INFORMATICS SYSTEMS USABLE FOR ECOSYSTEMS SERVICES' QUANTIFICATION – A METHODOLOGICAL APPROACH

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Abstract: *The present paper aims to present the main informatics systems/programs that can be used in the process of qualitative and quantitative evaluation of the services provided by ecosystems, in general and by agro-ecosystems in particular. The study starts from presenting the main goods and services generated by natural and entropic ecosystems, as well as the main informatics programs that can be used in the quantitative and qualitative analysis of data/information regarding these systems. Also, the main correlations and data processing methods for the quantification of services generated by the ecosystems are presented, based on the data collected during a study case on rural communities.*

Key words*: ecosystem, ecosystems services, qualitative and quantitative analysis, informatics programs*

INTRODUCTION

The ecosystems represent the basis of life and all human activities. The goods and services they provide are essential for maintaining the general welfare level and also for the sustainable socio-economic development. The process of evaluation of these goods and services and the complex relations between natural and human systems is supported by various informatics programmes that facilitate the quantitative and qualitative analysis of both aspects (ecosystems' goods and services and human-nature interactions). The present paper focuses on two informatics programs designed for qualitative and quantitative analysis of data/information collected, in this case, during a case study regarding Romanian rural communities.

MATERIALS AND METHODS

The evaluation of the goods and services provided by the ecosystem, in general, and by the agro-ecosystem in particular, identified during the case study at the level of several rural communities, turns to qualitative and quantitative analysis assisted by two informatics programs SPSS and ATLAS Ti. The data was collected during 2009-2010 at the level of 11 communes from Hateg-Retezat area located in Hunedoara county.

The main instruments used for data collection were:

A. questionnaire applied to rural households from Hateg area, containing socio-economic data regarding the anthropic activities (especially agriculture) and the human-nature interaction in order to evaluate the values and ecological behaviors. The total number of investigated households was 400. The collected data was later uploaded and processed by using the SPSS program, designed for quantitative analysis.

B. In-depth interviews applied to agricultural producers from the investigated area (traditional agricultural products: cheese, potatoes, bee products, alcoholic drinks). The qualitative analysis of the in-depth interviews was performed by using the ATLAS Ti informatics program. From the identified sample of agricultural producers, 10 in-depth interview were selected for the qualitative analysis.

RESEARCH RESULTS

An ecosystem represents a complex and dynamic combination of flora, fauna, microorganisms and natural environment that coexist in a unitary and interdependent way.

The ecosystems generate a large variety of benefits for mankind, known as ecosystems' goods and services. The ecosystems' goods include food, water, different kinds of fuels and wood, while the services refers to air purification, water supply, natural recycling of waste, soil regeneration, pollination and balancing mechanisms.

Experts around the world have identified four types of services that ecosystems provide, each one of them being of vital importance for the welfare of mankind:

- Provisioning services – responsible for production of goods (food, water, wood etc),
- Control services – responsible for controlling the climate and pluvial precipitations, water and wastes,
- Cultural services – referring to recreational services (like natural landscapes),
- Assistance services – including soil regeneration, photosynthesis and the nutrients cycle that stand at the base of production.

The present study focuses on the processing of data regarding the ecosystem's services, both internal to each type of service and external (correlation between data regarding different types of services), based on the study case on Romanian rural communities, undertaken in 2009-2010. The accent falls on the provisioning services of the ecosystems, namely food production and on the relation between natural and human capital. The natural and human systems represent a coupled system in which people interact with the natural elements, understanding the complexity of the interactions within this system being very important both to mankind's welfare and natural resources sustainability. Within this coupled system the agro-ecosystem represents an important component which covers, at global level, an important part of the total area, being dominated by anthropic activities. The analysis of the relation between agriculture and ecosystem represents a natural undertaking, taking into consideration the fact that, in essence, agriculture represents an ecosystem dominated by human activities and that between this two components there are mutual inter-conditioning relations.

