Evaluation of Ecosystem Services Production under Different Agricultural Policy Scenarios

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Summary

This paper presents an evaluation of the provision of Ecosystem Services. The overall aim is to contribute in understanding the value and improving valuation methods for ecosystem, in an attempt to provide an instrument that contributes to closing the gap between the ES concept, regional planning and agricultural policies. The analysis is based on the design of a framework suitable to be translated in a multicriteria evaluation process, followed by its empirical testing. It focuses on the different categories of the ES trying a set of indicators that is non-overlapping and without redundancy, and assessing different aspects of ES: the capacity of ecosystems to provide services, changes in the provision of ES, and benefits thus derived. The framework is applied in the 26 municipalities of the Province of Ferrara. To develop an applicable framework, we have chosen a set of ES from the Millennium Ecosystem Assessment. The focus of this paper is the evaluation of the provision of ecosystem services that are currently provided by agricultural areas that evidently support provisioning services and are appreciated for their recreational value explaining their inclusion under recreation services. While existing ecosystem service metrics and indicators have many gaps and limitations, applying those existing indicators in diverse policy processes and further assessments should be a priority.

Keywords: ecosystem services, multicriteria analysis, evaluation, CAP, scenarios

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1. Introduction and Objectives

Ecosystem services (ES) are the benefits that humans derive from ecosystems. These include provisioning services, all nutritional, material and energetic outputs from living systems; regulating services that cover all the ways in which living organisms can mediate or moderate the ambient environment that affect human performance; supporting services that can mainly be seen as the basis upon which the consumable services can be created by an ecosystem; and cultural services that cover all the non-material, and normally non-consumptive outputs of ecosystems that affect physical and mental states of people (MEA, 2005). Agriculture and ES are interrelated in at least three ways: (1) agro-ecosystems generate beneficial ES such as soil retention, food production, and aesthetics; (2) agro-ecosystems receive beneficial ES from other ecosystems such as pollination from non-agricultural ecosystems; and (3) ES from non-agricultural systems may be impacted by agricultural practices. Furthermore, ES contribute to national economies, according to The Economics of Ecosystems and Biodiversity reports (TEEB, 2010). This contribution is not usually accounted for in national economies, partly because the financial benefits of many ES cannot be measured directly.

The concept of ES is integrated in current biodiversity policies at global and European level (EC, 2009; Perrings et al., 2011). The European Commission has called for a more coherent approach to planning and development of land that can take into account areas important for the provision of ES. The global strategic plan for biodiversity for the period 2011–2020 of the Convention of Biological Diversity complements previous conservation based biodiversity targets with the addition of ES. *Biodiversity, the extraordinary variety of ecosystems, species and genes that surround us, is our life insurance, giving us food, fresh water and clean air, shelter and medicine and contributes to regulating the climate. Biodiversity is also our natural capital, delivering ecosystem services that underpin our economy. Its deterioration and loss jeopardises the provision of these services: we lose species and habitats and the wealth and employment we derive from nature, and endanger our own wellbeing. This makes biodiversity loss the most critical global environmental threat alongside climate change — and the two are inextricably linked* (EC, 2011).

The Europe 2020 strategy (EC, 2010a) aims at building smart, sustainable and inclusive growth for the European Union. It establishes resource efficiency as the guiding principle for other EU policies. As a result, the EU water policy and the EU common agricultural policy (CAP) are now aligning their objectives with the target of the Europe 2020 strategy. Importantly, also the EU's regional and cohesion policy now recognizes the importance of investing in natural ecosystems, in particular urban green areas, floodplains and nature for recreation, as a source of economic development. Both agriculture and regional development contribute to over 80% the annual EU budget, so the inclusion of ES in these policies is considered an important step towards a more sustainable economy.

Following the global agreement, the EU Biodiversity Strategy to 2020 (EC, 2011) integrates the sustainable use of ES as underpinning element of human economies to complement the non-utilitarian conservation approach to biodiversity, thus contributing to the Europe 2020 target, in particular through the resource efficiency flagship.

In the EU, many ecosystems and their services have been degraded, largely as a result of land fragmentation. Nearly 30 % of the EU territory is moderately to very highly fragmented. The European Commission has adopted an ambitious strategy to halt the loss of biodiversity and ES in the EU by 2020. There are 6 main targets, and 20 actions to help Europe reach its goal. Target 2 focuses on maintaining and enhancing ES and restoring degraded ecosystems by incorporating green infrastructure in spatial planning. This will contribute to the EU's sustainable growth objectives[1] and to mitigating and adapting to climate change, while promoting economic, territorial and social cohesion and safeguarding the EU's cultural heritage. It will also ensure better functional connectivity between ecosystems within and between Natura 2000 areas and in the wider countryside. Target 2 incorporates the global target agreed by EU Member States and the EU in Nagoya to restore 15% of degraded ecosystems by 2020.

Improved ways and methods for ES quantification, mapping and assessment are needed to investigate the number and quality of ES produced by the individual ecosystems and to increase the ability to feed such knowledge into policy design. Unfortunately, many ES cannot be directly quantified, thus making the use of indicators indispensable. While ES providing market goods can be directly quantified, most regulating, supporting, and cultural services are less straightforward and researchers must rely on indicators or proxy data for their quantification. Furthermore, data on quantifiable ES remain limited and only a small number of indicators are being used for those that cannot be measured directly (Feld et al., 2010, 2009; Layke et al., 2012). In order to produce reliable outcomes in congruent analysis, valuation, or assessment of trends in ES, robust biophysical quantification is required. A review of indicators used for mapping ES is a necessary first step towards developing reliable and feasible indicators for mapping and modelling, as well as for bridging current data gaps. In studies that focused on a regional scale, spatial distribution of specific ES needs to be evaluated. Such approaches require the inclusion of manifold different data sources, spatial reference units, and advanced analysis methods, and are therefore difficult to be transferred from the original case study to other areas, where the access to respective data might be more limited.

The objective of this paper is to evaluate the provision of different categories of ecosystem services. The evaluation focuses on the different categories of the ES trying a set of indicators that is non-overlapping and without redundancy, and assessing different aspects of ES: the capacity of ecosystems to provide services, changes in the provision of ES, and benefits thus derived. The overall aim is to contribute in understanding the value and improving valuation methods for ecosystem, in an attempt to provide an instrument that contributes to closing the gap between the ES concept, regional planning and agricultural policies. The analysis is based on the design of a framework suitable to be translated in a multicriteria evaluation process, followed by its empirical testing.

The framework is applied in the 26 municipalities of the Province of Ferrara. To develop an applicable framework, we have chosen a set of ES from the Millennium Ecosystem Assessment (MEA, 2005). The next step was to develop a multi-criteria assessment framework in order to evaluate the provision of the ES and compare different alternative scenarios. In the present study, the provision of the proposed ES is evaluated through the PROMETHEE II multicriteria decision-making approach.

The evaluation of the ES in the present study is based on the current policy. The Rural development plan 2007-2013 of the Emilia Romagna's region have proposed 30 measures for the rural and agricultural areas. Different measures adopted in the proposed RDP's contribute to the preservation of landscapes and focus on the delivery of ES, such as agri-environmental measures (Pillar II, axis 2, measure 214), competitiveness and quality of life of the agricultural sector (Pillar II, Axis 1, measures 111 and 123), diversification of rural economy (Pillar II, Axis 3, measures: 311, 313, 321 and 323. Pillar I consists mostly of decoupled payments (EC, 2010b). In areas that have been assessed as sensitive for economic, environmental or social reasons, coupled payments are still granted. However, it is not obvious that decoupled payments will contribute to the preservation of landscapes with a high cultural value, since most payments are concentrated in the most productive areas with intensive and large scale farming.

