UNDERSTANDING SOCIO-ECOLOGICAL NETWORKS OF BIODIVERSITY CHANGE

Nancy Arizpe[1], Beatriz Rodríguez-Labajos[2] and Rosa Binimelis[1]

Abstract

In recent years, novel theories and methods have enriched the possibilities for an integrated socio-ecological assessment of biodiversity loss. In order to contribute to the methodological discussion we propose an innovative procedure to build a multifunctional network of the ecological, social, economic and political interactions accompanying biodiversity change. The analytic toolbox includes networks analysis, the assessment of ecosystem services, the Drivers-Pressures-State-Impacts-Response (DPSIR) model, and the environmental, social, economical and political framework for sustainability.

While in the past the efforts for integrating these views mainly came from theoretical reviews, this application is empirically grounded. Field data were obtained at the site level in 11 field sites of 10 European countries, through the ALARM project Field Site Network. Each site includes two plots representing both preserved and perturbed conditions of the respective ecosystems thus allowing a comparative analysis.

The analysis of data allows identifying linked events so as to describe the underlying multifunctional network between factors. Reciprocal relations between the environmental, social, economic and politic spheres are elicited. Besides exploring the interfaces where each one of the DPSIR model categories are operating, the study also aims to identify main stakeholders and indicators linked to each phase of the process.

Results include the socioeconomic characterization of the different field sites where we analysed main economic activities, environmental activities. The analysis of the DPSIR processes, and is discussed the proposed methodologies: the associative network of the D-P-I components, and the multifunctional network which we can identified the interaction between DPSIR, the policies that are taken in the field sites and a diagram with the main indicators and stakeholders.

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Keywords

Biodiversity conservation   Multifunctional network   DPSIR
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1. Introduction

In the last year, the studies in biodiversity change has tackling in different ways, one of this is focus in biodiversity conservation that promoted research projects in ecosystem services (De Groot, 1992; Daily, 1997; Balvanera *et al*., 2001; De Groot *et al.*, 2002; Singh, 2002; Chan *et al*., 2006; Constanza *et al*., 2007). The ecosystem services are defined as *"the benefits that people obtain from the ecosystem"* (Millenium Ecosystem Services Assessment, 2003). A review by Chan *et al*., (2006) explores the planning with existing data and the correct implementation focus. In order to advance in this way, overall mechanisms enhancing a dynamic and organic view of the socio-environmental interactions have to be adapted to encompass them. Egoh *et al*. (2002) mentions that limitations of conservation assessments are related, on the one hand, to challenges for defining and measuring ecosystem services, and on the other, to coordinate actions between stakeholders involved with ecosystem management

The aim of this paper is to propose multifunctional networks as a tool for the biodiversity conservation across the categories of the DPSIR model (Drivers-Pressures-State-Impact-Response) in order to understand and structure the associative links. An innovative model that integrates reciprocal relations between the four environmental, social, economic and politic spheres will be employed. Besides exploring the interfaces where each one of the DPSIR model categories are operating, this study also aims to identify main stakeholders and indicators linked to each phase of the process.

2. Two models for an integrated view of biodiversity and society

The DPSIR model is defined by EEA (2005; 2006) as "*the causal framework for describing the interactions between society and the environment*". Since it allows establishing key connections between society and the environment, it can be used as a communication tool between researchers from different disciplines, on the one hand, and between researchers and other stakeholders, like policy makers, on the other (Rekolainen *et al*., 2003).

The DPSIR framework has been already applied to biodiversity issues (Delbaere, 2002; Rogers and Greenaway, 2005). Svarstad *et al*. (2008) analyzed the DPSIR framework through the 'lenses' of four major types of discourses on biodiversity: preservationist, win–win, traditionalist and promethean. They concluded that the DPSIR framework is not seen as a tool for generating neutral knowledge since it tends to reproduce discursive positions. Accordingly, the authors propose that the understanding of socio-economic and cultural drivers should be broadened. Then it is essential to analyze properly social, economic and cultural conflicts surrounding the issue in focus. Therefore, they suggest that DPSIR must be extended in order to understand correctly socio-economic and cultural drivers.

In this sense different European projects are used DPSIR and integration of the field sites like the European project ALTER-Net provides other contribution in the employment of the DPSIR framework for biodiversity assessment. ALTERNET-Net aims at Long Term Socio Ecological Research (LTSER). To this end, the project pursues a selection of indicators that link socioeconomic and environmental processes, and criteria for establishing focal research sites (Ohl *et al.*, 2007; Haberl *et al.*, 2006). In the present study, a final result is also a set of indicators steaming from the proposals of the informants in the different sites. In the ALARM project, the categories of DPSIR framework are revised and defined to delimit socio-economic factors influencing changes in biodiversity (Maxim *et al.*, 2007). The authors underline that the implementation of the DPSIR framework is influenced by different factors depending on the problem at hand. Some of these influences are relevant for the development of the present study, particularly those related to the state of knowledge in the ambits where the study is undertaken, the existence of different methodologies for approaching the problem and the background of the observer.

