

# HABILITATION THESIS

## **Application of spatial quantitative methods to study the dynamics of relations between socioeconomic and natural systems**

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### **Abstract**

While the phrase '*application of spatial quantitative methods to study dynamics of relationships between socioeconomic and natural systems*' describes my entire research activity, in addition to the teaching and scientific career, several directions can be differentiated, forming three sides; the first one consists of the theoretical issues of natural and man-dominated systems, including the ecology of territorial systems and the theory of microbial Geographical Information System from the mainstream directions, and the ecological implications of the spatial planning process of transforming former military units into entrepreneurial centers and the relationship between ecology and theology from the secondary ones. The second consists of methodological elements supporting the first direction, and consists of the spatial statistics, geo- and biostatistics mainstream direction, and management of electronic health records as secondary direction. The third one supports the first two sides, and consists of the educational principles and methods used in educating students on topics related to these two sides.

From a theoretical standpoint, the ecology of territorial systems is a joint trans-disciplinary approach involving ecology, geography, spatial planning and statistics. The core concept is 'hierarchy of functional structures' as an organizational principle of the environment; in the dynamics of these functional systems, eco-energy is related to the degree of anthropization and also to their diversity at different spatial levels. Other changes induced in the process translate into changes of land cover and use, in tight relationship with the use of energy and climate changes. The consumption of primary eco-energy is translated into an extended scale of trophic levels, accounting for the consumption of energy in man-dominated systems. All these theoretical considerations set additional constraints over the development process, in order to ensure its sustainability; among the most important is integrating economic, social, cultural, and environmental criteria, while accounting also for the territorial dimension of the process.

In methodological terms, the most important principles relate to spatial and quantitative interpretations of the theoretical foundation. Trans-disciplinary thinking is equally important, leading to the creation of new disciplines at the confluence of quantitative and spatial approaches with the discipline drawing benefits from them. The approaches form a hierarchy depending on the purpose, spatial scale, and degree of abstractness. In this framework, the extended view of 'regression', encompassing all approaches to the simultaneous study of related independent and dependent variables, including the spatial ones, provides for a methodological framework for the study of man-dominated and natural systems in a spatial perspective, as well as for investigating their dynamic relationships, in full compliance with the principles of systemic analysis.

One of the core concepts bridging the ecology of territorial systems and the methodological developments related to spatial, geo- and biostatistics is diversity. Diversity is an essential characteristic of systems, allowing for understanding their dynamics, and has an important statistical dimension, in both qualitative and quantitative perspectives.

The attempt to develop a spatial and quantitative approach for the study of the microbiological realm resulted into an algorithm involving confocal scanning laser microscopy, digital image analysis and processing, image classification techniques, and ultimately the use of Geographical Information Systems used in conjunction with statistical tools for the spatial analyses resulting into the quantification of information in statistical parameters. While during the doctoral studies the approach was used mostly in its beginning phase, undergoing calibration by addressing research questions where answers were already known, the later research, presented in this thesis, shows its potential to be used as a research tool for the examination of the autecology and synecology of sulfate reducing microorganisms, an essential constituent of marine stromatolites. Understanding the structure (including microspatial organization) and functions of the stromatolites systems, the research has an important potential for understanding pre-historical life conditions. The main limitation of the approach is inferring causality from spatial relationships.

The trans-disciplinary approach to life systems, resulted from joining theology and ecology, showed that despite of describing the reality in different terms, the two have a potential for cooperation and even translation.

In terms of teaching methods, the research and experience underlined the importance of differentiated teaching, used in conjunction with a grading system increasing the number of criteria to approach a correct measurement of performance, heuristic strategies, feedback, transparency (including provision of course materials), and, most important, support of excellence.

The future plans are focused on effective teaching supported by research focused on continuing the studies of microbiological realm, of 'real' scale systems, by the publication of several books, by strengthening the ability to apply statistical methods and Geographical Information Systems in new research areas, by improving my editorial activity, and hopefully by a third doctoral degree.