The structure of this paper is as follows: Section 2 describes the PROMETHEE multicriteria analysis, in Section 3, the case study and the data are presented. In Section 4, the PROMETHEE method is applied for the evaluation of the provision of the ES in the case study and the results are presented. The final section summarises the paper and suggests potential future directions in the implementation of different policy measures and scenarios.

2. METHODOLOGY

Several models have been developed to account for changes in farming activities and related land use. They also provide information about the effects of CAP and other policy drivers. In many cases, their output includes environmental and land use information that can be connected to landscape features, although few yield a direct assessment of changes in landscape services. A literature review has been performed that covers an overview of various methodologies that seek to improve the knowledge base of the contribution of landscape management to the rural economy. This review of the literature concerning methods relevant to the landscape management taking into account the CAP strategies can help the understanding of limits and potentialities of such different approaches, in order to evaluate the land-use options in a region as a whole and considering all the stakeholders and taking into account the relevant ecological and socio-economic effects. Based on the analysis of the literature performed, the methodological tools were classified into three main categories:

- Identification and valuation of the ecosystem services and natural resource management.
- Structure of the landscape, and linkages with environmental impacts and climate change.
- Sustainable land use, in terms of assessment of agricultural systems and linking socio-economic requirements with landscape potentials.

As a next step, we reviewed studies that have used different multicriteria methods, since different factors should be taken into consideration. Multi-criteria approaches (MCA) are formal approaches to address a problem in a structured way. The considered goals are usually too complex to be properly assessed by a single criterion or indicator. Therefore, multiple relevant criteria or indicators are considered at the same time. MCA offer the possibility to use quantitative and qualitative information as obtained, for example, from expert judgments. Thus, data of diverse sources can be applied in an aggregation framework allowing for an examination of the initial problem. The review included different studies that provide information about the effects of past and future CAP and other policy drivers, examine how the new CAP is expected to contribute to maintaining the rural landscape adapting to climate change and finally they review how the CAP has worked in the design and implementation of sustaining biodiversity and associated ES. Their output include environmental and land use information that can be connected to landscape features.

In the present study, the PROMETHEE II method (preference ranking organization method for enrichment evaluation) will be used. PROMETHEE is a multicriteria decision-making method developed by Brans and Vinke (Brans et al., 1986a; Brans and Mareschal, 2005; Brans and Vincke, 1985) . It is well adapted to problems where a finite number of alternatives are to be ranked considering several and sometimes-conflicting criteria (Brans et al., 1998)([2]Brans et al.)(15)(Brans et al., 1998). In addition, the mathematical model in PROMETHEE is relatively understandable by the decision makers and find out the preferences among multiple decisions in a relatively easy way (Vinodh and Jeya Girubha, 2012). PROMETHEE, in comparison with other outranking methods, (Macharis et al., 2004; Albadvi, 2007):

- the mathematical model is relatively understandable by the decision makers and can easily find out the preferences among multiple decisions,
- does not aggregate good scores on some criteria and bad scores on other criteria,
- has less pairwise comparisons,
- does not have the artificial limitation of the use of the 9-point scale for evaluation,
- has advantages in the procedure of structuring the multicriteria problem,
- allows flexibility in determination of the weights.

The PROMETHEE I (partial ranking) and PROMETHEE II (complete ranking) were developed by J.P. Brans and presented for the first time in 1982 at a conference organized by R. Nadeau and M. Landry at the Université Laval, Québec, Canada (L'Ingéniérie de la Décision. Elaboration d'instruments d'Aide à la Décision). The same year several applications using this methodology were already treated by G. Davignon in the field of Heath care. A few years later J.P. Brans and B. Mareschal developed PROMETHEE III (ranking based on intervals) and PROMETHEE IV (continuous case). In 1992 and 1994, J.P. Brans and B. Mareschal further suggested two nice extensions: PROMETHEE V (MCDA including segmentation constraints) and PROMETHEE VI (representation of the human brain).

A considerable number of successful applications has been treated by the PROMETHEE methodology in various fields such as Banking, Industrial Location, Manpower planning, Water resources, Investments, Medicine, Chemistry, Health care, Tourism, Ethics in OR, Dynamic management, (Albadvi, 2007, 2004; Amador et al., 1998; Andreopoulou et al., 2011, 2008, 2009; Behzadian et al., 2009; Koutroumanidis et al., 2002; Olson, 2001; Olson et al., 1998). The success of the methodology is due to its mathematical properties and to its particular friendliness of use.

2.1. The Multicriteria Problem

The PROMETHEE II method (preference ranking organization method for enrichment evaluation) is a multicriteria decision-making method developed by (Brans and Vincke, 1985). It is well adapted to problems

[2] (Brans et al., 1998)(J. P. Brans, Macharis, Kunsch, Chevalier, & Schwaninger, 1998)(J. P. Brans, Macharis, Kunsch, Chevalier, & Schwaninger, 1998)[15]Brans and others.(

where a finite number of alternatives are to be ranked considering several, sometimes conflicting criteria. (Brans, et al., 1986) considered the following multicriteria problem:

$$Max\{f_1(a), \dots f_k(a), \backslash\ a \in K\}, \quad (1)$$

where K is a finite set of actions and $f_i, i = 1, \dots k$, are k criteria to be maximized.

The PROMETHEE methods include two phases (Roy, 1991):

- the construction of an outranking relation on K,
- the exploitation of this relation in order to give an answer to (1).

In the first phase, a valued outranking relation based on a generalization of the notion of criterion is considered: a preference index is defined and a valued outranking graph, representing the preferences of the decision maker, is obtained. The exploitation of the outranking relation is realized by considering for each action a positive and a negative flow in the valued outranking graph: a partial preorder (PROMETHEE I) or a complete preorder (PROMETHEE II) on the set of possible actions can be proposed to the decision maker in order to achieve the decision problem. Only a few parameters are to be fixed in these methods and they all have an economic signification so that the decision maker is able to determine their values easily. Furthermore, some small deviations in the determination of these values do not often induce important modifications of the obtained rankings.

2.2. PROMETHEE II: Modeling Framework

The preference structure of PROMETHEE is based on pair wise comparisons. In this case the deviation between the evaluations of two alternatives on a particular criterion is considered. The preference index for each pair of alternatives $a, b \in K$, ranges between 0 and 1. The higher it is (closer to 1) the higher the strength of the preference for a over b is. The function P represents the intensity of preference of action a with regard to action b and such that:

- $\mathrm{P(a,b)} = 0$ means an indifference between a and b, or no preference of a over b;
- $\mathrm{P(a,b)} \sim 0$ means weak preference of a over b;
- $\mathrm{P(a,b)} \sim 1$ means strong preference of a over b;
- $\mathrm{P(a,b)} = 1$ means strict preference of a over b.

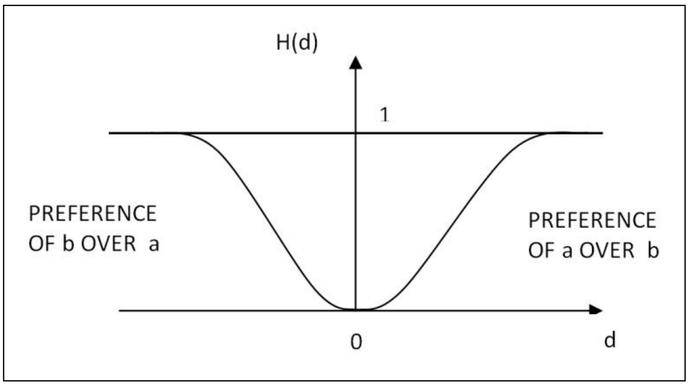
For each criterion f we consider a generalized criterion defined by f and a corresponding preference function P .

