THE GEOMORPHOMETRIC DESCRIPTION OF CLUSTER MAPS

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ABSTRACT:
The aim of this paper was to describe from the geomorphometric point of view a cluster map derived by classification. More specifically an ASTER image of the study area was radiometrically and geometrically corrected. Maximum likelihood classification defined the landcover classes of the study area (various types of forest, cultivated land and bare ground). The digital elevation model of the study area was derived by contour lines digitization from topographic maps. The landcover classes were parametrically represented with attribute-value pairs. The attributes corresponded to the following geomorphometric parameters, mean elevation, maximum elevation, roughness, local relief, mean gradient. It was found that the fir forest presents the greatest mean elevation while the mixed forest and the bare ground class follows. The cultivated landcover class occupies areas with lower mean elevation. The greatest mean gradient values are observed for both the fir forest and the mixed forest classes. The cultivated lands also present the lowest mean gradient values while the barren class to present high mean gradient value. Then, a connected component labeling algorithm identified distinct objects in the barren class. Each object was described by geomorphometric parameters and the objects were ranked on the basis of landslides susceptibility. The most interesting finding was the greatest in size objects of the barren class occupy the highest in elevation places and presents the greatest gradient values. Additionally the spatial distribution of these polygons is along the main road connecting the capital with the main port of the island.

1. INTRODUCTION

The landcover mapping is of great significance in change detection, urban planning and environmental protection. On the other hand due to the severe climatic change and abrupt meteorological incidences that take place recently, the correlation between landcover and geomorphometry is of great importance (Elumnah and Shrestha, 2000). The risk and hazard assessment studies for flash floods, landslides caused by heavy rainfalls etc. (Miliareis, 1999a; 1999b; 2001; White, 1993) require knowledge of landcover type (Panagou and Miliareis, 2003) and the geomorphometry (Pike, 2002) of the local landscape neighbourhood (Treitz and Howarth, 2000). The aim of the study is to a)parametrically represent the landcover map derived by image classification techniques on the basis of geomorphometrical parameters, and b)interpret the spatial distribution of landcover types within the landscape.

2. METHODOLOGY

A terrain partition framework was composed on the basis of the landcover types and objects (pixel arrangements with the same landcover) were defined. Then, each object was parametrically described on the basis of geomorphometric attributes and mapped.

2.1 Study Area

The study area was Kefalonia Island in Ionian Sea.
2.2 Data

The A.S.T.E.R. image captured on 22/09/2001 with ID pg-PR1A0000-2001092201_019_057 was used. It covers the area geographic coordinates (38.3235, 20.5307), (38.2266, 21.2362), (37.6733, 21.0737), (37.7694, 20.3734). The bands 01 (green), 02 (red), 03 (near infrared) of the V.N.I.R. sensor were used with spatial resolution 15 m (Fujisada, 1998; Kahle et al., 1991). The radiometric conditions (gains) for it’s band during the data acquisition was high gain for bands 01 and 02, normal for band 03 (Abrams and Hook, 2002; Chavez, 1996).

2.3 Pre-processing of A.S.T.E.R. Imagery

First radiometric correction was implemented. Each band was distriped by using the histogram matching technique. Then digital values were converted to radiance on the basis of the corresponding band gain. Finally path radiance was removed on the basis of linear regression of green and red band to the near infrared band (Eastman, 1999).

Then non parametric geometric correction was implemented by the use of a second degree polynomial and ground control points (gcps) derived by field survey with a hand-held Garmin G.P.S. The root mean square error of the transformation was 16.47 m for 14 gcps. The images were resampled to 30 m. A color composite image of the corrected bands is given in figure 3.

2.4 Cluter Map

Training areas were selected for the major thematic classes occurring in the study area (Table 1).

<table>
<thead>
<tr>
<th>ID</th>
<th>Thematic Class</th>
<th>Occurrence (number of pixels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fir Forest</td>
<td>9,660</td>
</tr>
<tr>
<td>2</td>
<td>Barren</td>
<td>24,023</td>
</tr>
<tr>
<td>3</td>
<td>Cultivated 1</td>
<td>22,757</td>
</tr>
<tr>
<td>4</td>
<td>Cultivated 2</td>
<td>21,714</td>
</tr>
<tr>
<td>5</td>
<td>Cultivated 3</td>
<td>20,609</td>
</tr>
<tr>
<td>6</td>
<td>Cultivated 4</td>
<td>3,307</td>
</tr>
<tr>
<td>7</td>
<td>Lake</td>
<td>329</td>
</tr>
<tr>
<td>8</td>
<td>Mixed Forest</td>
<td>86,242</td>
</tr>
</tbody>
</table>

Table 1. The thematic classes and their occurrence in the cluter map.

