



ULBS

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PhD Domain: **Cybernetics and Statistics**

Phd Thesis - Abstract

ECOSYSTEMS MODELING PROCEDURAL APPROACH FOR SUSTAINABLE MANAGEMENT

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Keywords

Cybernetic modeling, ecosystems, associations rules, processes, sustainable management.

Abstract

In the context of sustainable development strategies, this PhD thesis aims at generating a cybernetic modeling system with applicability in the management of bioresources.

The process approach to modeling ecosystems - defined as a scenario of prediction and response to the problems created by change - is a natural treatment in terms of the regional, institutional, economic and social framework in which sustainable management of bioresources is achieved. Economically, it is desired to maximize welfare as a result of profitable activities, while maintaining or increasing in time the stock of economic, ecological and socio-cultural assets and meeting the basic needs of all members of society. Combating poverty and social exclusion, promoting equal opportunities and keeping the balance in terms of capital and income sharing, the fair distribution of opportunities between generations are just some of the objectives of socially sustainable development. From an ecological point of view, the ecosystem imbalance is closely related with life support systems (on which the economy is based), exceeding their tolerance limits by generating very large volumes of waste (due to the expansion of human activities, growing population, increasing use of natural resources), and even the impact of development that produces major environmental changes are principles that should be further exploited to make economic decisions.

A fundamental role for ecologists is to send credible warnings about the risks of neglecting environmental conservation measures. Normative scenarios are a good means of spreading such messages because they take into account values and interests, describe the desired future or a multitude of specific goals, explore different ways to reach the intended purpose, or test different alternatives to find out how effective they are.

The cybernetic model on which the "tool" is carried out is used to describe management measures for the conservation of analyzed fish species and possible habitat indicators.

Thanks to the significant contribution to the economy, the protection of water resources and the preservation of bioresources are one of the most addressed themes of environmental principles. Integrating the goals of the various stakeholders and the interdisciplinary approach

to fish species management must be fulfilled by effective allocation and accountability to the responsibilities for their long-term conservation.

The main ideas underlying this thesis are: a. Synthetic presentation of how the procedural approach of ecosystem modeling should be carried out so that the bioresources analyzed are maintained or even improved, given their importance in preserving biodiversity, but also as an economic resource; b. application of cybernetic modeling on ecosystem services aiming at preserving bioresources (data and results refer to fish species and possible habitat indicators from protected areas ROSCI0132 and ROSCI0227) by using normative and descriptive scenarios; c. identification and highlighting of relevant management measures, association rules, for the conservation of the favourable status of fish species analysed and ecological balances.

Bioresources, in this paper, are studied and managed from the point of view of their intrinsic, unmeasurable value, difficult to value through economic and social indicators, and not from the perspective of direct economic capitalization. The importance of fish species and habitats for the preservation of nature, the living environment, the ecological services that we benefit from and which are needed, thereby entering the category of indirect economic values are emphasized. In order to correctly determine the importance of bioresource, it is crucial that the interested persons know all the values that characterize the natural resource and be aware of the benefits produced by it, whether quantifiable or non-quantifiable.

The chosen theme "Ecosystems Modeling Procedural Approach for Sustainable Management" is a crossroads of decision-making support systems, ecosystems, cybernetics, resource management and statistics. In this context, this paper aims at developing tools for the cybernetic modeling of ecosystems relevant to the sustainable management of natural resources.

This PhD thesis, through the interdisciplinary subject approached, wants to be part of the international concerns in the areas of cybernetics and statistics, information technologies, ecosystems and environmental resource management. The thesis consists of two sections: the theoretical part (containing chapters one, two and three) and the practical part (which contains chapters four and five) (Figure 1).

