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

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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 Model (DEM) (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.

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

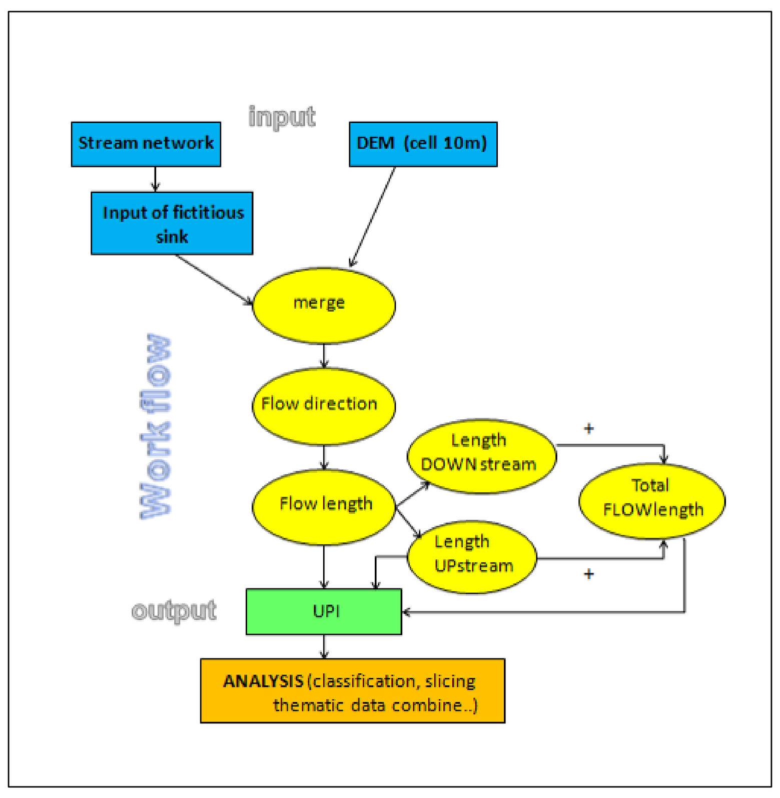

Fig.1 – Work flow of the procedure for calculating the UPI

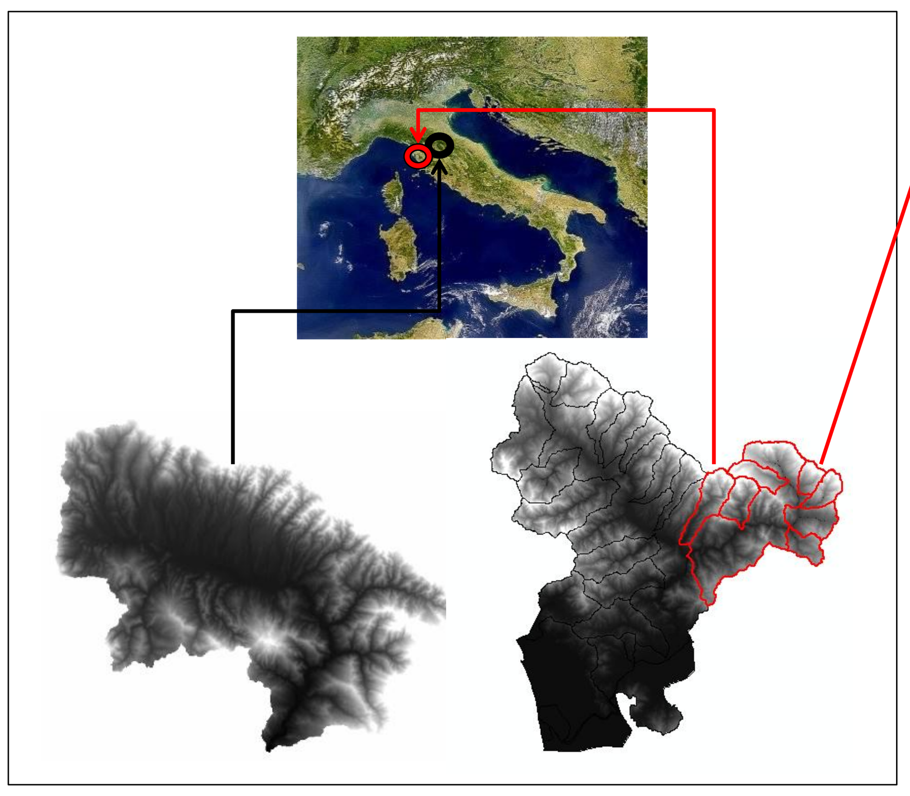

Fig.2 – The study areas: the Sieve river and the Serchio river watersheds, Tuscany, Italy