The data processing was accomplished by using two informatics programs SPSS and ATLAS Ti designed for quantitative and qualitative analyses. The data regarding the specific ecosystem of the investigated area was collecting by means of two instruments: first was the questionnaire for rural households containing sections regarding socio, demographic, economic, environmental and ecological behavior data; the second instrument was the in-depth interview applied to agricultural producers from the investigated area.

The first data set contains information regarding the rural households, structured by several categories:

- Socio-demographic : age, gender, education, status, occupational status of respondents and other household members, status of membership in different types of associations;
- Economic : monthly household's income by type of income, data regarding the agricultural activities (agricultural area, cultivated area, crops, area by crops, number of animals, inputs, outputs, commercial behavior);
- Environmental and ecological data: household's annexes, water supply, respondents' opinion regarding the impact of household and agricultural activities on the ecosystem's components, valorization of ecosystem's components by

respondents, respondents' opinion regarding the impact of anthropic activities (like dams, roads, tourism, private constructions) on the environment.

The next step, after collecting the data, was the elaboration of the SPSS database: for each column of the questionnaire a specific variable was created corresponding to the nature of information contained by the column. In total, 529 variables were created for the data set. The verification of the database's integrity was the next step – generation of reports for each of the variables in order to highlight possible data upload errors and correct them. After this process was over, the data from the questionnaires was uploaded into the database, verified and corrected if necessary.

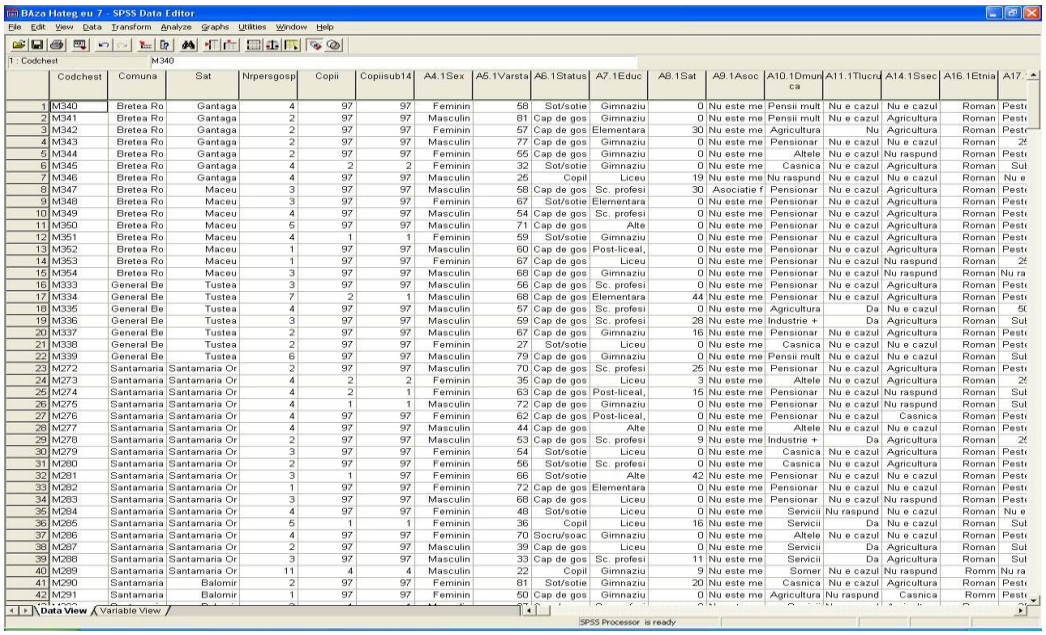

Fig 1 SPSS study case database in Data View mode

The next step consisted in processing the data uploaded into the database, process that followed the main objectives of our study case – the socio-economic analysis of the rural households and evaluation of the households' behavior in relation to the specific ecosystem of the investigated area and ecological values.

