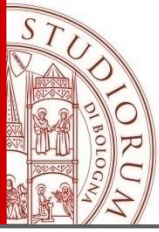


# Evaluation of Ecosystem Services Production under Different Agricultural Policy Scenarios

Chatzinikolaou Parthena, Davide Viaggi  
University of Bologna - Department of Agricultural Sciences

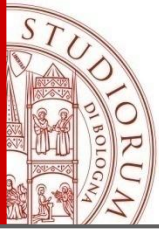
**4<sup>th</sup> AIEAA Conference - Innovation, Productivity and Growth  
Ancona, 11-12 June 2015**



# Overview

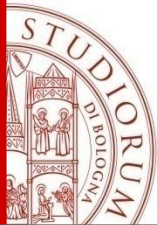
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- Introduction
- Objective
- Methodology
- Area of Study & Data
- Results
- Conclusions
- Further Steps



# Introduction

- Ecosystem services (ES) are the benefits that humans derive from ecosystems. The concept is integrated in current biodiversity policies at global and European level.
- Agriculture and ES are interrelated in at least three ways:
  - agro-ecosystems generate beneficial ES such as soil retention, food production,
  - agro-ecosystems receive beneficial ES from other ecosystems such as pollination,
  - ES from non-agricultural systems may be impacted by agricultural practices.
- The EU's regional and cohesion policies recognize the importance of investing in natural ecosystems, green areas, floodplains, nature for recreation, as a source of economic development.



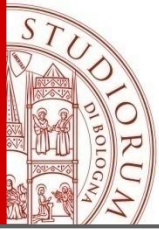
# Objective

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Evaluation of the provision of **Ecosystem Services**. Focus on:

- **different categories** of the ES
- a set of **indicators** non-overlapping and without redundancy,
- assessing different aspects of ES:
  - the capacity of ecosystems to provide services,
  - changes in the provision of ES, and
  - benefits thus derived.

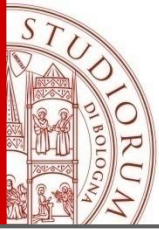
**Overall aim:** to contribute in understanding and improving valuation methods for ecosystems, in an attempt to provide an instrument that contributes to closing the gap between the ES concept, regional planning and agricultural policies.



# Methodology

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- Need for a multicriteria method adapted to problems where a finite number of alternatives are to be evaluated considering several and conflicting criteria.
- An out ranking method is suitable for the concept, based on pair wise comparison of different alternatives.
- PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations), one of the most recent MCDA outranking methods (developed by Brans (1985) extended by Vincke and Brans (1992), in comparison with other outranking methods: (Macharis 2004)
  - the mathematical model is relatively understandable by the decision makers,
  - 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,
  - allows flexibility in determination of the weights.

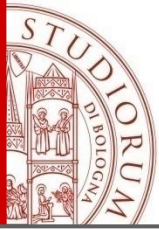


# PROMETHEE II - Modeling Framework

- The multicriteria problem  $Max \{f_1(a), \dots, f_k(a), \mid a \in K\}$ , where  $K$  is a finite set of actions and  $f_i, i = 1, \dots, k$ , are criteria to be evaluated.
- The preference structure of PROMETHEE is based on pair wise comparisons. The deviation ( $d$ ) between two alternatives on a particular criterion is considered.
- For each criterion we consider a corresponding preference function  $P$ .
- $H(d)$  is an increasing function of the difference  $d$  between the performances of alternatives  $a$  and  $b$  on each criterion:  $H(d) = \begin{cases} P(a,b), & \text{when } d \geq 0 \\ P(b,a), & \text{when } d \leq 0 \end{cases}$
- The multicriteria preference index  $\Pi$  is then defined as the **weighted average** of the preference functions  $P_i$  :

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

k: the alternatives  
 $P(\alpha, b)$ : the preference function



# PROMETHEE II - Modeling Framework

When each alternative is facing other alternatives, the following outranking flows are defined:

- The positive outranking flow:  $\phi^+(\alpha) = \sum \Pi(\alpha, b)$

The positive outranking flow expresses how an alternative is outranking all the others. It is its power, its outranking character.