This section presents three ways to approach the implementation of DPSIR to assess interactions between society and biodiversity: the 'Four spheres' (4S) model, the long term socio-ecological research framework and multifunctional networks analysis. The three of them are relevant for the design of the methodology in this study.

Maxim *et al.* (2007) integrate biodiversity analysis including the DPSIR model in the so-called "the four spheres" organization framework (environmental, social, economic and politic) and this framework was initially proposed by O'Connor (2007).
The idea is the representation of the DPSIR components within a tetrahedral framework for sustainability analysis. It consists on a 4×4 matrix array with the social, economic, environmental and political components, where their different intersections are the interfaces of two dimensions (O'Connor, 2007; Maxim *et al.*, 2007). This can be useful, for instance, to disclose issues in the public discussion about biodiversity conservation. In this study, the four spheres framework allows organizing the items obtained through the survey in the multifunctional network.

A final application of the DPSIR model is the building of multifunctional networks as a graphical representation of the interconnections between different components and processes. bc2008@zedat.fu-berlin.de (2007) developed this implementation for the case of human-related Nitrogen processes and derived a set of environmental indicators.

While in the past the efforts for integrating these views mainly came from theoretical reviews (Ragin, 1994; Giupponi, 2005; Svarstad *et al.*, 2007; Maxim *et al*., 2007), this paper relies on the empirical data provided for the Field Site Network of the ALARM project (ALARM, 2003). Thus, the study integrates ecosystem services in a socioeconomic field protocol run in 10 EU countries. Organized around the categories of the DPSIR Framework, the survey disguised between the conditions of two types of sites, natural and disturbed.

This paper is structured as follows. In the next section we describe the theoretical background that includes the DPSIR model, the 4S framework and theoretical basis of multifunctional network analysis. In Section 3 we describe the methodology and the section 4 presents the results. They include the socioeconomic characterization of the field sites, the joint analysis of the DPSIR model, the ecosystem services and the multifunctional network analysis. Finally, we discuss the advantages and disadvantages of this method and give some recommendations in Section 5.

3. Methodology

Based on the concepts described above, the methodology employed during the research process is summarized in the Fig. 1 and described in the sections 3.1 to 3.3.

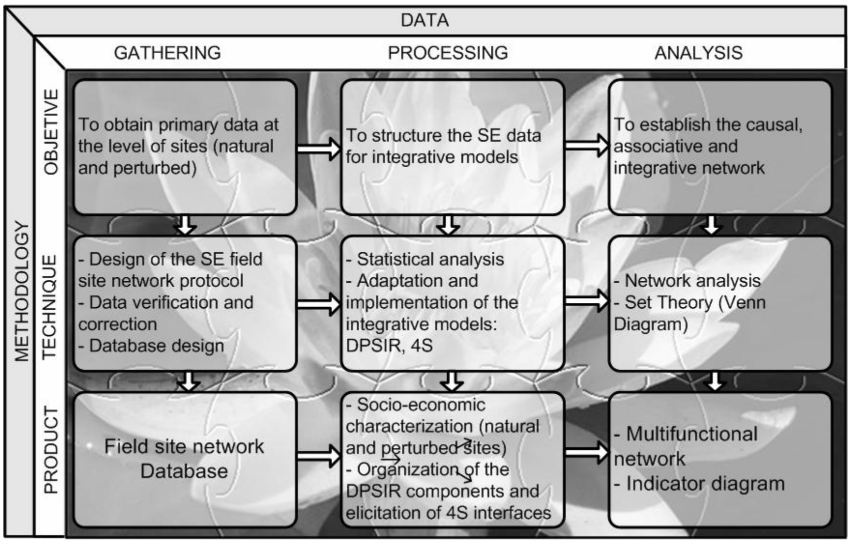

Fig. 1 Data Flow Analysis

3.1 Data gathering

The main instrument for data gathering was the implementation of a field site protocol containing a questionnaire to be answered by local field managers in the territory. The questionnaire was structured in three parts:

- General information about the informants
- Socio-economic characteristics of the region containing the site (demographic and economic features, and institutional aspects of biodiversity conservation) and the site (demographic aspects, access and property rights and land cover)
- The dynamics of the site according to the DPSIR components. This includes a review of involved stakeholders and a proposal of indicators associated with these components. The State and Drivers consider the ecosystem services framework and was implemented/developed in other works (Binimelis *et al.*, 2007)

The socio-economic protocol (SE) was designed in 2006. From March to September of 2006, the questionnaire was piloted in the field sites of Garraf (Spain), Île-de-France (France) and Tartu (Estonia). After the adjustments, the protocol was run in the set of ALARM field sites from October 2006 to July 2007. Questionnaires were checked and possible mistakes and/or omissions were verified with the site managers.

