An Analytic Network Process approach for the evaluation of second order effects of agricultural landscape management on local economies

Targetti S.[1], Schaller L.[2], Villanueva A.[3], Arriaza M.[3], Bal T.[4], Bossi Fedrigotti V.[5,] Giray H.[4], Häfner K.[6], Kantelhardt J.[2], Kapfer M.[2], Majewski E.[7], Malak-Rawlikowska A.[7], Nikolov D.[8], Örmeci C.[4], Paoli J.P.[9], Piorr A.[6], Raggi M.[10], Rodríguez-Entrena M.[3], Ungaro F.[6], Verburg P.[11], van Zanten B.[11], Zasada I.[6] Viaggi D.[1]

[1] Dept. of Agricultural Sciences, University of Bologna, Bologna, Italy.

[2] Institute of Agricultural and Forestry Economics, University of Natural Resources and Life Sciences, Vienna, Austria.

[3] Instituto de Investigación y Formación Agraria y Pesquera, Cordoba, Spain.

[4] Suleyman Demirel University, Faculty of Agriculture, Department of Agricultural Economics, Isparta, Turkey.

[5] Faculty of Science and Technology, Free University of Bozen-Bolzano, Bolzano, Italy.

[6] Institut für Sozioökonomie, Leibniz-Zentrum für Agrarlandschaftsforschung e. V. Müncheberg, Germany.

[7] Faculty of Economic Sciences, Warsaw University of Life Sciences, Warsaw, Poland.

[8] Agricultural University, Plovdiv, Bulgaria.

[9] Institut national de la recherche agronomique, Laboratoire de Recherches sur le Développement de l'Elevage, Corse, France.

[10] Dept. of Statistical Sciences, University of Bologna, Bologna, Italy.

[11] Institute for Environmental Studies, VU University, Amsterdam, Netherlands

Paper prepared for presentation at the EAAE 2014 Congress
'Agri-Food and Rural Innovations for Healthier Societies'

August 26 to 29, 2014
Ljubljana, Slovenia

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1. Abstract

Agricultural landscape is a complex system composed by interrelated ecological, economic and social sub-systems. Disentangling interactions and mechanisms in such a context is, therefore, difficult and involves knowledge and methodologies developed in different scientific fields. In this paper we propose a multicriteria approach – namely the Analytic Network Process (ANP)- with three objectives. a) to present the application of the ANP method to the agricultural landscape topic in 8 EU case study areas; b) to underline strenghts and weaknesses of that method; c) to discuss evidences and possibilities for the improvement of the method. Main results highlighted the possibility to employ the ANP as a structured integrated tool able to cross-compare similarities and dissimilarities between different case studies characterized by different biophysical features and socio-economic conditions. Building upon the results, our analysis underlined that the ANP technique confirmed the existence of local differences between case studies (for instance between EU countries and Turkey). However, these differences were not so emphasized at this scale of analysis as evidenced by other studies. The ANP could serve as a new approach, able to provide a ”snapshot” of the system and the underneath cause-effect mechanisms.

2. Introduction

Agricultural landscape is a complex system composed by interrelated ecological, economic and social sub-systems. Disentangling interactions and mechanisms in such a context is, therefore, difficult and involves knowledge and methodologies developed in different scientific fields. A holistic analysis of such a system is hampered by the existence of tangible and non-tangible processes. Following the European Landscape Convention (ELC), landscapes embed an essential role in individual and social well-being and represent important resources “conducive to economic activity”. Consequently, an appropriate understanding of “landscape” must go beyond concepts considering landscapes solely as part of physical space (such as a “natural” or “cultural” landscape) and attribute to landscape a “socio-economic”” dimension, representing its function as a precondition for social well-being. In that vision, diverse approaches to landscape protection will contribute more significantly to the maintenance and enhancement of landscape functions, than single general approaches (Jones & Stenseke, 2011).

Society has a growing interest in benefits and activities related to “services” provided by landscapes (e.g. food safety and quality, tourism and recreation, cultural heritage and identity, etc.), However, current levels of landscape services production are not at the optimum (i.e. yielding the maximum welfare) because dynamics and trade-offs of landscape services provision are not fully understood and mainly driven by market forces that do not consider the whole bundle of benefits to derived from landscapes and the preferences of society with respect to them.

