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Investigation of Landform Classes in Geomorphology Units (Case Study: South of Isfahan, Fars Province, Iran)

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ABSTRACT

The aim of this study is to perform landform classification in the south of Isfahan, Iran. In order to make landform classification, Digital Elevation Models (DEMs) with 30 m resolution and Topographic Position Index (TPI) were used. Also, the percentage of each landforms classes in geomorphological units was determined. The results show that there were ten classes for the study area that consist of classes of canyons, shallow valleys, upland drainages, U-shaped valleys, plains small, open slopes, upper slopes, hills in valleys, midslope ridges and mountain tops. Also, the results show that the highest area of landform was for the classes of plain small for Playa unit. While for pediment unit, the area of landform was canyons, streams, U-shaped valleys, mountain tops and plains small. It was also determined that the highest area of landform for mountain units was mountain tops, canyons and stream landforms.

INTRODUCTION

Several papers documented the applicability of landform classification and relationship with mapping of soil, especially in steep land areas (Schmidt 2004). There are new opportunities in this field, resulting from the existence of relatively precise global and regional digital elevation models (Meybeck 2001). However, the term sand methods used in different fields of science vary in detail (Barka 2009, MacMillan 2000, Ratajczak & Jasiewicz 2009, Straumann & Purves 2008).

Geomorphometrics consist of geometry, topography, and physical landforms of the earth's horizons, over time, and branches out from the disciplines of geomorphology, geomatics and geomorphometry. It is a response to the development of this GIS technology, to gather and process DEM data (e.g. remote sensing, the Landsat program and photogrammetry). Geomorphometry provides a quantitative description of the shapes of landforms. According to Blaszczynski (1997), landforms are defined as specific geomorphic features on the earth's surface, ranging from large-scale features such as plains and mountain ranges to minor features such as individual hills and valleys. Geomorphometric properties have been measured by calculating the geometry of the landscape manually (Horton 1945, Miller 1953, Coates 1958). Recently, advances in computer technology, increased processing power, new spatial analytical methods and the increasing availability of digital elevation data have re-oriented geomorphometry (Pike 1999).

Landform units can be carried out using various approaches, including automated mapping of landforms (MacMillan et al. 2000, Burrough et al. 2000, Meybeck et al. 2001, Schmidt & Hewitt 2004, Saadat et al. 2008), classification of morphometric parameters, filter techniques, cluster analysis and multivariate statistics (Dikau et al. 1995, Dikau 1989, Sulebak et al. 1997, Adediran et al. 2004).

The purpose of the study is the make landform classification in south of Isfahan, Iran. In order to perform the landform classification Digital Elevation Models (DEMs) with 30 m resolution, and Topographic Position Index (TPI) were used. Also, the percentage of each landforms classes in the geomorphological units was determined.

MATERIALS AND METHODS

TPI (Weiss 2001) compares the elevation of each cell in a DEM to the mean elevation of a specified neighbourhood around that cell. Positive TPI values represent locations that are higher than the average of their surroundings, as defined by the neighbourhood (ridges). On the other hand, negative TPI values represent locations that are lower than their sur-

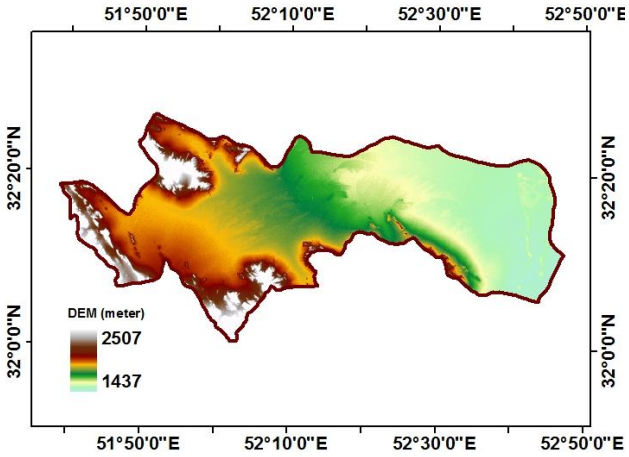


Fig. 1: Location of the study area.

roundings (valleys). TPI values near zero are either flat areas (where the slope is near zero) or areas of constant slope (where the slope of the point is significantly greater than zero) (Weiss 2001).

