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In this paper I propose an Agricultural Sustainability Index (ASI) starting from a 'political' perspective: European legislation in the rural sector. I try to answer these questions. How can we measure sustainability in agriculture? How do we measure the enhancement (if any) of the European policy for sustainability in agriculture? Why do some geographical areas perform better than others? Considering these questions, the paper suggests a model for measuring sustainability in agriculture and an approach to compare performances among different geographical contexts. The model puts together different dimensions of sustainability in agriculture, combining Geographical Information System (GIS) analysis and Multi-Criteria Analysis (MCA). Using eighteen agricultural indicators divided into three dimensions, social, economic and environmental, the model incorporates the following stages: (i) indicator specification and definition of the decisional framework; (ii) indicators' normalisation by means of transformation functions based on the fuzzy logic approach; (iii) indicators weighted by Analytic Hierarchy Process (AHP) techniques; (iv) indicators aggregated to obtain the ASI. The model is tested on a specific area: Alta Val d'Agri, a rural area in the southern Basilicata Region. Final results show that ASI consistently synthesises the evolution of thirty years of rural development policy.

Keywords: Agricultural sustainability, Indicators, GIS-MCA.

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1. Introduction

The primary goal of this paper is to elaborate an Agricultural Sustainability Index (ASI) and to propose an application for a specific area of the Basilicata Region: Alta Val d'Agri.
From a methodological perspective, it will study evolution in terms of sustainable development for eighteen elementary indexes from 1971 to 2001. The area's transformation will be identified in terms of the institutional goals for rural policy. All this information will finally be synthesised in the ASI.

Sustainable Development (SD) has been the buzz word of the last 40 years. The SD concept stems from the book *Limits to Growth*[2] (1972),. It found a definitive place on the political agenda starting in 1987 with the Brundtland Commission and the World Commission on Environment and Development.[3] From then until the end of the nineties the attempt to define the basic principles of SD was the object of considerable discussion (Dresner, 2002). Economists have focused on the weak[4] version of SD, trying to introduce environment and intergeneration equity into growth and development models (Dasgupta and Heal, 1974; Hartwick, 1977; Solow, 1974). In this scheme the basic idea is to internalise negative externalities by pricing all the environmental and agricultural amenities that are outside the market.
Economists have a propensity to see the environment as a 'green market', a market which has failures, regulations and a pricing dynamic. This point of view has led to incommunicability between economists and scientists,[5] blunting the construction of a unique framework of analysis.

Meadowcraft (2000) argues that SD has been seen as a meta-political concept that finds its natural place only in the political arena. Consequently, any efforts to marry economics and environment science risk failure. Moreover, as mentioned before, the absence of a well-recognised definition leads to another problem: the lack of a recognised evaluation methodology.
Considering the previous considerations, the paper adopts a 'political' definition of SD. The starting-point for building the ASI is the rural policy results verified for the specific area analysed. The paper is structured in a

[2] Dennis L. Meadows et al, The Limits to Growth, Universe Books, New York, 1972.
[3] World Commission on Environment and Development, Brundtland Commission, "Our Common Future" (1987).
[4] Depending on the role assigned to factors of productions, technological change and natural resources, we can distinguish between *Weak Sustainability* (Dasgupta and Heal, 1974; Hartwick, 1977; Solow, 1974) and *Strong Sustainability* (Daly and Cobb 1989; Costanza 1991).
5 See Fullerton and Stavins (1998).

multidimensional way in order to capture a highly complex phenomenon with several dimensions.

The pioneering academic advocates of sustainable agriculture date back to 1970s (Aerni, 2009). After the 1992 Rio Earth Summit an increasing need has emerged to define standards or indicators of sustainable development (Rigby et al. 2001). This impetus involves the study of the agricultural sustainability concept and his study from a holistic point of view (Andreoli and Tellarini, 2000). The analysis of agricultural sustainability by the aggregation of a set of indicators into a single index has been introduced in those years particularly in the international organizations context: WB, UN, OECD. A review on the evolution of the concept can be found in Hansen (1996), Polinori (1998) and Aerni (2009). Gomez-Limon and Riesgo (2008) and OECD (2010) provide a review on the alternative approaches on constructing a composite indicator to agricultural sustainability.
In recent years an increasing branch of the literature has been occupied in the construction of farm level indicator of agricultural sustainability (Andreoli and Tellarini, 2000; Pirazzoli and Castellini, 2000; Rigby et al. 2001; van Calker et al. 2006).
All these methods have been criticized because of the lack of objectivity in methodology, the largeness of the agriculture sustainability concept, the strong assumptions in terms of amalgamation of the different attribute of the sustainability function (van Calker et al. 2006).

In the first section, the model will be presented, the second section describes the area where the model will be applied, and the third section presents the indicators used. The last section presents results and conclusions.

2. Model

The land planning methodology presented includes Geographic Information System (GIS) techniques and Multi-Criteria Analysis (MCA) and was first applied at the beginning of the nineties6. It is a relatively new branch of land planning theory which evaluates and measures concepts in a multidimensional and multi-decisional context (Malczewski, 2004). The proposed model stems from Bernetti (1993, 2002) and introduces an index construction instead of a pure MCA application.
An important note concerns the empirical implementation of the model. Considering model sensitivity to different choices regarding indices, weight's procedure and fuzzy logic for normalization, it is tested for small and homogeneous rural area. In this perspective it will be proposed for application to a very small rural area located in South Italy.

[6] Carver (1991), Banai (1993), Eastman (1997), Malczewski (1999).

The first goal of the Model is to elaborate an ASI index starting from eighteen elementary indicators that form part of one of the three dimensions of the SD in agriculture. Aggregating from the bottom to the top and normalizing the variety of information included in the model we will build the ASI index as shown in Figure 1:

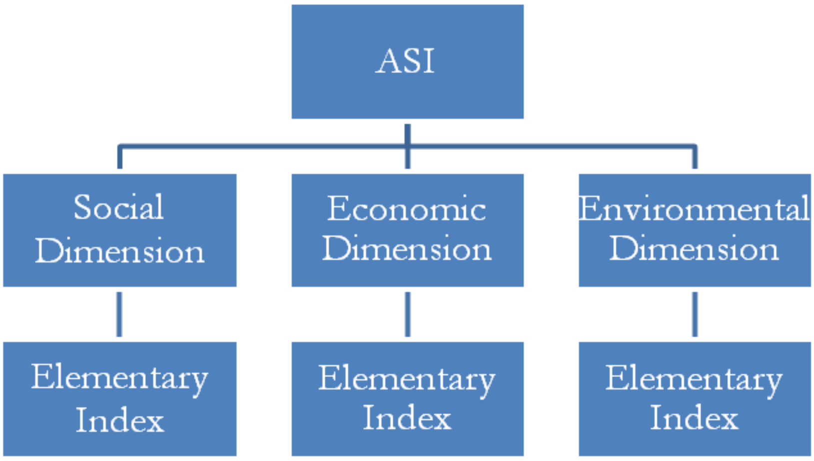

Figure 1: Indicators and model structure

The first step in the model consists of the identification of the eighteen elementary indicators7 divided into social, economic and environmental dimensions.