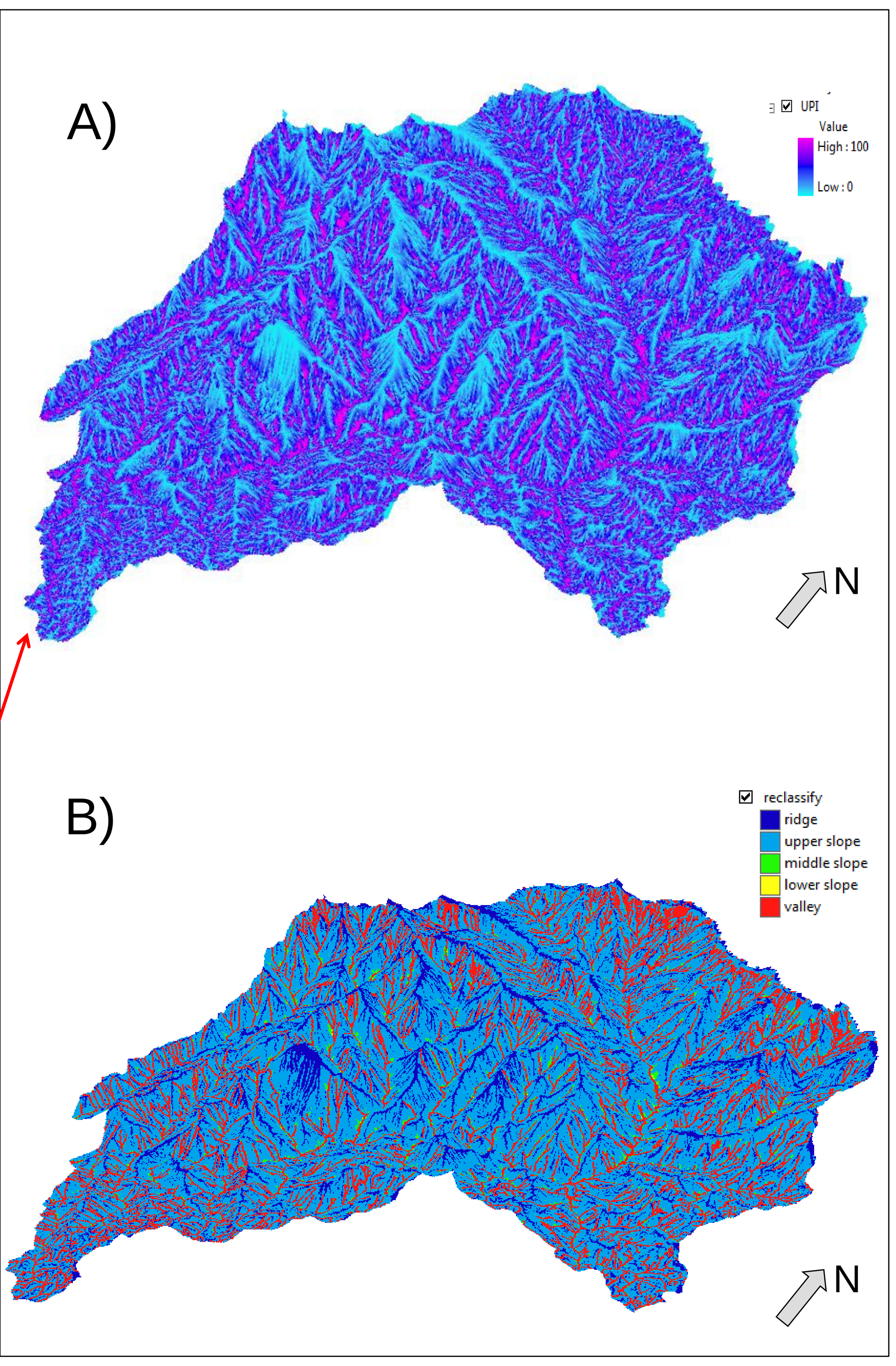

Fig.3 ; Fig.3A – UPI for a subset of the Serchio river watershed (Lima river); Fig.3B – Classification of the UPI for