

A NEW APPROACH IN THE USE OF GIS ON THE ESTIMATION OF VALUES, USING GRID MODELS TO DESCRIBE REAL NATURE CONDITIONS

Vaiopoulos, D. , Vassilopoulos A.** , Evelpidou N.****

**Athens University, Geology Department, Remote Sensing laboratory,
Panepistimiopolis, Zografou, 157-84, τηλ.: 7274299, fax:7274512
vaiopoulos@mail.geol.uoa.gr*

***Athens University, Geology Department, Remote Sensing laboratory,
Panepistimiopolis, Zografou, 157-84, τηλ./fax: 7274297, evelpidou@mail.geol.uoa.gr*

****Athens University, Geology Department, Remote Sensing laboratory,
Panepistimiopolis, Zografou, 157-84, τηλ./fax: 7274297
vassilopoulos@mail.geol.uoa.gr*

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ΠΕΡΙΛΗΨΗ

Οι περισσότερες Γεωλογικές και Περιβαλλοντικές μελέτες, απαιτούν το συνδυασμό πολλαπλών παραμέτρων, μερικές από τις οποίες θα πρέπει να θεωρηθούν σαν περιοχές (boundaries) με ακαθόριστα όρια ως προς τις γειτονικές τους. Στις ζώνες μετάβασης, ανάλογα με τον χρησιμοποιούμενο αλγόριθμο, οι τιμές μπορούν να αλλάξουν από το ένα σημείο στο άλλο, σταδιακά ή απότομα (εντός μίας ζώνης μετάβασης).

Στην μελέτη αυτή, οι παράμετροι εκφράζονται μέσω αρχείων κανάβου ('value grid files'), οι οποίοι μπορούν να παρουσιαστούν ξεχωριστά, ή να ενωθούν σε ένα νέο, μέσω μίας απλής πράξης, ή ενός πολυπλοκότερου μαθηματικού αλγορίθμου.

Ως περιοχή εφαρμογής της μεθόδου αυτής επιλέγηκε η νήσος Ζάκυνθος και χρησιμοποιήθηκαν οι παράμετροι της λιθολογίας και της κλίσης για την εξαγωγή ενός χάρτη διαβρωσιμότητας. Φυσικά και άλλες παράμετροι θα μπορούσαν επίσης να χρησιμοποιηθούν για την εύρεση της διαβρωσιμότητας. Η μέθοδος που περιγράφεται μπορεί να χρησιμοποιηθεί σε πολλές μελέτες και για πλήθος παραμέτρων, βοηθώντας στην διαχείριση χωρικών μεταβλητών (spatial variables) και τον μεταξύ τους συνδυασμό, με σκοπό την παραγωγή χαρτών που περιγράφουν πραγματικές συνθήκες στη φύση.

ABSTRACT

Most of the Geological / Environmental studies, use multiple parameters in order to extract the desired results and maps. Moreover, some of these parameters (e.g. slope factor) have to be considered as boundary areas with not strict limits. At the transition zones, depending on the used algorithm, the values can change rapidly, or not, from point to point.

In our paper, these parameters are expressed through 'value grid files', that can be presented separately, or mixed together into new ones, by applying on them proper mathematical algorithms (e.g. add, multiply, etc).

As a case study, we used the island of Zakynthos, and the parameters of lithology and slope to extract a vulnerability map. Of course other parameters can also be considered at a complete vulnerability study.

The described method can be used to many GIS-based studies, to help on the manipulation of different spatial variables and their combination in order to produce maps that describe real nature conditions.

INTRODUCTION

In applied Geology, in most cases it is useful to cross-examine and combine the values of many parameters in order to extract a new one, e.g. the vulnerability factor. Moreover, our calculations need to be global, but separate for each point of the studied area and result to separate output values for each point. Some of the properties change value in distinct boundaries, while others change gradually from one point to the next.