Social dimension refers to the agricultural system abilities: i) to guarantee the presence of human capital (index: 1-2-5); ii) to assure a certain equity level between social groups and between men and women in the sector (index: 2-4); iii) to guarantee social services, in terms of access to education (index: 3).

Economic dimension refers to three functions: i) the main features of the agricultural sector considering profitability and the firm's size (index: 8-10); ii) the efficient use of resources (index: 6-7-11); iii) the competitiveness of the sector taking into consideration technological innovation and activities diversification (index: 9-11).

Environmental dimension considers a "land use" approach (index: 12-13-14-15-16-17) giving a strong importance to biodiversity intended as the variety in land use destination (index: 18). On the one hand, this point of view has the advantage of verifying changes in land destination as a direct policy effect on the territory (i.e. Mac Sharry effect, reforestation policy), on the other hand, it did not consider other indicators to measure the impact on agriculture of pollutant agents (i.e. groundwater pollution, dehydration, acidification). This choice, taking into consideration the empirical

[7] In the MCA literature the term 'Criterion' is used instead of 'Indicator'.

application of the model, has been made also considering the lack of data dating back to 1971 for the eight analyzed villages.

In selecting indicators relating to the socio-economic dimension, we have referred mainly to Trisorio (2004) and documents of the European Commission (2001) and OECD (2001, 2005, 2010). In the matter of the approach proposed for the environmental dimension, it has not been found a similar methodology in literature.
One central aspect for establishing sustainability indicators is the adoption of a definite concept of sustainability. Following Lichtfouse et al. (2009, p.4): "[...] Agricultural systems are considered to be sustainable if they sustain themselves (three dimensions) over a long period of time, that is, if they are economically viable, environmentally safe and socially fair". Since the theoretical and methodological frameworks consider positively a generic augment in future capital stock (social, economic or environmental), the concept implies capital substitution law responding to a rule of "weak" sustainability.

Social Dimension

1. Employed in agriculture: is the ratio between employed in agriculture and in the whole economy. It is a measure to value: i) the relative agricultural sector importance with respect to other economy sectors and ii) how farmers contribute to preserving the viability of rural areas exercising their "land custodian" function.
2. Old-age Index: is the ratio between the numbers of those employed in agriculture over sixty years of age and the total number employed in the sector. This index is a measure of sector youthfulness and of the ability to perpetuate specific professional skills over time and in a intergenerational perspective. Young farmers are a key point to promote development in rural areas because of their greater aptitude to innovate, to intercept funds opportunities (is this the same as looking for ways of making money?) and to adopt new technological framework.
3. Farmer education: is the number of farmers with at least a high school degree over the total number of farmers. The higher the lever of education, the higher will be the farmer's ability to introduce technological innovations, to invest in an environmental friendly production process, to diversify the firm supply and to increase quality and productivity.
4. Employed in agriculture by gender: is a measure of equity in term of labor opportunity. It's calculated as the ratio between women and men employed in the agricultural sector.
5. Population resident: is the number of residents in a particular geographical area. Rural areas are subject to land abandonment. This

phenomenon has increased because of the decline in agricultural sector profitability and the increasing importance of the "centre" as a point of economic and cultural attraction. Increase in the rural population is a social objective that prevents problems of degradation both economically and environmentally (Trisorio, 2004).

Economic Dimension

6. Labor productivity: is the ratio between the final output in agriculture and the input measured in the labor unit. It provides an efficient measure of how the production process converts input into output. The higher labor productivity, the higher will be the potential output for future generations.
7. Land productivity: as the labor productivity index it provides a measurement of efficiency of the land used in production. It is the final output over the total agricultural surface area. In general, an increase in land productivity could not be necessarily associated to an improvement in the agri-environmental land conditions. It can, for example, derive from an intensive agricultural approach. However, considering the firm's characteristics in rural area (size, technology, profitability), it is reasonable to assume that an increase in land productivity tends to foster sustainable development.
8. Fragmentation farm Index: is the share of farms with a total agricultural surface area less than 5 hectares on the total farms. A higher fragmentation level may be positive in terms of sustainability because of the ability of the small farm factory to generate biodiversity, landscape and environmental protection, and local products. However, a high fragmentation level weakens the economic power of the small farmer in a sector dominated by large retailers. This double effect will be incorporated in the model thanks to an asymmetric function used in the fuzzy logic approach. The important point here is to recognize how this index is effective in capturing the "land custodian" propensity of a specific rural area.
9. Diversification Index in agriculture: is a measure of farms run by farm holders. It measures the share of labor hours provided by the farm holders on the total amount of worked hours. The higher the time spent by the farm holders, the smaller the aptitude to diversify their activity. To improve multifunctionality it's desirable to have a small diversification index. However a small diversification index could reduce the "land custodian" function of agriculture. As in the fragmentation index, an asymmetric function is used in the fuzzy logic approach.
10. Value added in agriculture: is the contribution as a share of agricultural value added on total value added. It is a measure of the

sector's importance with regard to other sectors. Moreover, considering that it measures also the level of maturity of the economy, it will be desirable to have a "fair" level of this index considering the overall economic situation of the analyzed rural area.

11. Mechanization Index: it provides a measure of the firm's technological level. It is measured as the ratio between firms with mechanized production process and the total number of firms. The higher the index, the higher the firm's propensity to generate sustainable development.

Environmental Dimension

As mentioned before, the environmental dimension considers a "land use" approach. This point of view permits one to verify changes in land destination as a tangible effect of the policy on the territory (i.e. Mac Sharry effect, reforestation policy, etc.). Environmental indices are the ratio between land use destinations and the total agricultural surface area considering the official distinction operated by the National Institute of Statistics (ISTAT):

12. Arable surfaces;
13. Permanent crops;
14. Meadow grass;
15. Poplar wood;
16. Woods;
17. Other surfaces;
18. Biodiversity: it is measured calculating a Shannon Index for biodiversity. Shannon Index is one of several diversity indices used to measure diversity in similar application. It has been used because it has the advantage to take into account the number of species and the uniformity of the species in the distribution at the same time. It has been calculated considering the different land use destinations and their relative weights on the total agriculture surface. Clearly the larger the index, the higher the positive impact in terms of sustainable development.

2.1 Modelling Elementary indicators

Defining O_j as the $_j$ pixel in a raster[8] representation of a specific area and $x_{i,j}$ as the value of the pixel for the elementary index i, we can define the set of the elementary index of our model thus:

$$\mathrm{OX} = \left\{ x_{i,j} \middle| x_{i,j} \in [0,1], i = 1,2,...,m; j = 1,2,...,n \right\}.$$

[8] In computer graphics, a raster graphics is a data structure generally representing a rectangular grid of pixels. In our model each pixel is assigned a specific value derived from the selected elementary indicator.