the Lima river watershed

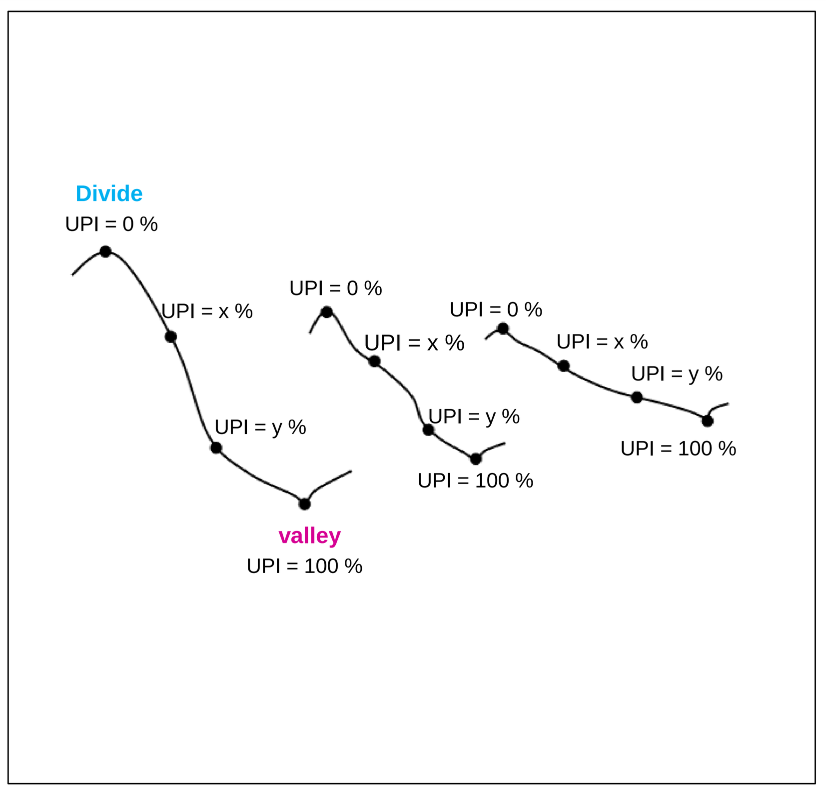

Fig.4 – Examples of comparison among UPI related to watersheds with different size and shape

