LA VALUTAZIONE DELLA SOSTENIBILITÀ A LIVELLO TERRITORIALE TRAMITE **SSAM – Spatial Sustainability Assessment Model**

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Multi- Criteria Decision Analysis (MCDA)- Analisi multi-criterio

MCDA → famiglia di metodi utilizzati nel supporto alle Decisioni.

Permette di: (a) tener conto contemporaneamente di molteplici aspetti (qualitativi e quantitativi) (b) considerare i diversi punti di vista degli attori coinvolti

PROBLEMATICA DA AFFRONTARE

→ **CRITERI** di natura diversa che descrivono un numero **DEFINITO** di **ALTERNATIVE** e che posso **PESARE** in modo diverso.

	Alternativa A1	Alternativa A2	…	Alternativa An
Criterio 1	V_{11}	V_{21}	…	V_{n1}
Criterio 2	V_{12}	V_{22}	…	V_{n2}
…	…	…	…	…
Criterio k	V_{1k}	V_{2k}	…	V_{nk}

I diversi metodi MCDA variano a seconda

- Dei criteri che possono considerare (qualitativi, quantitativi, entrambi) → **NORMALIZZAZIONE**
- Di come effettuo la fase di **PESATURA**
- Dell'algoritmo di **AGGREGAZIONE** criteri (compensazione)
- Del tipo di SOLUZIONE proposta (scelta, assegnazione, ordinamento)

TOPSIS- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

Si basa sull'idea che l'alternativa scelta dovrebbe avere la distanza geometrica più breve dalla soluzione ideale positiva (Best point)e la distanza geometrica più lunga dalla soluzione ideale negativa (Worst Point)

Definisce una classifica in base alla distanza dal punto peggiore e alla vicinanza a un punto ideale, per ciascun criterio utilizzato.

*Hwang C. L. and Yoon K. Multiple Objective Decision- Making Methods and Applications. A State-of-the-Art Survey. Springer-Verlag, 1981.

TOPSIS- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

1) Normalized decision matrix $z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{n} y_{ij}^2}}$ *i= 1, …, n; j=1, …, k*

2) Weighted normalized decision matrix: $x_{ij} = w_j z_{ij}$ *i=1, …, n; j=1, …, k*

3) Ideal point a^* and worst point a^- (Nadir)

$a^* = \{(\max_i x_{ij} \mid j \in J), (\min_i x_{ij}\ j \in J\text{^}) \mid i=1, \ldots, n\} = \{\}$

$a^- = \{(\min_i x_{ij} \mid j \in J), (\min_i x_{ij}\ j \in J\text{^}) \mid i=1, \ldots, n\} = \{\}$