Each pixel of the GIS picture will have a value related to the elementary index analysed. This value will be in the $\lfloor 0,1 \rfloor$ interval after normalisation. The set of the pixel values of a specific boundary line shapes the value that the elementary index assumes in that specific area. As mentioned before, indicators are always expressed in difference measures. For this reason it is necessary to normalise them as shown in the following part.

2.2 Fuzzy logic

One of the most popular ways to normalise is the method which uses the Euclidian distance from the ideal point.[9] This paper uses an alternative method based on fuzzy logic. Normalisation with the fuzzy logic approach allows us to normalise in the interval $\lfloor 0,1 \rfloor$ the indicators that do not present an ideal value. A good example is an indicator that does not assume a numeric value but a qualitative representation.

Fuzzy logic assigns at each indicator a membership function defined in the interval $\lfloor 0,1 \rfloor$. To simplify the analysis the selected functions are linear functions as shown in Figure 2.

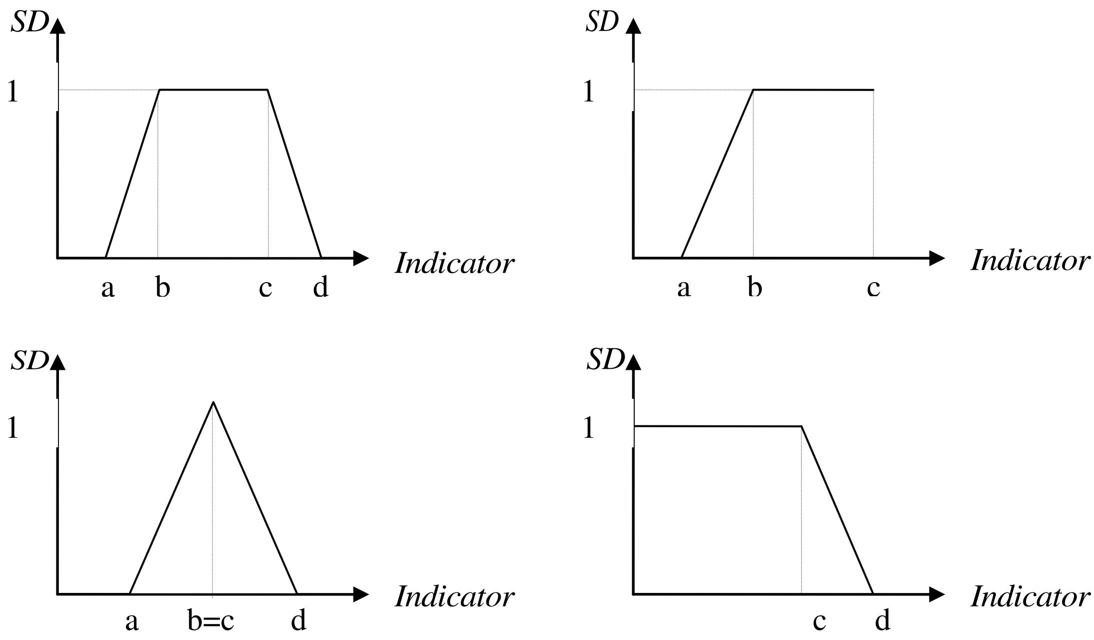

Figure 2: Linear functions and fuzzy logic

[9] The method is based on the following formula: $x_{i,j} = \frac{R_{i,j} - R_i^{\min}}{R_i^{\max} - R_i^{\min}}$. Where $R_{i,j}$ is the non-normalised value and e $R_i^{\min}$ and $R_i^{\max}$ are the minimum and maximum values assumed by the i indicator.

The fuzzy logic approach adopts the following steps:

1. specification of the level of consistency between the i indicator and the general goal for sustainability (SD on the y-axis in Figure. 2). Consistency is evaluated according to EU rural policy[10] resulting from legislation from 1971 to 2001 (see Table 5 in Appendix);
2. threshold specification at a local and national level to determine points a, b, c, d as shown in Figure 2;
3. data normalisation.

As an example, we will show the normalisation process for the elementary indicator 'fragmentation of farm factories'. The fragmentation index is the ratio between the number of farm factories with an agriculture surface <5 hectares and the total number of farm factories. On the one hand, a higher fragmentation level may be positive in terms of sustainability because of the ability of the small farm factory to generate biodiversity, landscape and environmental protection, and local products. On the other hand, a high fragmentation level weakens the economic power of the small farmer in a sector dominated by large retailers.

From a normative perspective, the trade-off stems from Regulations 797/1985, 2079/92 and 2085/93. Regulation 2085/93 affirms the importance of investment for the conservation and development of rural villages and typical products, whereas Regulations 797/1985 and 2079/92 promote economic productivity through higher concentration on agricultural enterprises. The trade-off is typical vs. economic concentration. To normalise this indicator we choose a symmetric function that can capture the double effect of the fragmentation indicator.

[10] The analysis adopts a "laws transfer" hypothesis: EU rural laws are homogenously transferred both at a national and regional level.

