USING THE ARCGIS SPATIAL AND 3D ANALYSIS TOOLS FOR A SUSTENABLE DEVELOPMENT OF LOCALITIES

P. GHERGHELAS ANDROO*, M. HERBEI**, R. HERBEI*

*University of Petroşani, Faculty of Mine

**Banat University of Agricultural Science and Veterinary Medicine Timisoara, Faculty of Agriculture

email:androopaul@gmail.com

Abstract: *The GIS technology is used in all fields for which the spatial information is relevant, that means in all fields that use the geographical map for stocking, analyzing and representing the data which are processed. No matter what is the field, any GIS application includes a spatial data base (a digital map) and a soft which exploit these data bases. The digital map must contain the spatial data specific to any field whose it is designated to this application. In order to furnish some useful information, this data base must be actual, which means it must represent correctly the terrain (geographic space) that is always under changing. This exploitation soft is made from many functions of analyzing the spatial data contained into the digital map and of visualizing the resulted information, specific to the application field. The most important feature of a GIS consists in its capacity to make spatial analyses, which means to process the spatial data (geographical data) with the purpose to obtain information (reports) regarding the studied area. With this feature of spatial analyze is different the software dedicated to GIS over the software like the CAD. The processing of spatial data is made based on some algorithms specific by using own operations for these such data.*

Key words: GIS, spatial analysis, 3D, slope, surface, TIN, vector, raster

INTRODUCTION

Spatial and 3D analysis tools from ArcGIS software allows modeling of key factors in solving critical problems frequently encountered in practice, such as: global climate changes, prudent use of energy, rational use of natural resources, equitable planning of new towns and transportation systems. Using ArcGIS software to combine different sets of data helps to create complex scenarios and allow the testing of more hypotheses. Below are presented the most important spatial and 3D analysis instruments which can be found in ArcGIS 10 software.

MATERIAL AND METHODS

MAPPING DISTANCE

The **distance mapping functions** are global functions. They compute an output raster dataset where the output value at each location is potentially a function of all the cells in the input raster datasets.

There are several distance mapping tools for measuring both straight-line (Euclidean) distance and distance measured in terms of other factors such as the cost to travel over the landscape.

Straight Line Distance functions describe each cells relationship to a source or a set of sources. **The Straight Line Distance** function measures the straight line distance from each

cell to the closest source (the source identifies the objects of interest, such as wells, roads, or a school). The distance is measured from cell center to cell center.

Example of usage: What is the distance to the closest town?

The Straight Line Allocation function assigns each cell the value of the source to which it is closest. The nearest source is determined by the Straight Line Distance.

Example of usage: Which town am I closest to?

The Straight Line Direction function computes the direction to the nearest source measured in degrees.

Example of usage: What is the direction to the closest town?

Allocation function allows to identify which cells belong to which source based on closest proximity (in a straight line).

Cost Weighted Distance mapping finds the least accumulative cost from each cell to the nearest, cheapest source. Cost can be money, time, or preference.

Example: Finding the least-cost route for a road

The Cost Weighted Distance function modifies the Straight Line Distance by some other factor, which is a cost to travel through any given cell. It produces an output raster in which each cell is assigned a value that is the least accumulative cost of getting back to the source.

For example, it may be shorter to climb over the mountain to the destination, but it is faster to walk around it.

The Cost Weighted Allocation function identifies the nearest source cell from each cell in the cost-weighted distance raster based on accumulated travel cost.

The Cost Weighted Direction function provides a road map, identifying the route to take from any cell, along the least-cost path, back to the nearest source.

The Distance and Direction raster datasets are normally created to serve as inputs to the pathfinding function, the shortest (or least-cost) path.

Shortest Path function determines the path from a destination point to a source. Once you have performed the Cost Weighted Distance function, creating distance and direction rasters, you can then compute the least-cost (or shortest) path from a chosen destination to your source point. The shortest path travels from the destination to the source and is guaranteed to be the cheapest route (relative to the cost units defined by the original cost raster).

♣ INTERPOLATION

Interpolation predicts values for cells in a raster from a limited number of sample data points. It can be used to predict unknown values for any geographic point data: elevation, rainfall, chemical concentrations, noise levels, and so on.

Inverse Distance Weighted (IDW) estimates cell values by averaging the values of sample data points in the vicinity of each cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process. This method assumes that the variable being mapped decreases in influence with distance from its sampled location.

For example, when interpolating a surface of consumer purchasing power for a retail site analysis, the purchasing power of a more distant location will have less influence because people are more likely to shop closer to home.

IDW has two options: a **Fixed search radius type** and a **Variable search radius type**.