Maximum likelihood classification (Mather, 1987) defined the landcover classes of the study area. The cluter map derived is given in figure 4 while the occurrence of it’s class is given in table 1 and figure 5.

2.5 Geomorphometric description of cluter map

Each thematic class was described on the basis of mean maximum and standard deviation of both elevation and gradient (table 2 and table 3) (Evans, 1980; Florinsky, 1998; Mark, 1975).
The table 2 indicates that fir forest terrain class presents the greatest height, while mixed forest and barren terrain classes follow. The cultivated landcover types are developed in lower elevation. These findings are in accordance with the local geomorphometric conditions of the study area (high mountain and limited plains). The most interesting finding of Table 1 was the relative high elevation of the barren terrain class.

The table 3 indicates that fir forest and mixed forest present the higher gradient values, followed by the barren terrain class. The explanation given is that the forests are developed on the highest areas which are quite steep in order to be protected by human activity. Human activity (cultivated lands) is limited to plain areas or to areas with lower gradient value. The high gradient of barren terrain class indicates that these polygons are of high risk relative to flash floods. That is why the relative distribution of barren polygons with high gradient/height values will be identified and studied in more detail in the following section.

### 2.6 Title

A connected components labelling algorithm is applied to the barren terrain class (Figure 6).

A total of 1314 objects (adjacent pixels of the barren terrain class) were found with various size dimensions as it can be observed in Figure 7.
Table 4. Size (1 pixel occupies 30 times 30 m²), mean elevation and mean gradient for the 50 objects of the barren terrain class with the greatest size

2.7 Statistical analysis and mapping

Statistics, correlation and linear regression were computed for the parametric representation of the objects of the barren terrain class (Table 5, 6 and 7).

Table 5. Statistics per geomorphometric attribute for the objects with size greater than 50 pixels.

<table>
<thead>
<tr>
<th>lnS</th>
<th>H</th>
<th>R</th>
<th>G</th>
<th>LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-4.99</td>
<td>442.7</td>
<td>46.2</td>
<td>16.8</td>
</tr>
<tr>
<td>St.dev</td>
<td>0.82</td>
<td>345.8</td>
<td>38.9</td>
<td>8.7</td>
</tr>
</tbody>
</table>

Table 6. Correlation coefficient per attribute pairs, for the objects with size greater than 50 pixels.

<table>
<thead>
<tr>
<th>lnS</th>
<th>H</th>
<th>R</th>
<th>G</th>
<th>LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnS</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>0.228</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.551</td>
<td>0.526</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>0.021</td>
<td>0.704</td>
<td>0.649</td>
<td>1.000</td>
</tr>
<tr>
<td>LR</td>
<td>0.632</td>
<td>0.569</td>
<td>0.969</td>
<td>0.656</td>
</tr>
</tbody>
</table>

Table 7. Correlation coefficient per attribute pairs, for the objects with size greater than 50 pixels.

It is observed that there is a positive correlation between H and G. There is also a great correlation between R and LR. The regression between mean gradient and mean elevation is expressed by the equation:

\[ H = 20.07 \times G + 86.12 \]

The linear regression was found to be statistically significant according to the analysis of variance (ANOVA) presented in Table 7. The linear regression line and the scatter diagram of objects is given in Figure 8.
The objects were sliced to 5 classes in increasing mean gradient and mapped (Figure 9).

3. CONCLUSION

The geomorphometric description of the cluster map indicated that the major landcover classes (forest versus cultivated land versus bare ground) present specific and distinct parametric representation. The barren class presents high elevation and gradient while the correlation and the linear regression indicated that the greatest in size objects occupy the greatest in height position and present the greatest gradient. This finding should be taken into account in the urban planning since barren class objects are distributed along the major highway that connects the major city with the major port of this island (Kefalonia).

4. REFERENCES


4.1 Acknowledgements and Appendix (optional)

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