GIS tools for erosion studies Development of Erosion Risk Index Map Case study: Tinos Island, Cyclades, Greece

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Geographical setting

Tinos is the third largest island of the Cyclades after Naxos and Andros and covers an area of 194.8km^2. Geographically the island belongs to the central Cyclades and is located south-east of Andros and north- west of Mykonos. Geographically it belongs to the central Cyclades.

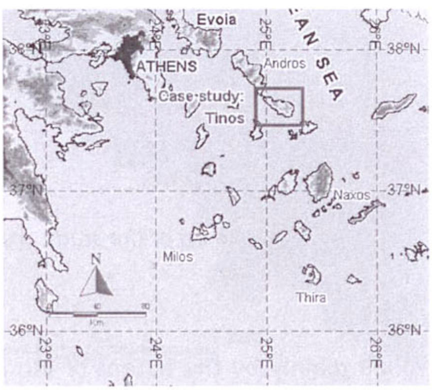

***Figure 1**: The location of the study area.*

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Climatic Conditions

The climate of the island is temperate (Theocharatos, 1978). The air temperature has lower values along the central Cycladic islands Andros - Tinos - Milos - Naxos. During the arid period, Tinos is more humid than the rest of central Cyclades, while in the humid period the precipitation is more than 100mm. Snow is very rare in the study area. Relative humidity over Tinos fluctuates between 65 and 70%. The prevailing wind during the year is northerly. The most common direction is the Etesian northerly and north-easterly wind that prevails in the Aegean Sea with increasing frequency and intensity during the summer (Theocharatos, 1978).

Geological setting

Tinos Island belongs to the geotectonic unit, known as Atticoclycladic complex (Melidonis, 1980). Three sequences of rocks participate in the geological structure of Tinos:

1. the sequence of metamorphic rocks, which dominates and takes up 79% of the total area of the island,
2. the sequence of igneous rocks and
3. the quaternary sediments.

The existence of three main categories of folds, with axes of NW-SE, NE-SW and N-S directions and two groups of faults with SE-NW and NNE-SSW directions, complete the geotectonic structure of the island.

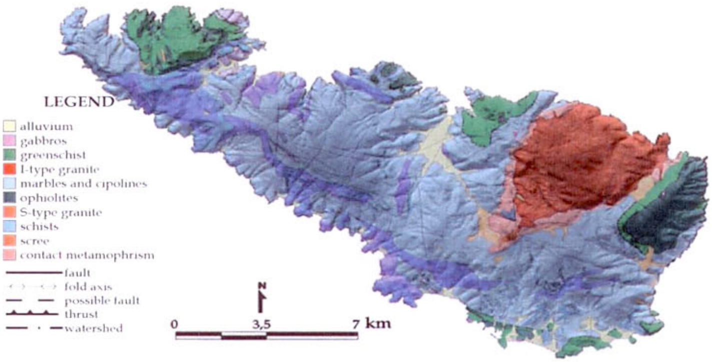

***Figure 2**: The geological map of the study area.*

Geomorphological setting

The morphology is controlled mainly by the extent of lithologic formations and the tectonics, together with the climatic characters. The high humidity and the strong NNE winds cause intense chemical alteration and weathering on schist and granite. Human activity is another important factor that affects the morphology of the island. This activity is consisted by the construction of artificial terracettes, which cover a large part of the island's surface, keeping the soil in place, and thus preventing it from erosion phenomena.

The island is characterized as semi-mountainous. Flat sections are plotted mainly in the discharge of the valleys; Komi-Kolimpithra's valley is a remarkable example.

Characteristic of the island is the intense asymmetry between the SW and NE part on both sides of the main watershed along the island, which coincides with the fold axis and separates the island in two regions with different forms of low relief, is characteristic (Livaditis & Alexouli-Livaditi 2001).

During the Miocene, the rise of plutonic rocks, as well as the consequent tectonic movements, indicate that the development of the relief occurred in a relatively short time interval under specific climatic conditions.

Livaditis & Alexouli-Livaditi (2001) has distinguished three morphological units with different relief types can be distinguished:

1. the first unit which covers the biggest part of the island,
2. the second unit which is present at the two ends of the island, and
3. the third unit which is found at the eastern part of the island and is characterized by granitic weathering forms.

