Using Topography Position Index for Landform Classification  
(Case study: Grain Mountain)

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ABSTRACT

Landform elements include land such 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,  
Midslope ridges, small hills in plains and Mountain tops, high ridges. The main objective of this study is to landform  
classification in Grain Mountain where located in Zagros mountain, Iran. In order to landform classification used Digital  
Elevation Models (DEMs) with 90 m resolution. In this study used Topography Position Index (TPI) classes for landform  
classification for the case study. TPI values are between – 128 to 161. By using TPI, the study area was classified into  
landform category. The result show that there are nine landform classes that Upper slopes, mesas and Local ridges/hills  
in valleys have high and small area respectively.  

Keywords—topography position index, landform classification, Grain Mountain.

INTRODUCTION

The Landform elements include land such as hills, mountains, plateaus, canyons, valleys, seascape and oceanic water body  
interface features such as bays, peninsulas, seas and so forth, including sub-aqueous terrain features such as mid-ocean  
ridges, volcanoes, and the great ocean basins. "Landform classification is reducing terrain complexity into a limited number  
of easily discernible functional units [1]. Landform classification, like any other categorization attempt by human is  
intrinsically complex and challenging. It is more likely that we can understand what the categories of land reveal, than  
to perceiving and evaluating continuous representations. There is a long tradition of mapping, which can be attributed to  
the relative ease of representing discrete spatial units compared to understanding and evaluating continuous representations  
of surface [2]. Landform classification emerged due to complexity of the earth surface which has necessitated seeking methods  
to quantify its form and subdivide it into more manageable components [3,4].

Landform classification has been of great interest in earth sciences as it has a wide range of application domains, including  
mapping lithology [5] predicting soil properties [6], vegetation mapping, precision agriculture [7]. Landform classification  
indeed constitutes a central research topic in geomorphometry [8, 9]. Geomorphometry is usually referred to as a sub-discipline  
of geomorphology [10, 11], as an interdisciplinary field from mathematics, and Earth sciences and computer science [12].

The main objective of this study is to landform classification in Grain Mountain where located in Zagros mountain, Iran.

MATERIAL AND METHOD

Topographic Position Index (TPI) is an adaptation of this method which compares the elevation of each cell in a DEM to the  
mean elevation of a specified neighborhood around that cell. Local mean elevation is subtracted from the elevation value  
at centre of the local window. Algorithm is provided as an ESRI script by Jenness Enterprises [13], and it has local window  
options of; rectangular, circular and annulus.

$$TPI_i = Z_o - \frac{\sum_{n=1}^{n} Z_n}{n}$$
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Where;

\[ Z_0 = \text{elevation of the model point under evaluation} \]
\[ Z_n = \text{elevation of grid within the local window} \]
\[ n = \text{the total number of surrounding points employed in the evaluation} \]

Positive TPI values represent locations that are higher than the average of the local window e.g. ridges. Negative TPI values represent locations that are lower e.g. 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), high positive values relate to peaks and ridges.

**Landform classification**

The TPI is the basis of the classification system and is simply the difference between a cell elevation value and the average elevation of the neighborhood around that cell. Positive values mean the cell is higher than its surroundings while negative values mean it is lower [13]. Combining TPI at small and large scales allows a variety of nested landforms to be distinguished (Table 1).

<table>
<thead>
<tr>
<th>Classes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canyons, deeply incised streams</td>
<td>Small Neighborhood: [ z_e \leq -1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ z_e &lt; -1 ]</td>
</tr>
<tr>
<td>Midslope drainages, shallow valleys</td>
<td>Small Neighborhood: [ z_e \leq -1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ -1 &lt; z_e &lt; 1 ]</td>
</tr>
<tr>
<td>U-shaped valleys</td>
<td>Small Neighborhood: [ z_e \leq -1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ z_e &lt; -1 ]</td>
</tr>
<tr>
<td>Plains small</td>
<td>Neighborhood: [ -1 &lt; z_e &lt; 1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ -1 &lt; z_e &lt; 1 ] Slope \leq 5°</td>
</tr>
<tr>
<td>Open slopes</td>
<td>Small Neighborhood: [ -1 &lt; z_e &lt; 1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ -1 &lt; z_e &lt; 1 ] Slope &gt; 5°</td>
</tr>
<tr>
<td>Upper slopes, mesas</td>
<td>Small Neighborhood: [ -1 &lt; z_e &lt; 1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ z_e \geq 1 ]</td>
</tr>
<tr>
<td>Local ridges/hills in valleys</td>
<td>Small Neighborhood: [ z_e \geq 1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ z_e &lt; -1 ]</td>
</tr>
<tr>
<td>Midslope ridges, small hills in plains</td>
<td>Small Neighborhood: [ z_e \geq 1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ -1 &lt; z_e &lt; 1 ]</td>
</tr>
<tr>
<td>Mountain tops, high ridges</td>
<td>Small Neighborhood: [ z_e \geq 1 ]</td>
</tr>
<tr>
<td></td>
<td>Large Neighborhood: [ z_e \geq 1 ]</td>
</tr>
</tbody>
</table>

TPI values can easily be classified into slope position classes based on how extreme they are and by the slope at each point. TPI values above a certain threshold might be classified as ridge tops or hilltops, while TPI values below a threshold might be classified as valley bottoms or depressions. TPI values near 0 could be classified as flat plains (if the slope is near 0) or as mid-slope areas (if the slope is above a certain threshold) (Table 2).

**Case study**

The study area is Grain Mountains, Iran, which is located at 33° 01’ 03” to 34° 00’ 09” N and 48° 00’ 00” to 48° 58’ 48” E, with area of 1061.7 km² (Figure 1). The highest elevation in this area is 3645 m, which is located in the north of the basin, while the lowest elevation is 1480 m, which is located in the south and southwest of basin. The dataset for the area originates from a DEM with resolution of 90 m.
RESULT AND DISCUSSION

Topography Position Index (TPI)
TPI values are between – 169.24 to 186.48 (Figure 2). TPI values near zero (close of -169.24) 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), high positive (close of 186.48) values relate to peaks and ridges.

Landform classification
The result show that there are three landform that consist of canyons / deeply incised streams, open slopes, and mountain tops / high ridges and the areas are 1071.02, 293.92, and 1028.11 for each of the classes respectively (Figure 3 to Figure 11 and Table 2).
Fig. 3 Canyons, Deeply Incised Streams class for the study area

Fig. 4 Midslope drainages, shallow valleys class for the study area

Fig. 5 Upland drainages, headwaters class for the study area

Fig. 6 U-shaped valleys class for the study area
Fig. 7 Open slopes class for the study area

Fig. 8 Upper slopes, mesas class for the study area

Fig. 9 Local ridges/hills in valleys class for the study area

Fig. 10 Midslope ridges, small hills in plains class for the study area
CONCLUSION
In this study, digital elevation models used as inputs data. TPI values are between – 169.24 to 186.48. By using TPI, the study area was classified into landform category. The result show that there are three landform that consist of canyons / deeply incised streams, open slopes, and mountain tops / high ridges. Using TPI and landform classification by Weiss in 2001 for category of different area can applied.

REFERENCES

**CITATION OF THIS ARTICLE**