TOPSIS- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

4) Distance from ideal point a^* *and distance from the worst point* a^-

$$S_i^* = \sqrt{\sum_{j=1}^{k} (x_{ij} - x_j^*)^2} \qquad i= 1, \ldots, n$$

$$S_i^- = \sqrt{\sum_{j=1}^{k} (x_{ij} - x_j^-)^2} \qquad i= 1, \ldots, n$$

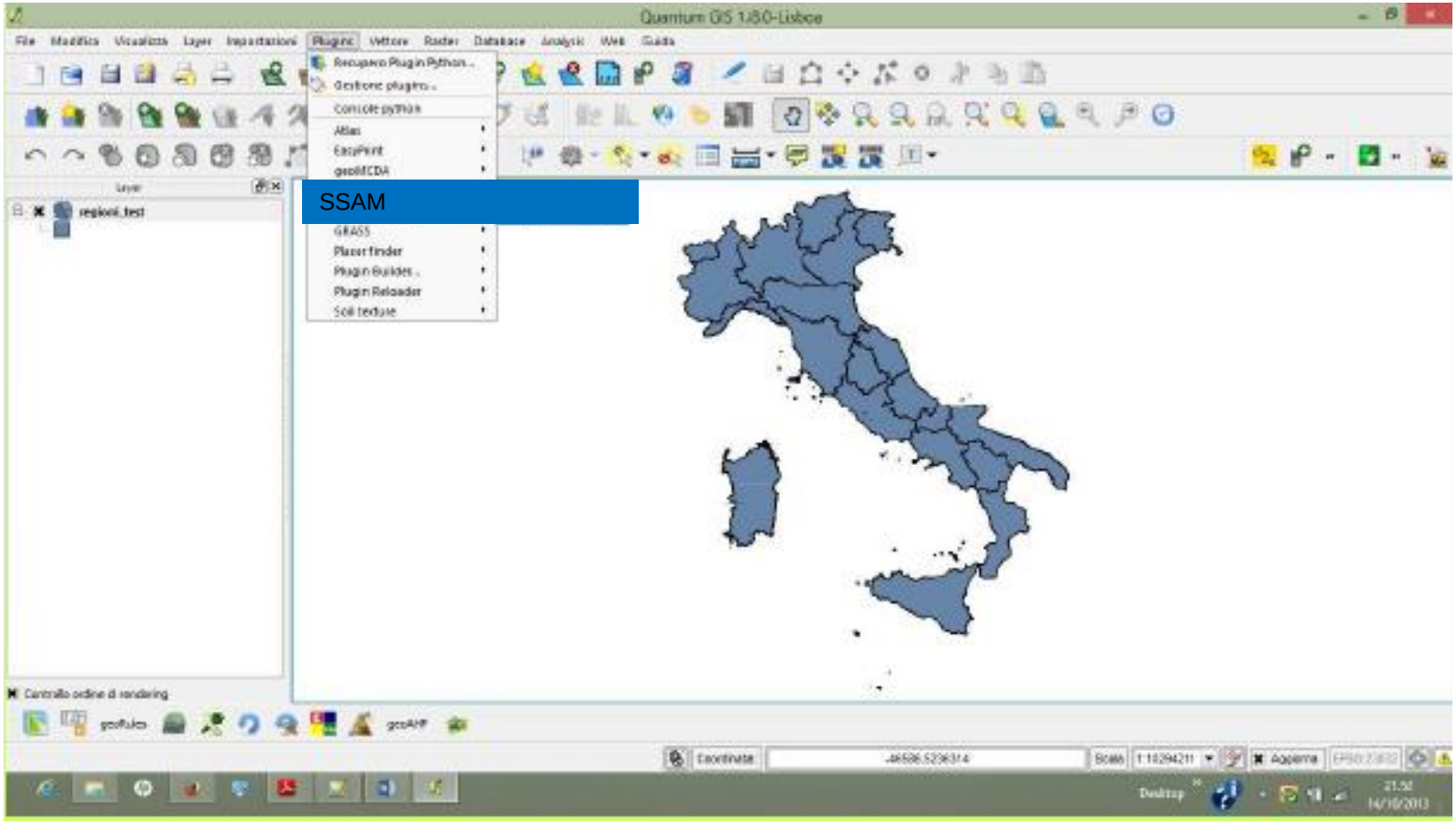
5) *Relative closeness* of each alternative to the ideal point