TPI (Eq. 1) compares the elevation of each cell in a DEM to the mean elevation of a specified neighbourhood around that cell. Mean elevation is subtracted from the elevation value at centre (Weiss 2001):

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

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 (Table 1). 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 neighbourhoods, may help delineate landforms more accurately (Weiss 2001).

In addition, the classes of canyons, deeply incised streams, midslope and upland drainages and shallow valleys, tend to have strongly negative plane form curvature values. On the other hand, local ridges/hills in valleys, midslope ridges, small hills in plains and mountain tops, and high ridges have strongly positive plane form curvature values.

STUDY AREA

The study area is south of Isfahan city which is located in 32°01' to 32°25' North and 51°24' to 42°38' East. The study area is located in the northeastern of Fars, Iran (Fig. 1), drains an area of 2,644 km^2. The elevation of the study area is from 1,437 to 2,507 m.

Table 1: Landform classification based on TPI (Source: Weiss 2001).

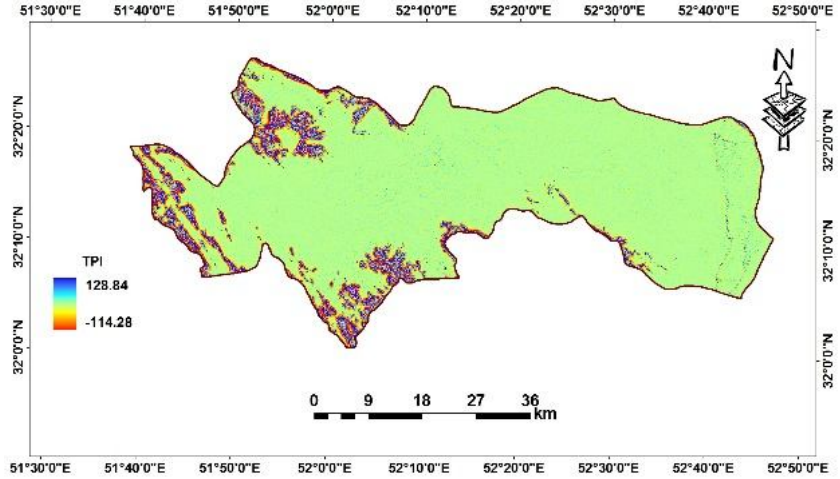
Classes	Description
Canyons, deeply incised streams	Small Neighborhood: $z_o \leq -1$ Large Neighborhood: $z_o \leq -1$
Midslope drainages, shallow valleys	Small Neighborhood: $z_o \leq -1$ Large Neighborhood: $-1 < z_o < 1$
Upland drainages, headwaters	Small Neighborhood: $z_o \leq -1$ Large Neighborhood: $z_o \geq 1$
U-shaped valleys	Small Neighborhood: $-1 < z_o < 1$ Large Neighborhood: $z_o \leq -1$
Plains small	Neighborhood: $-1 < z_o < 1$ Large Neighborhood: $-1 < z_o < 1$ Slope ≤ 5°
Open slopes	Small Neighborhood: $-1 < z_o < 1$ Large Neighborhood: $-1 < z_o < 1$ Slope > 5°
Upper slopes, mesas	Small Neighborhood: $-1 < z_o < 1$ Large Neighborhood: $z_o \geq 1$
Local ridges/hills in valleys	Small Neighborhood: $z_o \geq 1$ Large Neighborhood: $z_o \leq -1$
Midslope ridges, small hills in plains	Small Neighborhood: $z_o \geq 1$ Large Neighborhood: $-1 < z_o < 1$
Mountain tops, high ridges	Small Neighborhood: $z_o \geq 1$ Large Neighborhood: $z_o \geq 1$

Table 2: The area of the landform classification.