The main data processing reports operated on the database where: absolute and relative frequencies, number of cases, summary tables, custom tables, contingency tables, means, average value of selected indicators. The reports were operated following the data inputs regarding the main categories of the questionnaire:

- Socio-demographic: age structure of respondents, average age of respondents, average number of household's members, structure of respondents by gender, status, occupational status, average number of children per household etc;
- Economic: average household's income, structure of households' income by type of income, average household's income per person etc;
- Agricultural activities (food production): average area per household, structure of household's area by destination (agricultural, arable, forestry); average agricultural area of household, structure of agricultural production, average cultivated area per crops, total and average production per crops, structure of productive inputs (including average quantity of fertilizers and other chemical substances), livestock, average number of animals per household, total and average production, commercial behavior (types of markets where household sell the products,

quantities, prices), structure of households by type of agricultural activity (organic, traditional) etc;

- Environmental and ecological data: structure of households by type of household's annexes, average age of household annexes, distance from the household's water source, household's water source by types (network distribution, fountain, well, spring), structure of respondents' own evaluation of the quality of water, structure of households by ways of depositing the organic fertilizers resulted from livestock activities (on the ground, concrete platforms and pits) and distance to the main water source, structure of respondents' own evaluation regarding the impact of household's activities on environmental elements, structure of respondents' own evaluation regarding the importance of environmental issues, structure of respondents' own evaluation regarding the impact of other anthropic activities, from the investigated area, on the environmental elements (construction of dams, tourism, roads, holydays villas etc).

Besides these above mentioned reports, operated for each major questionnaire category (that we can call "internal"), many contingency reports were operated on the database ("external") linking together elements from different questionnaire categories, in order to surprise the main factors that influence the households' activities (mainly agricultural activity) and behavior in relation to the specific ecosystem of the investigated area. Among these reports we mention: structure of agricultural production, the type of agricultural activities (organic, traditional), livestock structure, total and average production, main water source, household annexes, distance to the main water source by age group, gender, educational level, status, occupational status of the household's chief; structure of respondents' own evaluation of the quality of water, structure of respondents' own evaluation regarding the impact of household's activities on environmental elements, structure of respondents' own evaluation regarding the importance of environmental issues, structure of respondents' own evaluation regarding the impact of other anthropic activities, from the investigated area, on the environmental elements by age group, gender, educational level, status, occupational status of the respondent. Once the data processing was over, the next step was to elaborate the analysis and to draw up the research report.

The second data set it's based on the in-depth interviews applied to agricultural producers from the investigated area and was processed with the ATLAS Ti informatics program, that is designed for qualitative analysis. From the identified sample of agricultural producers, 10 in-depth interviews were selected for processing. The main reason for choosing ATLAS Ti informatics program was the possibility of simultaneously working with multiple documents/interviews in a single project/file but also the numerous coding, visualization and data processing options and the possibility of exporting quantitative data to SPPS for further processing.

The steps taken in order to elaborate the qualitative analysis of data from the in-depth interviews were: transcription of in-depth interviews into reach text format MS Word files (.rtf or .txt) and uploading the files into ATLAS Ti. At the end of these stages, the project/file contained the 10 in-depth interviews. The next step was to identify and create the necessary codes for the qualitative analysis. This process (choosing codes and sub-codes) followed the specifics of traditional activities from the level of the rural households, namely: level of activity's traditionality, geographical traditionality, length, motivation, social type of activity, product's valorization, technological process and conditions, roles' distribution within the activity, commercial traditionality, projects, land and agricultural resources and socio-demographic characteristics of respondent's / household's. The next

step was to codify the text passages according to the previously design code structure, by going over each interview and assigning corresponding codes and sub-codes.

