27						
TRkk-nz	1.33	TRml	4.55						
pC-Ch	1.33	TRuJm	2.27						
		gb	2.27						
		h	2.27						

CONCLUSIONS

Method of Jennes is the most promising algorithm for classification of landforms for agriculture lands predictive mapping. It is highly configurable and this increases its applicability in different types of relief.

Estimation of topographic position index according to Jennes [4] is also of high interest, because of variability of input parameters and simple user interface.
A terrain classification is one of the methods which can significantly help in boundary delineation of agriculture land. It is clear that the landforms themselves, without information on other landscape components, cannot successfully predict distribution of specific agriculture land. It is necessary to incorporate other characteristics of environment (e.g. geology) and other characteristics of georelief itself (elevation, slope and aspect with respect to solar radiation, wetness index and other).However, the map of landforms, based on DEM, can significantly help in predictive mapping of land use and farming.
In the research use algorithms of Jennes in the Zagros mountain. Input data for landform classification was digital elevation model (DEM). We used 5 sub-basin in the Zagros mountain that such as Dena, Zardkooh, Oshtorankooh, Shahoo and Grain mountain. The results showed that open slope have most area on the agriculture land for cases study in Zagros Mountain, Iran. So class of the open slope as a good land for agriculture activities is recognized in the study. Also the results of relationship between geology units, landform and agriculture land show that most geology units are low level piedmont fan and valley terrace deposits and limestone, dolomitic limestone and thick layers of anhydrite in alternation with dolomite in middle part. So according to landform classes can predict geology units and land use.
The future research will concern on detailed specification of input parameters of selected methods suitable for predictive mapping of specific land use and farming types.

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