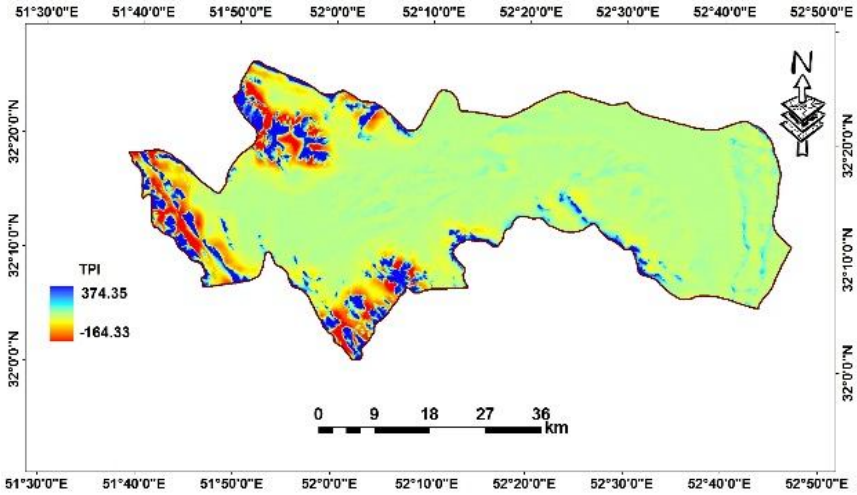
Landform	Area (%)	Area (km^2)
Canyons, streams	28.41	749.54
Shallow valleys	2.50	66.01
Upland drainages	1.40	36.81
U-shaped valleys	9.47	249.92
Plains small	27.68	730.21
Open slopes	0.05	1.19
Upper slopes	4.49	118.48
Hills in valleys	1.20	31.67
Midslope ridges	3.77	99.53
Mountain tops	21.02	554.64
	100.00	2638.00

Table 3: Slope of geomorphology units for the study area.

Classes (degree)	Slope units	Geomorphology
1	> 25	Mountain
2-1	8-12	Pediment
2-2	3-8	
2-3	1-3	
3	<1	Playa



TPI (5*5)



TPI (45*45)

Fig. 2: TPI value for the study area.

Table 4: Percent area of each geomorphology unit in ten landforms for the study area.

Slope/landform	1	2	3	4	5
Canyons, streams	18.92	24.47	37.21	56.75	42.13
Shallow valleys	2.81	2.73	2.35	1.98	1.42
Upland drainages	0.03	0.09	0.67	4.03	8.97
U-shaped valleys	8.14	9.91	16.50	6.79	1.59
Plains small	44.10	33.37	15.16	0.44	0.00
Open slopes	0.00	0.00	0.02	0.57	0.21
Upper slopes	5.24	5.03	3.99	2.91	2.17
Hills in valleys	0.17	0.49	2.84	3.54	2.97
Midslope ridges	3.85	4.60	4.27	0.82	0.59
Mountain tops	16.74	19.31	16.99	22.17	39.94
	100.00	100.00	100.00	100.00	100.00

RESULTS AND DISCUSSION

The TPI and landform classification maps generated are shown in Fig. 2. TPI is between -114.28 to 128.44 for scale of 5*5 and -164.33 to 374.35 for scale of 45*45 in quadratic parameterization. According to TPI of 5*5 and 45*45 landform map was prepared for the study area as shown in Fig. 3.