The field sites included: (a) Berkshire (UK), (b) Toledo (Spain), (c) Garraf (Spain), (d) Île de France (France), (e) Göettingen (Germany), (f) Meolo (Italy), (g) Uppsala (Sweden), (h) Krakow North (Poland), (i) Tartu (Estonia), (j) Lithuania (Lithuania), and (k) Lesvos (Greece). Each field site is composed by two areas of 4×4 km: a disturbed and natural plot with similar topographic characteristics.

3.2 Data processing

A database was constructed and made in *Access 2003*® distinguishing qualitative and quantitative information as well as open and closed answers. On the one hand, data was analyzed with descriptive statistics by means of *SPSS*® software. That allowed carrying out the socioeconomic characterization, emphasizing differences between natural and perturbed areas of each site. The specific aspects that were analyzed are: demographic information (population, density), average income, main economic activities, importance and regulation of biodiversity, stakeholders and institutions, and access and property rights.

Also, the socio-environmental processes occurring in the sites were systematized according to the DPSIR components. The data base registered these components, as well as their trend (evolution of the driver/pressure/impact) and intensity (strength of the influence of a given driver, pressure or impact). Along the scheme, the concept of ecosystem services was employed to indicate relations of society and biodiversity (e.g. to describe the 'state' of the site), and their alterations (e.g. to classify 'impacts').

On the other hand, it was necessary to classify the data of each DPSIR component as one of the categories proposed by the 4S framework. That meant to distinguish in the data the scope of the four spheres (social, economic, environmental and political) and their interfaces (the two dimensional intersections among them).

3.3 Data analysis

The main analytical tool data analysis was networks analysis. The phases for constructing the multifunctional network combined the three steps proposed by Niemeijer and de Groot (2008) and the design of a structure given by the 4S scheme and its interfaces. The first three steeps allow obtaining what is proposed to be called 'associative network' of socio-environmental processes on biodiversity change. The fourth step generates the final multifunctional network and a proposal of indicators set. Thus the analytical process followed the procedure described next.

1. *Delimiting domain of interest*: data were obtained from the 11 field sites (22 questionnaires) for establishing the link between socio-economical processes and changes in biodiversity, especially biodiversity loss.

2. *Specifying boundary conditions*: we took the principal components of the DPSIR model identifying concurrent cases in the field sites.

3. *Exploring network topology*: The questionnaire directly requested relations between components. For instance, it was asked to link a given pressure with a driver and in turn, to an impact(s). Through an associative network, the set of causal relations was identified.

   The analytic process was facilitated with the use of the *UCINE*® software oriented for social networks developed by Analytic Technologies (Borgatti *et al.*, 2002). The network analysis is based in the calculation of a series of centrality indices.

The centrality of a node in a network is a measure of the structural importance of that node. Thus, centrality indices point out the structural importance of nodes or edges in a graph. There are three important indices to take in consideration: degree, closeness, and betweenness. The calculation of these indices allows identifying the principal nodes, and consequently, the principal components of socio-environmental processes of biodiversity change.

4. *Organizing the multifunctional network structure*. The information is integrated into a Venn diagram. According to the set theory, that helps us to understand the principal sets with its logical relationships and basic dynamics. In this case, the Venn diagram is constructed as the intersection of the different spheres of the 4S model. The internal connections (nodes) displayed in the diagram are given by the components of the DPSIR model thus showing the data flow. Not all the possible interconnections are included. Just those with high rating in the centrality of the associative network are considered as the principal components of the network and consequently displayed in the final multifunctional network.
   Finally, the indicators of the main components of the DPSIR model are displayed also in a Venn diagram.

4. Results

4. 1 General socioeconomic characterization

The characterization of the field sites is important for knowing the context, building the multifunctional network and interpreting the results of the analytic process. For these reasons, we describe the overall characteristics of the sites according to the data gathered through the questionnaires. The main aspects of the characterization are population, socioeconomic activities and perception of public attitudes towards biodiversity.

Differences between natural and disturbed sites are emphasized in the description. The average population density of the region comprising the sites is higher in the disturbed sites than in the natural sites. At region level the annual income per capita average is above 15.300 euros and the unemployment rate is higher in the natural than in the disturbed sites.

