

**SESSIONE IV**  
METODOLOGIE DI SINTESI E ANALISI DEL  
TERRITORIO

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Indice di agricoltura sostenibile

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# Sustainable Agricultural Index (SAI)

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## Sommario

*La misura della sostenibilità in agricoltura è un argomento complesso a causa dei vari approcci esistenti e dei parametri qualitativi e quantitativi disponibili in funzione dei contesti nazionali. In questo studio è stato scelto un approccio multidimensionale del fenomeno, comprendente le dimensioni ambientale, economica e sociale. Il principale obiettivo del lavoro è la costruzione di 29 indicatori semplici per le tre dimensioni considerate, utilizzando come uniche fonti di dati le indagini comunitarie sulla struttura delle aziende agricole (FSS) e sui metodi di produzione agricola (SAPM) 2010, per raggruppare le aree NUTS2 a livello europeo in quattro livelli di sostenibilità: Alto, Medio-Alto, Medio-Basso e Basso. I risultati sono illustrati in una mappa sintetica.*

**Parole chiave:** Agricoltura sostenibile, FSS&SAPM 2010, indicatori di sostenibilità, indici sintetici.

## Abstract

*The measure of the sustainability in agriculture is a complex task because of various approaches existing and different quantitative and qualitative parameters available in function of the national contests. In this study it has been chosen a multi-dimensional approach of the phenomenon including environmental, economic and social dimensions. Main objective of the work is to build up 29 simple indicators for the three dimensions, using the only sources of EU FSS & SAPM 2010 to cluster the NUTS2 areas of EU in four level of sustainability: High, Medium-High, Medium-Low and Low. Results are shown in the synthetic map.*

**Key words:** Sustainable agriculture, FSS&SAPM 2010, indicators of sustainability, synthetic indices.

## 1. Introduction

The development of sustainable agriculture in the European Union is one of the most important strategic objectives of the actual and future Common Agriculture Policy (CAP). So much so that the three broad objectives of the future CAP are "viable food production", "sustainable management of natural resources" and "balanced territorial development", which respond directly to the economic, environmental and territorial balance challenges identified in the Communication and which guide the changes to the CAP instruments (European Commission, 2010).

The main objective of this study is to build a synthetic Sustainable Agricultural Index (SAI). A crucial aspect to be considered for building up the synthetic index (OECD, 2008) is the adoption of a specific concept of sustainability. Among the different approaches existing, in this study it has been adopted a multidimensional concept including three dimensions: environmental, economic and social ones. This approach hark back to the Brundtland Report (Our common future) of the World Commission on Environment and Development of United Nations (UN, 1987) based on the principle of the conservation of the

production capability in function of the factors availability.

## 2. Methodology

The indicators chosen are 29, split by three dimensions (Table 1): Environmental, Economic and Social ones.

Most of the proposed indicators are included in the European Commission communication entitled 'Development of agri-environmental indicators for monitoring the integration of environmental concerns into the common agricultural policy' (Council of the European Union, 2006). Further indicators have been selected from national sources (Trisorio, 2004).