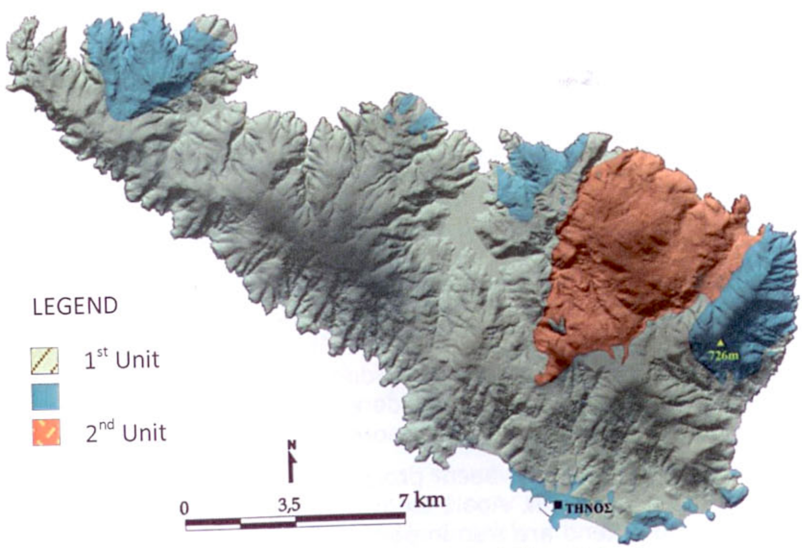

***Figure 3**: Morphology of Tinos Island.*

The description of the most important geomorphological formations that were mapped on the Island of Tinos follows (Leonidopoulou 2008).

Tafoni and Alveoles. These formations are developed along rock's discontinuities where porosity is higher and rock's strength reduced.

In some cases, intense deep erosion takes place in Tinos. This type of erosion is linear, directly connected with the movement and the amount of water discharged from the drainage network.

Another important geomorphological characteristic is peneplains. These formations are developed as a result of erosion processes, creating a layer of soil on their surface, which in combination with the reduced angle slope of the peneplain surfaces, less than 10°, facilitate infiltration, leading to the development or the enhancement of the aquifer.

Tinos' drainage network comprises from 170 torrents of seasonal mainly flow. Form them 89 torrents are Ist order, 62 are IInd order, 15 are IIIrd order, 3 are IVth order and only one is Vth order. Entirely, it consists of 632 Ist order streams, 158 IInd order streams, 31 IIIrd order streams, 6 IVth order streams and only one Vth order stream.

Erosion risk maps

The development of erosion risk maps involves a series of different stages, as field work, air-photo stereo-observation, digitization of geological, topographical and drainage system maps, definition of the input and output variables, establishment of logical rules between the input and the output variables, analysis and visualization of the results.

The principal variables used in this work will be:

1. erodibility of the rocks,
2. slope gradient of the morphology,
3. drainage density, and
4. land use

The erodibility variable is very complicated as it depends on the physical and chemical composition of the rock and the existence of major (folds, faults) and minor (bedding, foliation and joints) tectonical structures. Generally, the erodibility of the rock depends on the lithology, the process involved and the protective mechanisms. Lithology is connected to the hardness of the rocks and the resistance to erosion. This variable is difficult to be directly measured. Erodibility is a function involving rock's hardness, permeability and infiltration capacity. Marbles and blueschists are considered to be more resistant to erosion, while alluvials, soil and weathered mantle more prone to erosion.

The second variable that has been processed is the morphological slope gradient of each drainage basin. Apart from the slope gradient, form (convex, concaves), aspect and extend are also important factors. It is obvious that slope steepness is critical to the erosional intensity.

Drainage density input variable (ratio of the total stream lengths to the drainage basin's area) which is highly related to water's runoff quantity and substratum's permeability. In general, drainage density is high at basins of weak impermeable rocks and low in basins of resistant and permeable rocks. It was found that drainage density increases according to basin's average slope (Gregory & Wallig, 1973). Furthermore, drainage density of rills is highly related to slope gradient (Schumm, 1977).

As far as land use is concerned, erosion occurs in exactly the same way on all land uses and is related directly to the forces applied to the soil by the erosive agents of raindrop impact and surface runoff in relation to the resistance of the soil. Land use and land-use activities affect both the forces applied to the soil and the resistance of the soil to those forces. Ground or surface cover is material in direct contact with the soil that protects the soil from raindrop impact and slows surface runoff. The effect of ground cover on erosion is related directly to the percent of the surface covered. The effect of ground cover varies among climate, topography, and soil conditions.

The first step of this study is the digitization of the geological and topographical maps, scale 1:50.000 and the interpretation of aerial photos in scale 1:33.000. The study of the above mentioned elements is focused on the recognition, definition and impression of the factors which affect the erosion risk.

The aim of this first collection of data is the development of a geomorphologic map, which is enriched through fieldwork during which GPS is used. Through GIS analysis of primary and secondary data new information layers are extracted. Logical rules are imported via mapbasic programming language into GIS MapInfo Professional and are formulated into different weight parameters which affect the erosion risk index (Table 1). Finally, thematic maps are developed, presenting the geographical distribution of each parameter, as well as the final output index of the erosion risk index.

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