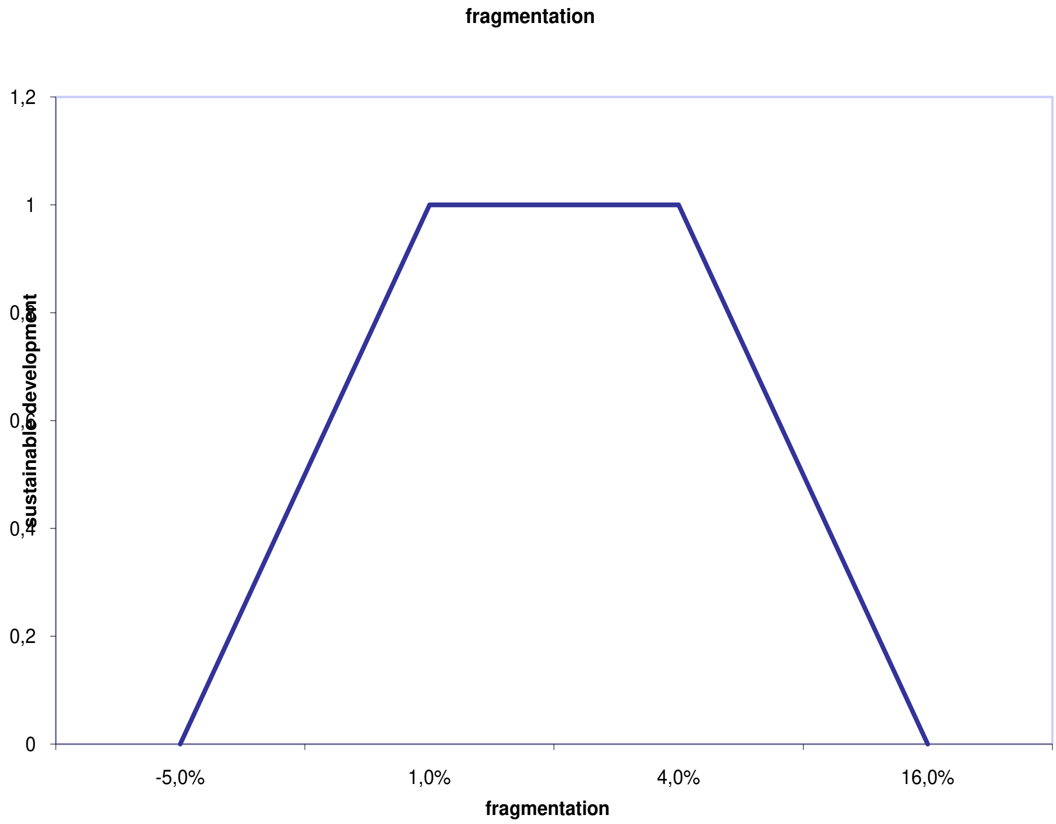

Figure 3: Normalising function for the indicator 'Fragmentation'

In Figure 3, $a = -5\%; b = 1\%; c = 4\%; d = 16\%$. The indicator has been normalised using the following values:

$$
\begin{array}{lll}
SD = 0 & if & -\infty \leq fragmentation \leq -5\% \\
0 < SD < 1 & if & -5\% < fragmentation < 1\% \\
SD = 1 & if & 1\% \leq fragmentation \leq 4\% \\
0 < SD < 1 & if & 4\% < fragmentation < 16\% \\
SD = 0 & if & 16\% \leq fragmentation \leq +\infty
\end{array}
$$

Values a, b, c and d are selected according to the internal values of *area 5*. The range between b and c is considered to be the optimal increase of the fragmentation index. In other words, if the indicator assumes a value between 1% and 4% it will be normalised and it will assume a value=1 (maximum sustainability). For fragmentation < $b = 1\%$ or > $c = 16\%$ the indicator is normalised with values included in the $\lfloor 0,1 \rfloor$ interval. Figure 4 shows graphical output for the fuzzy logic normalisation conduct on the fragmentation index.

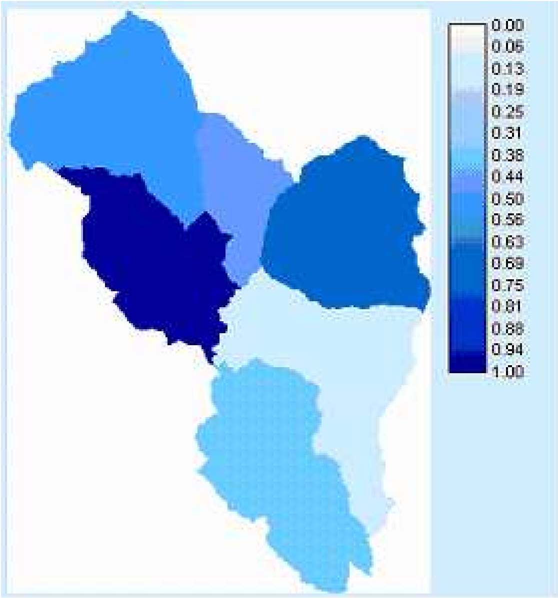

Figure 4: Fuzzy logic and Fragmentation

2.3 Weight

The third step assigns a particular weight (w_i) to each single indicator considering rural policy on the specific issue (Table 5) and respecting the obvious constraint: $\sum_i w_i = 1$.

The model assigns different weights with the Analytic Hierarchy Process (AHP). The AHP method, elaborated by Thomas L. Saaty (1980, 1992), establishes a hierarchy following the process structure and assigns to each indicator a weight according to its relative importance. The big advantage of the AHP method is that it permits a comparative analysis starting from one indicator and compares it with all the others. AHP may be illustrated in four steps.

The first step consists of building the hierarchy's process. Our model is based on three levels: ASI, Dimensions and Elementary Indicators as shown in Figure 1.

The second step consists of the assignment of a degree of relationship among dimensions and indexes. In this context, Saaty elaborated a table that uses pairwise comparisons, verbal expression and numerical values (Table 1). In practice each elementary index is compared with all the others, assigning a verbal expression to represent the relative importance of the selected indicator. In the assignment process, the model makes a distinction between structural elementary indicators and qualitative elementary indicators.[11] The latter are considered the most important in the EU rural policy perspective (see Table 5). For the social, economic and environmental dimensions a weight of 0.3, 0.3 and 0.4 respectively has been assigned. These weights were determined through consultation with academic and local experts of the sector, for each dimension and for each elementary index.

Table 1: Scale for pairwise comparisons

Definition	**Intensity of Importance**	**Explanation**
Equal importance	1	Two elements contribute equally to the general objective.
Moderate importance	3	Experience and judgment slightly favour one element over another.
Strong importance	5	Experience and judgment strongly favour one element over another.
Very strong importance	7	One element is favoured very strongly over another.
Extreme importance	9	The evidence favouring one element over another is of the highest possible order of affirmation.
Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

To test the consistency of the choices made during the pairwise comparisons, matrix A must satisfy the following conditions: (a) $a_{ij} = 1$ diagonal values must be equal to 1; (b) $a_{ij} = x \rightarrow a_{ji} = x^{-1}$ values below the diagonal must be the reciprocal of the values above. The matrix will assume the following form:

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & a_{ii} & \vdots \\ a_{n1} & a_{n2} & \vdots & a_{nn} \end{pmatrix}$$

[11] Structural Index: Social dimension: (i) Employed in agriculture, (ii) Agricultural employee. Economic dimension: (i) Added values in agriculture; (ii) Fragmentation Index; (iii) Labour productivity; (iv) Land productivity. Environmental dimension: (i) Biodiversity Index; (ii) Woods; (iii) Permanent crops. Remaining indexes are considered as qualitative.

The third step consists of pairwise comparisons using weights derived from the previous analysis: $a_{ij} = \frac{w_i}{w_j}$. Using new weighted values it is possible to build a new matrix W such that:

$$W = \begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \frac{w_i}{w_i} & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \vdots & \frac{w_n}{w_n} \end{pmatrix}$$

The fourth step in the AHP process consists of the construction of the Consistency Index CI:

$$CI = \frac{(\alpha_{\max} - n)}{(n-1)}$$

where $\alpha_{\max}$ is the principal eigenvalue and n the number of the model's variables. If $CI < 0.1$, the matrix is consistent. Approaching zero, the matrix is more and more consistent. If $CI > 0.1$, the matrix is inconsistent. Table 2 describes values assigned with the AHP approach.