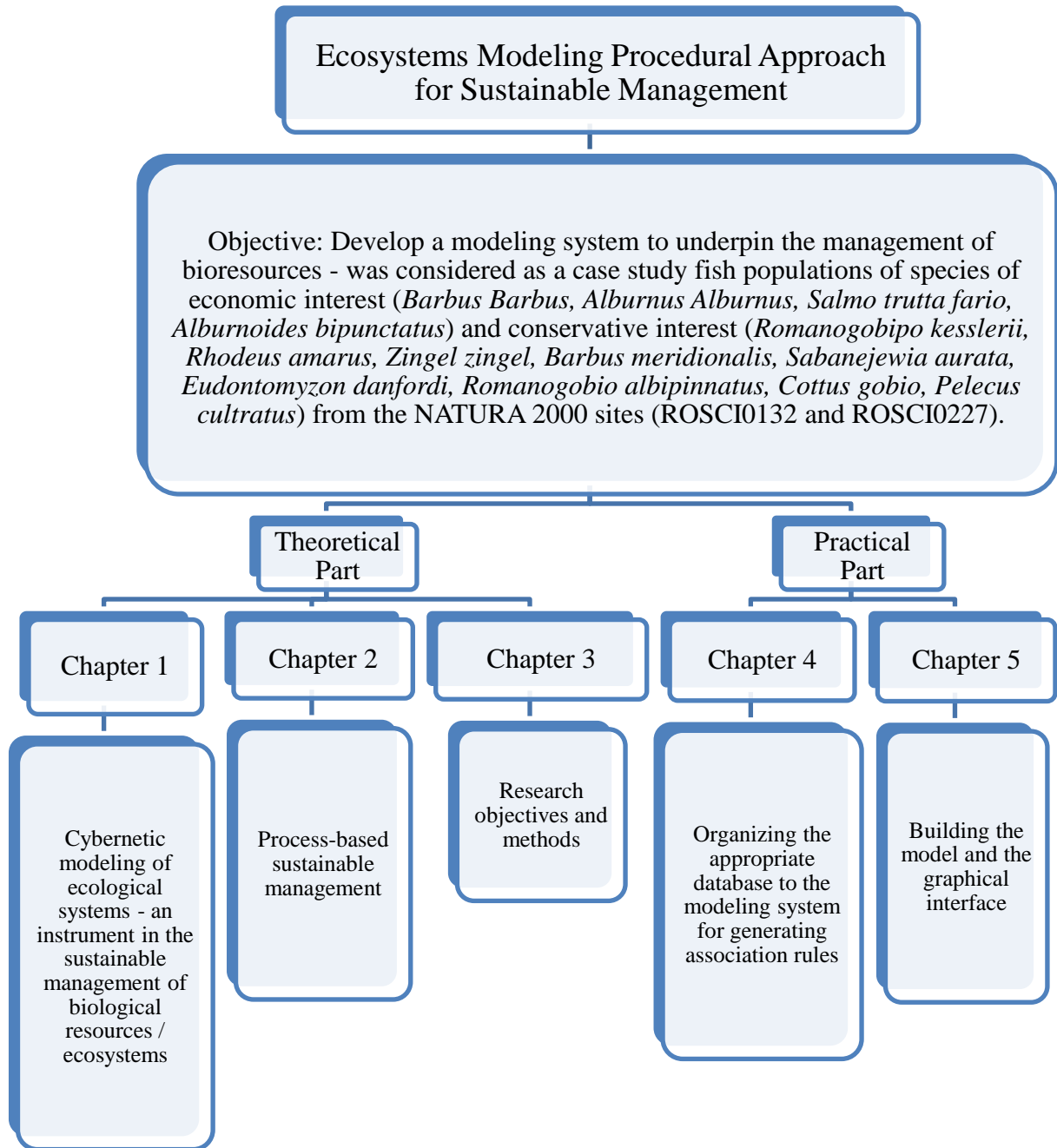


Figure 1: Structure of the thesis.

Chapter 1 contains a brief introduction to the motivation of the theme and its integration in the Europa2020 / Orizont2020 strategies, as well as the general aspects of cybernetics, outlining a cybernetic model adapted to the practical part of the thesis. It presents the relationship between biodiversity, ecosystem services and human well-being, as well as a set

of tools that analyze ecosystem services. Ecosystem services are researched from two points of view: as components of sustainable development strategies, as well as ecological models described through normative and descriptive scenarios. For the implementation of sustainable development strategies, it is essential to operationalize the principle of the use of ecosystems resources and services within the capacities of support and self-regulation of ecosystems, a principle underpinning sustainable development.