The current programming period of the Common Agricultural Policy (CAP) aims to a balanced provision of private and public goods from agriculture (EU, 2013). Here, in particular, the non-market nature of non-tangible processes poses big challenges for the evaluation and design of agricultural policies (Hall et al., 2004). Moreover, the design of policies needs to tackle the difficult identification of measures able to promote synergistic effects between biophysical and socio-economic components of a landscape system and has to be sufficiently flexible to address the particularities of regional and local landscape potentials.

During the last decade, the links between “nature” or “environment” and social wellbeing have been framed by the approach of ecosystem services (ES). The understanding is, that ecosystem services are “flows of value to human societies as a result of the state and quantity of natural capital" (Costanza et al, 1997) or, fairy simple, 'benefits people obtain from ecosystems' (MA, 2005). The approach of ES has been adopted by a huge body of literature that has focused the development and application of techniques able to assess and value the supply and demand of landscape services (De Groot et al. 2002; Hein et al. 2005,TEEB, 2010). Yet, the development of a consistent framework indicating the most appropriate techniques and methods for the valuation of landscape services is at an early stage (Farber et al., 2006; Layke, 2009). In fact, the complexity of multiple processes connecting landscape elements, actors, framework conditions and benefits, hampers the assessment of services and the identification of optimal levels of ES provision.

Promising methods to tackle with such a complex problem are the multi-criteria techniques (Hall, et al., 2004; Spangerberg and Settele, 2010). Among these techniques, the Analytic Network Process (ANP) allows assessing trade-offs between the relevant elements and their interrelationships (Saaty, 2005). Therefore, this paper is aimed at exploring the combined use of ES approach and the ANP technique as a way to assess the agricultural landscapes. For it, 9 European case study areas (CSAs) have been selected. From the results, some strengths and weaknesses initially identified in the use of this combined approach will be discussed as well. The remainder of the paper is organized as follows: section 2 deals with the state of the art on landscape services and feedbacks with local economies. Section 3 presents a) the CLAIM analytical framework addressing the relationship between agricultural landscape structure, and the contribution of these services to regional competitiveness; and b) the ANP application to our CSAs. Results, discussion and conclusions are included in sections 4, and 5 respectively.

3. State of the art

A growing body of literature concerns the question to which extent landscape represents an asset of local development in terms of welfare, population growth and employment creation. (Courtney et al., 2006; van der Meulen et al., 2011; Courtney et al., 2013; Dissart & Vollet, 2011; van Zanten et al., 2014; Schaller et al., 2013). The ES approach is a valuable framework for the analysis of the connection between landscape and economy because it highlights relationships between natural assets and human welfare (MEA, 2005; TEEB, 2010; Haines-Young & Potschin, 2013). However, depending on the type of the ecosystem, the role of humans can be different in obtaining "welfare" or "benefits" from ecosystems. For instance, in semi-natural ecosystems, like agricultural ecosystems, the role of humans is even more prominent given their direct management of this type of ecosystems.

In spite of the wide use of the ES framework, operational applications are challenging because of the huge amount of information needed and the lack of clear association between services, values and local competitiveness. A list of specific difficult tasks concerns the differentiation of intermediate ecological functions and processes from actual final services (Boyd and Banzhaf, 2007; Haines-Young & Potschin, 2013), the identification of beneficiaries, the measurement of benefits and the translation of benefits to competitiveness through a number of multifaceted indirect effects and trade-offs (Fieldsend, 2011).

The term local "competitiveness" – itself – is controversial. Competitiveness could be defined as the economic capacity of a defined area to compete on international markets. But, at a deeper insight, social competitiveness and sustainability should be included in its definition (Krugman, 1990; Porter, 1992; Krugman, 1994; European Commission, 1999a, 1999b, and 2009; Porter & Ketals, 2003; Thomson & Ward, 2005). A trait d'union of the different definitions of regional competitiveness is the general idea of productivity and employment in connection with the living standard of local population.

In this context, a deeper understanding of second order effects of landscape services on local competitiveness is of specific importance (van Zanten et al., 2014; Cooper et al. 2009, ENRD 2010, Domanski & Gwosdz, 2010). Second order effects could be defined as socio-economic consequences generated through the provision of public goods that affect economic actors (Schaller et al., 2013). In agricultural landscapes, second order effects can characterize loop effects between agriculture and local economy which are not trivial to disentangle.