$\mathrm{H(d)}$ is an increasing function of the difference d between the performances of alternatives a and b on each criterion. $\mathrm{H(d)}$ is a type of preference intensity (Vincke, 1992).

$$\mathrm{H(d)} = \begin{cases} \mathrm{P(a,b)}, & \mathrm{d} \geq 0, \\ \mathrm{P(b,a)}, & \mathrm{d} \leq 0. \end{cases} \quad (2)$$

The $\mathrm{H(d)}$ function can be of various different forms, depending upon the judgment policy of the decision maker (Kalogeras et al., 2005). Generally, six forms of the $\mathrm{H(d)}$ function are commonly used (Brans et al., 1986b).

Figure 1: The function $\boldsymbol{H(d)}$



Brans et al. (1998) suppose that the decision maker has specified a preference function P, and weight πi for each criterion $f, (i = 1 \ldots\ldots k)$ of problem (1). The weight π_i is a measure of the relative importance of criterion f_i if all the criteria have the same importance for the decision maker, all weights can be taken equal. The multicriteria preference index Π is then defined as the weighted average of the preference functions P_i:

$$\Pi(a,b) = \frac{\sum_{i=1}^{k} \pi_i P_i(a,b)}{\sum_{i=1}^{k} \pi_i}, \qquad (3)$$

$\Pi(a,b)$ represents the intensity of preference of the decision maker of action a over action b, when considering simultaneously all the criteria. It is a figure between 0 and 1 and:

- $\Pi(a,b) = 0$ denotes a weak preference of a over b for all the criteria,
- $\Pi(a,b) = 1$ denotes a strong preference of a over b for all the criteria.

This preference index determines a valued outranking relation on the set K of actions. This relation can be represented as a valued outranking graph, the nodes of which are the actions of K. When each alternative is facing other alternatives in K, the following outranking flows are defined:

The positive outranking flow. The positive outranking flow expresses how an alternative is outranking all the others. It is its power, its outranking character. The higher the $\varphi^+(a)$, the better the alternative:

$$\varphi^+(a) = \sum_{b \in k} \Pi(a,b), \quad (4)$$

The negative outranking flow. The negative outranking flow expresses how an alternative is outranked by all the others. It is its weakness, its outranked character. The lower the $\varphi^-(a)$, the better the alternative.

$$\varphi^-(a) = \sum_{b \in k} \Pi(b,a), \quad (5)$$

The net outranking flow can is the balance between the positive and the negative outranking flows. The higher the net flow, the better the alternative:

$$\varphi(a) = \varphi^+(a) - \varphi^-(a), \ (6)$$

In the present study, the multi-criteria method PROMETHE II was applied as a part of the theory of relevance superiority. The shape of the H(d) function selected is the Gaussian form (Gaussian criterion) defined as follows:

$$H(d) = 1 - exp\{-d^2/2\sigma^2, (7)$$

where d is the difference amo7ng the municipalities a and b [$d = f(a) = f(b)$] and σ is the standard deviation of all differences d and for each ecosystem service indicator.

The multicriteria indicator of preference $\Pi(a, b)$ which is a weighted mean, of the preference functions $P(a, b)$ with weights π_i for each criterion, express the superiority of the municipality a against municipality b after all the criteria tested.

The values of $\Pi(a, b)$ are calculated using the following equation (Brans and Mareschal, 2005):

$$\Pi(a,b) = \frac{\sum_{i=1}^{k} \pi_i P_i(a,b)}{\sum_{i=1}^{k} \pi_i}, \quad (8)$$

We received 50 scenarios of weights and on each scenario of weights we receive ten scenarios on the standard deviation of σ distribution of Gauss. The ten scenarios σ oscillate from 0.25 s until 2.5 s with step 0.25 s, where s the standard deviation of all differences d for the each criterion. Globally, we take 500 prices for each net flow per municipality and find the medium value (Mareschal and Brans, 1991).

k, is defined to be the number of criteria and $P_i(a, b)$ the preference functions for the k criterions. The multicriteria preference indicator $\Pi(a, b)$ takes values between 0 and 1. When two municipalities (a, b) are compared to each other one is assigned two values of flows: the positive and the negative outranking flow. The positive flow expresses the total superiority of the municipality a against all the other municipalities for all the ecosystem services indicators. The negative flow expresses the total superiority of all the other municipalities against municipality a for all the ecosystem services indicators. The net flow is the number that is used for the comparison between the municipalities in order to obtain the final evaluation. $\Phi(x)$ is the net flow of each municipality.

3. APPLICATION IN A STUDY AREA

The study area is the Province of Ferrara, located in the eastern side of the Region Emilia-Romagna. Its capital is the city of Ferrara. It comprises 26 municipalities covering an area of 2,632 km^2 and a total population of about 359,000 (table 1). Extending to the Po River Delta, the Province of Ferrara offers sceneries of rare charm and contains important Natura2000 sites. Lagoon settlements and valleys, pinewoods and seaside resorts along the coast, and cities rich in art allow for itineraries of great interest. The countryside is rather flat, surrounded by expansive plains and an abundance of canals. Land use has been highly influenced by the intensification of mechanization to improve agricultural production, replacing the typical landscape elements. Agriculture and trade are sectors relevant to the area, followed by building and industry. The main activities are related to habitat restoration and conservation, species protection habitat, management of selected critical areas, and the elaboration of development plans. In general, agriculture activities into the park area are seen negatively, mainly because of the negative effect on water quality. However, at this time scarcely productive agriculture areas have been flooded again and reforested making use of the CAP incentives. Furthermore, thanks to this policy action the park is improving the change of agriculture to more sustainable direction, e.g.organic production. Agriculture has been modified in several ways from the extent of surface used to the intensification of mechanization to improve production. Since reclaimed lands replaced the humid environments, agriculture has replaced the typical landscape elements (marshes, pine woods) with large extensions of embankments and water channels (Viaggi et al., 2014).

Table 1. Municipalities in the Province of Ferrara

Territory	Population	Density (per sq km)
Argenta	22,087	71,0
Berra	5,088	74,1
Bondeno	14,864	84,9
Cento	35,444	547,2
Codigoro	12,337	72,7
Comacchio	22,428	79,0
Copparo	16,943	107,9
Ferrara	131,842	326,1
Formignana	2,802	125,5
Goro	3,879	123,6
Jolanda di Savoia	3,016	27,9
Lagosanto	4,978	145,4
Masi Torello	2,344	102,3
Massa Fiscaglia	3,543	61,3
Mesola	7,092	84,2
Migliarino	3,670	103,8
Migliaro	2,225	98,8
Mirabello	3,420	212,6
Ostellato	6,462	37,2
Poggio Renatico	9,770	122,4
Portomaggiore	12,190	96,4
Ro	3,380	78,5
Sant'Agostino	7,052	200,3
Tresigallo	4,553	219,0
Vigarano Mainarda	7,491	177,2
Voghiera	3,823	94,4

Source: ISTAT and own elaboration

In order to select a set of representative indicators, an extended literature review was completed. The ES conceptual framework provided by the Millennium Ecosystem Assessment has proven effective for communicating how ecosystems underlie human well-being. Efforts to apply ES concepts and information have strengthened both public and private sector development strategies and improved environmental outcomes. Identifying consistent, quantifiable and comparable indicators supports the development of models and evaluation of ES. Determining what to measure and what method to use is directly related to the availability of data and the type of indicator. However, mainstreaming ES concepts more broadly will require information designed for policy-makers, including data, decision support tools, and "indicators"—information that condenses complexity to a manageable level and informs decisions and actions (Bossel, 2002). Although global indicators provide an overview permitting a regional or national scale analysis, in many cases there is limited information available. As a result, proxy indicators are often used as surrogates. Proxy methods are normally used for cultural services, as these services are difficult to directly measure and model. There are of course limitations to their use. Several reviews have set out to assess and summarize the use of indicators to provide information (Feld et al., 2009; Layke et al., 2012). Moreover, (Egoh et al., 2008) provided a extensive literature review of studies, excluding sub-global assessments and national assessments, identifying primary and secondary ES indicators.