Examples of the first case are the boundaries of the districts of a country, or the geological properties that are examined in ideal conditions. Example of the second case are the geological properties that refer to real conditions, which are mostly vary from point to point, either regularly or irregularly, as in nature we may meet all the intermediate values between extreme conditions.

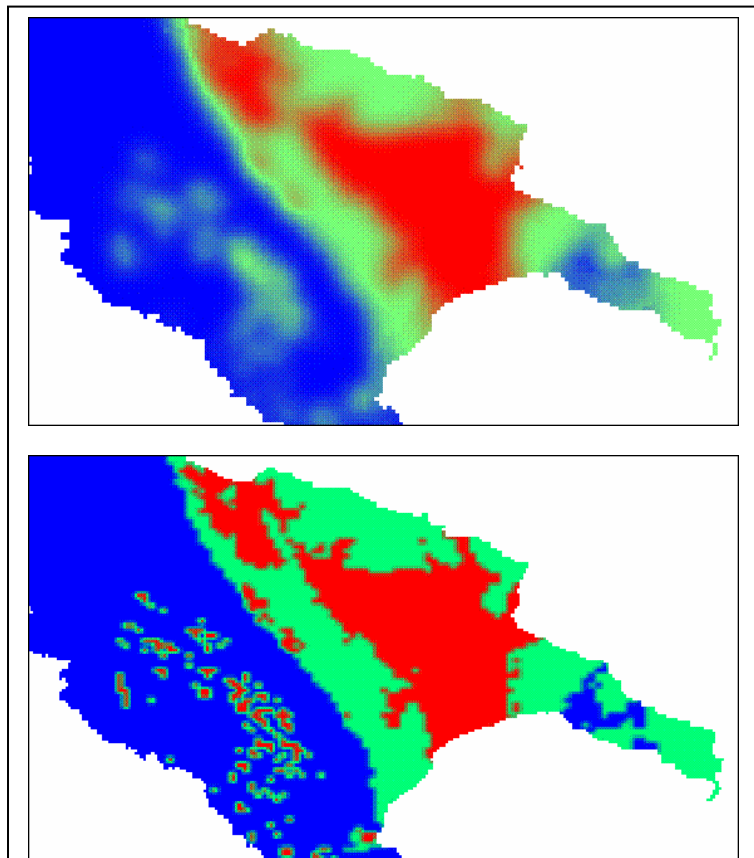


Fig.1.-Depending on the algorithm that creates the value grids, the result has different transition zones. The first (top) image, resulted from 'Inverse Distance Weighting' algorithm having large transition zones, while the second one resulted from 'Rectangular Bilinear Interpolation' algorithm with small transition zones and values of the grid that meet the initial values