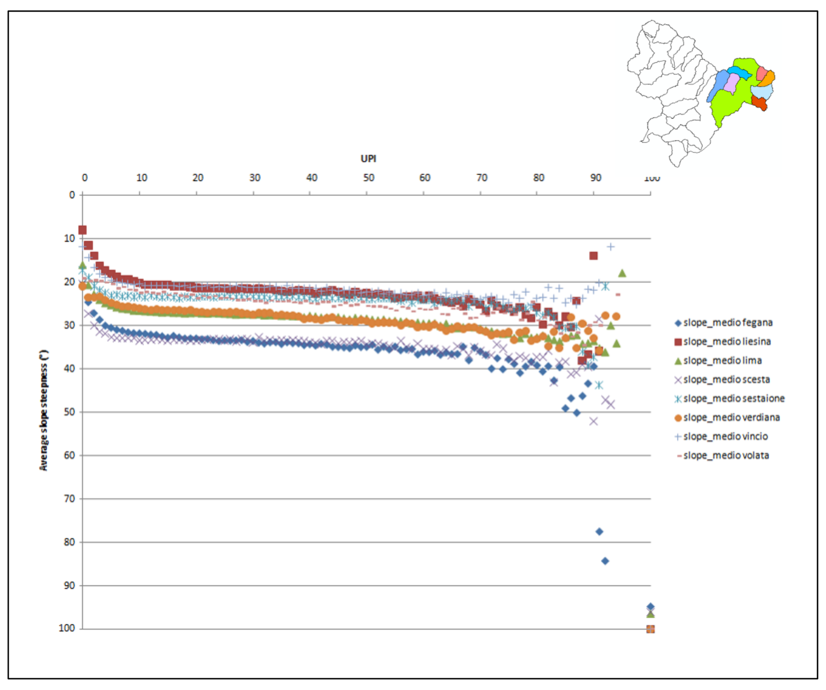

Fig.5 – Examples of distribution of average slope steepness vs. UPI (0-100%) for eight second order watersheds of the Serchio river

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.

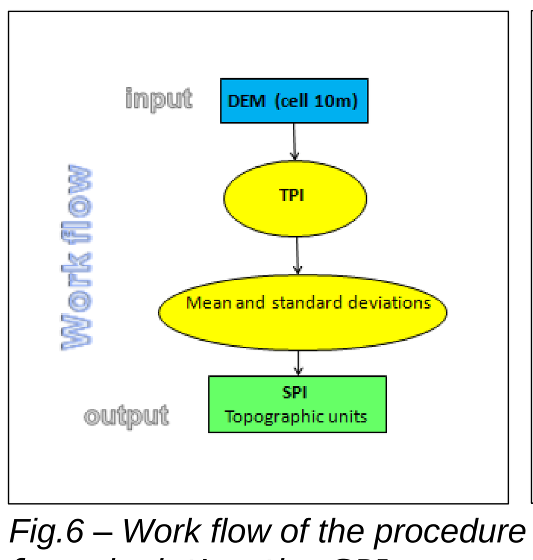

Fig.6 – Work flow of the procedure for calculating the SPI

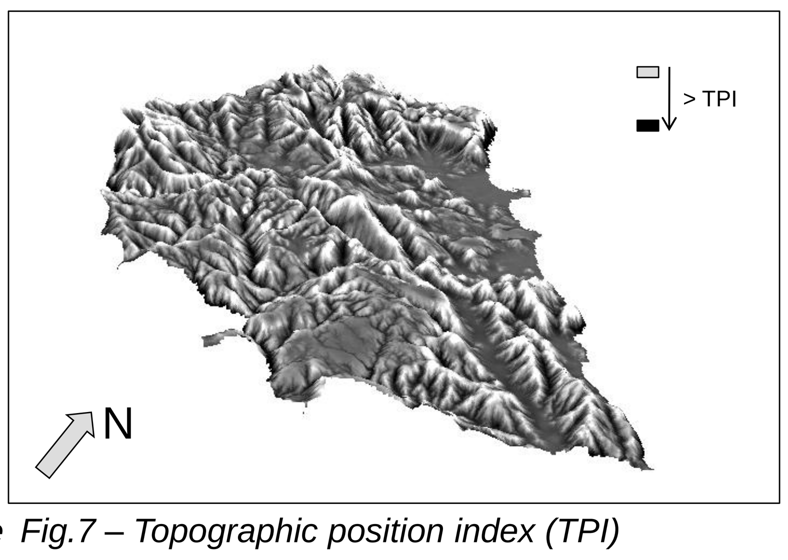

Fig.7 – Topographic position index (TPI)