Provisioning services

Among the studies that evaluate provisioning services, food provision receives the most attention. Secondary indicators used for food production include agricultural production measured in hectares of land, livestock numbers or vegetation suitability for fodder production and grain yield. Other provisioning services directly linked to human well-being are crop production, capture fisheries, livestock production and are locally, nationally and globally important. Data for these indicators are obtained from national statistics or global datasets. Another primary indicator that is used is water provision. It is important to note that water provision or supply is not the same as water regulation. The latter is the process through which clean water becomes available, while water provision or supply is water that is already available for use. Water provision is measured through secondary indicators that include surface or ground water availability.

Regulating services

Generally, there is a lower number of indicators for regulating services as they are not directly consumed and physically perceived by people. The majority of studies that evaluate regulating services, have evaluated in particular climate and water regulation. Climate regulation services mainly relate to the regulation of greenhouse gases; therefore, the primary indicators for climate regulation included carbon storage, carbon sequestration, and greenhouse gas regulation. Secondary indicators used to model these primary indicators are still less than those used for food production or water regulation (aboveground biomass, land cover and belowground biomass). Another most common regulating service mapped is water flow regulation. Secondary indicators used for mapping water flow regulation are nutrient retention and land cover. The amount of water that reaches streams or sinks into the ground and the quality of such water is also a function of water infiltration, which is mainly dependent on soil characteristics and land cover.

Supporting services

This category of ES according to the conceptual framework of CICES is categorized under regulating and maintenance services. The few primary indicators that have been identified are relating to species and habitat. There are also fewer secondary indicators compared to other services. These included land cover/land use, and species and habitat conservation indices. The comparatively lower numbers of indicators for supporting ES could be attributed to the lack of information on these services and the few classes. The identification of indicators for services such as the life cycle maintenance and maintenance of genetic diversity, are generic for which it is difficult to find suitable indicators. Even if one could map this service, it might be difficult to find data on indicators for evaluation.

Cultural services

Cultural services are non-material benefits, which include recreation, spiritual and aesthetic value. Of course, the flow of many of these benefits are dependent on the accessibility to humans. For example, those ecosystems holding aesthetic value but are inaccessible to humans due to distance will not provide a flow of ES. Identifying an indicator that represents these challenges and is spatially represented, is fundamental in measuring the capacity of ecosystems to generate human benefits. Primary indicators vary among studies, from accommodation suitability and summer cottages, deer hunting and fishing to natural areas and forest area for recreational purposes (Naidoo et al., 2011). Secondary indicators can include a scenic site, water bodies or forest as well as visitor numbers and accessibility to natural areas. Visitor information can be obtained from national statistics or from park inventories. Overall, the most common indicators for cultural services include recreation and ecotourism, which can be directly measured through a number count of visitors. Other methods include the income generated from nature-based tourism. Although these indicators are relatively easily to quantify some indicators for aesthetic and spiritual services are still in early stages of development and existing ones are difficult to quantify and compare between countries or regions. Much of the indicators for cultural services are subjective and identifying indicators requires some understanding of the social-ecological dynamics, which is not an easy task. The information collected for cultural indicators are generally carried out at the local and national scale through a periodic regional survey, with little consistency between countries (Eagles, 2002). Schaich et. al. (2010) proposed an alternative approach to fill the knowledge gaps in cultural services, linking ES research with cultural landscape research. This approach of linking the provisioning of cultural ES to human well-being is based on the development of an index of well-being based on indicators and metrics derived from existing measures of well-being. Groups of indicators described by suites of metrics are commonly aggregated to evaluate components of well-being. These indicators represent social cohesion, education, health, leisure time, safety and security (Guhn et al., 2012, Huntington, 2000).

The selected ES indicators in the present study are those that can give sufficient estimation of the benefits that people derive from an ecosystem. The focus is on the different categories of the ES trying non-overlapping and without redundancy, and assessing different aspects of ES: the capacity of ecosystems to provide services, changes in the provision of ES, and benefits thus derived. Secondary indicators used as input information for ES show the same trends as the primary indicators. Provisioning and cultural services have the greatest number of secondary indicators compared to other services. Land cover proved to be an important secondary indicator for all four categories of services. Land cover data typically contain land use, such as agricultural land, vegetation types, and forest. The proposed indicators have been examined in practice, reflecting the balance between the ideal and the constraints of data availability. The data used in this paper derive mainly from statistics usable as proxies of ES provision in the area provided by the National Institute of statistics (ISTAT), other statistical databases (EUROSTAT, FAOSTAT) and regional sources (Appendix, table 4). The selected ES indicators are presented in Table 2, divided, according the different categories of ecosystem services.

Table 2 Selected Ecosystem Services Indicators

ES category		Primary indicator	Secondary Indicator
Provisioning	Food provision	Agricultural production	Number of agricultural holdings
	Food provision	Agricultural production	utilised agricultural area
	Food provision	Agricultural production	arable land
	Water provision	Irrigation Water	irrigated area
	Water provision	Irrigation Water	irrigated area - surface water (natural and artificial basins, lakes, rivers or waterflows)
	Water provision	Irrigation Water	irrigated area - underground water
	Raw materials	Timber production	wooded area
Regulating	Regulation of Water	Water supply	volume of irrigation water
	Regulation of Water	Water supply	volume of irrigation water - surface water (natural and artificial basins, lakes, rivers or waterflows)
	Regulation of Water	Water supply	aqueduct, irrigation and restoration consortium
Supporting	Biological Control	Organic farming	organic agricultural area
	Production Quality	Quality of agricultural production	agricultural area of PDO and/or PGI farms
Cultural	Recreation and tourism	Tourism	Visitors Arrivals
	Recreation and tourism	Tourism	Italian Visitors, Arrivals
	Recreation and tourism	Tourism	Foreighners Visitors, Arrivals
	Aesthetic enjoyment	Spiritual, aesthetic, recreational services	collective accommodation establishments
	Aesthetic enjoyment	Spiritual, aesthetic, recreational services	hotels and similar establishments
	Aesthetic enjoyment	Spiritual, aesthetic, recreational services	holiday and other short-stay accommodation, camping grounds, recreational vehicle parks and trailer parks
	Recreation and tourism	Recreational use	number of active enterprises (total)
	Recreation and tourism	Recreational use	number of active enterprises in agriculture (crop and animal production, support activities to agriculture and post-harvest crop activities, forestry and logging, fishing and aquaculture)
	Recreation and tourism	Recreational use	number of active enterprises in accomodation and food services activities
	Recreation and tourism	Recreational use	number of farms with other gainful activities (agritourism, recreational and social activities, initial processing of agricultural products, renewable energy production, wood processing)

Source: MEA and own elaboration

4. RESULTS

This section presents the evaluation of the 26 municipalities of the province of Ferrara (case studies), according to the selected ecosystem services indicators (criteria), with the implementation of the multicriteria method of PROMETHEE II. The evaluation of the study areas as obtained from the net flows, is presented in Table 3. According to the results of the analysis, the 26 municipalities are divided into 5 groups. The first group of case studies, with high positive net flows consists of Comacchio, Goro, Argenta and Jolanda di Savoia. The second group, with positive net flows around 1, is Migliaro, Codigoro, Vigarano Mainarda and Bondeno. The next group with positive net flows around 0, consists of Massa Fiscaglia, Portomaggiore, Mesola and Poggio Renatico. The next group, with positive or negative net flows around 0 is Cento, Ro, Sant'Agostino, Migliarino, Ostellato and Lagosanto. The next group, Mirabello, Masi Torello, Ferrara and Voghiera, has negative net flows around -1. Finally the last group, that consists of Formignana, Copparo, Tresigallo and Berra has lower negative net flows.