- The negative outranking flow:  $\phi^-(\alpha) = \sum \Pi(\alpha, b)$

The negative outranking flow expresses how an alternative is outranked by all the others. It is its weakness, its outranked character.

- The net outranking flow is the balance between the positive and the negative outranking flows. The higher the net flow, the better the alternative:  $\phi(\alpha) = \phi^+(\alpha) - \phi^-(\alpha)$

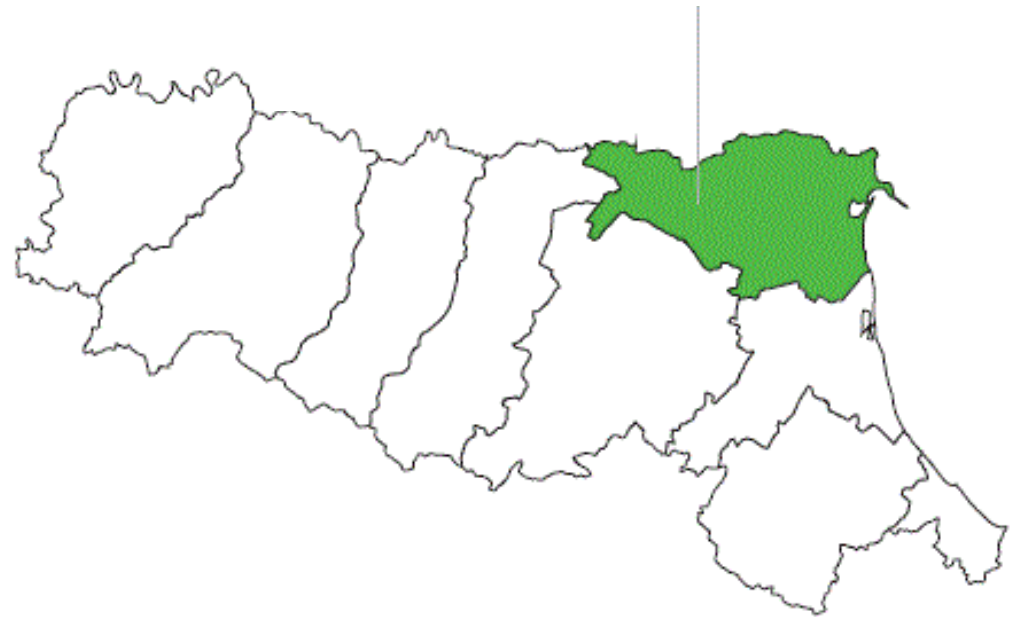
# Area of Study

- |     |                   |
|-----|-------------------|
| X1  | Argenta           |
| X2  | Berra             |
| X3  | Bondeno           |
| X4  | Cento             |
| X5  | Codigoro          |
| X6  | Comacchio         |
| X7  | Copparo           |
| X8  | Ferrara           |
| X9  | Formignana        |
| X10 | Goro              |
| X11 | Jolanda di Savoia |
| X12 | Lagosanto         |
| X13 | Masi Torello      |
| X14 | Massa Fiscaglia   |
| X15 | Mesola            |
| X16 | Migliarino        |
| X17 | Migliaro          |
| X18 | Mirabello         |
| X19 | Ostellato         |
| X20 | Poggio Renatico   |
| X21 | Portomaggiore     |
| X22 | Ro                |
| X23 | Sant'Agostino     |
| X24 | Tresigallo        |
| X25 | Vigarano Mainarda |
| X26 | Voghiera          |

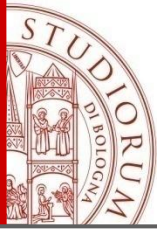


Emilia-Romagna

## Ferrara Province







# Ecosystem Services

## **Provisioning Services**

*Products obtained from ecosystems*

Food  
Fresh water  
Fuelwood  
Fiber  
Biochemichals

## **Regulating Services**

*Benefits obtained from regulation of ecosystem process*

Climate regulation  
Water regulation  
Water purification  
Pollination

## **Cultural Services**

*Non material benefits obtained from ecosystems*

Spiritual - religious  
Recreation  
Aesthetic  
Inspirational  
Educational  
Sense of place