Available methods for the analysis of this topic focus on multiplier effects of public goods provision which are appropriated by private actors and generate socio-economic value (jobs, income, etc.; Domanski & Gwosdz, 2010). Nonetheless, the assessment of the existing links between landscape and economy is hampered by the difficult evaluation of non-tangible benefits stemming from landscape management and the evaluation of cause-effect chains that are –in part- beyond economics. For instance, second order effects can i) alter behaviours of local actors and can give rise to new – marketed – products and demands; and ii) enter directly the utility function of individuals e.g. by enhancing water quality or living standards (Freeman, 2003). Moreover, second order effects can re-bound on landscape management feeding back the agricultural sector or other economic sectors different from agriculture by means of a wide range of feed-backs. Additionally, local features and social conditions play a consistent role in that process. This involves the need of localized studies that usually generate localized results with a limited range of evidence.

Strengths of valuation methods are represented by the sound theoretical backgrounds and the relevant theory for the phenomenon under study (economic, social, and environmental) that allows defining the quantities of interest and the relationships among them. The intrinsic limitations of valuation methods are related to the actual ability of a theory to exactly reproduce the phenomenon under study and to the possibility to correctly implement the models derived from a theory. Although results from case studies can contribute to orientate policies and management decisions at different scales and critical areas, these studies may reflect only the specific local variability of a certain landscape (as a spatial unit), which is directly affected by the local environmental and socio-cultural context.

Multicriteria analysis can overcome some of the limits of monetary evaluation because it does not rely on a strict utility theory framework (Hall et al., 2004). Besides that, a strict mathematical basis is usually framed in order to translate judgements in values. The ANP is a multicriteria technique that combines mathematical and psycho-cognitive roots in order to bridge a complex system within a formal mathematical system in connection to an explicit network. It is specifically designed to cope with complex systems and the presence of loops and trade-offs that hampers decision processes. One of the main features of the ANP is the possibility to assess intangibles and the inclusion of inconsistencies of judgement by means of an absolute scale of measurement (Saaty, 2005).

Unlike other multicriteria analysis methods, ANP has been gaining popularity in environmental evaluations only in very recent years. Aragonés-Beltrán et al. (2010) developed an ANP to evaluate solid waste management; García-Melón et al. (2010) applied an ANP for sustainable tourism and management of natural parks, even in combination with other methods, such as Delphi (Garcia-Melon et al., 2012). Other complex systems requiring sophisticated ANP networks regarded environmental assessments for sustainable urban development (Gómez-Navarro et al., 2009), farmland appraisals (Garcia-Melon et al., 2008), soil erosion risks (Nekhay et al., 2009), landslide hazard (Neaupane & Piantanakulchai, 2006) and forest management (Wolfslehner et al., 2005). Finally, examples of works particularly focused on the provision of public goods by olive growing and dairy farming systems are to be found in Villanueva et al. (2014) and in Parra-López et al. (2008) respectively.

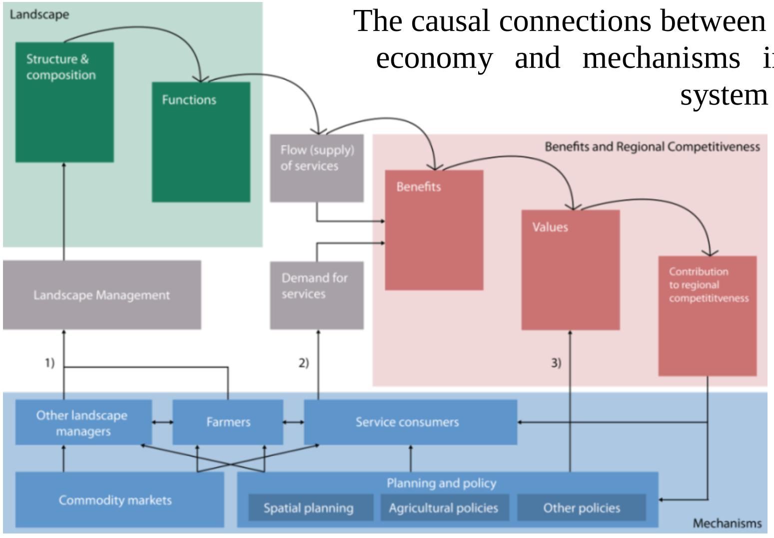

Figura 1 Analytical framework addressing the relationship between agricultural landscape structure and composition, the supply and demand of ecosystem services and the contribution of these services to regional competitiveness. (van Zanten et al., 2014).