Table 2: AHP weights

Social dimension	**Weight**
Population	0.3945
Employed in agriculture	0.2808
Old-age index	0.2030
Education	0.0824
Gender composition	0.0393
Consistency Index	0.07
Economic dimension	
Added value	0.3873
Fragmentation	0.2727
Labour productivity	0.1361
Land productivity	0.1361
Mechanisation	0.0417
Diversification	0.0261
Consistency Index	0.07
Environmental dimension	
Biodiversity	0.3423

Woods	0.2865
Permanent crops	0.1436
Arable surface	0.0922
Meadow grass	0.0659
Poplar woods	0.0448
Other surfaces	0.0247
Consistency Index	0.09

2.4 Aggregation

The last stage of our model consists of the specification of the aggregation function:

$$ASI = \underset{i}{agg}\left\{w_i x_{i,j}\right\}$$

where ASI is the agricultural sustainable index. To aggregate the three dimensions the model uses the Ordered Weighted Average (OWA), an aggregation technique that has had substantial application in land planning models (Bernetti and Fagarazzi, 2002). The OWA develops for each village a linear combination among the indicators excluding any that assume the maximum values in the selected subset. To put it more simply, OWA filters values considered too extreme for the computation of the index. By construction, $0 \le ASI \le 1$: $ASI = 1$ means full sustainability in agriculture, $ASI = 0$ null sustainability.

3. Alta Val d'Agri

Alta Val D'Agri is an Apennine area located on the west side of the Basilicata bordering the Campania Region. The area starts from 600 metres above sea-level and the territory is very homogeneous. People living in that area number about 28.000, a quarter of them living in urban areas (ISTAT, 2001).

Because of its homogeneous characteristic Alta Val D'Agri is classified in terms of agricultural statistical data as an 'only' area (area 5) which includes eight villages: Grumento Nova, Marsico Nuovo, Marsicovetere, Moliterno, Paterno, Sarconi, Tramutola, and Viggiano. Figure 4 represents the administrative subdivision of the villages of Basilicata and that of area 5.

Alta Val D'Agri is very rich in water resources and woods which are very important for the biodiversity of the region (Romano and Cozzi, 2007). In the area we can find about 4.000 farms, most of them in the -valley. Apart from cattle breeding, farms produce fruits, vegetables, and cereals and are part of the animal husbandry sector. The size of the farms in the area is quite small, 80% of them working fewer than five hectares (ISTAT, 2001).

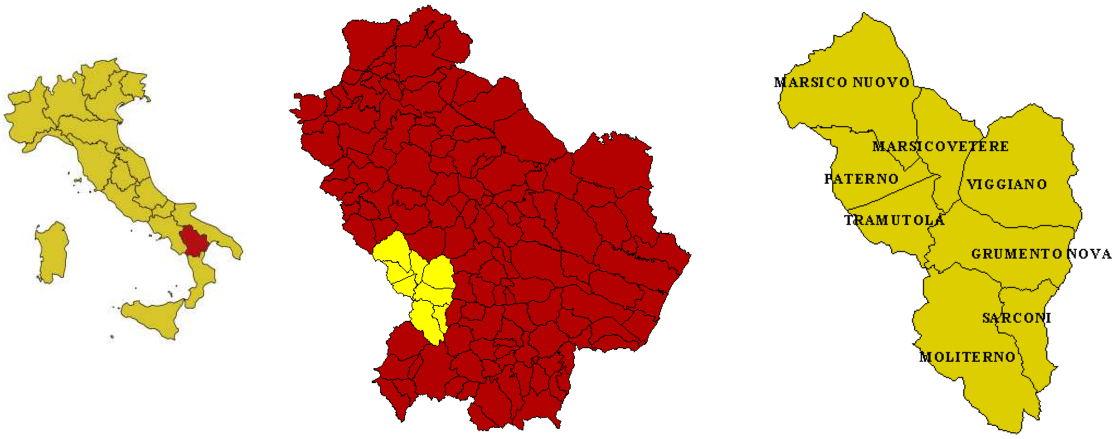

Figure 4: Regione Basilicata and area 5: administrative confines

In a study on the demographic problem, De Vivo and D'Oronzio (INEA, 2005) analysed the depopulation of the little villages with fewer than 5.000 people in Basilicata. Table 3 represents the demographic statistics from the ISTAT censuses from 1971 to 2001 and also INEA data. In 1971 the population numbered 27.299 people,[12] in 2001, 28.072. The positive variation was 2.83%.[13]

Table 3: Statistical demography. Sources: ISTAT and INEA

	Surface (Kmq)	Population 2001	Density	Population Variation 1971-2001 (%)
Area 5	794.72	28,072	35.32	+ 2.85
Comuni < 5000	5,449.81	199,175	36.55	- 20.51
Provincia Potenza	6,548.51	393,529	60.15	- 3.79
Basilicata	9,992.23	597,768	59.85	- 0.95
Italia	301,336.00	57,995,744	192.55	+ 5.02

Taking a careful look at Table 3, we see that area 5 presents a positive trend compared with the average of the whole Basilicata Region. The trend is also higher compared with villages with a population lower than 5.000.[14] During the last few years demographic development shifted in the valley and near the main communication connections. Seventy-one per cent of the population of the entire Alta Val D'Agri lives in urban centres. This shift caused environmental damage: land was abandoned and urban areas in the valley enlarged.

Concerning the economic side, the territory of Alta Val D'Agri presents the typical features of an agricultural area. According to ISTAT data, in 2001 agriculture was still the highest employment sector. Considering the active

[12] Paterno was founded in 1973 after separation from Marsico Nuovo.
[13] The variation between 1991 and 2001 is -1.77%.
[14] Among our villages, only Marsico Nuovo has a population in excess of 5,000.

population is about 35%, the agricultural employee represents more than one-third of it and the other employment sectors are the construction sector and public administration. The oil deposits of Alta Val D'Agri and the presence of Centro Oli in the industrial area of Viggiano represent a real opportunity for the whole area. The only problem is to see how oil extraction and agricultural and environmental development could live together. This represents a huge challenge for the area.

4. Data

In selecting indicators we have referred mainly to Trisorio (2004) and documents of the European Commission (2001) and OECD (2001, 2005, 2010). Table 4 shows data for the eight villages in 1971 and 2001. It is important to add some details:

1. data have been collected for two periods, 1971 and 2001, from official statistics provided by ISTAT, INEA and scientific studies;
2. for 2001 indicators have been collected for each of the eight villages;
3. for 1971 the majority of indicators are the same as 2001 (with a village feature), other indicators (old age index, farmers education, work productivity and land productivity) are taken from provincial and regional indexes because they are the only available official statistics;
4. Paterno was founded in 1973, after separation from the village of Marsico Nuovo. For that reason all data relating to 1971 for Paterno are those pertaining to Marsico Nuovo;
5. to compare the transition between 1971 and 2001, the variations for each indicator were studied for the whole period. This approach guaranteed more coherence with the chosen normalisation functions of the fuzzy analysis.[15]

[15] To normalise data we used appropriate functions with relative ideal threshold. Working on the % variations instead of the absolute values for each year (1971 and 2001) allowed us: (i) to consider as threshold internal values of area 5; Iii) to use as reference the same variations in the Basilicata Region, Mezzogiorno and Italy. Considering the time distance (1971-2001) in terms of rural EU strategy, our choices afforded more consistency to the final results.