A fixed search radius requires a distance and a minimum number of points. The distance dictates the radius of the circle of the neighborhood (in map units). The distance of the radius is constant, so for each interpolated cell, the radius of the circle used to find input points is the same.

With a **variable search radius**, the number of points used in calculating the value of the interpolated cell is specified, which makes the radius distance vary for each interpolated cell, depending on how far it has to search around each interpolated cell to reach the specified number of input points.

Spline estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.

There are two Spline methods: **regularized** and **tension**.

The **Regularized method** creates a smooth, gradually changing surface with values that may lie outside the sample data range.

The **Tension method** tunes the stiffness of the surface according to the character of the modeled phenomenon. It creates a less-smooth surface with values more closely constrained by the sample data range.

IDW and Spline are referred to as deterministic interpolation methods because they are directly based on the surrounding measured values or on specified mathematical formulas that determine the smoothness of the resulting surface.

A second family of interpolation methods consists of geostatistical methods (such as **Kriging**) that are based on statistical models that include autocorrelation (the statistical relationship among the measured points). Because of this, not only do these techniques have the capability of producing a prediction surface, but they can also provide some measure of the certainty or accuracy of the predictions.

Kriging method is a geostatistical interpolation method based on statistical models that include autocorrelation (the statistical relationship among the measured points). **Kriging** weights the surrounding measured values to derive a prediction for an unmeasured location. Weights are based on the distance between the measured points, the prediction location, and the overall spatial arrangement among the measured points.

Spatial Analyst provides two Kriging methods**: Ordinary** and **Universal Kriging**

Ordinary Kriging is the most general and widely used of the Kriging methods. It assumes the constant mean is unknown. This is a reasonable assumption unless there is some scientific reason to reject this assumption.

Universal Kriging assumes that there is an overriding trend in the data (for example, a prevailing wind), and it can be modeled by a deterministic function, or polynomial. This polynomial is subtracted from the original measured points, and the autocorrelation is modeled from the random errors.

Universal Kriging should only be used when we know there is a trend in our data and we can give a scientific justification to describe it.

⁙ THE 3D ANALYSIS

3D Analyst works with real or hypothetical surfaces with two types of surface models: *rasters* and *TINs (Triangulated irregular network* = A data structure that represents a

continuous surface through a series of irregularly spaced points with values that describe the surface at that point (for example, an elevation).

RESULTS AND DISCUSSIONS

CREATING TIN

TINs are usually created from a combination of vector data sources. It can be used point, line, and polygon features as input data for a TIN. Some of these input features should have z-values, though not all of the features need z-values. The input features to a TIN may also contain integer attribute values that are preserved in the resulting TIN features. These may be used to indicate the relative accuracy of different input data or to identify features such as roads or lakes.

A TIN can be create all at once from one or more kinds of input data, it can be create it in stages, or data can be add to refine an existing TIN. **TINs** are made from *mass points, breaklines, and polygons*.

Mass points are point height measurements; they become nodes in the network. Mass points are the primary input into a TIN; they determine the overall shape of the surface.

Breaklines typically represent either natural features such as ridgelines or streams or built features such as roadways. There are two kinds of breaklines: *hard and soft.*

Hard breaklines represent a discontinuity in the slope of the surface. Streams and road cuts could be included in a TIN as hard breaklines. Hard breaklines capture abrupt changes in a surface and improve the display and analysis of TINs.

Soft breaklines let us to add edges to a TIN to capture linear features that do not alter the local slope of a surface. Study area boundaries could be included in a TIN as soft breaklines to capture their position, without affecting the shape of the surface.