Table 3: Classification of the 26 municipalities

	Municipality	Net Flow (Φ)
1	Comacchio	2,888194373
2	Goro	2,543589598
3	Argenta	1,997682356
4	Jolanda di Savoia	1,190854183
5	Migliaro	0,720865791
6	Codigoro	0,709070084
7	Vigarano Mainarda	0,694387495
8	Bondeno	0,614876652
9	Massa Fiscaglia	0,402104543
10	Portomaggiore	0,257389617
11	Mesola	0,194863948
12	Poggio Renatico	0,146803521
13	Cento	0,008314139
14	Ro	-0,14634547
15	Sant'Agostino	-0,21655112
16	Migliarino	-0,27198083
17	Ostellato	-0,28124392
18	Lagosanto	-0,30769265
19	Mirabello	-0,68414923
20	Masi Torello	-1,00385534
21	Ferrara	-1,14179801
22	Voghiera	-1,26554807
23	Formignana	-1,32908587
24	Copparo	-1,34379219
25	Tresigallo	-2,09068952
26	Berra	-2,28626409

Source: own elaboration

5. CONCLUSIONS

The focus of this paper is the evaluation of the provision of ecosystem services that are currently provided by agricultural areas, that evidently support provisioning services and they are appreciated for their recreational value explaining their inclusion under recreation services. Land use has been highly influenced in the Province of Ferrara, by the intensification of mechanization to improve agricultural production, replacing typical landscape elements. As we can observe also from the results, all the municipalities have high rates in the indicators that represent provisioning services like arable land and the distribution of the utilized agricultural area.

According to our analysis, the municipalities with the higher positive net flows are Comacchio, Goro, Argenta and Jolanda di Savoia. These municipalities have the highest rates in the indicators that represent cultural services, like foreigner visitors, hotels and similar establishments, number of active enterprises in accommodation and food services activities and number of farms with other gainful recreational activities. Goro has the highest rate in number of active enterprises in agriculture (crop and animal production, support activities to agriculture) and the highest rate in number of farms with other gainful agricultural activities. Moreover, Jolanda di Savoia has the highest rate in the agriculture area of PDO and/o PGI farms. Since a large part of the territory is within the Po Delta Park, contains important Natura2000 sites. Local summer tourism is an important market for horticultural farms (mainly placed on the beach side). Visits to the area increase considerably during summer. During holiday time, the demand for beaches, the presence of areas of high naturalistic value, and the historical places have promoted an increment of receptive structures, rental houses, hotels, camping areas, beaches with restaurants, etc.

The next municipalities in the evaluation, is Migliaro, Codigoro, Vigarano Mainarda and Bondeno. These municipalities have also high rates in the indicators that represent cultural services, like Italian visitors, holiday and short-stay accommodation, camping grounds, recreational vehicle parks and trailer parks. Migliaro has also the highest rate in organic agricultural area. Moreover, Bondeno and Vigarano Mainarda, has also the highest rate in the irrigated area from natural and artificial basins. The next group with net flows around 0 consists of Massa Fiscaglia, Portomaggiore, Mesola and Poggio Renatico. Small negative flows around 0 have also Cento, Ro, Sant'Agostino, Migliarino, Ostellato and Lagosanto. These municipalities are in the middle of this evaluation, since the rates are not extremely high or respectively low.

In the Province of Ferrara, traditional agricultural practices do not exist. Projects and activities of the park administration affects the agricultural areas, which are connected to different habitats protected by the park. The main activities are related to habitat restoration and conservation, species protection habitat (especially birds), management of selected critical areas, and the elaboration of development plans.

In general, agriculture activities into the park area are seen negatively, mainly because of the negative effect on water quality. However, at this time scarcely productive agriculture areas have been flooded again and reforested making use of the CAP incentives. As the results also reveal, municipalities with negative net flows, have low rates in more than one ecosystem system indicator, like agricultural farms with other gainful activities such as agritourism, recreational and social activities, initial processing of agricultural products or renewable energy production and the agricultural area of PDO and/or PGI farms. The last group of case studies Formignana, Copparo, Tresigallo and Berra has negative net flows more than -1. Berra has no organic agricultural area, hotels or similar establishment and any kind of accommodation. Tresigallo has no wooded area. Formignana has no hotels or similar establishments. Other indicators with low rates are agricultural farms with other gainful activities such as agritourism, recreational and social activities, initial processing of agricultural products or renewable energy production and the agricultural area of PDO and/or PGI farms. There is the potential to modify/improve the landscape through different projects (e.g. some initiatives have been the evaluation of the economic impact of climate change on agriculture, conservation of natural areas and valorization of local products, restoration of ecological areas as Touristic attraction, restoration of forested areas, greening of farms to restore the traditional landscape).

This evaluation identified the ecosystem services that are more enhanced and allows an evidence based structuring and supporting of related policies. This can also support the characterization of agricultural lands in terms of the provision of multiple ecosystem services and the maintenance and enhancement of biodiversity. This exercise also supports the discussion on public goods provided by agriculture and better use of resources, and can improve a better spatial targeting of policy measures.

A key challenge of ecosystem management is determining how to manage multiple ecosystem services across landscapes. Enhancing important provisioning ecosystem services, such as food and timber, often leads to tradeoffs between regulating and cultural ecosystem services, such as nutrient cycling, flood protection, and tourism. In the present study we developed a framework for evaluating the provision of multiple ecosystem services in a landscape consisting of 26 municipalities in the province of Ferrara. Our results show a priority in provisioning and almost all cultural ecosystem services, and a greater diversity of the provision of regulating and supporting services.

There are many gaps in ecosystem service metrics and indicators available at regional level. The most important challenge in our analysis was related to lacking knowledge on the provision of ES at a regional level. The indicators available for most ecosystem services are insufficient to evaluate the quality and quantity of benefits provided by many ecosystem services. This prevented us to conclude to a specific understanding of the behavior of individual services. In addition, because of data paucity, it was not possible to consider the interactions between specific services. Related to the previous limitation, total ecosystem service values were estimated only by specific types of ecosystem services.

At a next stage, as further research, the model will be used to simulate an alternative scenario, based on the future agricultural policies that can affect the supply or demand of ES (EC, 2010b). This will be the CAP reform scenario, presenting the new programming period affecting landscape structure and behaviors related to ES. In particular the CAP reform scenario will include post-2013 measures such as agri-environmental payments to improve ES, mechanisms that can affect landscape management, such as, water policies and nature conservation; and other mechanisms promoting demand for ES, such as rural tourism e.g., altering tourist demand for cultural and recreational service flows. To involve stakeholder preferences in terms of the services to be provided and the indicators and criteria to assess the services, we conducted weighting goal programming. For the valuation of ES, identification of relevant stakeholders is a critical issue (Hein et al., 2006). In almost all steps of the valuation procedure, stakeholder involvement is essential in order to determine main policy and management objectives and to identify the main relevant services and assess their values.

REFERENCES

Albadvi, A., 2007. Formulating national information technology strategies: A preference ranking model using PROMETHEE method. Eur. J. Oper. Res. 153, 290–296. doi:10.1016/S0377-2217(03)00151-6

Albadvi, A., 2004. Formulating national information technology strategies: A preference ranking model using PROMETHEE method. Manag. Future MCDA Dyn. Ethical Contrib. 153, 290–296. doi:10.1016/S0377-2217(03)00151-6

Amador, F., Sumpsi, M.J., Romero, C., 1998. A non-interactive methodology to assess farmers' utility functions: an application to large farms in Andalusia, Spain. Eur. Rev. Agric. Econ. 25, 92–109.