The causal connections between landscape management, local economy and mechanisms influencing and driving the system have been recently framed by van Zanten et al. (2014), who complement the widely adopted ecosystem services cascade (Haines-Young and Potschin, 2010), with elements specific to the analysis of landscape-valorisation: van Zanten et al.'s (2014) framework distinguishes between service-demand and service-supply as the determinants of their value and specify different actors and pathways of mechanisms that affect the contribution of agricultural landscapes to the regional economy and human well-being (see Figure 1). Van Zanten et al.'s (2014) framework has been validated by an extensive stakeholder process both on the local level of the nine EU CSAs as well as on the European level, where representatives of stakeholders in the CSAs' countries as well as representatives from other EU countries and from EU-wide institutions have been involved.

4. Methodology

Taking into account van Zanten et al.'s (2014) framework, we developed an ANP network targeted at estimating the effects of agricultural landscapes on local economies and regional competitiveness and outlined "landscape valorisation" processes. The concept of landscape valorisation is the prerequisite for landscape services to create socio-economic benefits that contribute to competitiveness and it is at the core of the analytical framework presented in Figure 1. The ANP network was built using 'landscape valorisation' as the control criterion (control criterion, Figure 2). Economic actors, services, socio-economic benefits and local competitiveness are the clusters that summarize the elements at play. Local stakeholders were involved at different stages of the whole process of validation and implementation of 1) the framework (van Zanten et al., 2014); and 2) the translation of the framework to the analytical network. Assuming to have the strongest impact on local demand and supply of landscape-services, the cluster of Actors is formed by the following elements Agriculture and forestry, Local population, Tourism as well as the mainly local Trade and services. To reflect the supply and demand of tangible and intangible landscape services, the network incorporates two "Services" clusters. Basically, these clusters follow the ES approach of TEEB (2010), though a more "economic" component is added by distinguishing between public and private good-type landscape services. The cluster Private good-type services is represented by marketable (provisioning) services which are synthesised in the two cluster elements Supply of food and Production of raw materials. The cluster Public good-type services principally incorporates TEEB's (2010) regulating, cultural and, to some extent, supporting ecosystem services. TEEB's (2010) category of "regulating services" has been divided into the two subcategories Protection function and Natural processes: As TEEB's (2010) regulating service "Moderation of extreme events" plays a prominent role in some CSAs, it is given a separate mention in the public good-type services cluster. As the term "Moderation of extreme events" appeared to be too unfamiliar and difficult to picture for the stakeholders, the topic has been synthesised in the more familiar term Protection function of the landscape. The remaining regulating services are merged into the more user-friendly term Natural processes, summarizing the TEEB's (2010) services "Local climate and air quality", "Carbon sequestration and storage", "Waste-water treatment", "Erosion prevention and maintenance of soil fertility", "Pollination" and "Biological control". In line with the consideration of supporting services, a focus has been put on Biodiversity – again based on the stakeholders' survey indicating that biodiversity is of special importance and understood as a useful term to describe supporting services. Cultural services in contrast, are included into the public good-type services cluster in the original sense of the TEEB (2010) category.

