Landform classification using topographic position index of Coimbatore district of Tamil Nadu, India

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Abstract
A variety of landforms occupy the surface of the earth, that are formed as a result of natural geomorphologic process that takes place. The main aim of the research is to produce a landform classification map of Coimbatore district of Tamil Nadu using Topographic Position Index (TPI). Input data for classification is a digital elevation model (DEM) of 30m resolution. With the advent of computer technologies, and subsequent emergence of Geographical Information System (GIS), a simple and quicker approach to extract meaningful information from the terrain data has become possible. The results clearly show that 60% of the area was occupied by open slopes and 15% by plains in the entire district. The Jenness algorithm of landform classification proved to be the easiest and applicable method of classification.

Keywords: landforms, jenness algorithm, DEM, topographic position index (TPI)

Introduction
Due to the wide variety and complexity of landforms that occupy the surface of the earth, it is important to classify and characterize each landform as it has a broad range of applications. It is difficult to classify a whole land surface than extraction of particular landforms from it (Evans, 2012) [5]. Landforms are discontinuous and does not cover the entire surface. It is formed as a result of geologic and geomorphologic process that takes place on the surface of the earth. Several landform elements include mountains, valleys, hills, plateaus, plains to water body features such as seas, bays, peninsulas that include terrain features like volcanoes, mid-ocean ridges (Seif, 2014) [14]. Specific geomorphometry deals with the topological and geometric characteristics of landforms (Evans, 1972) [4]. Field survey studies and aerial photo interpretation are the early methods of classification and identification of landforms. Initially it was a difficult and time consuming process for manual identification of landforms. Due to the advancements in computer technology, several computer based algorithms have been developed to calculate geomorphometric properties of the earth’s surface and their temporal change (Horton, 1945) [7]; (Mokarram et al., 2015) [11]. Based on the fundamental characteristics of the Digital Terrain Models (DTMs) several methods have been developed for modeling land surface elements. Several automated techniques and algorithms have been developed for DEM processing and extraction of landforms. Landforms can also be defined by their location and the shape of their surface that is related to the soil attributes and the geologic materials (Hammer, 1998) [6]. Each landform may be a combination of several landform elements which have stable morphometric properties (Iwahashi and Pike, 2007) [8]. In the past, the geomorphometric properties were calculated manually and it was time consuming(Horton, 1945) [7]; (Coates, 1958) [2]. The recent developments in computer algorithms, new spatial analytical methods and the availability of DEM data, improved the methods for automatic classification of geomorphometric properties. It helps in digital representation of landforms that helps in modeling(Dikau, 1999) [5]; (Pike, 1999) [13]. In the early 1970’s, more complex statistical based methods to identify landscape features were made possible with the availability of computers(Chorley, 1972) [1]; (Evans, 1972) [4]. Moreover the advancements in technology paved the way for quantitative comparison of terrain units (Onorati et al., 1992) [12]. GIS plays an important role in using several algorithms to mathematically analyze digital elevation data that serves as a base for landform classification (Jacek, 1997) [9].
The aim of the paper is to prepare a landform classification map of Coimbatore district of Tamil Nadu, India based on Jenness algorithm.

**Materials and Methods**
The study area is Coimbatore district, located at $11^o\,24'\,23''$ latitude and $76^o\,39'\,20''$ to $77^o\,18'\,00''$ E longitude with an area of 4721.28 sq.km as shown in Fig 1. The data source for the study is ASTER DEM. It is a satellite product with 30m resolution provided by NASA.

Method of classification
The Topographic Position Index (TPI) is used to classify landscape into landform category and also slope position. It is a simple algorithm that was developed by (Jenness, 2006)\(^{[10]}\) and (Weiss, 2001)\(^{[15]}\). TPI is the difference between elevation value of a cell and the average elevation of a neighbourhood around that cell.
Fig 2: Input data for landform classification

Fig 3: TPI value of the study area
Positive TPI means the cell is higher than its surroundings whereas negative TPI means it is lower. Mean elevation is subtracted from the elevation value at center.

$$TPI = M_0 - \frac{\sum_{n=1}^{n} M_n}{n}$$

Where, $M_0$ = elevation of the model point under evaluation

$M_n$ = elevation of grid

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

**Results & Discussion**

Several input parameters used for preparing landform classification are aspect, elevation, slope, plan curvature, profile curvature, total curvature are in Fig 2.

TPI map for the study area was prepared to produce a landform classification map using Jenness algorithm. According to Fig 3, the minimum TPI value is -2.0 and the maximum TPI is 1.6. Landform classification map is shown in Fig 4. Landform classification consists of classes such as high ridges, midslope ridges, local ridges, upper slopes, open slopes, plains, valleys, upland drainages, midslope drainages, streams. The area that occupies the classes is given in Table 1 and Fig 5.

![Landform classification map](image)

**Fig 4: Landform classification map**

**Table 1: Areas of features for the landform classification maps in Fig 4**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Classes</th>
<th>Area (ha)</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High ridges</td>
<td>14460.84</td>
<td>2.87</td>
</tr>
<tr>
<td>2</td>
<td>Midslope ridges</td>
<td>22352.31</td>
<td>4.44</td>
</tr>
<tr>
<td>3</td>
<td>Local ridges</td>
<td>4064.94</td>
<td>0.80</td>
</tr>
<tr>
<td>4</td>
<td>Upper slopes</td>
<td>23222.88</td>
<td>4.62</td>
</tr>
<tr>
<td>5</td>
<td>Open slopes</td>
<td>304987.68</td>
<td>60.70</td>
</tr>
<tr>
<td>6</td>
<td>Plains</td>
<td>76952.16</td>
<td>15.31</td>
</tr>
<tr>
<td>7</td>
<td>Valleys</td>
<td>14137.56</td>
<td>2.81</td>
</tr>
<tr>
<td>8</td>
<td>Upland drainages</td>
<td>2143.26</td>
<td>0.42</td>
</tr>
<tr>
<td>9</td>
<td>Midslope drainages</td>
<td>23356.17</td>
<td>4.64</td>
</tr>
<tr>
<td>10</td>
<td>Streams</td>
<td>16707.96</td>
<td>3.32</td>
</tr>
<tr>
<td></td>
<td><strong>Sum</strong></td>
<td><strong>502385.76</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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Conclusion
Landforms define the specific geomorphic structures on the earth’s surface. Digital Elevation Models (DEM) forms the basis for landform classification. Jenness algorithm proves to be the most promising and easiest method of landform classification. The results clearly shows that open slopes occupy more area of Coimbatore of about 60% followed by plains of about 15%.

References