**Table 1. The sustainability dimensions chosen.**

### A - Environmental dimension

Code	Indicator name	Indicator description	Indicator formula
A1	Tillage practices	Conservation tillage reduces or prevents soil sealing and crusting, which inhibit water infiltration and induces surface runoff and soil erosion. It provides economic benefits for the farmer (i.e. fuel savings and reduced working hours) and important benefits for the environment.	Share of arable areas under conservation tillage/Arable area
A2	Soil cover	The soil cover of arable lands with plants and crop residues provides many environmental benefits as they protect soils from erosion risk, reduce runoff of nutrients and pesticides and contribute to maintenance of biodiversity.	Share of the area covered by plants or plant residues or normal winter crops/Arable area
A3	Crop rotation	Crop rotation prevents risks of plant diseases and improves the soil fertility.	Share of arable land out with crop rotation $\geq 75\%$ / Arable land out with crop rotation $< 25\%$
A4	Livestock patterns	High density of livestock farming causes degradation of the soil, eutrophication of water for the presence of high quantity of nitrogen and phosphorus in the manure and has a significant influence on climate gas and other emissions.	Share of the Livestock Units/Area grazed
A5	Specialization	Specialization can cause loss of diversity in farmland habitats, associated flora and fauna, crop varieties and livestock breeds and leads to changes in management practices and land use intensity since production is limited to a few number of agricultural products.	Share of mixed farm types/Total farms
A6	Animal housing	Modern housing systems are based on slurry, a liquid mixture of faeces and urine without a straw component. As slurry allows for higher livestock densities, these systems are often associated with environmental problems (i.e. ammonia release, surplus of nitrogen and offensive smell).	Share of cattle houses/Total cattle
A7	Manure application	The technique of manure application in the soil influences the emission of ammonia (NH <sub>3</sub> ) in the air. The application with immediate incorporation is the modality with less environmental impact	Share of area with manure and slurry application with immediate incorporation $\geq 75\%$ / Area with manure and slurry application with immediate incorporation $< 25\%$

A8	Renewable energy production	Renewable energy production from agriculture reduces CO2 emissions from burning fossil fuels, develops a local energy production to reduce dependency on foreign energy imports, and provides new and diverse sources of income for farmers and agribusinesses in rural Europe.	Share of farms producing renewable energy/Total farms
A9	Irrigation methods	Main environmental water impact from the different systems of irrigation are: water pollution, damage to habitats and aquifer exhaustion, salinization, ecological effects of large-scale water transfers, associated with irrigation projects. Sprinkler and drop irrigation entail a minor water consumption than the others.	Share of the farms with sprinkler or drop irrigation/Farms with area irrigated at least once a year
A10	Sources of irrigation water	Groundwater taking causes a greater environmental pressure. If the exploitation of the water is bigger of the time of refill, the level of the groundwater could decrease and, near the sea, the salt invasion could cause a qualitative impoverishment of the water.	Share of the farms using off-farm water from common water supply/Farms with area irrigated at least once a year
A11	Volume of water used for irrigation per year	A high quantity of water consumption show a bigger use of the water resource and, in some cases, could cause soil degradation (water erosion, chemical contamination) and biodiversity losses	Average volume of water used for irrigation per year/Irrigated area at least once a year
A12	Manure storage	Good management of livestock manure (storage capacity, timely spreading etc.) can prevent a range of pollution problems including nutrient leaching, water contamination, air emission and soil residues.	Share of LSU of farms with storage facilities for solid dung and liquid manure/LSU of the holdings with livestock
A13	Area under organic farming	Organic production is an overall system of farm management and agri-environmental production that combines best environmental practices, a high level of biodiversity, preservation of natural resources, the application of strict criteria in animal welfare, etc.	Percentage of organic farming area/UAA
A14	Agriculture propensity	Changes in the incidence of UAA in the territory involve changes in the landscape, since agriculture is the largest user of land. This indicator refers to the structure of the landscape and covers the portion of land used for agriculture.	Percentage of UAA/Total area
A15	Farm wooded area	Forests play a central role in the conservation of biodiversity, soil protection, and therefore to the formation of the landscape. They therefore represent a key element of the structure of the farm landscape.	Percentage of wooded area/Total farm area
A16	Intensive agriculture	Farming management methods affect the characteristics of agro-ecosystems and, therefore, the agricultural landscape. Intensive agriculture could have negative effects on the agricultural landscape and on the extent of soil management.	Percentage of farm land managed with intensive crops (potatoes, vegetables, vineyards, citrus plantation, fruit plantation/UAA
A17	Farm concentration	Different agricultural structures affect the landscape shape. The concentration of productive activity refers to the reduction of the number of farms (often accompanied by an increase of their average size), and to the reduction of the number of small farms with the consequent abandonment of the countryside and loss of agricultural landscape.	Farms with small size (UAA < 5 ha) /Farms with big size (UAA >= 50 ha)