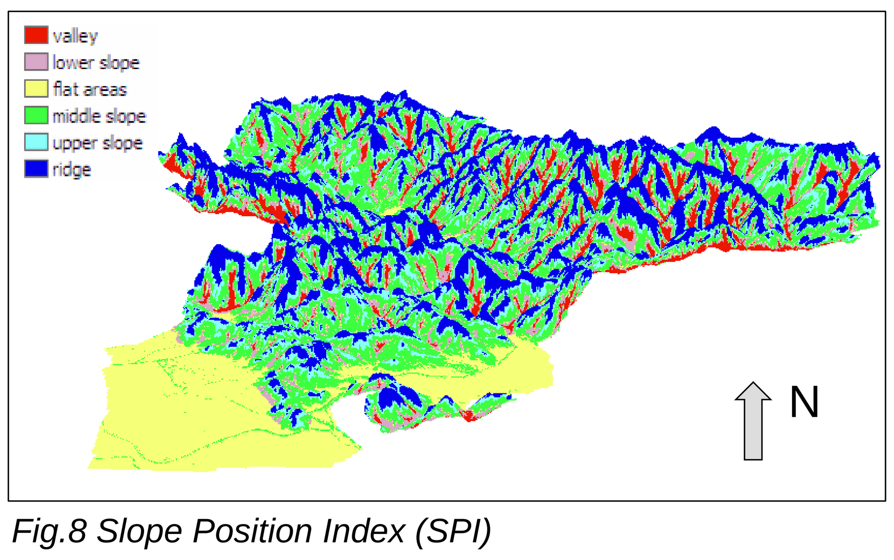

Fig.8 Slope Position Index (SPI)

C)Accuracy Assessment

We performed visual interpretation of geomorphologic features in order to assess and compare the accuracy of UPI and SPI. The values of SPI and UPI to be assessed were extracted from the corresponding raster maps. For each study area we applied a random sampling scheme. Two "expert" (A.C. & G.C.) independently collected two datasets of ground truths. Results are represented in Tab.1.

	Sieve river	Serchio river
UPI	47%	42%
SPI	52%	58%

Tab.1 – Accuracy assessment results

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.

5. WORK IN PROGRESS

A.Spatial relations UPI-landslide areas

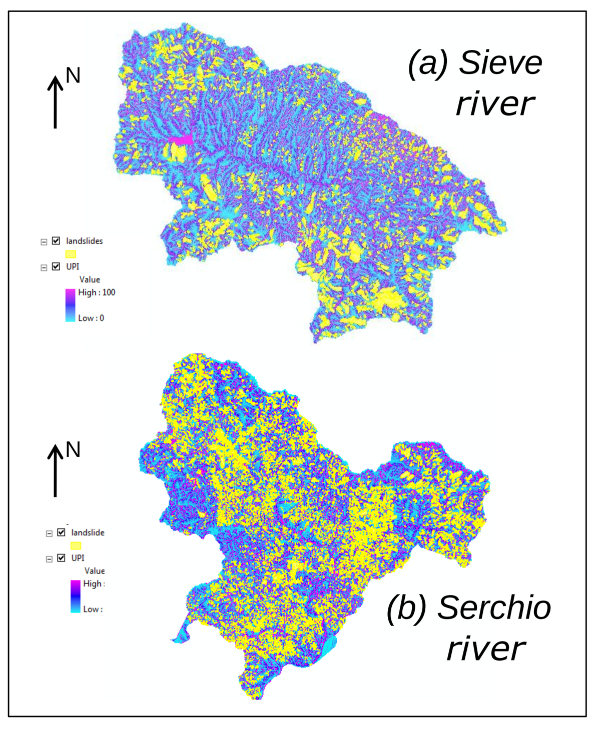

Fig.9 – Maps of UPI and landslides for the Sieve river (a) and the Serchio river (b) watersheds