The main economic activities in the natural and perturbed sites are important to know the level of development and kind of natural resource uses. For example the agriculture is, the main economic activity, since it is practiced in all the disturbed sites and in the 80% of natural sites. Industrial activities are reported in 70% of the disturbed sites versus 50% of the natural sites. Tourism is reported in 50% of the disturbed site versus 70% of the natural sites, pointing out a higher social preference for developing recreation activities in well-preserved ecosystems. Forestry activities are developed in 20% of both kinds of sites.

According to the informants, regulation for biodiversity preservation exists in 90% of the sites and is enforced in both natural and disturbed sites. The enforcement control involves different entities such as environmental departments, regional administrations, environmental institutions and natural museums.

The principal institutions and actors that consider biodiversity important are: governmental environmental departments, private societies with environmental interests, inhabitants, scientists, wildlife conservation organizations, NGOs and groups in charge of natural parks management.

Another relevant aspect for the socioeconomic characterization is related to property rights and the kind of access to the sites. Access to both natural and disturbed sites is mostly open. This affects areas such as road and rail networks, natural vegetation (coniferous, mixed, forest), urban areas, water masses and arable lands. Restricted access is higher in the natural sites. In general, restrictions affect areas destined for sport and leisure, like golf courses and cultivation areas or industrial sites.

The dynamics of the site

In order to know the state of the sites, we listed the reasons for selecting a given area as either disturbed or natural sites and linking its characteristics that are associated to the ecosystem services. Differences between ecosystem services provided by natural and perturbed clearly appear for the site services. Thus the existence of a typical habitat or the presence of endangered species in the natural sites contrasted with the intensive arable farming and the high level or natural resource use appearing in many of the disturbed sites. The interface identified in the State items was ‘environmental, environmental’ that comprise the “environmental sphere”.

Changes in the sites are driven by processes at different scales (global-European, national and regional-local). The respondents in the sites expressed the perception about which are these driving forces, and their trend and intensity. Results are displayed in the Table 1 arranged in order of frequency (from more to less frequently mentioned). The final column indicates the type of interface defined according to the ‘spheres’ of sustainability framework. The selected interfaced and spheres are given by the definitions given by O’Connor (2007), the introduction of DPSIR elements by Maxim et al. (2007) and the empirical knowledge based in the descriptive analysis and characterization.

TABLE 1. DRIVERS

Drivers	Scale			Trend			Intensity			Interfaces
	N	&	D	N	&	D	N	&	D	
Economic, social or environmental policies		GN		SI MI		MI		4		(political, political) (social, social) (social, economic)
Change in lifestyles, social or environmental values		GN L		SI MI		MI		3		(social, social)
Abandonment of agricultural land		GNL		S		MI		3		(Social, economic)
Urban development		GNL			SI			3		(social, economic)
Tourism development		NL			MI		3		2	(social, economic)
Technological change		GN			SI MI		3		4	(economic, economic)
Change in consumption patterns		GN		SI MI		MI		4		(social, economic)
Increase in energy use		GN			SI		4		3	(social, economic, environmental)
Lack of efficiency of institutions		N			U			3		(political, political)
Deliberate introduction of species		L		U		MI		2		(social, economic, environmental)
Expanding transport infrastructures			L			MI			2	(economic, economic)
Industrial development			L			MI			3	(economic, economic)
Intensification in the use of chemicals		LN		S		MI	2		3	(social, economic, environmental)
Generation of employment			N			S				(social, economic)
Extension of irrigate lands			G			S			2	(social, economic, environmental)
Other		GNL			SI MI MD			2-4		

Note:

Site	Scale	Trend		Intensity
N - Natural	G – Global	SD – Strongly decreasing	U - Uncertain	1 (low) to 5 (high)
D - Disturbed	Nt – National	MD – Moderately decreasing	MI – Moderately increasing	
	L – Local	S – Stable	SI – Strongly increasing	

It should be noted that the relation “social, social” constitutes the “social sphere” that is the social self-organization, where cultural values and lifestyle are considered. Changes in lifestyles are the cause of factors like globalization which are present in all scales. In fact, at the local scale the trend of this driver is strongly increasing. The abandonment of agriculture is a very relevant driver for the changes in the sites that involves, in turn, changes in the social organization and in the land use.

The self organization of the economic sphere (“economic, economic”) can be detected in driving forces such as the expansion of transport infrastructures that affect the level regional/local or the industrial development. The later stimulates the increase of economic income but may have negative repercussions on the environment like air, water and soil pollution.

The political sphere (“political, political”) is represented in economic, social, environmental policies. In the natural sites its trend is strongly increasing fostering biodiversity conservation though the implementation of different projects and programs.

In the relation “social, economic”, urban development contributes to urban expansion and industrialization.