A18	Landscape features	Landscape features could contribute to the landscape diversity and, in some cases, to their own cultural identity. The rows and hedges also carry out the function of biodiversity conservation.	Percentage of farms with linear elements established or maintained (hedges, etc.) / Total farms
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### B - Economic dimension

Code	Indicator name	Indicator description	Indicator formula
B1 B2	Work productivity	These two indicators measure the efficiency of agriculture to convert the factors of production in the final product and its ability to remunerate the factors employed. In general, if the work productivity increases the potential production can be sustained in the long period, with a positive impact on future generations.	Standard output / Annual Working Days (AWU) Standard output / Number of employees
B3	Soil productivity	It is in the group of indicators of production efficiency. For the same UAA, an increase of value of this indicator shows a higher profitability of the lands.	Standard output / UAA
B4	Economic Capacity	It's an indicator of farms vitality, the ability to produce a high income. This guarantees the survival of the farms.	Percentage of farms with Standard output higher than 50.000 euros / Total number of farms
B5	Diversification of the holder work	High density of livestock farming causes degradation of the soil, eutrophication of water for the presence of high quantity of nitrogen and phosphorus in the manure and has a significant influence on climate gas and other emissions.	Share of the Livestock Units/Area grazed
B6	Diversification of production	It is an indicator of competitiveness: farms with other gainful activities have high probability to resist on the market in the medium term.	Percentage of farms with other gainful activities / Total number of farms

### C - Social dimension

Code	Indicator name	Indicator description	Indicator formula
C1	Job stability	It's an indicator of human capital. Measures how the agricultural sector can guarantee the job stability	Hours worked by workers with permanent contracts and the total number of hours worked in the agricultural sector

C2	Generational re-placement	It's an indicator of human capital, too. It provides an signal of generational replacement of the holders in agricultural sector. Young farmers are essential for the development and vitality of rural areas. Compared to the older show a greater propensity introduction of innovations. The presence of young people also contributes to the vitality of rural areas.	Holders with less than 35 years/Holders with over 65 years
C3	Agricultural specialization	Measure the level of specialization of the holders of a territory. It is also an indicator of human capital.	Holders who have done studies in agricultural sector/total number of holders
C4	Femininity work	It calculates the distribution of permanent contract workers in the agricultural sector according to gender. This indicator, together with female entrepreneurship, provides a description of the characteristics and potential of the medium to long-term human re-source employed in agriculture. The reduction in the difference between the sexes in the employment rate helps to ensure greater equity within the economic sector. This indicator is in the group of equal opportunities.	Number of permanent contract female workers in the agricultural sector/ Number of permanent contract male workers in the agricultural sector
C5	Female entrepreneurship	It's an indicator of equal opportunities, too. It calculates the distribution of holders in the agricultural sector according to gender.	Number of female holders/Number of male holders

All the phenomena summarized through the 29 indicators have a positive impact on sustainable agriculture except for those related to the indicators 4, 6, 11, 16 (Environmental dimension). All parameters (except one - the Total Area in indicator number 14 of the Environmental dimension), used for building up the indicators, come from the same statistical source: the FSS&SAPM 2010. The choice of a single source of data is one of the strength point of this study since it avoids the problems of using multiple sources: different methods of collecting or estimating the information, of frames adopted, of reference times and of definitions of the parameters. Moreover, an high level of comparability among the Member States is guarantee by the adoption of a common legal framework to carry out the survey (European Parliament, 2008). But, at the same time, the use of a unique statistical source could limit the availability of a bigger number of variables to be analyzed (weakness point).

The analyses of simple indicators were made by using the Ranker tool, specifically developed by Istat. The computational process is performed in three steps, in each one a function is applied and a transformed matrix is obtained.

The process can be displayed as:

$${}_n X_p \Rightarrow {}_n T_p \Rightarrow {}_n I_1 \Rightarrow {}_n R_1$$

where each arrow represents a function and  ${}_n X_p, {}_n T_p, {}_n I_1, {}_n R_1$  represent the input/output

matrices.