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*} \qquad i= 1, \ldots, n$$

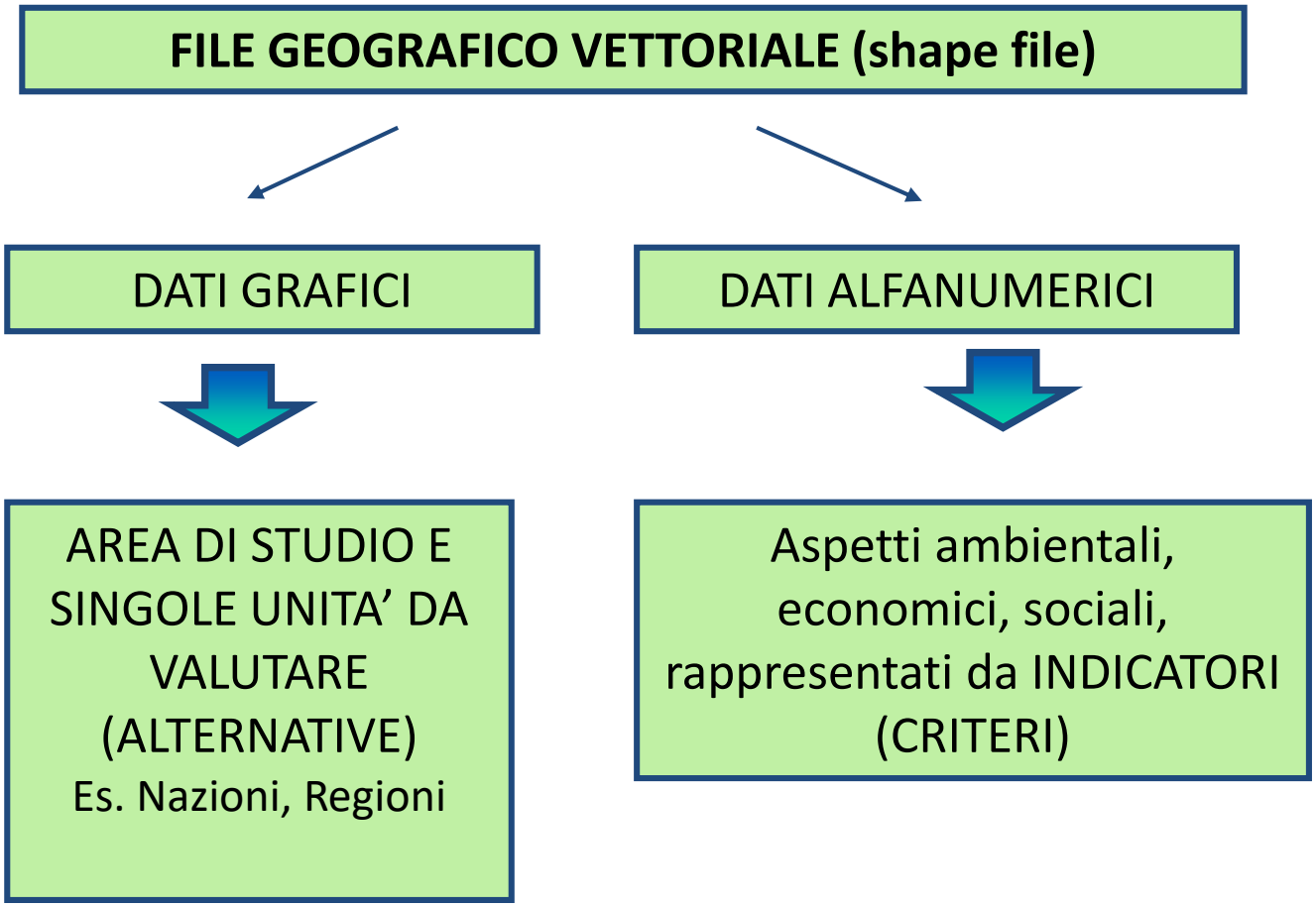
6) Ordering alternatives according to C^*_i, from best to worst (for each dimension)

→ f $C^*_i > C^*_j$, then a_i is better than a_j

Plugin dentro QGIS



SSAM - Caratteristiche



Tre indici di sostenibilità

Uso di TOPSIS per valutare:

- *Indice Ambientale*
- *Indice Economico*
- *Indice Sociale*

Più un INDICE DI SOSTENIBILITA' GLOBALE, per ciascuna unità geografica individuata nella valutazione.