## **Supporting Services**

*Services necessary for the production of all other ecosystem services*

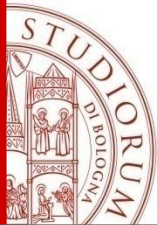
Soil formation

Nutrient cycling

Primary production

	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	organic agricultural area	agricultural area of PDO and/or PGI farms	Visitors Arrivals	Italian Visitors, Arrivals	Foreigners Visitors, Arrivals	collective accommodation establishments	hotels and similar establishments	holiday and other short-stay accommodation, camping grounds, recreational vehicle parks and	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)
Argenta	10,03%	91,20%	91,77%	12,99%	8,24%	0,88%	1,37%	9,62%	8,29%	82,26%	28,31%	13,72%	100%	84,66%	15,34%	100%	20,0%	80,0%	100%	1,19%	6,61%	10,30%
Berra	3,11%	90,02%	93,16%	2,78%	24,95%	2,24%	0,76%	3,85%	14,58%	40,90%	0,0%	3,28%	100%	86,81%	13,19%	100%	0,0%	0,0%	100%	3,46%	5,0%	5,81%
Bondeno	7,58%	92,72%	94,83%	4,71%	55,48%	2,13%	0,18%	3,78%	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	5,92%	91,54%	91,86%	0,83%	51,07%	6,53%	0,09%	0,62%	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	4,22%	91,36%	98,89%	11,00%	5,13%	0,34%	0,70%	18,92%	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	3,78%	91,09%	96,62%	10,54%	19,68%	0,69%	1,14%	8,05%	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	8,74%	91,06%	89,98%	3,95%	16,84%	1,69%	0,29%	4,44%	12,17%	37,16%	1,23%	3,88%	100%	84,93%	15,07%	100%	30,0%	70,0%	100%	0,72%	7,08%	3,99%
Ferrara	20,70%	91,12%	81,79%	12,23%	23,47%	7,96%	0,31%	9,84%	27,27%	29,27%	9,09%	1,58%	100%	72,0%	28,0%	100%	19,77%	80,23%	100%	0,28%	6,42%	3,99%
Formignana	1,33%	92,18%	85,46%	0,63%	20,48%	1,96%	0,12%	0,54%	23,09%	42,15%	0,30%	1,09%	100%	88,64%	11,36%	100%	0,0%	100%	100%	2,16%	5,76%	5,83%
Goro	0,31%	92,06%	99,53%	0,29%	12,63%	0,0%	0,47%	0,22%	51,28%	45,99%	0,0%	0,0%	100%	95,05%	4,95%	100%	25,0%	75,0%	100%	84,29%	1,75%	20,83%
Jolanda di Savoia	2,57%	90,57%	97,09%	5,26%	1,68%	0,37%	0,28%	12,15%	0,49%	97,28%	0,31%	46,19%	100%	100%	0,0%	100%	0,0%	100%	100%	4,62%	10,0%	5,53%