According to Fig. 3, it is determined that the classes of canyons, deeply incised streams, midslope and upland drainages, shallow valleys, and tend to have a strongly negative plane form curvature values. On the other hand, local ridges/hills in valleys, midslope ridges, small hills in plains

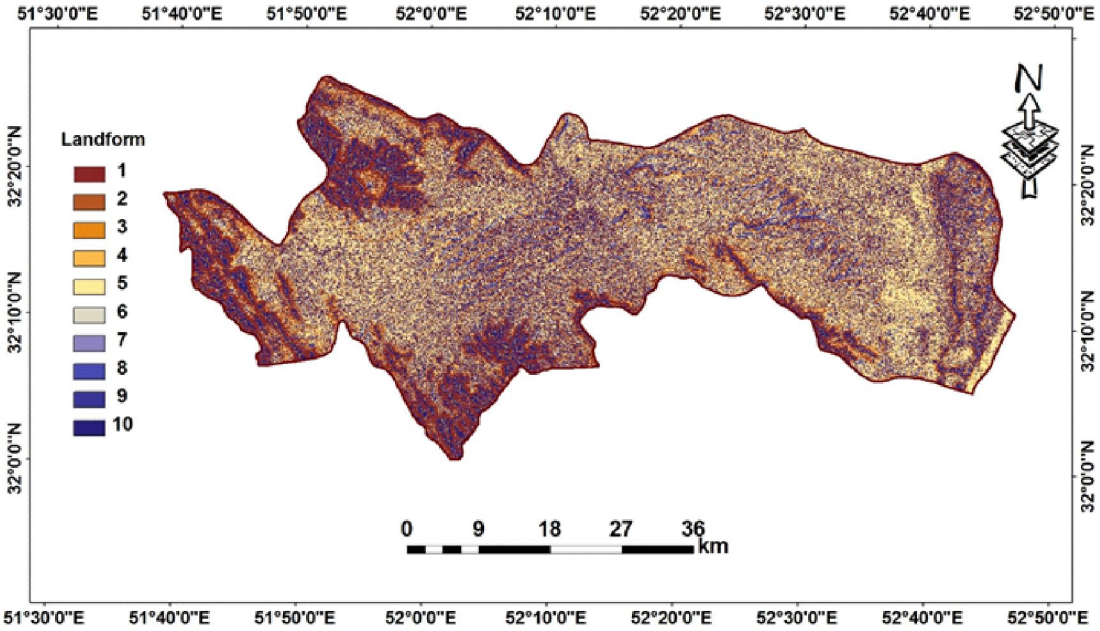


Fig. 3: Landform classification using TPI method.

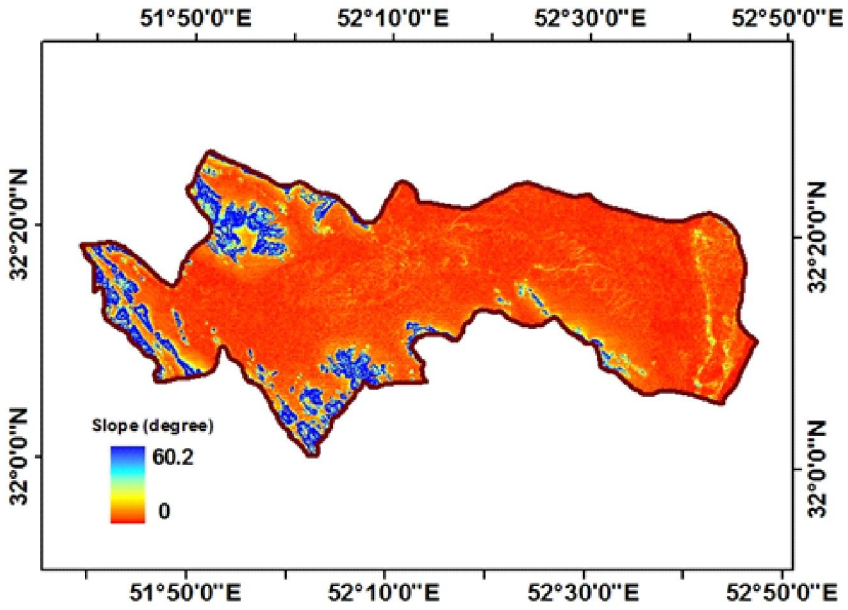


Fig. 4: Slope map of the study area.

and mountain tops, and high ridges have strongly positive plane form curvature values.