Polygons represent surface features with area such as lakes or boundaries (also called hulls) of separately interpolated areas. There are four polygon surface feature types: *clip polygons* (define a boundary for interpolation), *erase polygons, replace polygons (*set the boundary and all interior heights to the same value*),* and *fill polygons* (assign an integer attribute value to all triangles that fall within the fill polygon).
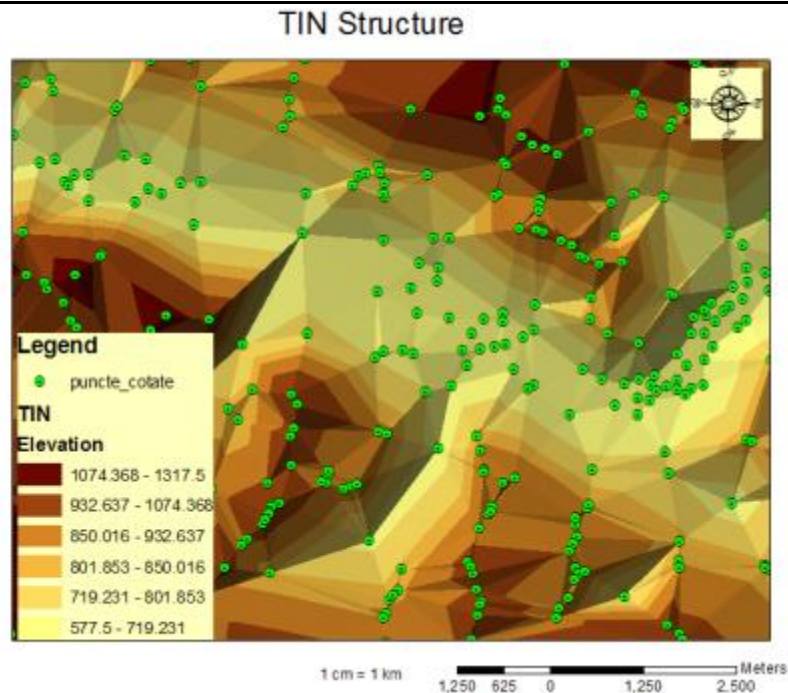
TIN Structure

Fig. 1 TIN visualization

SURFACE ANALYSIS

Contours are lines that connect points of equal value (such as elevation, temperature, precipitation, pollution, or atmospheric pressure). The distribution of the lines shows how values change across a surface. Where there is little change in a value, the lines are spaced farther apart. Where the value rises or falls rapidly, the lines are closer together.

Slope identifies the steepest downhill slope for a location on a surface. Slope is calculated for each triangle in TINs and for each cell in rasters. For a TIN this is the maximum rate of change in elevation across each triangle. For rasters it is the maximum rate of change in elevation over each cell and its eight neighbors.

Aspect identifies the steepest downslope direction from each cell to its neighbors. It can be thought of as slope direction or the compass direction a hill faces. It is measured clockwise in degrees from 0 (due north) to 360 (again due north, coming full circle). The value of each cell in an aspect dataset indicates the direction the cells slope faces. Flat slopes have no direction and are given a value of -1.
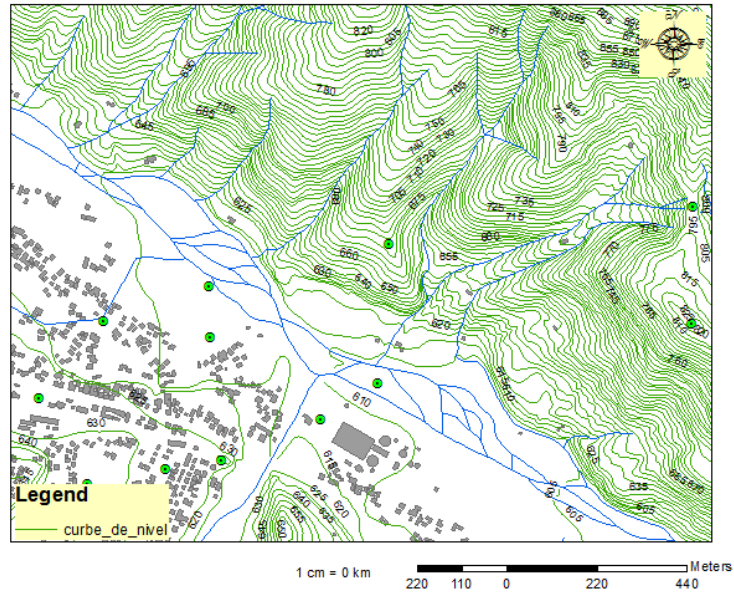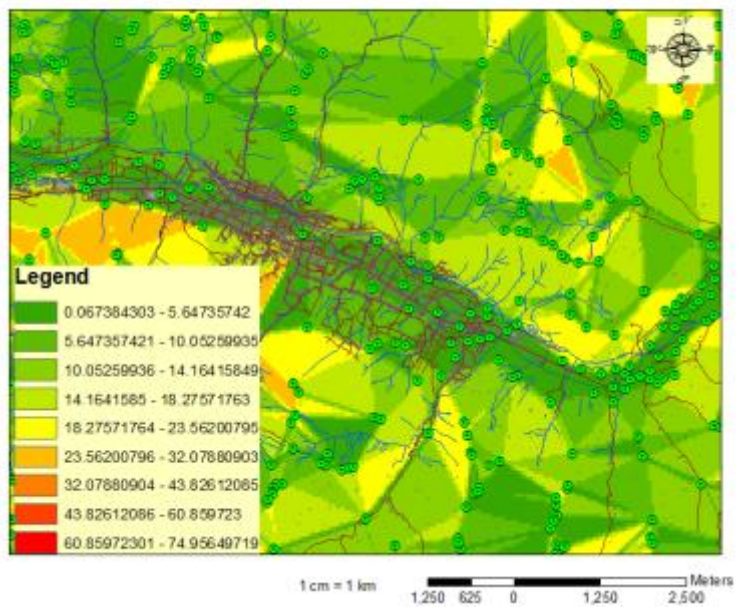
CONTOUR MAP