Lagosanto	0,88%	92,51%	93,23%	2,42%	4,03%	0,0%	0,83%	1,79%	3,41%	66,26%	0,0%	0,76%	100%	84,64%	15,36%	100%	33,33%	66,67%	100%	7,29%	5,54%	5,88%
Masi Torello	1,27%	92,73%	86,14%	0,57%	2,07%	0,0%	1,09%	0,44%	2,35%	8,16%	1,33%	8,43%	100%	91,94%	8,06%	100%	0,0%	100%	100%	0,9%	6,58%	6,12%
Massa Fiscaglia	1,32%	94,61%	98,63%	1,67%	5,61%	1,34%	0,06%	1,58%	13,05%	80,21%	18,15%	0,0%	100%	88,64%	11,36%	100%	0,0%	100%	100%	3,61%	7,73%	2,94%
Mesola	3,64%	88,17%	97,75%	5,55%	0,97%	0,0%	0,25%	3,67%	0,72%	91,69%	0,63%	11,23%	100%	86,35%	13,65%	100%	40,0%	60,0%	100%	26,99%	5,63%	12,41%
Migliarino	1,19%	90,54%	84,13%	1,84%	4,95%	0,0%	0,18%	1,70%	2,40%	90,92%	39,77%	3,13%	100%	90,63%	9,37%	100%	0,0%	100%	100%	0,38%	7,52%	9,78%
Migliaro	0,67%	92,68%	98,78%	0,43%	4,11%	0,0%	0,49%	0,41%	2,98%	97,02%	70,27%	0,0%	100%	88,64%	11,36%	100%	0,0%	100%	100%	0,86%	4,31%	3,85%
Mirabello	0,56%	86,05%	92,49%	0,12%	16,42%	32,64%	0,0%	0,09%	17,95%	50,70%	0,0%	0,0%	100%	88,64%	11,36%	100%	0,0%	100%	100%	1,08%	5,95%	9,30%
Ostellato	4,50%	93,54%	94,51%	9,44%	8,55%	1,08%	0,07%	8,14%	7,53%	87,45%	3,67%	0,24%	100%	84,47%	15,53%	100%	20,0%	80,0%	100%	2,75%	7,44%	4,58%
Poggio Renatico	3,15%	92,84%	88,79%	2,34%	37,85%	8,51%	0,26%	1,71%	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	4,18%	92,09%	91,33%	4,77%	8,77%	2,42%	0,59%	3,70%	9,86%	76,05%	3,15%	2,45%	100%	89,21%	10,79%	100%	10,0%	90,0%	100%	0,79%	7,25%	9,26%
Ro	2,10%	92,93%	93,97%	1,17%	0,83%	5,27%	0,73%	1,07%	0,86%	27,13%	1,08%	0,43%	100%	95,88%	4,12%	100%	0,0%	100%	100%	2,48%	8,70%	7,36%
Sant'Agostino	2,17%	90,23%	88,78%	0,68%	47,32%	5,55%	0,0%	0,54%	44,87%	46,12%	0,75%	0,60%	100%	79,92%	20,08%	100%	75,0%	25,0%	100%	0,66%	7,25%	2,98%
Tresigallo	1,03%	90,48%	86,34%	0,59%	14,58%	2,31%	0,0%	0,57%	10,50%	12,91%	7,49%	5,93%	100%	75,70%	24,30%	100%	66,67%	33,33%	100%	0,75%	6,72%	5,0%
Vigarano Maina.	2,28%	90,62%	89,76%	1,05%	55,31%	31,46%	0,30%	0,80%	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	2,76%	92,05%	84,78%	12,99%	26,81%	1,59%	0,31%	9,62%	21,26%	3,97%	0,04%	22,94%	100%	79,84%	20,16%	100%	0,0%	100%	100%	1,83%	5,49%	6,07%