The principal stakeholders (recognized) were:

- *At the global level*: governments, private companies related to natural resource use (e.g. forestry industry), politicians and environmental NGO's.
- *At the national level*: governmental environmental and agriculture departments, environmental and conservation NGOs and actors in charge of national and regional policies.

- *At the local level*: farmers and landowners, local and regional authorities, tourist agencies, actors in charge of environmental programs, regional industry and local population.

Table 2 condenses the information about those aspects identified as pressures according to the informants. Pressures are ranked according to their frequency.

TABLE 2. PRESSURES

Pressures	Trend			Intensity			Interfaces
	N	&	D	N	&	D	
Landscape fragmentation	SI		MI		2		(environmental, economic)
Increased pollution		MI		1		2	
Climate change		MI			3		
Reduced resources availability	I	MI		3		2	
Waste generation, disposal and incineration		S		2		3	
Change in fire regimes		MI			2		
Creation of invasion corridors		S/MI			1		
Technological change			MI			4	
Changes sp. composition and genetic diversity		S					

Table 3 shows the impacts on the ecosystem services provided by the sites, according to the perception of the informants. Ecosystem services are classified in four categories: source, sink, life support and scenery.

TABLE 3.IMPACTS

Impacts	Trend			Intensity			Interfaces
	N	&	D	N	&	D	
Source							
Pollination	SI		MI	2		3	(environmental, economic-social)
Pest regulation		S			2.5		(environmental, economic-social)
Water regulation and supply		MI			3		(environmental, economic)
Genetic resources	I	MI			3		(environmental, economic-social)
Primary production		MD		2		3	(environmental, economic)
Food, fuel, wood	U		MI	2		4	(environmental, economic)
Soil formation and protection		S			3		(environmental, economic-social)
Seedling survival	MI			3			(environmental, economic)
Recurrent loss by fires		MI			3		(environmental, economic-social)
High soil loss		S			3		(environmental, economic)
Provision of fish		MI			1		(environmental, economic)
Sink							
Carbon storage		MI		1		2	(environmental, economic)
Water filtration and purification	S		MI		3		
Air quality		MI		1		2	
Waste regulation	S		MI	4		2	
Landfill saturation			SI			5	
Site							
Habitat availability		MI			4		(environmental, economic-social)
Human made infrastructure	S		MI	3		2	(environmental, economic)
Fragmentation and habitat destruction		S		1		4	(environmental, economic)
Life Support							
Maintenance of genetic diversity		MI			3		(environmental, environmental)
Food quality	S		MI		2		
Ecosystem health		MI			2		
Climate regulation	MI		MD		2		
Human or animal health		MI		1		2	
Nutrient cycling	U		M	1		3	
Natural hazard regulation		M		4		3	
Scenery							
Recreational		MI			3		(environmental, social)
Cultural values /heritage		MI		3		1	
Educational		MI		3		2	
Aesthetics	MI		MD	2		1	
Ethical		MI			5		

The interface “environmental, economic” appears in impacts to source, sink and site services. The trend is moderately increasing in most impacts. The impact on sink services (like carbon storage and water filtration) are an important node in the ecosystem functioning.

The interface “environmental, economic-social” is a relevant link that in principle is not considered in the two dimension interfaces matrix. But it can be a way to understand some conspicuous impacts, e.g. invasive species or impacts in pest regulation. For this reason it is also included in the categorization of the interfaces.

The interface “environmental, social” involves the individual and social identity. The recreational and cultural values are the services most affected and they are moderately increasing with upward intensity. The environmental functions of scenery are important nodes for the society due to the awareness that a change in this service may raise.

Changes in biodiversity and the perceived impacts from these changes have triggered a wide scope of social responses. They include environmentally friendly farm management, conservation actions by voluntary groups, environmental education, programs and programs to promote historical values of biodiversity. All of them can be classified under the “politic, social” interface.

Other responses may be rather considered as the product of the “politic, economic” interface. They include introduction of agri-environment schemes, subsidies to crop production and to semi-natural grasslands, national measures for the water shortage, control of invasive species.
Finally, there are responses that may be comprised by the “politic, environmental” interface, such us the creation of natural reserves, launching biodiversity projects (e.g. tree planting or reintroduction of endangered species) and scientific research on flora and fauna.

4.3 Associations D-P-I

Following the procedure described above, the different associations between the drivers, pressures and impacts were put on view though an associative network. Based on this set of links, a series of centrality indices is calculated. Figure 2 shows the principal nodes interacting in the network. The more in the centre of the graph, the higher degree centrality has a given component of the network, indicating that is directly or indirectly related to a higher number of factors.