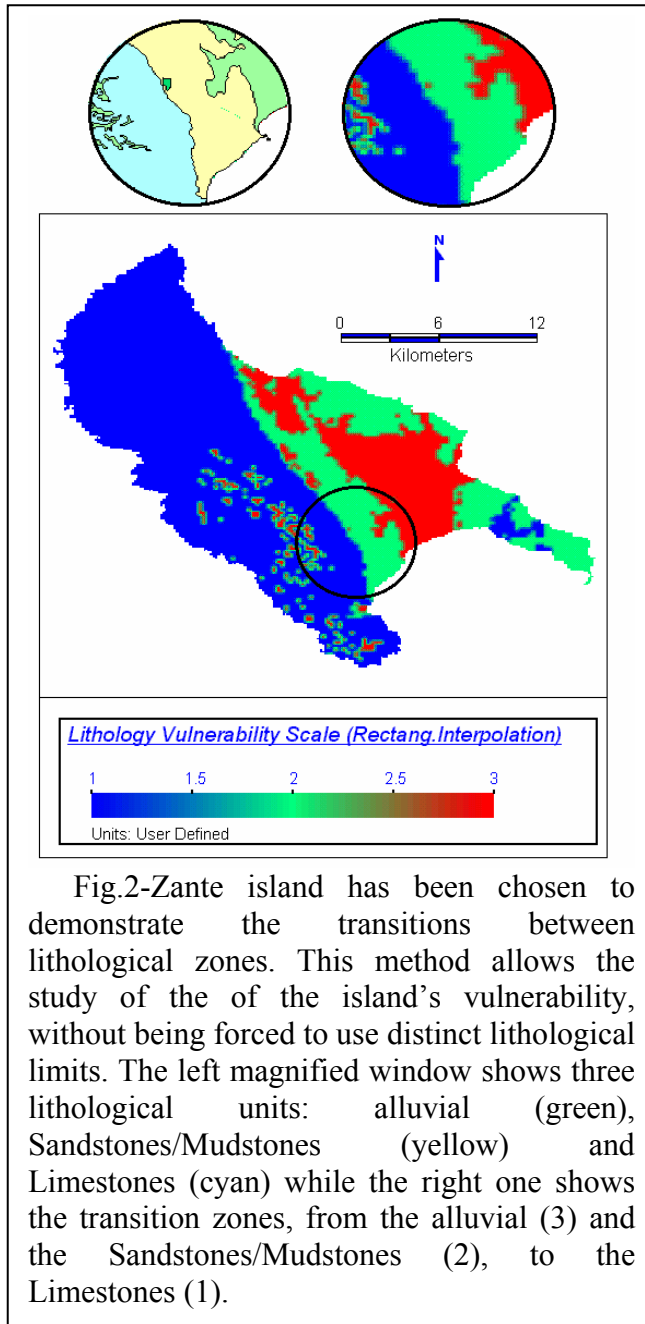


Fig.2-Zante island has been chosen to demonstrate the transitions between lithological zones. This method allows the study of the of the island's vulnerability, without being forced to use distinct lithological limits. The left magnified window shows three lithological units: alluvial (green), Sandstones/Mudstones (yellow) and Limestones (cyan) while the right one shows the transition zones, from the alluvial (3) and the Sandstones/Mudstones (2), to the Limestones (1).

It is therefore necessary to take into consideration the gradual transitions from point to point, in order to study geological properties. This paper intends to describe a method capable of handling separately the parameters, and creating grid values that cover the whole area. The requested value is finally calculated by applying an equation between the value grids, using different factors for each property, depending on the parameter's importance to the requested property.

CREATING AND COMBINING VALUE GRIDS

A value grid represents the values of a property over the whole studied area, even if the transitions of this property are distributed irregularly. With the use of computers, specific modeling algorithms (inverse distance weighting, triangulation with smoothing, rectangular (bilinear) interpolation), permit the filling of the null grid areas with values depending on the neighboring values. The use of the correct modeling algorithm, enables the user to change the values linearly or exponentially, and moreover to force the new calculated values either to meet or not the initial ones (figure 1).

For each geological/ environmental variable, we select the

appropriate algorithm, depending on the characteristics of the variable and the rate of the change. For example, lithologie's influence on weathering depends on the lithologie's position at the vulnerability series. At Zante island, we created a model of lithologies, applying values from 4 (for the allouvia) to 1 (for the limestones). For the creation of this model we used the «inverse distance weighting» algorithm, to achieve rapid transitions between lithologies. At the studied area along the limit of Marly Limestones and

Marls/Sandstones the transition zone is ranging from 180m to 430m, while between alluvial and Marls/Sandstones the zone is ranging from 180m to 670m (figure 2).

Following the concept of the described method, we process the layer of slopes, which is one of the most important vulnerability factors of the area. Instead of calculating the values of a square grid, we created a continuous value grid layer, where the slope changes gradually from point to point (figure 3). At the left magnification of figure 3, we may observe a part of the map where the slopes were estimated with the traditional method of the square grid cells.