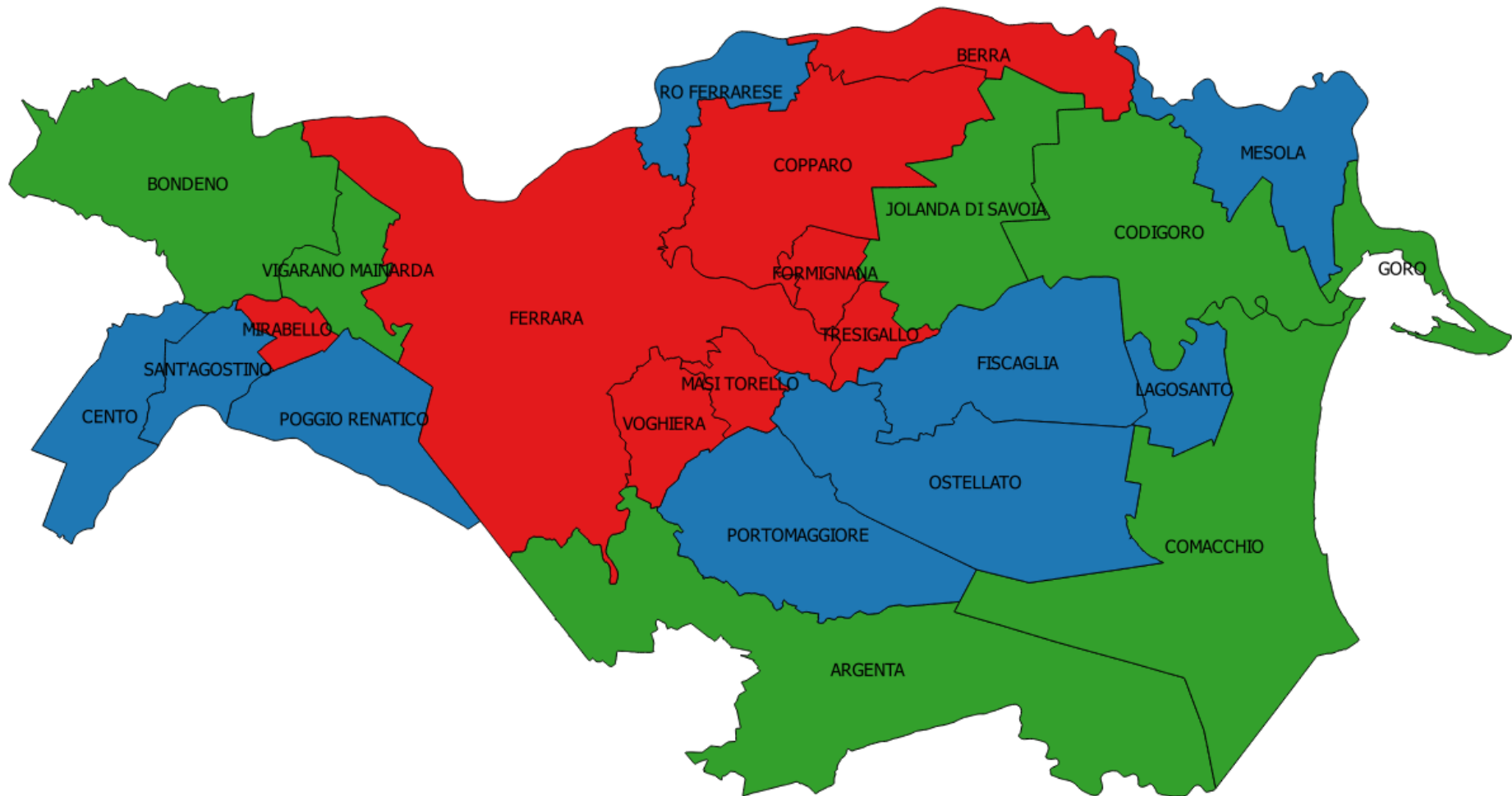
	Number of agricultural holdings	Utilized agricultural area		arable land	irrigated area	irrigated area - surface water (natural and artificial basins, lakes, rivers or waterflows)	irrigated area - underground water	Wooded area	volume of irrigation water	volume of irrigation water - surface water (natural and artificial basins, lakes, rivers or waterflows)	aqueduct, irrigation and restoration consortium	Organic area	agricultural area of PDO and/or PGI farms	Visitors Arrivals	Italian Visitors	Foreigners Visitors, Arrivals	collective accommodation establishments	Hotels and similar establishments	camping grounds, recreational vehicle parks and	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)
Argenta	10,03%	91,20%	91,77%	12,99%	8,24%	0,88%	1,37%	9,62%	8,29%	82,26%	28,31%	13,72%	100%	84,66%	15,34%	100%	20,0%	80,0%	100%	1,19%	6,61%	10,30%	
Berra	3,11%	90,02%	93,16%	2,78%	24,95%	2,24%	0,76%	3,85%	14,58%	40,90%	0,0%	3,28%	100%	86,81%	13,19%	100%	0,0%	0,0%	100%	3,46%	5,0%	5,81%	
Bondeno	7,58%	92,72%	94,83%	4,71%	55,48%	2,13%	0,18%	3,78%	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	5,92%	91,54%	91,86%	0,83%	51,07%	6,53%	0,09%	0,62%	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	4,22%	91,36%	98,89%	11,00%	5,13%	0,34%	0,70%	18,92%	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	3,78%	91,09%	96,62%	10,54%	19,68%	0,69%	1,14%	8,05%	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	8,74%	91,06%	89,98%	3,95%	16,84%	1,69%	0,29%	4,44%	12,17%	37,16%	1,23%	3,88%	100%	84,93%	15,07%	100%	30,0%	70,0%	100%	0,72%	7,08%	3,99%	
Ferrara	20,70%	91,12%	81,79%	12,23%	23,47%	7,96%	0,31%	9,84%	27,27%	29,27%	9,09%	1,58%	100%	72,0%	28,0%	100%	19,77%	80,23%	100%	0,28%	6,42%	3,99%	
Formignana	1,33%	92,18%	85,46%	0,63%	20,48%	1,96%	0,12%	0,54%	23,09%	42,15%	0,30%	1,09%	100%	88,64%	11,36%	100%	0,0%	100%	100%	2,16%	5,76%	5,83%	
Goro	0,31%	92,06%	99,53%	0,29%	12,63%	0,0%	0,47%	0,22%	51,28%	45,99%	0,0%	0,0%	100%	95,05%	4,95%	100%	25,0%	75,0%	100%	84,29%	1,75%	20,83%	
Jolanda di Savoia	2,57%	90,57%	97,09%	5,26%	1,68%	0,37%	0,28%	12,15%	0,49%	97,28%	0,31%	46,19%	100%	100%	0,0%	100%	0,0%	100%	100%	4,62%	10,0%	5,53%	