Andreopoulou, Z., Manos, B., Polman, N.B.P., Viaggi, D., 2011. Agricultural and Environmental Informatics, Governance and Management: Emerging Research Applications.

Andreopoulou, Z.S., Koutroumanidis, T., Manos, B., 2009. The adoption of e-commerce for wood enterprises. Int. J. Bus. Inf. Syst. 4, 440–459. doi:10.1504/IJBIS.2009.024505

Andreopoulou, Z., Tsekouropoulos, G., Koutroumanidis, T., Vlachopoulou, M., B. Manos, 2008. Typology for e-business activities in the agricultural sector. Int. J. Bus. Inf. Syst. 3, 231–251. doi:10.1504/IJBIS.2008.017283

Behzadian, M., Kazemzadeh, R.B., Albadvi, A., Aghdasi, M., 2009. PROMETHEE: A comprehensive literature review on methodologies and applications. Eur. J. Oper. Res. 200, 198–215. doi:10.1016/j.ejor.2009.01.021

Bossel, H., 2002. Assessing Viability and Sustainability: a Systems-based Approach for Deriving Comprehensive Indicator Sets. Ecol. Soc. 5.

Brans, J.P., Macharis, C., Kunsch, P.L., Chevalier, A., Schwaninger, M., 1998. Combining multicriteria decision aid and system dynamics for the control of socio-economic processes. An iterative real-time procedure. Eur. J. Oper. Res. 109, 428–441. doi:10.1016/S0377-2217(98)00068-X

Brans, J.-P., Mareschal, B., 2005. Promethee Methods, in: Multiple Criteria Decision Analysis: State of the Art Surveys, International Series in Operations Research & Management Science. Springer New York, pp. 163–186.

Brans, J.P., Vincke, P., 1985. A Preference Ranking Organisation Method: (The PROMETHEE Method for Multiple Criteria Decision-Making). Manag. Sci. 31, 647–656. doi:10.2307/2631441

Brans, J.P., Vincke, P., Mareschal, B., 1986a. How to select and how to rank projects: The Promethee method. Math. Program. Mult. Criteria Decis. Mak. 24, 228–238. doi:10.1016/0377-2217(86)90044-5

Brans, J.P., Vincke, P., Mareschal, B., 1986b. How to select and how to rank projects: The Promethee method. Math. Program. Mult. Criteria Decis. Mak. 24, 228–238. doi:10.1016/0377-2217(86)90044-5

Eagles, P.F.J., 2002. Trends in Park Tourism: Economics, Finance and Management. J. Sustain. Tour. 10, 132–153. doi:10.1080/09669580208667158

EC, 2011. European Commission: Our life insurance, our natural capital: an EU biodiversity strategy to 2020. COM(2011) 244. Brussels.

EC, 2010a. European Commission: Europe 2020. A strategy for smart, sustainable and inclusive growth. COM(2010) 2020. Brussels.

EC, 2010b. The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future, 18 November 2010,. Brussels.

EC, 2009. Consultation on the Future "EU 2020" Strategy. Commission of the European Communities, Brussels.

Egoh, B., Reyers, B., Rouget, M., Richardson, D.M., Le Maitre, D.C., van Jaarsveld, A.S., 2008. Mapping ecosystem services for planning and management. Agric. Ecosyst. Environ. 127, 135–140. doi:10.1016/j.agee.2008.03.013

Feld, C.K., Martins da Silva, P., Paulo Sousa, J., De Bello, F., Bugter, R., Grandin, U., Hering, D., Lavorel, S., Mountford, O., Pardo, I., Pärtel, M., Römbke, J., Sandin, L., Bruce Jones, K., Harrison, P., 2009. Indicators of biodiversity and ecosystem services: a synthesis across ecosystems and spatial scales. Oikos 118, 1862–1871. doi:10.1111/j.1600-0706.2009.17860.x

Feld, C., Sousa, J., da Silva, P., Dawson, T., 2010. Indicators for biodiversity and ecosystem services: towards an improved framework for ecosystems assessment. Biodivers. Conserv. 19, 2895–2919. doi:10.1007/s10531-010-9875-0

Guhn, M., Schonert-Reichl, K., Gadermann, A., Marriott, D., Pedrini, L., Hymel, S., Hertzman, C., 2012. Well-Being in Middle Childhood: An Assets-Based Population-Level Research-to-Action Project. Child Indic. Res. 5, 393–418. doi:10.1007/s12187-012-9136-8

Hein, L., van Koppen, K., de Groot, R.S., van Ierland, E.C., 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecol. Econ. 57, 209–228. doi:10.1016/j.ecolecon.2005.04.005

Huntington, H.P., 2000. USING TRADITIONAL ECOLOGICAL KNOWLEDGE IN SCIENCE: METHODS AND APPLICATIONS. Ecol. Appl. 10, 1270–1274. doi:10.1890/1051-0761(2000)010[1270:UTEKIS]2.0.CO;2

Kalogeras, N., Baourakis, G., Zopounidis, C., van Dijk, G., 2005. Evaluating the financial performance of agri-food firms: a multicriteria decision-aid approach. Oper. Res. Food Logist. 70, 365–371. doi:10.1016/j.jfoodeng.2004.01.039

Koutroumanidis, T., Papathanasiou, J., Manos, B., 2002. A multicriteria analysis of productivity of agricultural regions of Greece. Oper. Res. 2, 339–346. doi:10.1007/BF02936389

Layke, C., Mapendembe, A., Brown, C., Walpole, M., Winn, J., 2012. Indicators from the global and sub-global Millennium Ecosystem Assessments: An analysis and next steps. Indic. Environ. Sustain. Concept Appl. 17, 77–87. doi:10.1016/j.ecolind.2011.04.025

Macharis, C., Springael, J., De Brucker, K., Verbeke, A., 2004. PROMETHEE and AHP: The design of operational synergies in multicriteria analysis.: Strengthening PROMETHEE with ideas of AHP. Eur. J. Oper. Res. 153, 307–317. doi:10.1016/S0377-2217(03)00153-X

Mareschal, B., Brans, J.P., 1991. BANKADVISER: An industrial evaluation system. Vis. Interact. Model. 54, 318–324. doi:10.1016/0377-2217(91)90106-6

MEA, 2005. Millennium Ecosystem Assessment. Ecosystems and well-being.

Naidoo, R., Weaver, L.C., Stuart-Hill, G., Tagg, J., 2011. Effect of biodiversity on economic benefits from communal lands in Namibia. J. Appl. Ecol. 48, 310–316. doi:10.1111/j.1365-2664.2010.01955.x

Olson, D.L., 2001. Comparison of three multicriteria methods to predict known outcomes. Eur. J. Oper. Res. 130, 576–587. doi:10.1016/S0377-2217(99)00416-6

Olson, D.L., Mechitov, A.I., Moshkovich, H.M., 1998. Cognitive Effort and Learning Features of Decision Aids: Review of Experiments. J. Decis. Syst. 7, 129–146. doi:10.1080/12460125.1998.10511746

Perrings, C., Naeem, S., Ahrestani, F.S., Bunker, D.E., Burkill, P., Canziani, G., Elmqvist, T., Fuhrman, J.A., Jaksic, F.M., Kawabata, Z., Kinzig, A., Mace, G.M., Mooney, H., Prieur-Richard, A.-H., Tschirhart, J., Weisser, W., 2011. Ecosystem services, targets, and indicators for the conservation and sustainable use of biodiversity. Front. Ecol. Environ. 9, 512–520. doi:10.1890/100212

Roy, B., 1991. The outranking approach and the foundations of electre methods. Theory Decis. 31, 49–73. doi:10.1007/BF00134132

Schaich, H., Bieling, C., Plieninger, T., 2010. Linking Ecosystem Services with Cultural Landscape Research. GAIA - Ecol. Perspect. Sci. Soc. 19, 269–277.