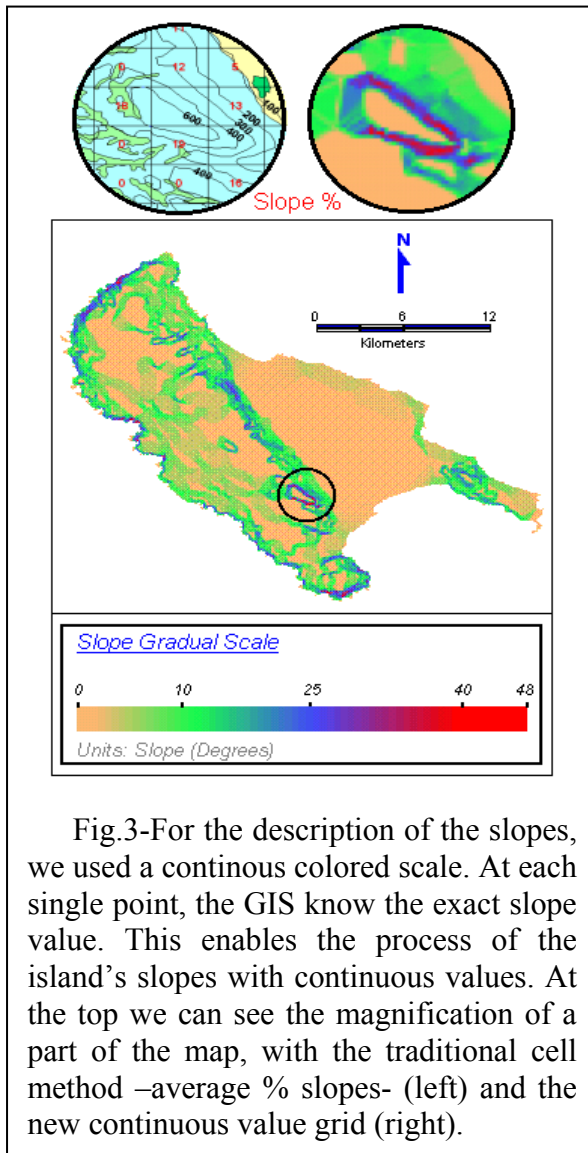


Fig.3-For the description of the slopes, we used a continuous colored scale. At each single point, the GIS know the exact slope value. This enables the process of the island's slopes with continuous values. At the top we can see the magnification of a part of the map, with the traditional cell method –average % slopes- (left) and the new continuous value grid (right).

With the use of the above method, we can create the rest of the layers that define the vulnerability of the area (we reserve ourselves to do so in a future study). At present, we will demonstrate the use of the value grids for the extraction of a vulnerability map of the island, using only the factors of lithologie's vulnerability and slope.

Taking into consideration that increase of slope at low resistance lithologies results in rapid increasement of the area's vulnerability, we multiplied the values of the two grid

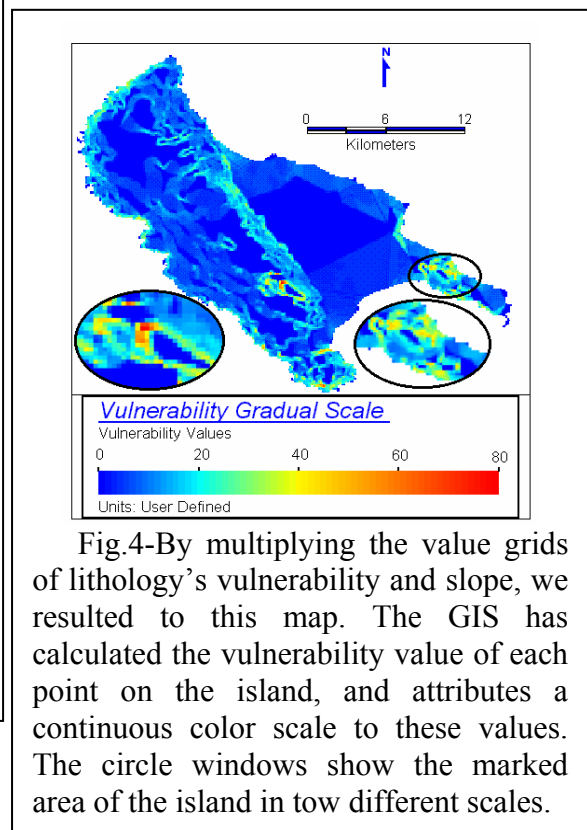


Fig.4-By multiplying the value grids of lithologie's vulnerability and slope, we resulted to this map. The GIS has calculated the vulnerability value of each point on the island, and attributes a continuous color scale to these values. The circle windows show the marked area of the island in tow different scales.

layers. We could of course use other mathematical ways, in other applications, to describe the interaction of the two layers in the best possible way.