Table 4: Elementary indicators for 1971, 2001 and variation % for the eight selected villages

		occ_agr	ind_vecc	istr_cond	com_occ	pop_res	prod_lav	prod_ter	polver	divers	va_agr	mecc	semin	colt	prat_pas	piopp	boschi	al_sup	bio
1971	Grumento Nova	48.64%	30.44%	7.07%	42.06%	2146	20,052.37	1,653.36	59.32%	78.45%	64.00%	12.94%	38.96%	1.35%	33.48%	0.00%	22.74%	3.47%	0.77
	Marsico Nuovo	43.84%	23.84%	2.60%	35.60%	2642	2,984.04	425.15	85.58%	77.12%	54.00%	13.54%	21.19%	3.40%	63.07%	0.28%	8.27%	3.78%	0.66
	Marsicovetere	41.21%	19.17%	6.92%	35.99%	2681	28.517.88	3,648.64	79.07%	62.53%	56.00%	12.31%	23.76%	1.30%	57.03%	0.02%	15.35%	2.53%	0.68
	Moliterno	30.84%	31.36%	4.12%	24.70%	4864	14,298.59	1,001.26	63.00%	61.91%	54.00%	8.12%	13.18%	2.72%	63.05%	0.00%	13.76%	7.29%	0.70
	Paterno	43.84%	23.84%	2.60%	35.60%	3892	2,984.04	425.15	85.58%	77.12%	54.00%	13.54%	21.19%	3.40%	63.07%	0.28%	8.27%	3.78%	0.66
	Sarconi	46.80%	27.49%	4.49%	46.34%	1249	6,203.60	531.70	75.57%	57.76%	54.00%	5.05%	28.46%	2.23%	39.92%	0.06%	27.65%	1.69%	0.77
	Tramutola	38.65%	26.77%	3.45%	40.05%	3091	11,374.20	2,087.58	81.82%	67.93%	60.00%	13.83%	22.26%	5.05%	29.91%	0.00%	39.95%	2.82%	0.82
	Viggiano	44.99%	34.96%	7.81%	39.78%	3179	20,135.68	1,458.57	64.25%	57.97%	56.00%	21.40%	25.10%	1.97%	44.38%	0.00%	24.74%	3.81%	0.78
	Average	42.35%	27.23%	4.88%	37.51%	2968.00	13,318.80	1,403.93	74.28%	67.60%	56.50%	12.59%	24.26%	2.68%	49.24%	0.08%	20.09%	3.65%	0.73
2001	Grumento Nova	29.86%	29.96%	28.28%	49.79%	1837	60,548.80	2,841.43	74.07%	54.07%	6.13%	20.29%	41.90%	4.94%	14.98%	0.02%	34.66%	2.30%	0.78
	Marsico Nuovo	10.65%	38.64%	10.41%	49.80%	5134	48,145.62	907.05	83.62%	61.34%	5.48%	18.73%	13.27%	2.03%	19.53%	0.13%	50.22%	3.57%	0.59
	Marsicovetere	7.08%	42.49%	27.68%	36.62%	4721	44,694.16	1,636.39	89.83%	63.80%	0.96%	11.51%	27.42%	0.96%	19.72%	0.00%	27.20%	15.93%	0.85
	Moliterno	12.95%	29.87%	16.46%	47.67%	4592	46,754.68	1,043.27	74.90%	66.54%	3.28%	11.49%	15.78%	1.00%	51.65%	0.36%	25.61%	2.00%	0.64
	Paterno	11.07%	36.30%	17.39%	45.56%	3967	57,987.38	2,159.44	87.52%	54.64%	6.14%	34.22%	34.83%	2.18%	22.34%	1.28%	37.59%	1.44%	0.73
	Sarconi	23.11%	34.38%	17.96%	48.14%	1349	49,536.39	1,552.53	71.85%	44.86%	9.20%	5.43%	25.33%	1.34%	29.04%	0.22%	40.45%	0.16%	0.63
	Tramutola	6.70%	34.09%	13.79%	48.34%	3250	65,295.56	1,372.20	85.75%	59.30%	2.71%	16.72%	21.22%	1.64%	26.37%	0.82%	49.03%	0.53%	0.58
	Viggiano	19.20%	29.17%	31.23%	45.75%	3148	59,236.31	1,719.58	63.66%	54.71%	3.23%	23.12%	27.61%	1.84%	35.77%	0.23%	28.85%	4.54%	0.80
	Average	15.08%	34.36%	20.40%	46.46%	3499.75	54,024.86	1,653.99	78.90%	57.41%	4.64%	17.69%	25.92%	1.99%	27.43%	0.38%	36.70%	3.81%	0.70
Delta	Grumento Nova	-18.78%	-0.48%	21.21%	7.73%	-14.40	201.95	71.86	14.75%	24.38%	57.87%	7.34%	2.93%	3.59%	-18.49%	0.02%	11.93%	-1.18%	0.51
	Marsico Nuovo	-33.18%	14.80%	7.81%	14.20%	94.32	1,513.44	113.35	-1.96%	15.78%	48.52%	5.19%	-7.92%	-1.37%	-43.54%	0.15%	41.95%	-0.21%	10.79
	Marsicovetere	-34.13%	23.32%	20.76%	0.63%	76.09	56.72	-55.15	10.76%	1.27%	55.04%	-0.80%	3.66%	-0.34%	-37.31%	0.02%	11.84%	13.40%	24.51
	Moliterno	-17.89%	-1.49%	12.35%	22.97%	-5.59	226.99	4.20	11.90%	4.62%	50.72%	3.37%	2.60%	-1.72%	-11.40%	0.36%	11.84%	-5.28%	8.16
	Paterno	-32.77%	12.46%	14.79%	9.96%	1.93	1,843.25	407.92	1.94%	22.47%	47.86%	20.68%	13.64%	-1.22%	-40.73%	1.00%	29.32%	-2.34%	10.04
	Sarconi	-23.69%	6.89%	13.47%	1.79%	8.01	698.51	191.99	-3.72%	12.90%	44.80%	0.38%	-3.13%	-0.89%	-10.88%	0.17%	12.81%	-1.53%	17.24
	Tramutola	-31.95%	7.33%	10.34%	8.29%	5.14	474.07	-34.27	3.93%	-8.63%	57.29%	2.89%	-1.05%	-3.41%	-3.54%	0.82%	9.08%	-2.30%	28.34
	Viggiano	-25.79%	-5.79%	23.42%	5.97%	-0.98	194.19	17.89	-0.59%	-3.26%	52.77%	1.73%	2.50%	-0.12%	-8.61%	0.23%	4.11%	0.73%	2.16
	Average	-27.27%	7.13%	15.52%	8.94%	20.57	651.14	89.72	4.63%	10.19%	51.86%	5.10%	1.65%	-0.68%	-21.81%	0.30%	16.61%	0.16%	3.41

Legend: occ_agr: employed in agriculture; ind_vecc: Old-age index; istr_cond: farmers education; comp_occ: gender composition of those employed in agriculture; pop_res: resident population; prod_lav: labour productivity; prod_ter: land productivity; polver: fragmentation; divers: farmers' diversification activities; va_agr: added value in agriculture; mecc: mechanisation; semin: arable surfaces; colt: permanent crops; prat_pas: meadow grass; piopp: poplar woods; boschi: woods; al_sup: other surfaces; bio: biodiversity.