Passi principali

1. Definizione di un set di indicatori ambientali (i_{a1}, i_{a2}, ... i_{an}).

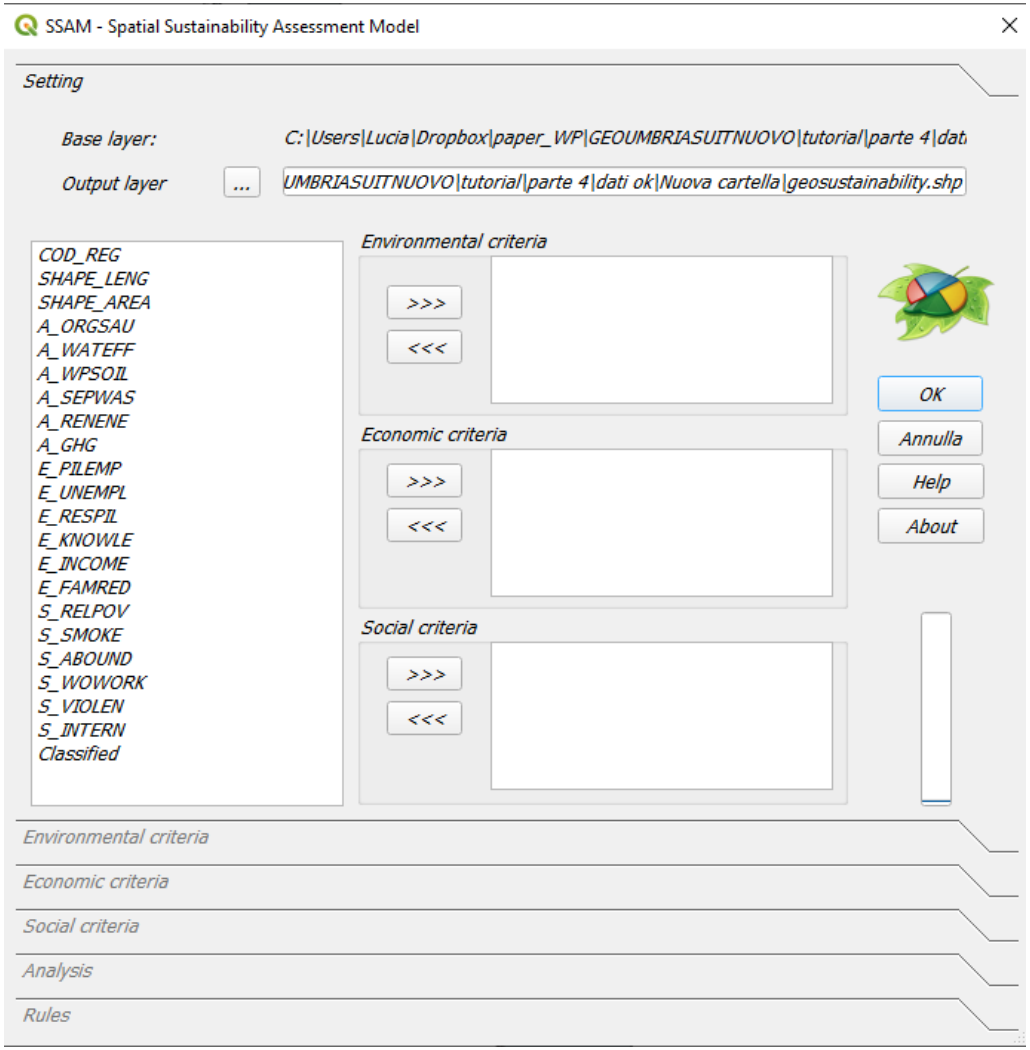
2. Definizione di un set di indicatori economici (i_{s1}, i_{s2}, … i_{sn}).

3. Definizione di un set di indicatori sociali (i_{e1}, i_{e2}, … i_{en}).

4. Ranking delle alternative grazie ad uso della metodologia multicriteri e classificazione del territorio sulla base del raggiunto livello di sostenibilità.