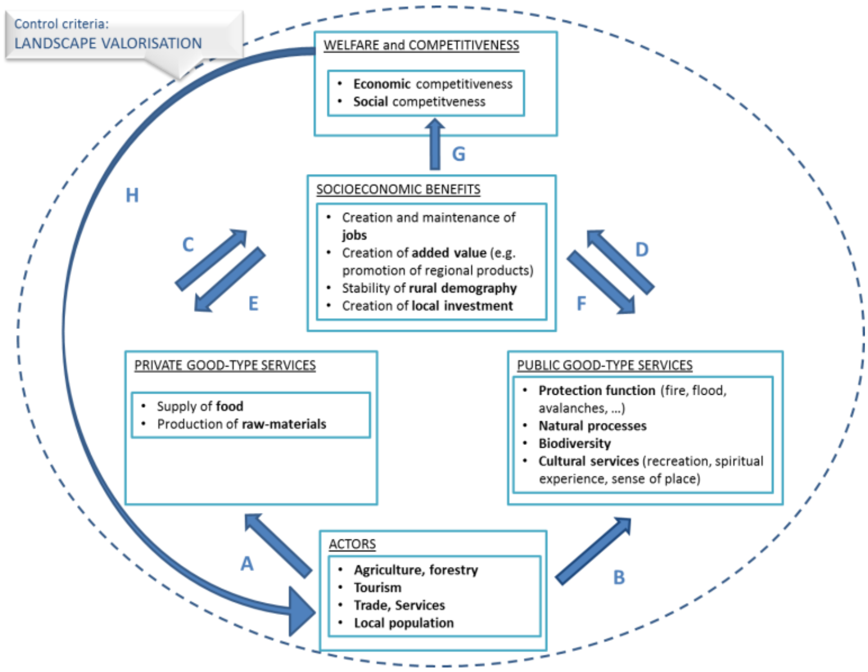

Figura 2 The landscape valorisation analytical network.

To reflect socioeconomic benefits from the consumption of landscape services, the network includes the Socioeconomic benefits cluster. Its elements again refer to the results of the stakeholders' survey: Here, Creation and maintenance of jobs, Creation of added value, Stability of the rural demography and the positive development of Local investment have been depicted as the most relevant benefits. The last cluster of the network approaches the topic of regional competitiveness. Labelled as Welfare and competitiveness, the cluster addresses competitiveness not only in the economic sense but also considers social and sustainability components. To this end, a distinction between "economic" and "social" competitiveness is made. Economic competitiveness is defined by productivity and economic indicators such as GDP, GVA, wage levels, etc. Social competitiveness addresses the contribution of valued benefits of landscape-service consumption to the wellbeing of the local population, the quality of life, the development of human capital, the sustainable use of resources, etc.

The five clusters are incorporated in a network of relations and feed-backs, altogether investigating eight causal connections. The connections describe the impact of the single elements of one cluster on the single elements of a related cluster (see Figure 2, arrows A to H). Arrows "A" and "B" represent how single actor groups positively contribute to Private and Public good-type services supply, e.g. how positively Agriculture and forestry influences food-supply compared to another actor or how positively "Agriculture and forestry" enhances cultural services (by contributing to the visual quality of the agricultural landscapes, local traditions, etc.) –compared to another actor . Arrows "C" and "D" represent to what extent Private and Public good-type services contribute to Socioeconomic benefits. Examples would be the questions, if the Supply of food rather than the Production of raw materials contributes to the Creation and maintenance of jobs or if the landscape's Protection functions enhance Local investments more than Natural processes, etc. For the interrelation between services and benefits however, it is likely that impacts are not unidirectional but have rather feed-back or multiplier-effect character. This assumption is expressed in arrows “E” and “F”, which investigate if Socio-economic benefits in turn affect Private and Public good-type services. Arrow “G” takes into account the hypothesis that Socioeconomic benefits stemmed from the use of landscape services contribute to Welfare and competitiveness. The last connection “H” reflects the assumption that regional Welfare and competitiveness have a positive impact on local Actors.

Landscape is, to a large extent, a “local issue”: its composition, elements and, consequently, the services and goods it might provide cannot be understood without considering their geographical location (Jones & Stenseke, 2011). However, to test if ANP is an applicable and suitable method for an overall evaluation of landscape effects on socio-economic systems, our study tries to overtake “localisms” by applying the method in nine European study regions covering different situations in EU and EU candidate countries. The CSAs are all faced with different natural and social basic conditions, although they are all “rural” and characterised by agricultural production which varies from rather marginal up to intensive management. The CSAs are described in Table 1.

Table 1: Description of the case study areas.