The first step, denoted as standardization, computes the standardized  ${}^nT_p$  matrix of  ${}^nX_p$  according to the selected method.

$${}^nX_p \Rightarrow {}^nT_p$$

The second step, denoted as aggregation, computes the matrix  ${}^nI_1$  of  $n \times 1$  dimension from  ${}^nT_p$ , where the vector is expression of each geographical unit.

$${}^nT_p \Rightarrow {}^nI_1$$

The third step, denoted as ranking, computes the matrix  ${}^nR_1$  of  $n \times 1$  dimension from  ${}^nI_1$ , where the values represent the ranking of each geographical unit. Each method has an embedded definition of polarity; the ranking can be the upper or the lower value of the distribution in the matrix  ${}^nI_1$ .

$${}^nI_1 \Rightarrow {}^nR_1$$

Here, for the synthesis of the simple indicators – among the 5 available methods - it was chosen the MPI method (negative variant), which consists of an arithmetic mean adjusted by a function of variability that penalizes the observations with a unbalanced distribution of the indicators (Mazziotta M., Pareto A., 2013). This method is explained as following.

Let  $T_{ij}$  be the  $ij$  element of the matrix  ${}^nT_p$  ( $i=1, \dots, n; j=1, \dots, p$ ) and  $X_{ij}$  be the  $ij$  element of the matrix  ${}^nX_p$  ( $i=1, \dots, n; j=1, \dots, p$ ), then the standardization step computes:

$$T_{ij} = 100 + \left( \frac{(X_{ij} - \bar{X}_j)}{\sigma_j} * 10 \right) \text{ (for the positive polarity basic indicator) and}$$

$$T_{ij} = 100 - \left( \frac{(X_{ij} - \bar{X}_j)}{\sigma_j} * 10 \right) \text{ (for the negative polarity basic indicator)}$$

$$\text{where } \bar{X}_j = \frac{\sum_{i=1}^n X_{ij}}{n} \text{ and } \sigma_j = \sqrt{\frac{\sum_{i=1}^n (X_{ij} - \bar{X}_j)^2}{n}}$$

Let  $MPI_{+i}$  be the  $i$  element of the vector  ${}^nI_1$  ( $i=1, \dots, n$ )

The aggregation step gives:  $MPI_{-i} = \bar{T}_i (1 - cv_i^2) = \bar{T}_i - \sigma_i cv_i$