Lagosanto	0,88%	92,51%	93,23%	2,42%	4,03%	0,0%	0,83%	1,79%	3,41%	66,26%	0,0%	0,76%	100%	84,64%	15,36%	100%	33,33%	66,67%	100%	7,29%	5,54%	5,88%	
Masi Torello	1,27%	92,73%	86,14%	0,57%	2,07%	0,0%	1,09%	0,44%	2,35%	8,16%	1,33%	8,43%	100%	91,94%	8,06%	100%	0,0%	100%	100%	0,9%	6,58%	6,12%	
Massa Fiscaglia	1,32%	94,61%	98,63%	1,67%	5,61%	1,34%	0,06%	1,58%	13,05%	80,21%	18,15%	0,0%	100%	88,64%	11,36%	100%	0,0%	100%	100%	3,61%	7,73%	2,94%	
Mesola	3,64%	88,17%	97,75%	5,55%	0,97%	0,0%	0,25%	3,67%	0,72%	91,69%	0,63%	11,23%	100%	86,35%	13,65%	100%	40,0%	60,0%	100%	26,99%	5,63%	12,41%	
Migliarino	1,19%	90,54%	84,13%	1,84%	4,95%	0,0%	0,18%	1,70%	2,40%	90,92%	39,77%	3,13%	100%	90,63%	9,37%	100%	0,0%	100%	100%	0,38%	7,52%	9,78%	
Migliaro	0,67%	92,68%	98,78%	0,43%	4,11%	0,0%	0,49%	0,41%	2,98%	97,02%	70,27%	0,0%	100%	88,64%	11,36%	100%	0,0%	100%	100%	0,86%	4,31%	3,85%	
Mirabello	0,56%	86,05%	92,49%	0,12%	16,42%	32,64%	0,0%	0,09%	17,95%	50,70%	0,0%	0,0%	100%	88,64%	11,36%	100%	0,0%	100%	100%	1,08%	5,95%	9,30%	
Ostellato	4,50%	93,54%	94,51%	9,44%	8,55%	1,08%	0,07%	8,14%	7,53%	87,45%	3,67%	0,24%	100%	84,47%	15,53%	100%	20,0%	80,0%	100%	2,75%	7,44%	4,58%	
Poggio Renatico	3,15%	92,84%	88,79%	2,34%	37,85%	8,51%	0,26%	1,71%	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	4,18%	92,09%	91,33%	4,77%	8,77%	2,42%	0,59%	3,70%	9,86%	76,05%	3,15%	2,45%	100%	89,21%	10,79%	100%	10,0%	90,0%	100%	0,79%	7,25%	9,26%	
Ro	2,10%	92,93%	93,97%	1,17%	0,83%	5,27%	0,73%	1,07%	0,86%	27,13%	1,08%	0,43%	100%	95,88%	4,12%	100%	0,0%	100%	100%	2,48%	8,70%	7,36%	
Sant'Agostino	2,17%	90,23%	88,78%	0,68%	47,32%	5,55%	0,0%	0,54%	44,87%	46,12%	0,75%	0,60%	100%	79,92%	20,08%	100%	75,0%	25,0%	100%	0,66%	7,25%	2,98%	
Tresigallo	1,03%	90,48%	86,34%	0,59%	14,58%	2,31%	0,0%	0,57%	10,50%	12,91%	7,49%	5,93%	100%	75,70%	24,30%	100%	66,67%	33,33%	100%	0,75%	6,72%	5,0%	
Vigarano Maina.	2,28%	90,62%	89,76%	1,05%	55,31%	31,46%	0,30%	0,80%	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	2,76%	92,05%	84,78%	12,99%	26,81%	1,59%	0,31%	9,62%	21,26%	3,97%	0,04%	22,94%	100%	79,84%	20,16%	100%	0,0%	100%	100%	1,83%	5,49%	6,07%	