Case study	Country	Area	Description
Lowlands of Ferrara	Italy	900 km²	Flat landscape, agriculturally managed with middle to high intensity for the production of market crops, vegetables and quality products.
Märkische Schweiz	Germany	580 km²	Landscape characterised by a gradient from intensively managed, large-scale farming area to low-intensively managed area inside a natural park
Mittleres Ennstal	Austria	250 km²	Alpine conditions, characterized by rather low-intensive dairy farming in a classical and richly structured mountainous scenery. Covering valley as well as high alpine locations
Winterswijk Municipality	Netherlands	140 km²	Hedgerow mosaic landscape with high agro-biodiversity. The region is characterized by a strong agricultural focus on dairy farming.
Montoro	Spain	590 km²	Low mountainous area characterised by olive production. Of strong interest is the gradient from high intensive to low intensive olive groves and the resulting differences in landscape appearance.
General Chlapowski Landscape Park	Poland	172 km²	Typical agricultural lowland landscape, rich in small-structured landscape elements like field ponds, water catchments and shelterbelts.
Isparta	Turkey	9,000 km²	Mix of landscape features including lakes, hills and mountains. The agricultural focus is intensive rose oil production.
Pazardzhik Region	Bulgaria	4.500 km²	Mountainous landscape, characterised by sheep, cattle and dairy farming as well as wine production.
North Corsica	France	420 km²	Mediterranean mountainous region managed with low intensity by small cow, pig, goat and ewe breeders as well as by chestnut farmers.

The ANP analysis was carried out in all of the CSAs via a comprehensive expert/stakeholder panel exercise, including 8 to 15 persons per CSA, who all were involved in the topic of landscape valorisation on a local or regional level (overall 84 stakeholders). Due to the different regional basic conditions, the composition of the expert/stakeholder panel slightly differed throughout the study areas; however, in all regions stakeholders from landscape management (agriculture and forestry), economy, tourism, environmental protection, research, as well as from the local administrative level were included. Every interviewee was asked to fill in a questionnaire, based on pairwise comparisons, using the Saaty scale (Saaty, 2005), where 1 means "equal importance between two elements" and 9 means "complete dominance of one element". The questionnaires were processed following the eigenvector methodology. This allowed for the calculation of priority vectors that summarize the impact of each element on the network (Saaty, 2005).

In this work, we focused the differences between the opinions expressed by the stakeholders as summarized by the priority vectors. The difference between the priority vectors calculated on the basis of each pairwise comparison expressed by the stakeholders was measured by means of an analysis of variance (ANOVA) to test whether the opinions of the stakeholders in the 9 case studies highlight significant differences. The Euclidean distance was also employed to quantify the divergence between the opinions expressed by the stakeholders one to each other (equation 1):

$$\sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \qquad \textbf{Equation (1)}$$

Where *xi* and *yi* are the priorities expressed by two different stakeholders for the *i* element of the ANP network. As such, the Euclidean distance assesses the geometrical distance between the questionnaires on a multidimensional space where the number of dimensions equals the number of elements of the network.

5. Results

In Table 2 average results from the ANP are reported. As outlined by the local stakeholders, the Supply of food resulted as the most important factor concerning the impact on landscape valorisation. Economic competitiveness was ranked as the second most important element. To be noticed that around one third of the influence on landscape valorisation was attributed to the Socioeconomic cluster (without wide differences between the four elements included in the cluster). The difference between the socio-economic and the other clusters was evident. Specifically, the cluster of Public good type services was considered the least influential cluster.

Table 2: Aggregated and normalized priority vectors of the landscape valorisation analytical network. 9 CSAs, n = 84 questionnaires

Element	Elements' priority	Clusters' priority
Agriculture	0.085	
Tourism	0.024	17%
Trade & services	0.031	
Civil society	0.033	
Supply of food	0.121	18%
Production of raw materials	0.062	
Protection function	0.031	
Natural processes	0.023	14%
Biodiversity	0.030	
Cultural services	0.059	
Creation and maintenance of jobs	0.087	
Creation of added value	0.083	33%
Stability of rural demography	0.060	
Creation of local investment	0.097	
Economic competitiveness	0.101	17%
Social competitiveness	0.072	

In Figure 3 a more detailed distribution of the priority vectors in the 9 CSAs is presented. Priorities attributed to the Supply of food resulted very heterogeneous but the ANOVA did not evidence statistically significant differences between the CSAs. Similarly, differences between the other priority vectors were not significant except for Trade & services (Actors cluster), Protection function (public goods cluster), Stability of rural demography (Socio-economic benefits cluster) and Social competitiveness (Welfare and competitiveness cluster).