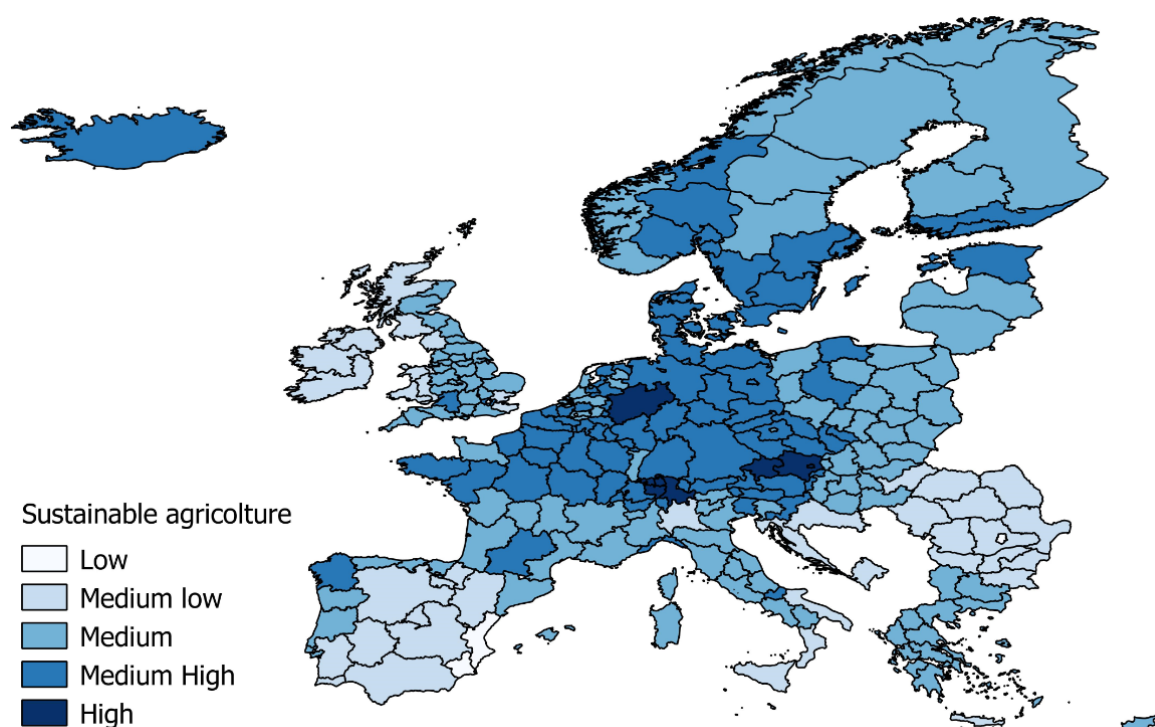
$$\text{Where } cv_i = \frac{\sigma_i}{\bar{T}_i} \text{ being } \bar{T}_i = \frac{\sum_{j=1}^p T_{ij}}{p} \text{ and } \sigma_i = \sqrt{\frac{\sum_{j=1}^p (T_{ij} - \bar{T}_i)^2}{p}}$$

This conversion allows to obtain indicators for each units with mean equal to 0 and standard deviation equal to 1. The synthetic index shows an increasing value.

### 3. Results

SAI has been applied at European Nomenclature of Territorial Units for Statistics (NUTS) 2 areas<sup>1</sup> level: 262 territorial areas, parted in 28 EU Members States plus Iceland, Norway, Switzerland and Montenegro. The results for SAI are showed in the figure 1.

Figure 1. The Sustainable Agricultural Index in EU NUTS 2.



The index distribution is fairly homogeneous. It was decided to divide it in five groups with different sustainability level: Low, Medium-Low, Medium, Medium-High, High.

Areas with higher level of sustainability are 8 in total and they are all located in Centre Europe. They are listed as below:

- Austria: Oberösterreich, Niederösterreich, Wien;
- Swiss: Zentralschweiz, Zürich, Nordwestschweiz, Ostschweiz;
- Deutschland: Nordrhein-Westfalen.

All these areas have obtained values of the indices above average in the environmental, economic dimensions (except for Niederösterreich) and social dimension (except for Zentralschweiz).

Areas with lower level of sustainability are 3 and they are located in Spain and Romania:

<sup>1</sup> Except for Germany where NUTS1 area have been utilized. SAI could not be estimated for Ceuta and Melilla, Bruxelles and Inner-London NUTS2 areas because the missing values existing in some indices' parameters.



- Spain: Comunidad Valenciana, Región de Murcia;
- Romania: Bucuresti – Ilfov.

These areas have obtained values of the indices less than average in each dimension except for Bucuresti – Ilfov where the score of the social dimension indices have been higher of the average.

#### 4. Discussions

This study proposes a synthetic Sustainable Agriculture Index to be made available for Policy Makers and researches. Its main peculiarity is the use of a single statistical source for feeding the selected indicators (EU 2010 FSS&SAPM). This strategy implies strengths and weakness points as above:

Strengthens: building up homogeneous indicators in terms of collecting/estimating methods and of parameters' definitions, adopted frames and reference times among the Countries.

Weakness: it limits the choice of the indicators, since data availability depends exclusively on FSS&SAPM surveys.

Further developments of the work could be oriented to:

- Weight each indicator according to its impact on the sustainability.
- Enhance the study of each dimension.
- Apply the index to other NUTS levels for a National study.

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