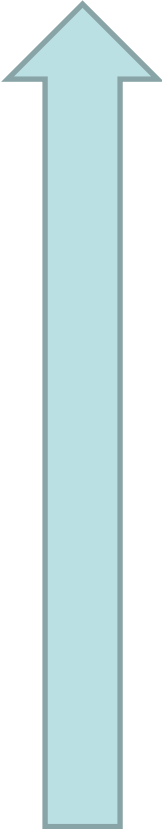
# Results - Classification

	<b>Municipality</b>	<b>Net Flow (<math>\Phi</math>)</b>
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

# Results - Classification



# Results - Classification



**Comacchio, Argenta** : foreigner visitors, hotels and similar establishments, number of active enterprises food services activities

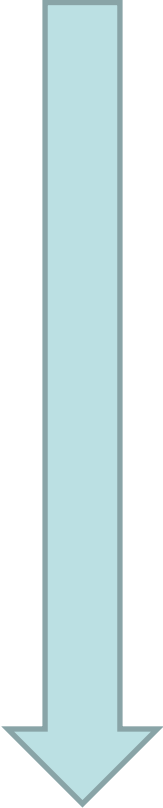
**Goro**: number of farms with other gainful agricultural activities

**Jolanda di Savoia**: PDO and/o PGI farms

**Migliaro**: organic agricultural area

**Codigoro**: Italian visitors, holiday and short-stay accommodation, camping grounds, recreational parks

**Vigarano Mainarda and Bondeno**: irrigated area from natural and artificial basins

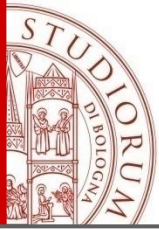


**Formignana**: no hotels or similar establishments

**Copparo**: agricultural farms with other gainful activities such as agritourism, recreational and social activities, initial processing of agricultural products, or agricultural area of PDO and/or PGI farms

**Tresigallo**: no wooded area

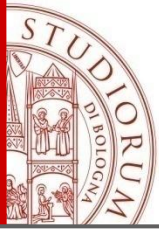
**Berra**: no organic agricultural area, hotels or similar establishment and any kind of accommodation



# Conclusions

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- In the present study we developed a framework for **evaluating the provision of ES in a landscape** (26 municipalities).
- Results show a priority in provisioning and almost all cultural ecosystem services, and a greater diversity of the provision of regulating and supporting services.
- A key challenge is determining **how to manage multiple ES** across landscapes.
- There are many gaps in ecosystem service metrics and indicators available at **municipality level**. The indicators available for most ecosystem services are insufficient to evaluate the quality and quantity of benefits provided.
- This evaluation identified ES that are more enhanced and can also support the **characterization of agricultural lands** in terms of the provision of multiple ES and the maintenance and enhancement of biodiversity.



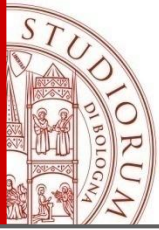
## ...further steps/research

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At a next stage, the model will be used to simulate alternative scenarios, based on the future agricultural policies that can affect the supply or demand of ES.

- **CAP reform scenario**, presenting the new programming period affecting landscape structure and behaviors related to ES:
  - 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.





Thank you

[parth.chatzinikolao2@unibo.it](mailto:parth.chatzinikolao2@unibo.it)