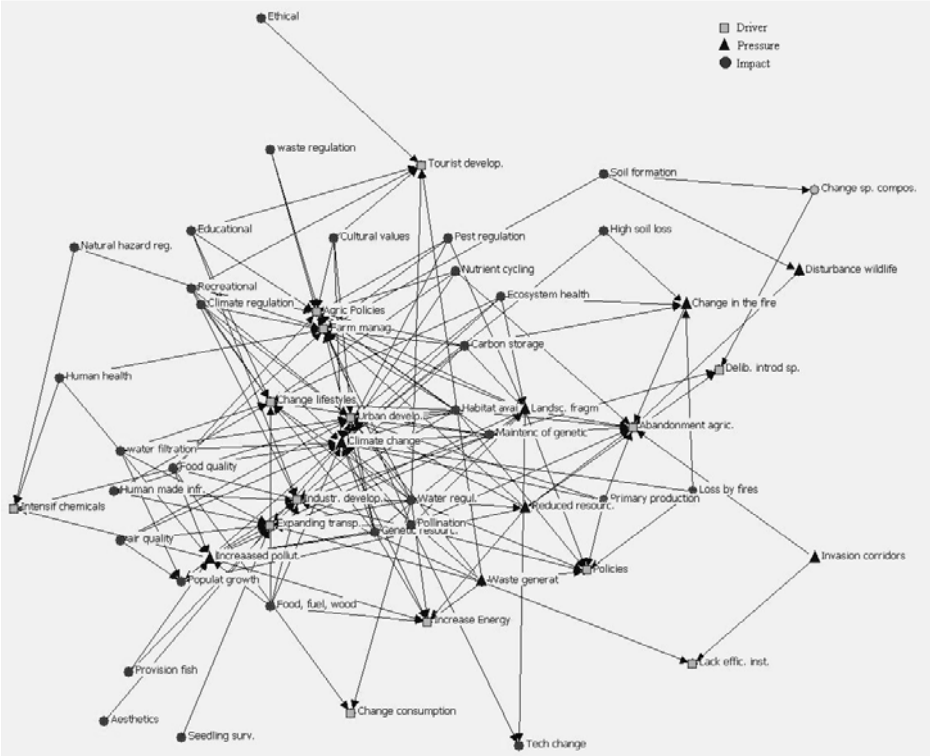

Fig 2. Association in drivers, pressures and impacts

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According to the results of degree centrality, the central drivers are urban development, farm management, changes in lifestyle, agriculture policies, industrial development, expanding transport and abandonment of agricultural practices. The central pressures derived from them are climate change, landscape fragmentation, increased pollution, waste generation, and reduction of resources availability. From such pressures, central impacts are perceived in water regulation, habitat availability, and maintenance of genetic diversity, pollination, food quality, genetic resources and water filtration.

The betweeness centrality identifies the principal "bridges" between the factors. Thus drivers and impacts are connected through the following pressures: climate change, landscape fragmentation, increased pollution and reduced resources availability.

Finally, though closeness we identify which elements may change due to their link with other influencing components. Those aspects showing a highest closeness are expanding transport, increase energy consumption, urban development, European policies, population growth, climate change, abandonment of agricultural practices and industrial development.

4.3.2 Multifunctional network into the Venn diagram

The associative network integrates the database information with some of the components of the DPSIR model. The structure presented in the previous section has facilitated the understanding of the set of relations, by disclosing principal subgroups and their importance in the network.

This kind of networks can be complemented with a specific network theory. This is useful when interactions between different spheres and its interfaces should be unveiled in order to understand the influence in biodiversity of different scopes human of intervention.

The 4S framework (environmental, social, economic and political) may be used an analytical scheme to organize the multifunctional network. The main drivers, pressures, impacts and responses to be included as interfaces in this scheme were selected from the complete associative network according to the centrality indices calculated above. The Venn diagram was the easy, effective and quick way to combine the nodes. Figure 3 shows the result of this procedure.