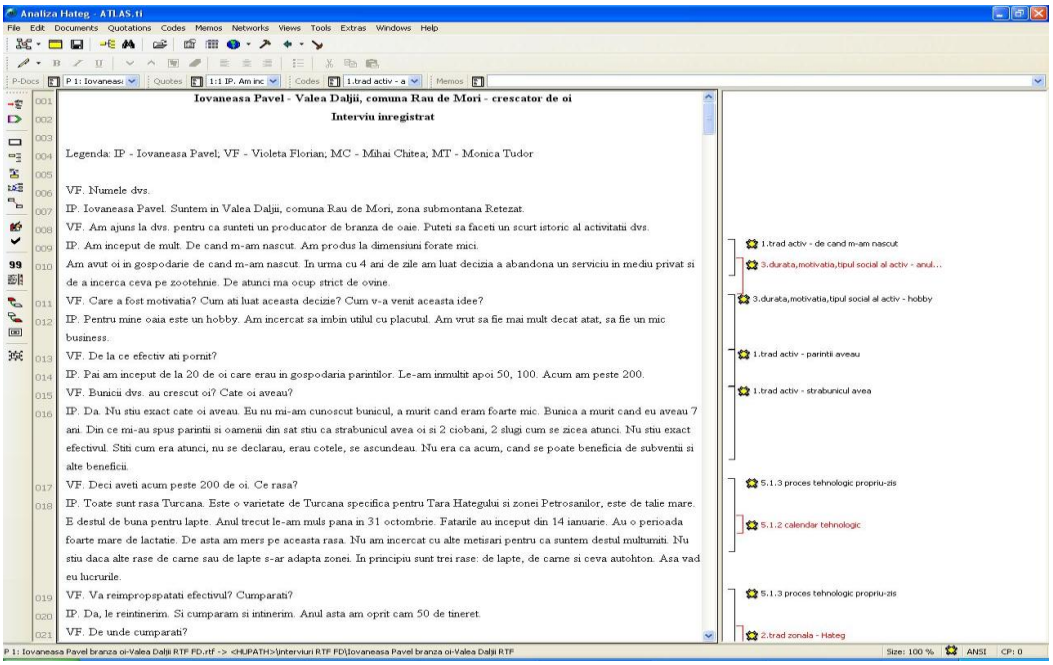

Figure 2 Case study ATLAS Ti project overview, in Data View mode

The next step was the processing of data contained by the project. This process consisted in listing all the codes and sub-codes, the incidence, the quotations and realization of network view schemes charts for each individual category (traditionality, motivation, technological process etc).

The last step was represented by the analysis of the processed data and elaboration of the qualitative analysis regarding the traditional agricultural activity deployed at the level of the investigated rural area.

Next we will present the main research results of our study case regarding the specific agro-ecosystem from the investigated area and the ecological behavior and values of the rural households, structured by two dimensions: objective and subjective.

The first dimension (*the objective one*) refers to the main agricultural models that are practiced at the level of the investigated area. The analysis of the agricultural activities deployed by the rural households reveals the existence of two agricultural models, namely: one that makes use of both organic fertilizers and chemical substances (fertilizers, pesticides etc) and other ecologically traditional, with a minimal impact on the ecosystem's components. Some key facts about the rural households that deploy agricultural activities at the level of the investigated area:

- the structure of the agricultural land, by destinations, at the level of the investigated area, is: arable land 48.5%, pastures and hays 49.47%, orchards 1.83% and vineyards 0.20%;
- the average area of the rural household is 4.6 ha, out of which 76.41% represents agricultural land and 23.59% forestry land; the average agricultural area of the investigated rural households is 3.51 ha and it varies from 2.23 ha in Baru commune to 5.81 ha in General Berthelot commune;
- the main agricultural land destination is represented by pastures and hay (49.47%) but this value varies significantly from one commune to another (the smallest one in Totesti commune – 22.56% and the largest one in Pui commune – 67.75%);