5. Results

The cartographic outputs described in Figures 5 and 6 are the result of the normalisation function which used the techniques of fuzzy logic. Figure 5 represents maps of area 5 for all indicators. Figure 6 links indicators for each dimension. Table 6 contains indexes for the three dimensions, assigning scores of the ASI index and rankings for each village. As regards the political effects of the 30 years between 1971 and 2001, the main results analyse the dimensions of sustainable development.

As regards the social dimension, we find among the positive effects the decrease of the agricultural unemployment rate. The Alta Val D'Agri area registered a strong decrease (27%) of employees in agriculture compared with the total active population. The same positive effects are also represented in the depopulation process of rural areas. Excluding the large increase of Marsico Nuovo and Marsico Vetere, the majority of the area presents a low negative trend, much lower than the Basilicata Region and Italian Mezzogiorno. With regard to these two indicators we can observe a positive effect of the political reforms on agricultural society in Alta Val D'Agri, especially in the north. Looking at the trend of qualitative indicators, however, we see that results are not as positive as before. The old-age index represents a strong increase in the area compared with the regional and national average. The education index is still far from the regional and national average trend. The index for agricultural employment has very good performance but this result should be analysed in terms of the depopulation index: women replaced the young workforce that left the area.

According to the economic dimension there has been an improvement in the economic conditions of agricultural enterprises in Alta Val D'Agri. The impact of the agricultural added value on total added value, the productivity index and the differentiation of the activity of the farmer present satisfactory results. The fragmentation level of agricultural enterprises is still high and the mechanisation index is the weak point of the agricultural enterprise in Alta Val D'Agri.

According to the environmental dimension the results are positive in terms of effects on the distribution of the agricultural surface and in the period analysed there has been no land abandonment. Cultivation of fruits and vegetables increased more than cereal cultivation. In 1971 the meadow grass registered an important decrease, particularly in the valley area. In general, final results show a good preservation of arable surfaces and an important forestry improvement. Other variables are substantially unchanged. Over the years the valley has changed its morphological conformation: level plain changes in malls, residential districts and SMEs. In this land evolution, there have been two negative experiences in Marsico Vetere and Grumento Nova. In the first, the urbanisation process undermined the agricultural sector. In Grumento Nova, the oil deposit jeopardised the environmental and agricultural landscape.

Let us come back to our initial questions. How do we measure the impact of the European rural policy on the Alta Val d'Agri area in the period 1971 to 2001? Why do some geographical areas perform better than others? Of course, we do not know what the situation would have been without any rural policy for the area, and for this reason we are not able to define a clear causal relationship between policy and results. We cannot, however, ignore the general improvement of the area during the thirty years analysed. This improvement is significant even considering the EU goals for rural development. From this perspective: (i) the phenomenon of rural depopulation did not involve the area of interest as it did the whole region; (ii) firms' productivity has considerably increased; (iii) agricultural surfaces have maintained their original purpose.

Protecting the valley and improving transport infrastructure in the central and south-east area could be two long-term strategies to develop new opportunities for economic growth. In the short term suggested guidelines are: (i) policies to increase young people's participation in agriculture; (ii) policies to increase education among farmers; (iii) policies to introduce innovation in the agricultural productive process; (iv) policies to improve the labour division processes; (v) policies to increase tourism in the area; (vi) policies to promote typical local products. In the past, geographical isolation and a strong lack of transport infrastructure heavily influenced the economic development of area 5. During the last decades these conditions have guaranteed environmental conservation and the opportunity to maintain a strong local character. In other words, they have been good for sustainable development. Nowadays it is fair to say that the oil discovery of the last years has dramatically changed the future scenarios for Alta Val d'Agri. Oil extraction can provide economic opportunities for the entire area but at what cost to the natural environment? What kind of development will take place in the area in the next few years? Local bodies seem to be caught between two strategies. On the one hand, they encourage agreements with the oil company, on the other, they foster the creation of an important natural park, Parco nazionale dell'Alto Agri e Lagonegrese. Is there room for peaceful cohabitation?

6. Conclusions

This paper proposed an Agricultural Sustainable Index (ASI) to measure the impact of EU rural policy. A model was built starting from the selection of eighteen elementary indexes and finishing with the creation of only one measure: the ASI. Others works consider a micro approach (farm or industrial level using specific surveys) to measure sustainability in agriculture; this paper proposed an indicator's application on a specific area formed by eight villages in south Italy.
The value of this approach is to contribute to the creation of an effective way to make the concept of agricultural sustainability operational (Rigby et al. 2001). Besides, indicator showed consistent results in the proposed application showing the ability to represent faithfully the real situation in the specific area.

However, the model proposed has at least three weaknesses inasmuch as: i) it does not include a full GIS analysis; ii) the subjective element of assessing sustainability in agriculture using EU legislation (fuzzy logic and AHP methods); iii) it does not consider other indicators to measure the impact on agriculture of pollutant agents

With regards to the first point, in this paper GIS is used only as a graphical tool. To be more precise, the environmental dimension could profit from using GIS to obtain the real picture of the agricultural surface. Even if the process were time-consuming, the accuracy of the results would largely compensate.
With regards to the second point, subjectivity is evident in decisions about normalization and the relative weights given to different dimensions and elementary index. Quoting Rigby et al. (2001, p.465) “Given the strong and differing opinions regarding sustainability and sustainable agriculture it is likely that the omission, presence and/or weighting of any or all of the components of the index presented in this paper will provoke disagreements and debate. Without a clear and objective definition of sustainability is it useful to discuss or begin the operationalisation of the term via indicators?” Finally, more accurate data could extend the analysis adding information to measure the impact on agriculture of pollutant agents.

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Table 5 EU rural legislation: 1971-2001.