Scenarios can be seen as a tool for improving decision-making in the context of different ways of managing natural resources. Cybernetic modeling of systems should take into account a strategy that sets the direction to follow, concentrates efforts, ensures consistency and flexibility. The goods and services that ecosystems offer are vital to maintaining well-being, as well as for future social and economic development. Their disappearance will require the adoption of costly alternatives ([http://ec.europa.eu/environment/pubs/pdf/factsheets/Ecosystems_goods_and_Services / Ecosystem_EN.pdf](http://ec.europa.eu/environment/pubs/pdf/factsheets/Ecosystems_goods_and_Services_Ecosystem_EN.pdf)).

One of the principles of environmental protection policies is the principle of decision-making precaution, operationalized in environmental legislation by requiring an environmental impact assessment on plans, programs and economic activities to be implemented. Thus, those development models that respect ecological constraints will be promoted.

Chapter 2 presents the main elements of a business process management system. This is seen as a process of five sub-processes: the strategic decision process, the optimization process, the resource allocation process, the workflow process and the performance evaluation process. The method presented for a sustainable management of lotic systems is based on processes and optimization by assessing and monitoring fish species to preserve biodiversity by keeping an optimal ecological status of conservation and economic interest of fish populations.

The advantages are: observing all processes and their relationships; customer requirements (identification of critical requirements for the habitat of different fish species, monitoring and conservation of different species / ecosystems) are integrated into processes; the potential of the whole corporation / institution can be used efficiently with optimized processes meaning increased quality and low costs (environmental conservation institutions, protected area foundations, etc.); the skills and responsibilities of a sustainable management plan are transparent; clear product relationships (management measures for species conservation) and service-process-resources (specific habitat indicators species) ensure synergic effects and accurate resource planning; quality becomes quantifiable.

Based on the ecological characteristics of fish species of conservative and / or economic interest, the processes and manner in which they are transformed into models are outlined, highlighting the necessity and importance of using the process management system in any area that wants to be competitive and the style in which this system can be adapted to ecological models. It presents the process management tool that facilitates graphical visualization which is based on a clear description of activities, decisions, parallelism and subprocesses. Modeling components in Adonis: CE are some of the most usual and probably common tools used.

Computer support used in sustainable management of ecosystems allows much easier updating of information, activities, processes, step by step, visualization, and monitoring their medium and long term.

Chapter 3 outlines the general and specific objectives of the thesis as well as research methods. In this study, quantitative research combines with qualitative research to identify ways to improve bioresource management. The results can help decision-makers identify potential conservation issues and take appropriate management measures.

Chapter 4 describes the Apriori and FP-Growth algorithms and presents the sequence of operations that are performed to obtain association rules. Frequent sets play an important role in data mining applications, and the most common feature is finding association rules - in this case, finding association rules between the various management measures recommended in conserving the species of fish analyzed. Specifically, the rules seek to find those relationships of dependence between management measures of fish species. This chapter shows the software and the algorithms used to obtain association rules. The nineteen management measures applicable to fish species analyzed - detailed in Chapter 5 - are described and the database for generating association rules is presented. These management measures are determined on the basis of the value measured on the ground of the possible habitat indicators of the studied species. Finally, an example of these rules is presented, which suggests that the application of certain management measures groups to fish species determines the utility of other measures.

Chapter 5 outlines the main features of protected areas and the Natura 2000 network. Protected areas are the best paradigms for natural and semi-natural ecological systems, through their true quality and the low level of human intervention in their region. The Natura 2000 network is a European ecological network of special areas for the conservation of natural habitats and species of community interest. Includes special areas of conservation (designated

in accordance with the Habitats Directive 92/43/EEC) and special protection areas for avifauna (classified according to the Birds Directive 79/409/EEC).

The research was based on the description of the fish species, the ecological requirements sheet, the recommended management measures for maintaining the favorable conservation status and the cybernetic model was concretized through ADONIS: EC. The nine species of conservative fish in the ROSCI0132 and ROSCI0227 sites are *Romanogobio kesslerii*, *Rhodeus amarus*, *Zingel zingel*, *Barbus meridionalis*, *Sabanejewia aurata*, *Eudontomyzon danfordi*, *Romanogobio albipinnatus*, *Cottus gobio*, *Pelecus cultratus*, and the four species of fish of economic interest direct and indirect are *Barbus barbus*, *Alburnus alburnus*, *Salmo trutta fario*, *Alburnoides bipunctatus*.