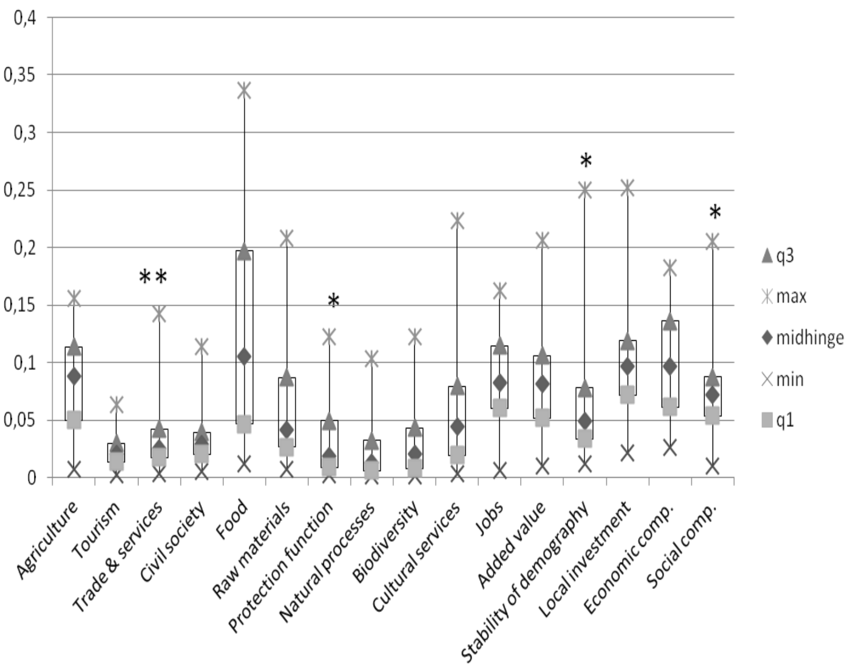

Figura 3 Plots of priority vectors distribution in the 9 case study areas. ANOVA on the elements priority: n= 84; Tukey HSD test: * p < 0.05, ** p< 0.01, no label = not significant. q3 = third quartile; q1 = first quartile.

The Euclidean distance allowed for the analysis and comparison of the "distance" between the stakehoders' opinions as evidenced by the ANP questionnaires (Figure 4). The average distance between the priority vectors was limited to 0.22 out of a possible 1 (i.e. 22%). This can be related to consistent opinions concerning the feedbacks between local economy and landscape services in the case study areas. Nevertheless, the Turkish case study was clearly an outlier in respect of the others. Moreover, internal distance between stakeholders in that CSA was relevant even though lower than 30% on average. Except for Turkey, average internal divergences in the CSAs were always lower than the aggregated distance between the CSAs (aggregate distance: 0.22; average internal distance going from 0.15 to 0.21 for the EU case studies). Nonetheless, internal distances in the Austrian and Bulgarian CSAs were not so far from the aggregated distance

Internal heterogeneity was high in Austria and France, whereas Netherlands, Spain and Bulgaria evidenced a lower internal heterogeneity. On the contrary, Italy and Germany showed an average internal heterogeneity.

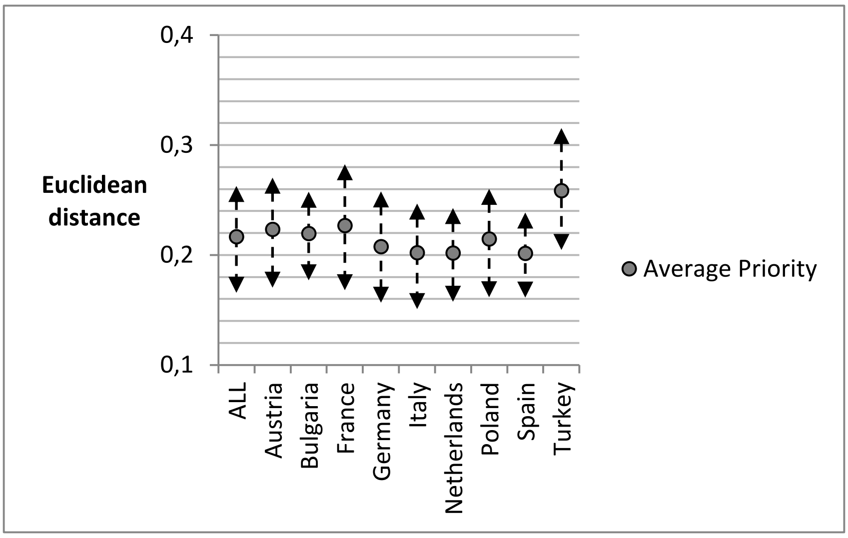

Figura 4 Euclidean distance: average distance and inter-quartiles between the priorities coefficients on aggregate and in each CSAs. Dotted segments are the inter-quartiles of the distributions (50% of cases are included between the segments).