5. Estrazione di regole decisionali e effettuazione della “back analysis” (Metodo Dominance Based Rough Set Approach).

Data input


SSAM - Spatial Sustainability Assessment Model
Setting
Base layer:
C:\Users\Lucia\Dropbox\paper_WP\GEOUMBRIASUITNUOVO\tutorial\parte 4\dat
Output layer
...
UMBRIASUITNUOVO\tutorial\parte 4\dati ok\Nuova cartella\geosustainability.shp
COD_REG
SHAPE_LENG
SHAPE_AREA
A_ORGSAU
A_WATEFF
A_WPSOIL
A_SEPWAS
A_RENENE
A_GHG
E_PILEMP
E_UNEMPL
E_RESPIL
E_KNOWLE
E_INCOME
E_FAMRED
S_RELPOV
S_SMOKE
S_ABOUND
S_WOWORK
S_VIOLEN
S_INTERN
Classified
Environmental criteria
>>>
<<<
Economic criteria
>>>
<<<
Social criteria
>>>
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OK
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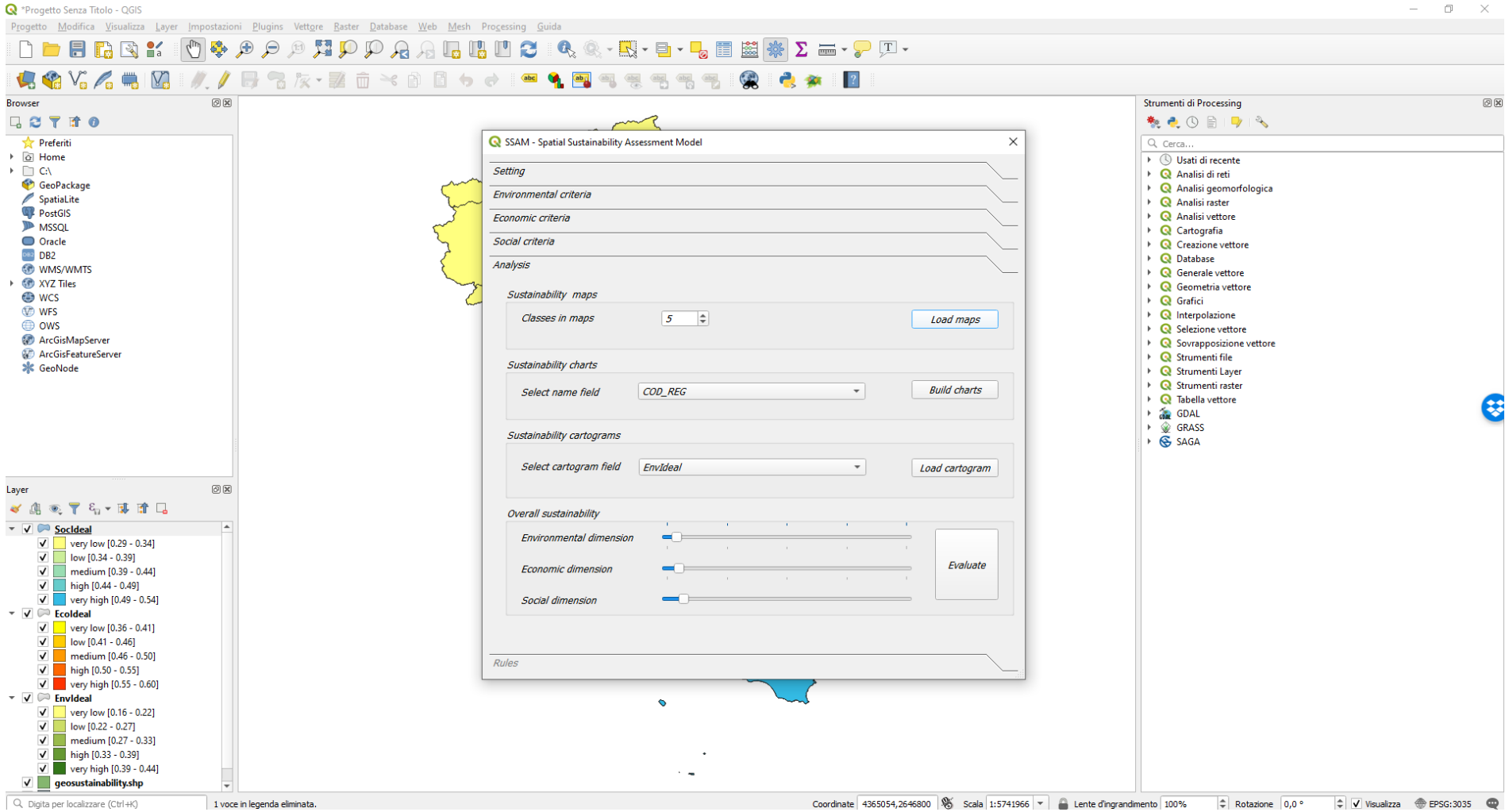
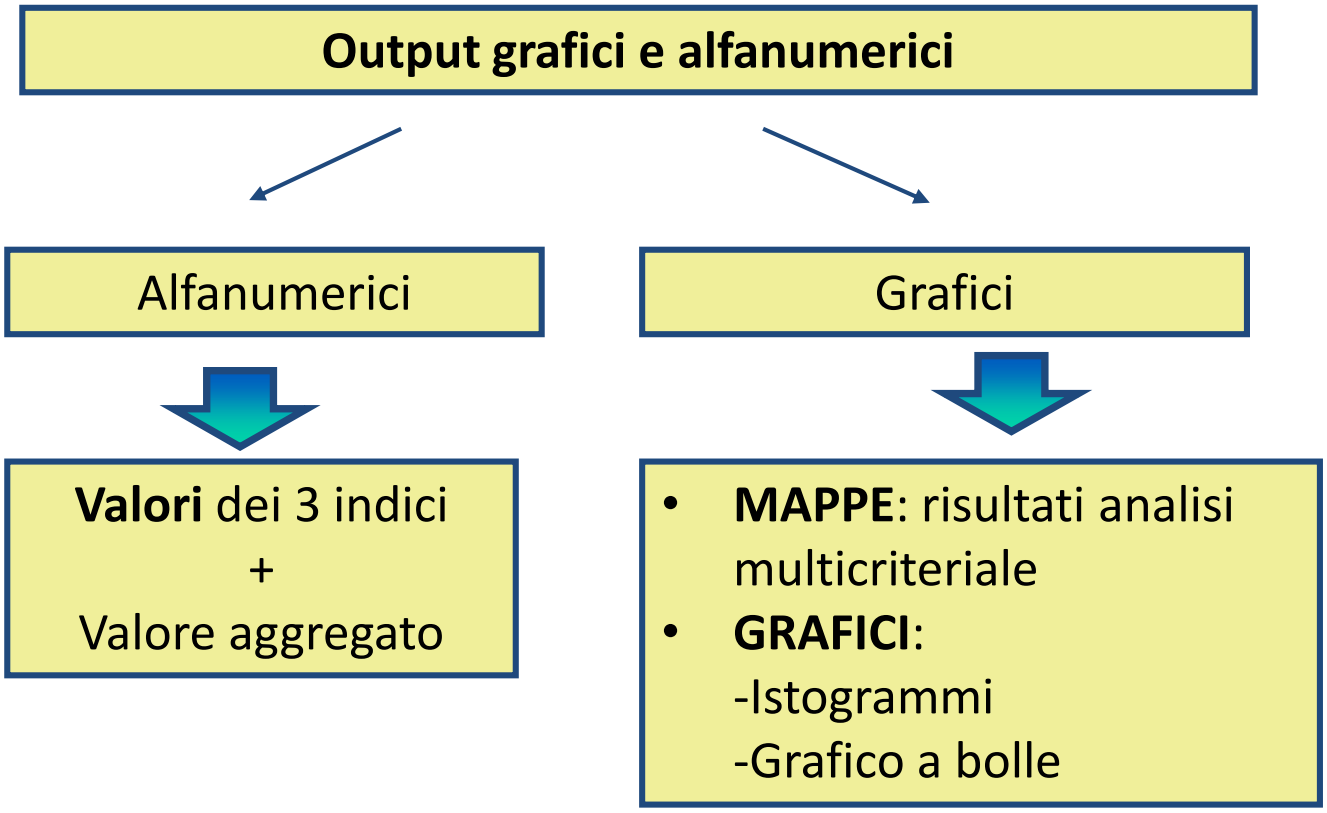
Help
About
Environmental criteria
Economic criteria
Social criteria
Analysis
Rules