- the second largest agricultural land destination is represented by the arable land (48.50%); the percentage also varies between communes, from 30.88% in Pui commune to 75.50% in Sântămăria-Orlea commune; the average size of the arable land is of 1.71 ha;
- the main crops, cultivated at the level of the investigated area, are: maize 36.69%, wheat 25.06% and potatoes 20.58; other crops are also present, but their share in the total cultivated area are relatively low: vegetables 4.44%, clover and alfaalfa 4.36%, fodder plants 1.33%, oats 1.03%, barley 0.74%, tworow barley 0.63%;
- the main agricultural inputs used in the agricultural activity are: *seeds* – rural households buy seeds especcialy for maize (52.48% of the households), potatoes (33.22%) and wheat (31.17%); *chemical fertilisers* – the percentage of the households that buy this type on input is of 59.15%; *organic fertilisers* – they are widely used mainly from own production (from livestock activity): 60.34% of the households use organic fertilisers from thieir own production and 7.07% of them turns to buying; pesticides – 48.73% of the households use this type of input; this percentage varies across the investigated communes.

Within in this first agricultural model, the rural households turn, both during the vegetational stage of the crops and in the stage of preparing the land for the next crops, to organic fertilisers resulted from livestock activities and to chemical substances (fertilisers, pesticides etc). The execesive use of these last mentioned inputs can lead to the degradation of the environmental factors and, furthermore, to the emergence of dezequilibriums between the natural and human systems.

The second agricultural model identified at the level of the investigated area is represented by that of traditional agriculture. Based on the level of traditionality and ecological sustainability, the traditional products fall under two categories:

- traditional products with maximum ecological sustainability – obtained only by respecting the traditional technological ways and fully complying with environmental restrictions, without any chemical aggression (no chemical treatment is applied); some examples of such products are: goat and sheep cheese, potatoes, honeybee products, alcoholic drinks and forest fruits gems;
- ecological traditional products - obtained only by respecting the traditional technological ways and partially complying with environmental restrictions, by using some minimal chemical treatments, only when it is strictly necessary; some examples of such products are: potatoes, sheep cheese.

This category of ecologically traditional products generates a minimal impact over the elements of the natural system from the investigated area, by rationally use of chemical substances, along organic ones, only when their use in absolutely necessarily. Together with the traditional products with maximum ecological sustainability they represent an agricultural model that has to be sustained and developed, process that represent a way of supporting the "local patrimony" and an important endeavor in the act of keeping/preserving the cultural and acting identity of the rural space.

Regarding the *subjective dimension*, this refers to the way that respondents have evaluated the impact of anthropic activity on the elements of the natural system from the investigated area – household's activity, agricultural activities, tourism and construction of dams on the Raul Mare river. The main research results regarding the subjective dimension are:

- the environmental behavior is influenced by the socio-demographic characteristics of the respondents, out of which the educational level seems to be the main one: respondents with a higher education tend to evaluate, much higher, the household

activities and agricultural ones as being pollutant than the respondents with a lower educational level;

- regarding the anthropic factors like dams, construction of roads, tourism the respondents consider that these had a low or very low impact on the natural system's elements : dams – average value 1.88, pensions – average value 1.55, holiday villas – 1.46 and construction of roads – 1.81 (the average value varies from 1 to 5, 1 being the "no impact" and 5 being "very high impact");
- the spatial distribution of answers doesn't show significant differences regarding the evaluation of the polluting potential of anthropic activities. More, average and high values can be found at the level of those communes where large hydro technical constructions were erected and a large part of the tourism housing units are located, fact that can be explained through the valorization, by the respondents, mainly of the economic advantages induced by these factors (jobs, economic development of the area).

CONCLUSIONS

The process of analyzing such an complex and important subject as the services provided to humankind by the ecosystems, especially by the agro-ecosystems, can be made easier by turning to informatics programs designed for quantitative and qualitative research like SPSS and ATLAS Ti. The multiple options for analyzing the data, either from statistical sources or collected during case studies, and the inter operability of the programs represent powerful instruments for researchers dealing with natural and human systems, that can be extended to other research domains as well. Furthermore, the possibility of working with multiple documents / data sets under a single project supports the efforts of an integrated analysis of the investigated area of interest and represent a good opportunity to ensure that all data/information is processed with a high level of accuracy that is absolutely necessary in the process of analyzing large amount of interconnecting data.

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