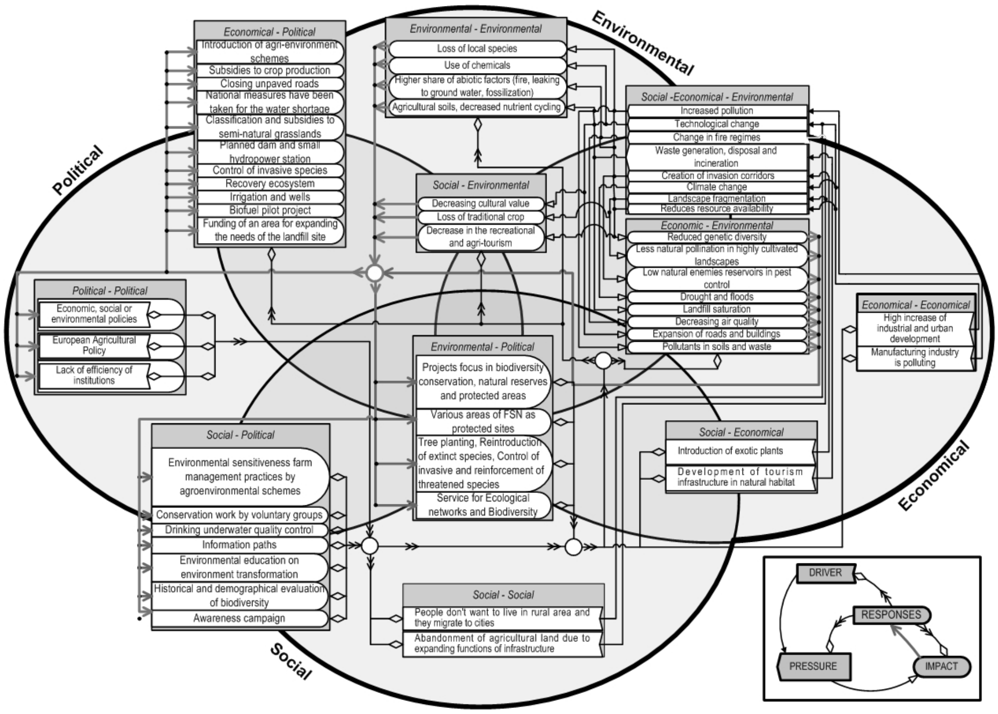

Fig. 3. Multifunctional network components

In this multifunctional network, the elements in DPSIR components and the associative network provided by the informants of each field sites are analyzed.

In the background of the figure the structure of the four spheres and the intersection between the spheres are represented. They are the basic structure of the network. In the foreground the interfaces are fulfilled with the boxes representing the nodes of the network. They are fulfilled with the principal DPSIR categories that were prioritized in the associative network of the previous section. The different nodes are linked by arrows indicating the flow of the DPSIR causal model that is described in the right side of the figure. In this way it is possible to visualize the complete set of main socio-environmental processes accompanying biodiversity change.

An additional analytical proposal of this study is identifying a set of general indicators for such processes of changes in biodiversity. The components and intersections of the

DPSIR are similarly employed for structuring a Venn diagram and the more frequently mentioned indicators are selected for fulfilling the scheme. Figure 4 represents the Venn diagram with the principal indicators implicated in the multifunctional network.

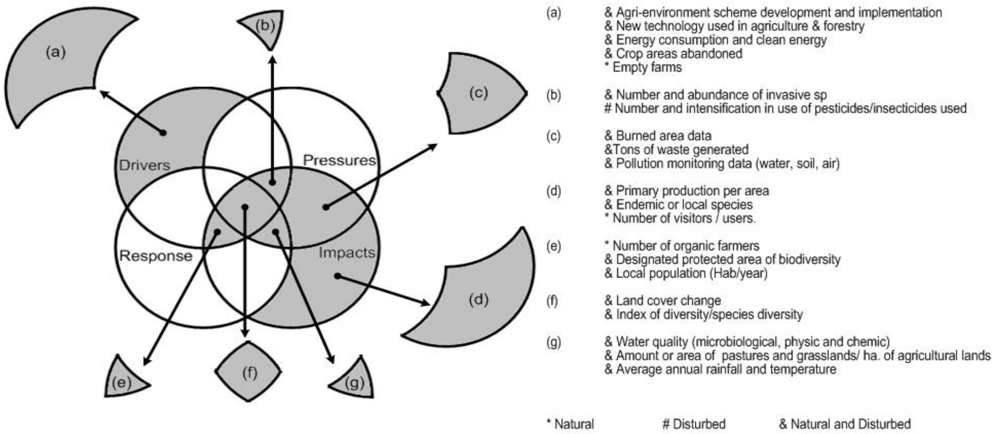

Fig. 4 DPSIR framework

Here, the Venn diagram allows the integration of the principal indicators suggested by the informants at the different sites. Each set represents the components of the DPSIR and the subsets of the intersections can be represented by one indicator. For instance, the indicator ‘number and abundance of invasive species’ can be considered depending on the focal interest, as an indication of either driver, pressure or impact on biodiversity. In the same place we can identify the different stakeholders involved in the process.

5. Discussion

According to the methodological proposal of this study a multifunctional network explaining change in biodiversity, based in socioeconomic data, can identify the principal policies implicated in those changes. According to the methodological proposal of this study, a multifunctional network explaining changes in biodiversity can be based in socioeconomic data and identified the principal policies implicated in those changes. The design of this multifunctional network takes into account the following considerations: a) the characterization of the study area, b) the identification of the DPSIR components including the analysis of the four spheres of socio-environmental organization and the construction of multifunctional networks summarizing the information of an associative network.

a) The socioeconomic characterization has an important role for sketching the multifunctional network. In this paper the analysis at local level for each field site was useful to gain better comprehension of the different interactions and their components. Some general statements regarding to biological, physical and socio-economic characteristics and policy setting have been drawn. However, there are also conspicuous differences between the sites that cannot be obviated.