According to Fig. 3, it is determined that there are ten classes in the study area that consist of classes of canyons, shallow valleys, upland drainages, U-shaped valleys, plains small, open slopes, upper slopes, hills in valleys, midslope ridges, and mountain tops. The area of each class is given in Table 2. Based on Table 2, the high area for landform classification was canyons, streams with 28.41% (749.54 km^2), while the lowest area of landform classification was an open slope with 0.05% (1.19 km^2).

Finally, percentage of each landforms class in the geomorphological units was used in the slope map as shown in Fig. 4. Accordingly, slope more than 25 is mountain unit, slope lower than 1 is playa and slope between 25 and 1 is for pediment unit, were separated as three units (Table 3). The

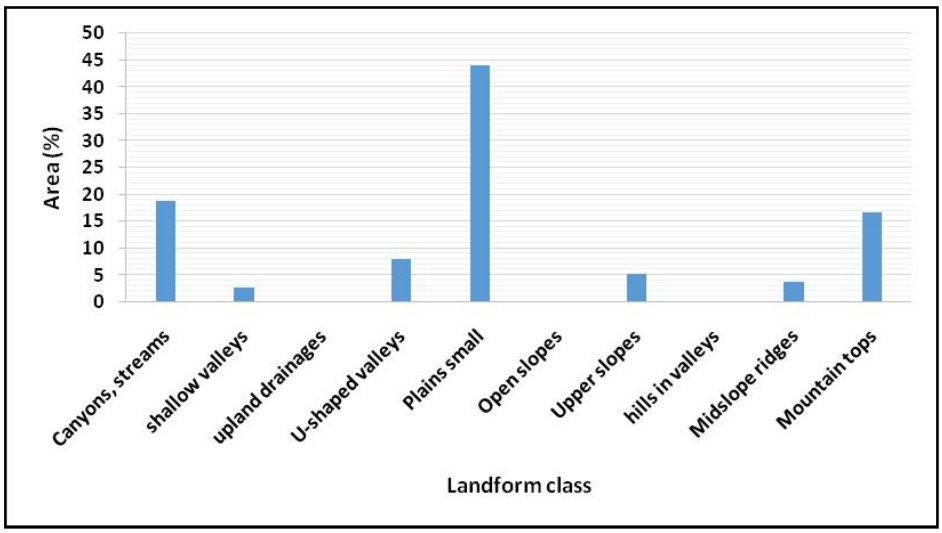


Fig. 5: Area of landform classes for playa unit.