Fig. 2 Contour Map

THE MAP OF SLOPE

Fig. 3 The Map of Slope

⊥ ANALYZING VISIBILITY

The shape of a terrain surface dramatically affects what parts of the surface someone standing at a given point can see. What is visible from a location is an important element in determining the value of real estate, the location of telecommunications towers or the placement of military forces.

3D Analyst allows us to determine visibility on a surface from point to point along a given line of sight or across the entire surface in a *viewshed.*

The **viewshed** identifies the cells in an input raster that can be seen from one or more observation points or lines. Each cell in the output raster receives a value that indicates how many observer points can see the location.

The **viewshed** is useful when we want to know how visible objects might be, for example, we may need to know From which locations on the landscape will the landfill be visible if it is placed in this location?, What will the view be like from this road? or Would this be a good place for a communications tower?.

A **line of sight** is a line between two points that shows the parts of the surface along the line that are visible to or hidden from an observer. Creating a line of sight lets you determine whether a given point is visible from another point. If the terrain hides the target point, you can see where the obstruction is and what else is visible or hidden along the line of sight. The visible segments are shown in green, and the hidden segments are shown in red.

The **hillshade** function obtains the hypothetical illumination of a surface by determining illumination values for each cell in an elevation grid. It does this by evaluating the relationship between the position of the light source and the direction and steepness of the terrain. It can greatly enhance the visualization of a surface for analysis or graphical display.

Azimuth is the angular direction of the sun, measured from north in clockwise degrees from 0 to 360. An azimuth of 90 is east. The default is 315 (NW). *Altitude* is the slope or angle of the illumination source above the horizon. The units are in degrees, from 0 (on the horizon) to 90 degrees (overhead). The default is 45 degrees.
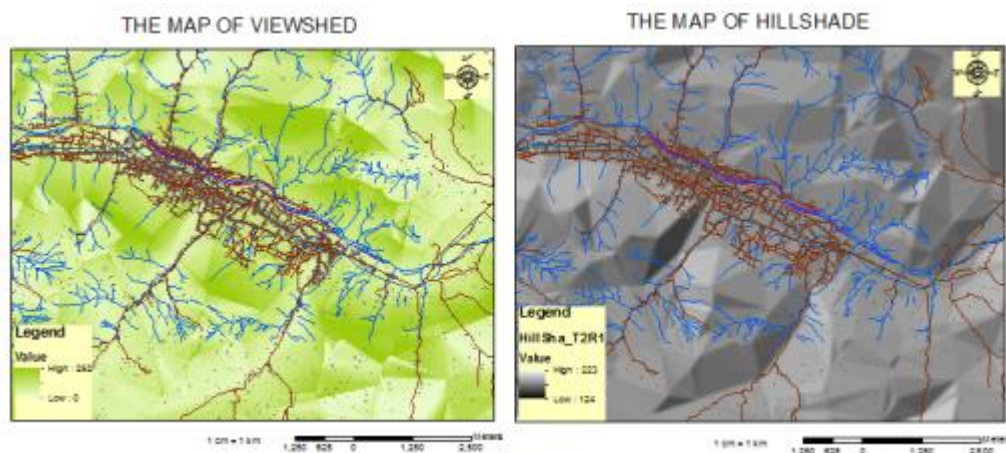

Fig. 4 The Maps of Viewshed and Hillshade

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The **Steepest Path** tool calculates the direction a ball would take if released at a given point on the surface. The ball will take the steepest path downhill until it reaches the perimeter of the surface model or it reaches a pit - a point all surrounding areas flow into. The result is a 3D graphic line added to the map or scene.

The **Steepest Path** tool can be used in order to evaluate the integrity of a TIN surface model, for example, to find paths that end unaccountably or meander off in a direction different from runoff on the actual site.

CONCLUSIONS

To accomplish the digital maps and to introduce the GIS systems into local community sectors will increase the level and quality of their decisional process. Being very used in different fields, and starting from the information necessary to any citizen and till environment protection, from the marketing strategies to resources administration, the GIS marked a revolution in solving the problems. The quality information means quality decisions. And GIS offers this possibility, transforming some simple information in real information and offering the interactive access to them.

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