TEEB, 2010. The economics of ecocystems and biodiversity: A quick guide to the economics of ecosystems and biodiversity for local and regional policy makers.

Viaggi, D., Raggi, M., Galimberti, G., Manrique, R., Targetti, S., Zavalloni, M., 2014. CSA1: The Eastern Ferrara lowlands, Italy, in: Deliverable D4.20 Summary Report on WP4 Task 2, Activities A) B) C) D).

Vincke, P., 1992. Multicriteria Decision-aid. Wiley, New York.

Vinodh, S., Jeya Girubha, R., 2012. PROMETHEE based sustainable concept selection. Appl. Math. Model. 36, 5301–5308. doi:10.1016/j.apm.2011.12.030

APPENDIX

Table 4: Ecosystem services provision

		Number of agricultural holdings	utilised agricultural area	arable land	irrigated area	irrigated area - surface water (natural and artificial basins, lakes, rivers or waterflows)	irrigated area - underground water	wooded area	volume of irrigation water	volume of irrigation water - surface water (natural and artificial basins, lakes, rivers or waterflows)	aqueduct, irrigation and restoration consortium	volume of irrigation water - underground water in or near the farm	organic agricultural area	agricultural area of PDO and/or PGI farms	Visitors Arrivals	Italian Visitors, Arrivals	Foreighners Visitors, Arrivals	collective accommodation establishments	hotels and similar establishments	holiday and other short-stay accommodation, camping	number of active enterprises (total)	number of active enterprises in agriculture (crop and animal	number of active enterprises in accomodation and food	number of farms with other gainful activities (agritourism, recreational and social activities)
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23
Argenta	K1	777	23104,96	21202,5	7897	650,83	69,83	317,2	22219871,85	1842392,49	18277528,04	18277528,04	6542	3169	5409	4579	830	25	5	20	1347	16	89	80
Berra	K2	241	5005,19	4662,83	1692	422,35	37,98	38,17	8888067,05	1295545,48	3634800,82	3634800,82	0	164	91	79	12	0	0	0	260	9	13	14
Bondeno	K3	587	12818,7	12156,22	2864	1588,8	61	22,7	8721393,28	4753715,27	880400,95	880400,95	100	563	898	735	163	9	2	7	748	16	50	19
Cento	K4	459	4965,41	4561,23	503	256,98	32,85	4,34	1425067,73	785070,95	108623,73	108623,73	18,3	56,5	11696	9101	2595	16	7	9	2154	17	131	15
Codigoro	K5	327	10891,06	10769,79	6685	343,19	22,6	75,71	43698065,67	1058176,82	40023575,57	40023575,57	1389	426	3985	3244	741	14	5	9	837	56	60	22
Comacchio	K6	293	10033,64	9694,82	6406	1260,9	44,07	114,77	18585945,8	3681841,57	13115943,65	13115943,65	1140	651	455142	365022	90120	107	27	80	2545	289	393	22
Copparo	K7	677	11631,09	10465,28	2402	404,45	40,68	33,63	10260339,76	1248347,74	3813132,4	3813132,4	143	451	4889	4152	737	10	3	7	975	7	69	27
Ferrara	K8	1604	27874,6	22799,17	7433	1744,5	591,27	86,82	22737104,04	6201258,36	6654913,52	6654913,52	2535	440	175549	126404	49145	172	34	138	10860	30	697	64
Formignana	K9	103	1720,67	1470,55	382	78,18	7,5	2,09	1257376,39	290371,02	529924,59	529924,59	5,2	18,7	88	78	10	1	0	1	139	3	8	6
Goro	K10	24	638,48	635,48	174	22	0	3	514795,61	264000	236735,34	236735,34	0	0	465	442	23	8	2	6	1197	1009	21	5
Jolanda di Savoia	K11	199	8230,48	7991,19	3200	53,8	12	23,13	28055933,9	138237,82	27293092,73	27293092,73	25,6	3802	56	56	0	3	0	3	130	6	13	11
Lagosanto	K12	68	2124,74	1981	1468	59,16	0	17,73	4133759,17	141047,59	2738931,48	2738931,48	0	16,3	358	303	55	3	1	2	343	25	19	4
Masi Torello	K13	98	1527,95	1316,11	349	7,2	0	16,64	1019254,47	23917,94	83147,47	83147,47	20,4	129	124	114	10	5	0	5	152	0	10	6
Massa Fiscaglia	K14	102	3042,2	3000,49	1017	57,06	13,6	1,77	3653570,09	476962,64	2930395,31	2930395,31	552	0	88	78	10	1	0	1	194	7	15	3
Mesola	K15	282	4698,31	4592,52	3375	32,58	0	11,7	8472806,43	60708,87	7768578,41	7768578,41	29,5	528	2944	2542	402	10	4	6	604	163	34	35
Migliarino	K16	92	2831,47	2382,05	1121	55,52	0	5	3917812,87	94048,48	3562210,88	3562210,88	1126	88,7	1025	929	96	7	0	7	266	1	20	9
Migliaro	K17	52	3111,55	3073,59	264	10,85	0	15,24	943095,47	28136,22	914959,25	914959,25	2187	0	88	78	10	2	0	2	116	1	5	2
Mirabello	K18	43	1293,97	1196,75	70,7	11,6	23,06	0	198455,23	35615,66	100623,67	100623,67	0	0	88	78	10	1	0	1	185	2	11	4
Ostellato	K19	349	11857,18	11206,6	5738	490,46	61,99	8,69	18812898,76	1416033,01	16451586,06	16451586,06	435	28,1	5668	4788	880	10	2	8	363	10	27	16
Poggio Renatico	K20	244	5894,04	5233,23	1423	538,62	121,05	15,26	3957393,46	1420865,38	2017315,88	2017315,88	6,2	93,5	271	223	48	7	1	6	488	5	27	8
Portomaggiore	K21	324	10036,12	9166,19	2901	254,48	70,35	59,04	8556809,49	843795,16	6507314,36	6507314,36	316	246	3328	2969	359	10	1	9	759	6	55	30
Ro	K22	163	2756,83	2590,52	709	5,9	37,34	20,12	2460678,75	21073,95	667629,1	667629,1	29,8	11,9	97	93	4	4	0	4	161	4	14	12
Sant'Agostino	K23	168	2404,4	2134,56	414	196,09	23	0	1241949,89	557231,38	572812,61	572812,61	18,1	14,3	792	633	159	4	3	1	386	1	28	5
Tresigallo	K24	80	1436,99	1240,67	359	52,41	8,31	0	1326476,31	139231,6	171284,57	171284,57	108	85,3	1066	807	259	3	2	1	268	2	18	4
Vigarano Mainarda	K25	177	3182,31	2538,07	638	353	200,76	9,54	1858061,51	995519,79	228545,16	228545,16	13,9	41,9	2471	1758	713	7	3	4	390	4	28	7
Voghiera	K26	214	3763,29	2814,05	1301	348,72	20,62	11,61	4077942,32	866873,9	161755,34	161755,34	1,62	863	258	206	52	3	0	3	273	5	15	13

Table 5: Multicriteria table (rates)