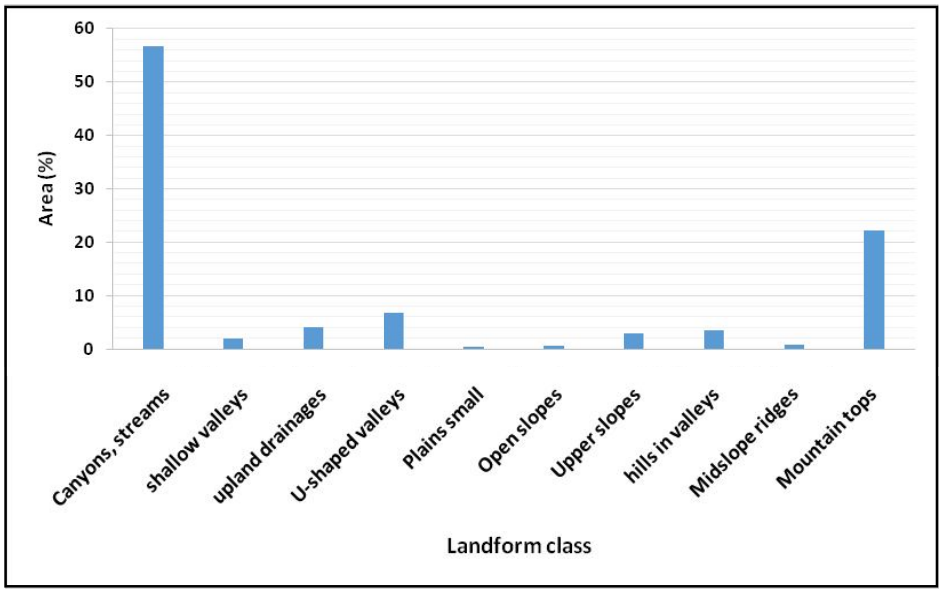


Fig. 6: Area of landform classes for pediment unit.

area for each geomorphology unit is given in Table 4.

Based on Table 4 and Fig. 5 to Fig. 7, the highest area of landform was for classes of plain small for playa unit. While for pediment unit, the area of landform was canyons, streams, U-shaped valleys, mountain tops and plains small. Also it was determined that the highest area of landform for mountain units was mountain tops and canyons, stream landforms.

CONCLUSION

Landforms are defined as specific geomorphic features on the earth's surface, ranging from large-scale features such as plains and mountain ranges to minor features such as individual hills and valleys. The aim of this study was landform classification in south of Isfahan, Iran. The results show that the highest area of landform was for classes of plain small for playa unit. While for pediment unit, the area of landform was canyons, streams, U-shaped valleys, mountain tops and plains small. Also it was determined that the highest area of landform for mountain units was mountain tops and canyons, stream landforms. The results show that there were ten classes for the study area that consist of classes of canyons, shallow valleys, upland drainages, U-shaped valleys, plains small, open slopes, upper slopes, hills in valleys, midslope ridges and mountain tops.

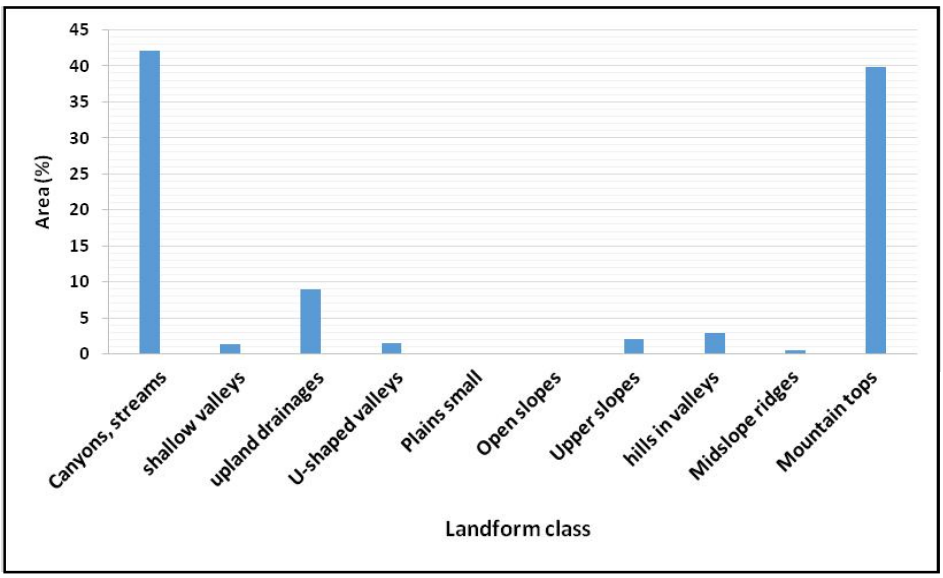


Fig. 7: Area of landform classes for mountain unit.

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