For each fish species described and modeled in this study, there are a number of possible habitat indicators analyzed. The fish population management model verifies whether the current state of the indicators have or have not achieved the favorable conservation status. To assign the percentage of these decisions, the values of all the indicators in their present state were gathered, the sum obtained being divided by the sum of all values of the indicators in the favorable conservation status. The value obtained represents the percentage of achieving / attaining favorable conservation status (the "yes" branch of the decision). The method used to assign the percentage of each decision that verifies the indicators is: for the "Yes" branch of the decision, the percentage is the one that appears at the favorable conservation status in the critical habitat requirements table for each analyzed species, and for the "No" branch of the decision , the difference between 100% and the percentage value of the "Yes" branch.

The graphical interface provided by this cybernetic modeling system, by exporting processes modeled in html format, is meant to be understood by anyone, even without computer skills or code sequences generated by programmers.

In line with the European Commission's view on the implementation of a new strategy for sustainable management of natural resources, this paper highlights the timeliness and urgency of supporting the Horizon 2020 strategy, providing a cybernetic and modeling tool appropriate to bioresource management. The basic ideas of the thesis are: a. the use of cybernetic modeling of ecological systems based on scenarios; b. adapting the business process management system in terms of modeling ecosystem services; c. organizing the database appropriate to the modeling system to generate association rules; d. exemplifying the above by building the model and the graphical interface. Conclusions: a. to ensure a sustainable management of bioresources, the ecological systems should be modeled as cybernetic systems

by including the reverse reaction elements and thus including the recommended management measures for the conservation of the fish species studied; b. sustainability is based on intense interdisciplinarity and the modeling system should be systematically revised in the future; c. As a result, the proposed system can be integrated into any online platform.

The present research proposes a modeling system based on bioresources management, a cybernetic system designed to increase the efficiency of interested organizations by training and improving staff to preserve the favorable status of fish species in Natura 2000 sites of community importance. The proposed approach is based on the visualization of fish species models and on the identification of recommended management measures based on habitat indicator values.

To ensure success in modeling ecosystems for sustainable management, we discussed about cybernetic modeling, ecosystems, ecosystem services, and we presented the current concerns in the field. An overview of ecosystem services analysis methods has been carried out and associated models have been identified for the correct choice of the software tool for bioresource management.

Association rules on management measures to preserve the favorable status of fish species analyzed provide benefits when implemented in accordance with good practice and principles as well as organizational commitment to decision-making and action in an open manner. This cybernetic modeling system should be integrated into a general fish species management plan to provide realistic ways and easier risk management of open, dynamic, heterogeneous and uncertain environment.

The thesis is organized into two main parts, of which the first (chapters one, two and three) represent the theoretical support of the research, providing the basis of essential information in acquiring the knowledge necessary for carrying out the practical researches. The first two chapters also provide an analysis of the cybernetic, ecological and economic domains as well as the methodologies used in the research.

Our goals were, on the one hand, to investigate the possibility of applying Data Mining techniques to fish species management measures in order to obtain the association rules described in chapter four; on the other hand, in chapter five, to create a cybernetic system for modeling bioresources in order to achieve sustainable management.

The possibility of relatively easy visualization of cause-effect interconnections recommends using the results of such a method for a large number of stakeholders and involved both in the management of bioresources and protected areas.

The original contributions of the proposed theme cover both theoretical and practical aspects. The theoretical contributions aim at a synthesis of the main theoretical approaches of cybernetic modeling concepts, ecosystem services and sustainable management. They also seek to identify the main actions, conferences, conventions of the international community that generated statements, resolutions, recommendations, statistical and non-statistical standards. Practical contributions aim at analyzing the management of target bioresources; developing a cybernetic system able to establish the main ways of using natural resources and ecosystem services; collecting existing data (case studies on lotic systems and associated biological resources) and processing them to quantify existing performance; evaluation and modeling of the processes involved.

Some of the results and information that have been obtained from the research have been disseminated and published in the scientific series of specialized periodicals and in the volumes of international scientific conferences.

The doctoral thesis consists of 214 pages, the theoretical part has 52 pages, while the practical part has 149 pages, plus the bibliography and the list of papers published in the doctoral thesis. This doctoral thesis consists of 77 figures and 24 tables (of which 73 figures and 6 tables are original) and 177 bibliographic references.

The results of this thesis were included in 6 articles published in indexed ISI journals (Web of Science - All databases) and 12 articles published in indexed BDI journals.

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