In Table 3 the Euclidean distance between the 9 CSAs is detailed. Even though internal distances were always at the lowest level in all the CSAs (except Turkey), it is interesting to notice how distances between different CSAs was not wide in several cases. On the contrary, distances between Austria, Bulgaria and France are higher than average. The French CSA was distant from Germany too. The lowest internal distance was evidenced in Italy and low internal distances were also recorded in Spain, Netherlands and France. Finally, wide distances were confirmed between the Turkish CSA and the others (average distance above 0.25 in all cases).

Table 3: Average Euclidean distance between and in each CSA. Underlined values points to distances below the aggregated Euclidean distance. 9 CSAs, n = 84 questionnaires

	Austria	Bulgaria	France	Germany	Italy	Netherlands	Poland	Spain	Turkey
Austria	0.21								
Bulgaria	0.22	0.20							
France	0.24	0.25	0.17						
Germany	0.21	0.20	0.24	0.18					
Italy	0.21	0.22	0.20	0.21	0.15				
Netherlands	0.22	0.22	0.21	0.20	0.18	0.17			
Poland	0.22	0.22	0.23	0.21	0.20	0.20	0.20		
Spain	0.22	0.21	0.20	0.19	0.19	0.18	0.21	0.16	
Turkey	0.27	0.26	0.28	0.25	0.25	0.25	0.26	0.26	0.26

6. Discussion and conclusions

The ANP allowed for the comparison of different case studies characterized by different biophysical features and socio-economic conditions by means of a structured methodology. Priorities resulted from the local stakeholders' analysis evidenced differences between the CSAs that could be likely attributed to inherent peculiarities. For instance, Protection function (wildfires, floods, avalanches) was relevant in some CSAs, whereas other services were more important in other (e.g. Production of raw materials). Nonetheless, no significant differences were usually recorded. This result was significant if one considers the difficult transposition of local results to larger areas that is claimed in the application of other techniques (see e.g. Hall et al., 2004).

Building upon the results of our upstream local stakeholder survey, we can state that the ANP technique confirmed the existence of local differences between CSAs (for instance between EU and Turkey). However, these differences were not so emphasized at this scale of analysis. In other words, focusing on cause-effect mechanisms fitted to landscape assessments and cross-comparisons on larger scale.

Difficulties have commonly arisen in the use of the different techniques based on different theoretical frameworks that have been employed in the assessment of intangibles at landscape level (see e.g. Spangerberg and Settele, 2010). The ANP may serve as a new integrated approach, able to provide a "snapshot" of the system and the underneath cause-effect mechanisms. This does not mean that the ANP should be applied as a stand-alone method able to cope with the whole landscape analysis. On the contrary, the ANP fits to be used in conjunction with other monetary or non-monetary methods. By doing this, the shortcomings of other valuation techniques could be overcome.

Therefore, in order to take full advantage of the ANP approach, the network should focus on the gaps left by other methods (indicators, models, economic valuation) which could be achieved by connecting the different levels of the landscape system. Although mechanisms and feedbacks in the landscape system are complex, the separating nature of pairwise comparisons and the absolute scale of measurement provided with the ANP method were a valid help to avoid cognitive stress and allowed for consistent judgements by the stakeholders.

Even though the design of this analysis followed a co-ordinated process with local stakeholders, knowledge and understanding of the complex relationships that operates at landscape level is the main limit of the ANP method. Indeed, outlining the network, focusing efforts on clearly defining their clusters and elements and the relationships between the elements is critical in applying ANP. Here, the participation of local experts and actors has turned out to be useful for designing the ANP network, thus we suggest an inclusive participation of local stakeholders.

7. Acknowledgements

This research has been funded by EU's 7th FP for Research, Technological Development and Demonstration under grant agreement n° 289578 (CLAIM project, www.claimproject.eu). This work does not necessarily reflect the view of the EU and in no way anticipates the Commission's future policy.

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