		Number of agricultural holdings	utilised agricultural area	arable land	irrigated area	irrigated area - surface water (natural and artificial basins, lakes, rivers or waterflows)	irrigated area - underground water	wooded area	volume of irrigation water	volume of irrigation water - surface water (natural and artificial basins, lakes, rivers or	aqueduct, irrigation and restoration consortium	organic agricultural area	agricultural area of PDO and/or PGI farms	Visitors Arrivals	Italian Visitors, Arrivals	Foreighners Visitors, Arrivals	collective accommodation establishments	hotels and similar establishments	holiday and other short-stay accommodation, camping grounds, recreational vehicle	number of active enterprises (total)	number of active enterprises in agriculture (crop and animal production, support activities)	number of active enterprises in accomodation and food services activities	number of farms with other gainful activities (agritourism, recreational and social activities)
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23
Argenta	K1	100%	91,20%	91,77%	100%	8,24%	0,88%	1,37%	100%	8,29%	82,26%	28,31%	13,72%	100%	84,66%	15,34%	100%	20,00%	80,00%	100%	1,19%	6,61%	10,30%
Berra	K2	100%	90,02%	93,16%	100%	24,95%	2,24%	0,76%	100%	14,58%	40,90%	0,00%	3,28%	100%	86,81%	13,19%	100%	0,00%	0,00%	100%	3,46%	5,00%	5,81%
Bondeno	K3	100%	92,72%	94,83%	100%	55,48%	2,13%	0,18%	100%	54,51%	10,09%	0,78%	4,39%	100%	81,85%	18,15%	100%	22,22%	77,78%	100%	2,14%	6,68%	3,24%
Cento	K4	100%	91,54%	91,86%	100%	51,07%	6,53%	0,09%	100%	55,09%	7,62%	0,37%	1,14%	100%	77,81%	22,19%	100%	43,75%	56,25%	100%	0,79%	6,08%	3,27%
Codigoro	K5	100%	91,36%	98,89%	100%	5,13%	0,34%	0,70%	100%	2,42%	91,59%	12,76%	3,91%	100%	81,41%	18,59%	100%	35,71%	64,29%	100%	6,69%	7,17%	6,73%
Comacchio	K6	100%	91,09%	96,62%	100%	19,68%	0,69%	1,14%	100%	19,81%	70,57%	11,36%	6,49%	100%	80,20%	19,80%	100%	25,23%	74,77%	100%	11,36%	15,44%	7,51%
Copparo	K7	100%	91,06%	89,98%	100%	16,84%	1,69%	0,29%	100%	12,17%	37,16%	1,23%	3,88%	100%	84,93%	15,07%	100%	30,00%	70,00%	100%	0,72%	7,08%	3,99%
Ferrara	K8	100%	91,12%	81,79%	100%	23,47%	7,96%	0,31%	100%	27,27%	29,27%	9,09%	1,58%	100%	72,00%	28,00%	100%	19,77%	80,23%	100%	0,28%	6,42%	3,99%
Formignana	K9	100%	92,18%	85,46%	100%	20,48%	1,96%	0,12%	100%	23,09%	42,15%	0,30%	1,09%	100%	88,64%	11,36%	100%	0,00%	100,00%	100%	2,16%	5,76%	5,83%
Goro	K10	100%	92,06%	99,53%	100%	12,63%	0,00%	0,47%	100%	51,28%	45,99%	0,00%	0,00%	100%	95,05%	4,95%	100%	25,00%	75,00%	100%	84,29%	1,75%	20,83%
Jolanda di Savoia	K11	100%	90,57%	97,09%	100%	1,68%	0,37%	0,28%	100%	0,49%	97,28%	0,31%	46,19%	100%	100,00%	0,00%	100%	0,00%	100,00%	100%	4,62%	10,00%	5,53%
Lagosanto	K12	100%	92,51%	93,23%	100%	4,03%	0,00%	0,83%	100%	3,41%	66,26%	0,00%	0,76%	100%	84,64%	15,36%	100%	33,33%	66,67%	100%	7,29%	5,54%	5,88%
Masi Torello	K13	100%	92,73%	86,14%	100%	2,07%	0,00%	1,09%	100%	2,35%	8,16%	1,33%	8,43%	100%	91,94%	8,06%	100%	0,00%	100,00%	100%	0,00%	6,58%	6,12%
Massa Fiscaglia	K14	100%	94,61%	98,63%	100%	5,61%	1,34%	0,06%	100%	13,05%	80,21%	18,15%	0,00%	100%	88,64%	11,36%	100%	0,00%	100,00%	100%	3,61%	7,73%	2,94%
Mesola	K15	100%	88,17%	97,75%	100%	0,97%	0,00%	0,25%	100%	0,72%	91,69%	0,63%	11,23%	100%	86,35%	13,65%	100%	40,00%	60,00%	100%	26,99%	5,63%	12,41%
Migliarino	K16	100%	90,54%	84,13%	100%	4,95%	0,00%	0,18%	100%	2,40%	90,92%	39,77%	3,13%	100%	90,63%	9,37%	100%	0,00%	100,00%	100%	0,38%	7,52%	9,78%
Migliaro	K17	100%	92,68%	98,78%	100%	4,11%	0,00%	0,49%	100%	2,98%	97,02%	70,27%	0,00%	100%	88,64%	11,36%	100%	0,00%	100,00%	100%	0,86%	4,31%	3,85%
Mirabello	K18	100%	86,05%	92,49%	100%	16,42%	32,64%	0,00%	100%	17,95%	50,70%	0,00%	0,00%	100%	88,64%	11,36%	100%	0,00%	100,00%	100%	1,08%	5,95%	9,30%
Ostellato	K19	100%	93,54%	94,51%	100%	8,55%	1,08%	0,07%	100%	7,53%	87,45%	3,67%	0,24%	100%	84,47%	15,53%	100%	20,00%	80,00%	100%	2,75%	7,44%	4,58%
Poggio Renatico	K20	100%	92,84%	88,79%	100%	37,85%	8,51%	0,26%	100%	35,90%	50,98%	0,11%	1,59%	100%	82,29%	17,71%	100%	14,29%	85,71%	100%	1,02%	5,53%	3,28%
Portomaggiore	K21	100%	92,09%	91,33%	100%	8,77%	2,42%	0,59%	100%	9,86%	76,05%	3,15%	2,45%	100%	89,21%	10,79%	100%	10,00%	90,00%	100%	0,79%	7,25%	9,26%
Ro	K22	100%	92,93%	93,97%	100%	0,83%	5,27%	0,73%	100%	0,86%	27,13%	1,08%	0,43%	100%	95,88%	4,12%	100%	0,00%	100,00%	100%	2,48%	8,70%	7,36%
Sant'Agostino	K23	100%	90,23%	88,78%	100%	47,32%	5,55%	0,00%	100%	44,87%	46,12%	0,75%	0,60%	100%	79,92%	20,08%	100%	75,00%	25,00%	100%	0,26%	7,25%	2,98%
Tresigallo	K24	100%	90,48%	86,34%	100%	14,58%	2,31%	0,00%	100%	10,50%	12,91%	7,49%	5,93%	100%	75,70%	24,30%	100%	66,67%	33,33%	100%	0,75%	6,72%	5,00%
Vigarano Mainarda	K25	100%	90,62%	79,76%	100%	55,31%	31,46%	0,30%	100%	53,58%	12,30%	0,44%	1,32%	100%	71,15%	28,85%	100%	42,86%	57,14%	100%	1,03%	7,18%	3,95%
Voghiera	K26	100%	92,05%	74,78%	100%	26,81%	1,59%	0,31%	100%	21,26%	3,97%	0,04%	22,94%	100%	79,84%	20,16%	100%	0,00%	100,00%	100%	1,83%	5,49%	6,07%