The application of the questionnaires in both natural and perturbed sites has allowed obtaining data for establishing differences between both kinds of sites. Although many of the DPSIR components were similar in both, trend and intensity clearly differed. A long term study could support a closest view on this specific aspect.

b) Another aspect to take into account is the use of results obtained though the characterization. For instance, in the case of the ‘State’, besides the identification of the ecosystem services involved, the characterization also unveils why the stakeholders may value differently a natural or disturbed site. In general, the ecosystem services are directly linked to the state and impacts.

The wide scale of our study helps us to identify general social, economical and institutional drivers of changes in biodiversity. It has been confirmed that in Europe pressures to biodiversity triggered by human activities are producing changes in the so-perceived ‘normal’ state of the biodiversity. The perception of impacts arising from such changes is facilitated when it is structured around the different kind of ecosystem services affected (sink, life support, and site). Similarly, the understanding of changes in biodiversity as the origin of disruption of ecosystem services may explain the kind of responses given by the stakeholders and the social actors involved. This can complement existing information on biodiversity regulation and management.

All the processes that have been mentioned may be classified around the effect on the social, economic and environmental ambits or their interfaces. In the 4S framework it is necessary to considerate the extension of the pair-wise interfaces proposed by to model to additional associations, such as the social-economic interface with environmental. This has been employed in this study thus avoiding to force classifications that did not fit with the registered data.

The multifunctional network proposed by this study integrates the field information with some challenging theoretical models. The DPSIR model has allowed structuring the instruments for data gathering, providing a base set of interlinked processes between society and the environment. The associative network facilitates the ordering of the information, identifying the principal subgroups and their importance in the network. With the help of the associative network, we can infer the relations between them. Finally, the 4S model has articulated of a complex set of social, economic, environmental and politic relations in a compact structure where the field information can be arranged.

With this kind of network we can also identify the most involved drivers and pressures that induce the impacts, as well as the principal bridges. In this sense it does not only allow observing lineal processes and have a netlike analysis with a multidimensional vision useful for management.

With support in set theory, a visualization of general indicators has been generated from the information obtained from the informants and linked with the different stakeholders. In this case we can identify the principal interfaces in the different spheres and identify the principal polices and the links between the components of the DPSIR changing the, causal-effect to a netlike and visualize how does the change can affect the system. Besides, this integrative model is interesting combining the theoretical review with empirical quantitative information.

We consider that the methodological procedure can be applied to other analytical problems characterized by complexity. This kind of studies can be also useful for fostering the dialogue between the different stakeholders and the scientist that are concerned in the biodiversity conservation.

Since this is a new implementation, the methodological procedure may be improved by integrating data from others sites to the database and opening the methodological choices to social deliberation. For instance, labelling of a given component with a specific interface can be a social decision rather than an analytical choice based on theoretical considerations.

6. Conclusion

Human processes influence changes in biodiversity. Therefore, biodiversity conservation needs to incorporate a socioeconomic analysis including social, economic and political aspects. Sometimes this kind of analysis lacks integrative views, given the complexity of the involved issues. In this study a methodological proposal has been tested to foster this aim.

In this way we apply the integral multifunctional network of ecosystem services, the DPSIR model, a socioeconomic characterization, the four spheres organization and an associative network into the results of one socioeconomic project (ALARM). All this theoretical contributions have provided a rigorous complementary analysis.

The ecosystem services have been a relevant integrative category across the components of the DPSIR, helpful to characterize their situation and trend. Understanding of ecosystem services may support the communication of the relevance of biodiversity conservation to a wide set of stakeholders.

The use of the four spheres of socio-environmental organization facilitates the identification of the different links and the structuring of a multifunctional network emphasizing social, environmental, economical and political elements. Despite this, it is difficult to integrate the indicators at this level. Fortunately, we can use other implementations of network analyses or simply use basic set theory to this aim. The Venn diagram in set theory facilitates the visualization and the analysis of the matrix that include the spheres and interfaces for the multifunctional network.

Therefore, the methodological proposal presented in this paper has given a boost to the identification of the different components affecting the biodiversity conservation in 11 field sites all around Europe. Based on it, it is possible to propose strategies for the conservation of biodiversity and identified the principal components of the spheres like the political where was identified the drivers and responses in this level and the links with the other spheres that changes the causal to a netlike.

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