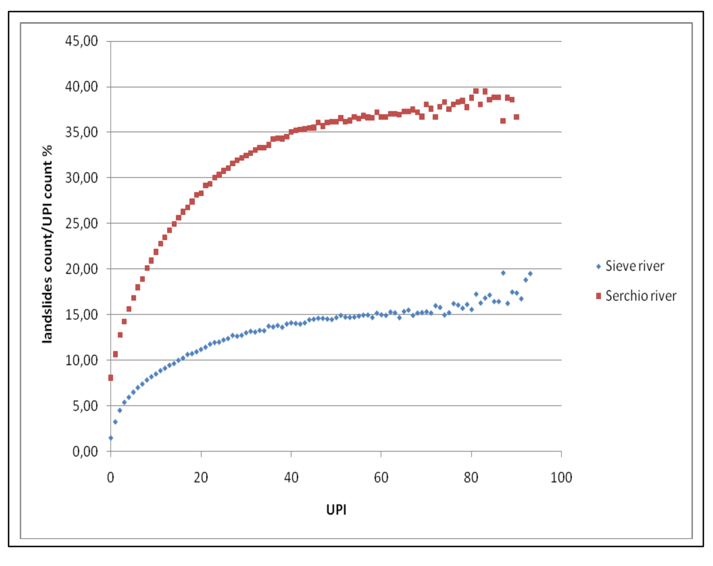

Fig.10 – Distribution of landslides vs. the UPI

B.UPI and "normalized" watershed profile

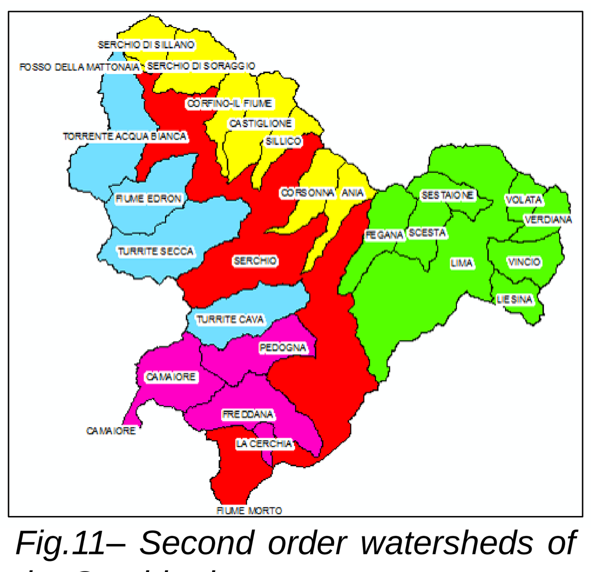

Fig.11– Second order watersheds of the Serchio river

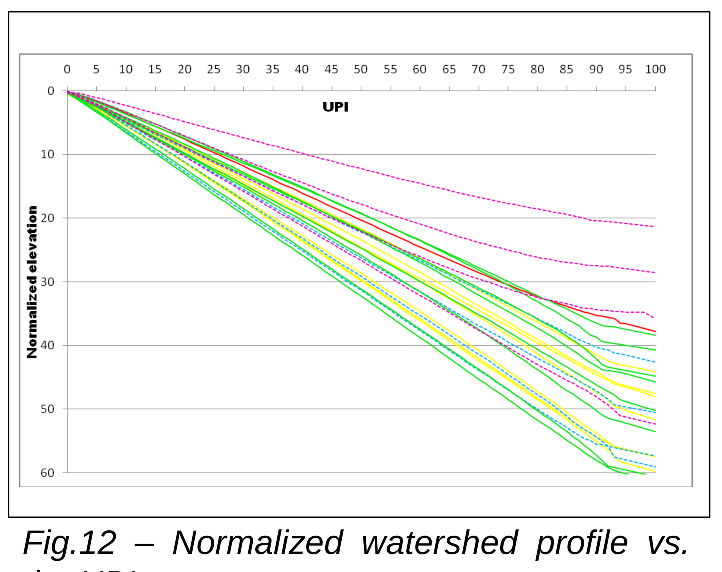

Fig.12 – Normalized watershed profile vs. the UPI

REFERENCES
[1] Shary P.A. 1991. The second derivate topographic method. In N. Stepanov (ed.) *The Geometry of the Earth Surface Structures*. Pushchino: Pushchino Reserch Centre Press, 30-60.
[2] www.jennessent.com
[3] ESRI™ ArcGIS/ArcInfo Desktop 9.3