Topographic units mapping from DEM analysis: evaluation of the Upslope Position Index (UPI) in two Tuscany (Italy) study areas

A. CIULLI (*), G. CHESSA (**), L. DISPERATI (*,*), S. GADENZ (**), M. PERNA (***)

* University of Siena, Department of Earth Science, Siena - * University of Siena, Centro di Geotecnologie (CGT)
** Geologyx s.r.l. – Castelfiorentino - Firenze
*** LAMMA – Laboratory of Monitoring and Environmental Modelling for the sustainable development

ciulli2@unisi.it

1. INTRODUCTION

The Earth’s surface can be classified into landforms as the result of the spatial distribution and redistribution of materials and energy in the landscape. The study of landforms can be used to infer expected site conditions such as kind and degree of pedogenesis, texture and stability of unconsolidated sediments [1]. In this work we present two different procedures for landform extraction and analysis based on processing of elevation data.

2. OBJECTIVES

1. To present the Upslope Position Index (UPI) obtained from processing of Digital Elevation Average (Fig.1); UPI is aimed at identification of topographic units for landforms analysis in two catchments in Italy (Fig.2).
2. To Compare the results of application of the UPI with the Jenness’ Slope Position Index (SPI) [2] and the related expert knowledge resulting from visual interpretation, geomorphologic features within aerial photos.

3. METHODOLOGY

A) The Upslope Position Index (UPI)

The UPI is based on the pixel by pixel calculation of the downstream ad upstream weighted distances, along a flow path, from each cell to either the valley bottom or the watershed divide. The distances are calculated by means of the flowlength function [3]. The UPI represents the upstream flow length normalized in respect to the (divide-bottom) flow path (Fig.1). We applied the method to two watersheds: the Sieve river and the Serchio river (Fig.2). Results are represented in Figs.3-6.

\[
\text{UPI} = \frac{\text{Upstream length}}{\text{Downstream length + upstream length}}
\]

B) The slope position Index (SPI)

We derived the Topographic Position Index (TPI) (Fig.7) and the Slope Position Index (SPI) (Fig.8) from DEM (Fig.6). These indexes are calculated in order to differentiate among geomorphological units, these latter expressing whether the elevation of a given cell is higher or lower than the mean elevation of its neighbors. Topographic categories based on SPI are represented by classes like ridge, upper slope, middle slope, lower slope, valley and flat area.

5. WORK IN PROGRESS

A. Spatial relations UPI-landslide areas

B. UPI and “normalized” watershed profile

4. CONCLUSIONS

1. The UPI allows us to make comparisons among morphologic features of catchments with different size and geographic location (Fig.4, 5).
2. Topographic units based on UPI can be obtained by classification (Fig.3; Fig.5) while the SPI directly provides topographic units (Fig.8).
3. The SPI accuracy resulted to be greater than the UPI accuracy.

REFERENCES

Fig.1 – Work flow of the procedure for calculating the UPI

Fig.2 – The study areas: the Sieve river and the Serchio river watersheds, Tuscania, Italy

Fig.3, Fig.3A – UPI for a subset of the Serchio river watershed (Linha river). Fig.3B – Classification of the UPI for the Linha river watershed

Fig.4 – Examples of comparison among UPI related to watersheds with different size and shape

Fig.5 – Examples of distribution of average slope steepness vs. UPI (△150°) for eight second order watersheds of the Serchio river

Fig.6 – Work flow of the procedure for calculating the TPI

Fig.7 – Topographic position index (TPI)

Fig.8 Slope Position Index (SPI)

Fig.9 Maps of UPI and landslides for the Sieve river (a) and the Serchio river (b) watersheds

Fig.10 – Distribution of landslides vs. the UPI

Tab.1 – Accuracy assessment results

<table>
<thead>
<tr>
<th>Model</th>
<th>Sieve river</th>
<th>Serchio river</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPI</td>
<td>47%</td>
<td>45%</td>
</tr>
<tr>
<td>SPI</td>
<td>52%</td>
<td>56%</td>
</tr>
</tbody>
</table>

Fig.11 – Second order watersheds of the Serchio river

Fig.12 – Normalized watershed profile vs. the UPI