In this example, we used multiplication, which means that if at a certain point, the lithology value is 1.3 and the slope is 8° , the vulnerability will result to 10.4. If the lithology value was 3.5 the vulnerability value would have been significantly higher (28). This process resulted in the map of figure 4.

In case we wanted to obtain normalized values of vulnerability (ranging from 0 to 1), we should have normalized the initial grid values by dividing each value by the maximum value of its field. At the end of this process, we would have normalized values, without units.

CONCLUSIONS

The most important benefits of this method can be summarized in the ability of:

- 1) Gradual transition of properties that in nature do not appear with distinct boundary limits. (e.g. vulnerability, precipitation)
- 2) Using GIS to apply FUZZY logic.
- 3) The GIS to have a continuous value grid of the properties and apply mathematical operations and functions to these values, for each point separately.
- 4) Visualizing the final results with 2-D (figure 4) and 3-D color maps that cover the area continuously.
- 5) Extracting profiles of the property along specified directions or along lines (faults, roads, rail lines, rivers, etc), with the horizontal axis describing the horizontal distance and the vertical axis describing the value of the property at each point.
- 6) Creating contour lines for each property and the resulting one, as well as maps with contour areas (figure 5).

A natural advantage of this method is the easy management of the value grids, during and after their creation applying mathematical operations and functions. This easy and fast management of the layers, allows scientists to try out many different possible solutions and choose the one that best fits the natural conditions of their studies.

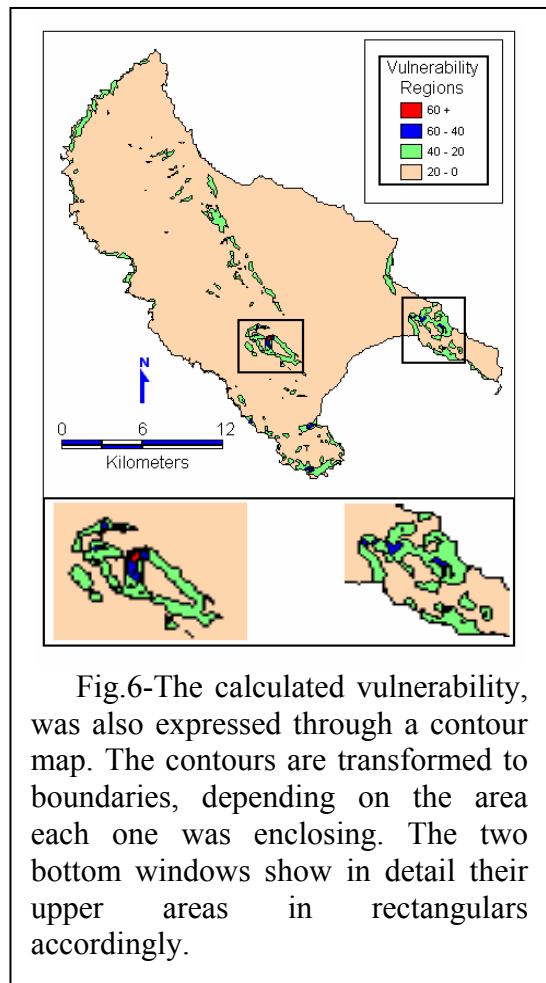


Fig.6-The calculated vulnerability, was also expressed through a contour map. The contours are transformed to boundaries, depending on the area each one was enclosing. The two bottom windows show in detail their upper areas in rectangulars accordingly.

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