Period	Action	Legislation	CAP strategy
1951-1984	a) Prevent rural depopulation b) Subsidy for farmers living in underdeveloped areas..	a) Directives 72/159/EEC 72/160/EEC 72/161/EEC b) Directive 75/268/CEE	Unlimited coupled payments
1985-1991	a) Environmentally-friendly practices; Afforestation; Young farmers; Farms management; IMP b) Structural funds; Leader	a) Regulations 797/1985/EC 2088/1985/EC 1609-1615/1989/ EC b) Regulations 2052/1988/ EC 2328/1991/ EC	Limited coupled payments Environmental measures
1992-2002	a) Accompaniment Measures; Environmental friendly; Extensivization; Young Farmers; Farm Management; Agricultural surfaces enlargement. b) Quality food; Rural development policy; Financial instruments; Research, innovation and technology c) Farms investments; Human resources investments; Preserve rural communities; Woods; Market and agricultural commercialization; Agri-environmental measures. d) Environmental conditions; Modultaion	a) Regulations 2078/92/ EC 2079/92/ EC 2080/92/ EC b) Regulations 2081/92/ EC 2082/92/ EC 2085/93/ EC c) Regulations 950/97/ EC 1257/99/ EC 1258/99/ EC d) Regulations 1259/99/EC	Decreasing and decoupled payments; Multifuncionality, Direct aids

Figura 5 Elementary indicators, cartography.

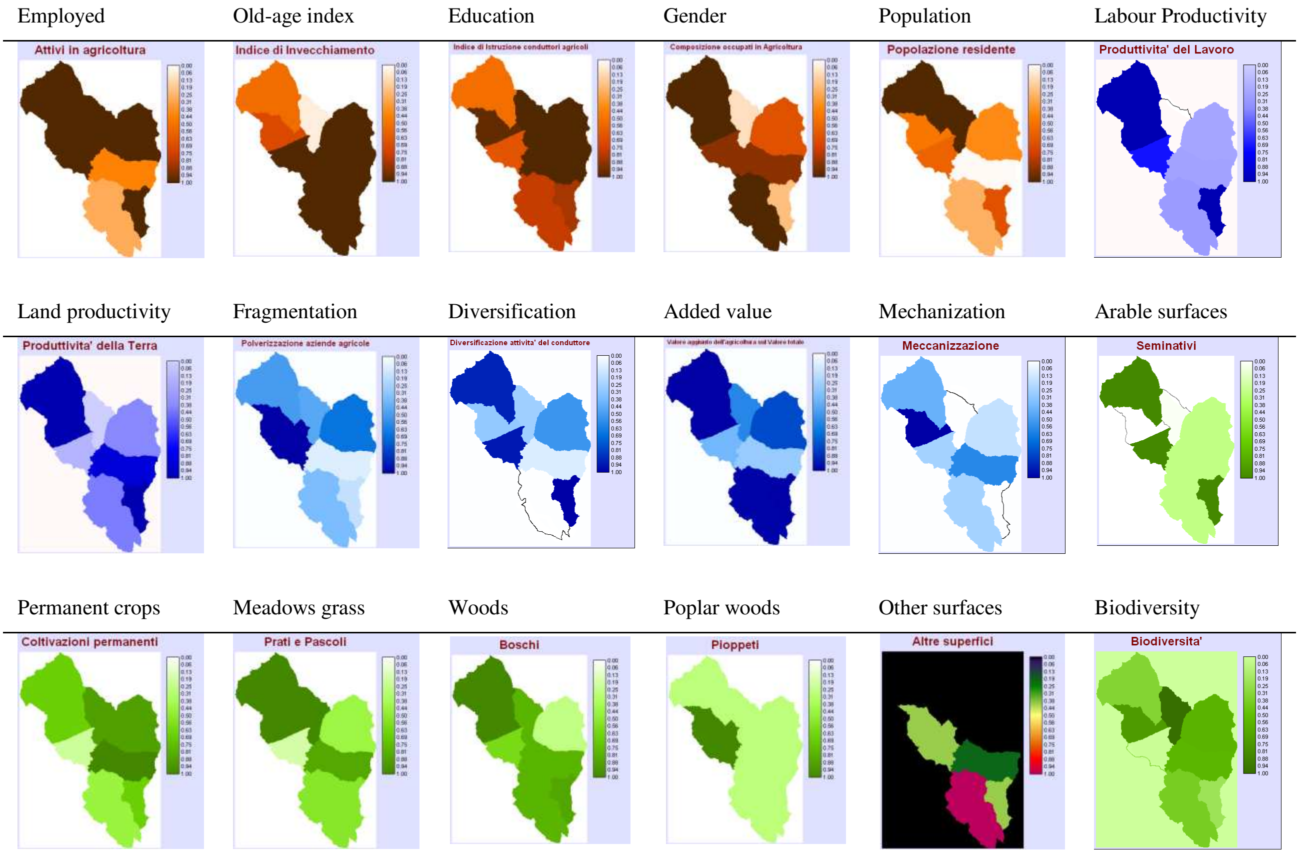

Figura 6 Dimensions, cartography

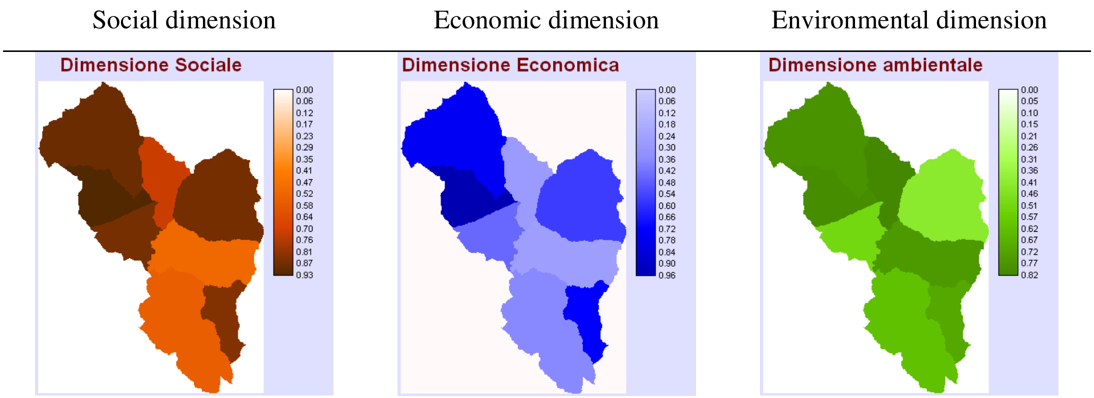

Table 6 ASI and ranking.

Villages	**SD**	**ED**	**AD**	**ASI**	**Rank**
Grumento Nova	0.51	0.26	0.76	0.56	7
Marsico Nuovo	0.88	0.74	0.77	0.79	2
Marsicovetere	0.71	0.28	0.82	0.64	4
Moliterno	0.56	0.36	0.61	0.53	8
Paterno	0.93	0.95	0.80	0.87	1
Sarconi	0.84	0.72	0.70	0.74	3
Tramutola	0.86	0.45	0.51	0.62	5
Viggiano	0.86	0.56	0.42	0.62	6