Processamento dei dati



SSAM – Spatial Sustainability Assessment Model

SSAM – Risultati (Output)



Potenziali applicazioni di SSAM

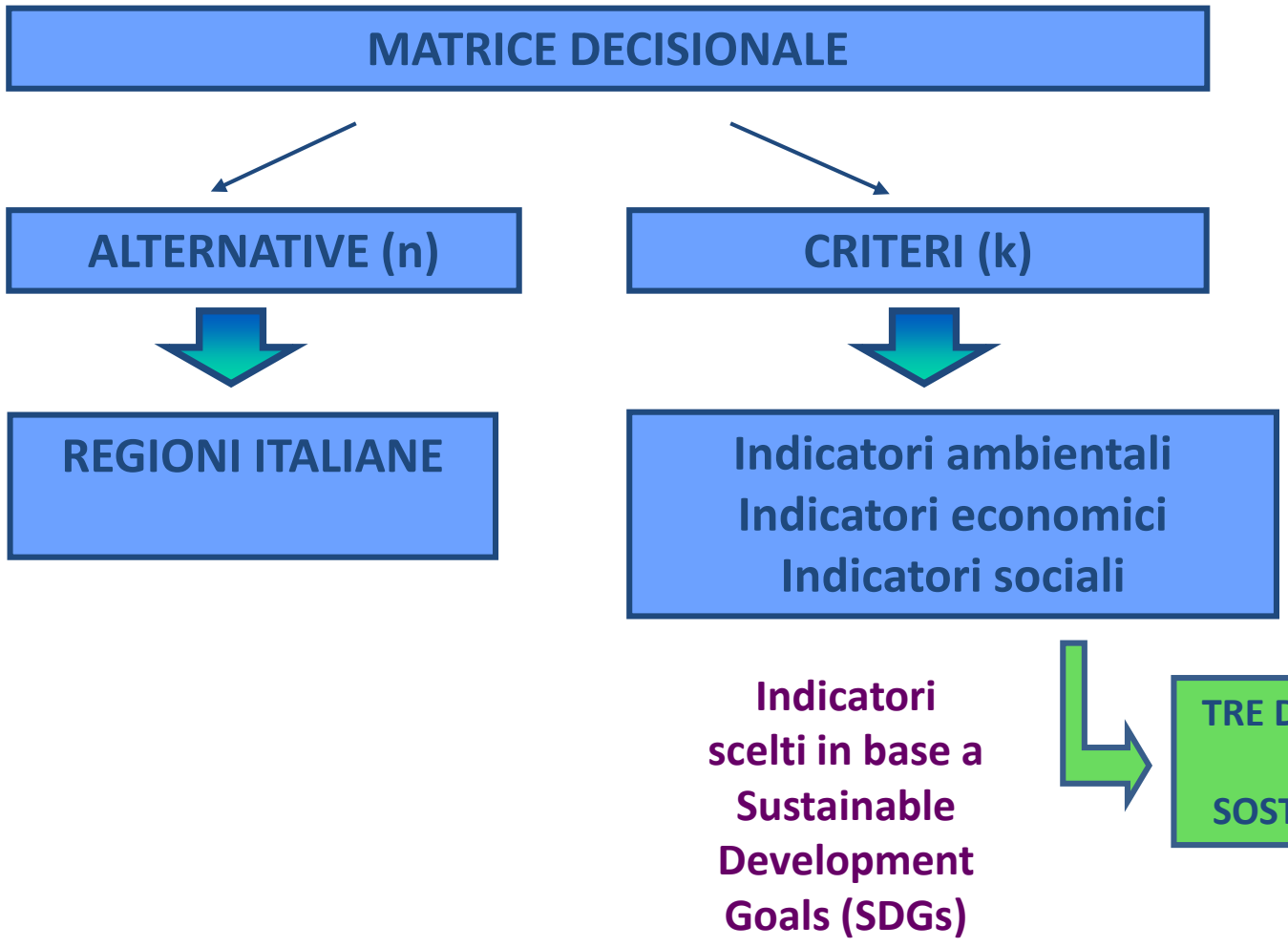
Strumento operativo in grado di supportare/indirizzare il decisore politico nelle scelte relative a:

PROGRAMMAZIONE COMUNITARIA
Valutazione ex-ante propedeutica alla definizione dei Piani Operativi Regionali 2021-2027 per l'utilizzo delle risorse del Fondo Europeo per lo Sviluppo Regionale (FESR) e del Fondo Sociale Europeo (FSE)

VALUTAZIONE AMBIENTALE STRATEGICA DI PIANI/PROGRAMMI

POLITICHE AMBIENTALI REGIONALI

CASO STUDIO – SOSTENIBILITA' REGIONI ITALIANE



Sustainable Development Goals (SGDs)

INDICATORI AMBIENTALI

INDICATOR	CODE	R.U.	GAIN/COST	WEIGHT
PERCENTAGE OF UTILIZED AGRICULTURAL AREA INVESTED BY ORGANIC CROPS	A_ORGSAU	%	GAIN	7
EFFICIENCY OF DRINKING WATER DISTRIBUTION NETWORKS	A_WATEFF	%	GAIN	14
WATERPROOFING AND LAND USE PER CAPITA	A_WPSOIL	m2/ab	COST	17
URBAN WASTE SUBJECT TO SEPARATE COLLECTION	A_SEPWAS	%	GAIN	17
GWH OF ENERGY PRODUCED FROM RENEWABLE SOURCES ON GWH PRODUCED IN TOTAL	A_RENNENE	%	GAIN	20
GREENHOUSE GAS EMISSIONS	A_GHG	TONN	COST	25

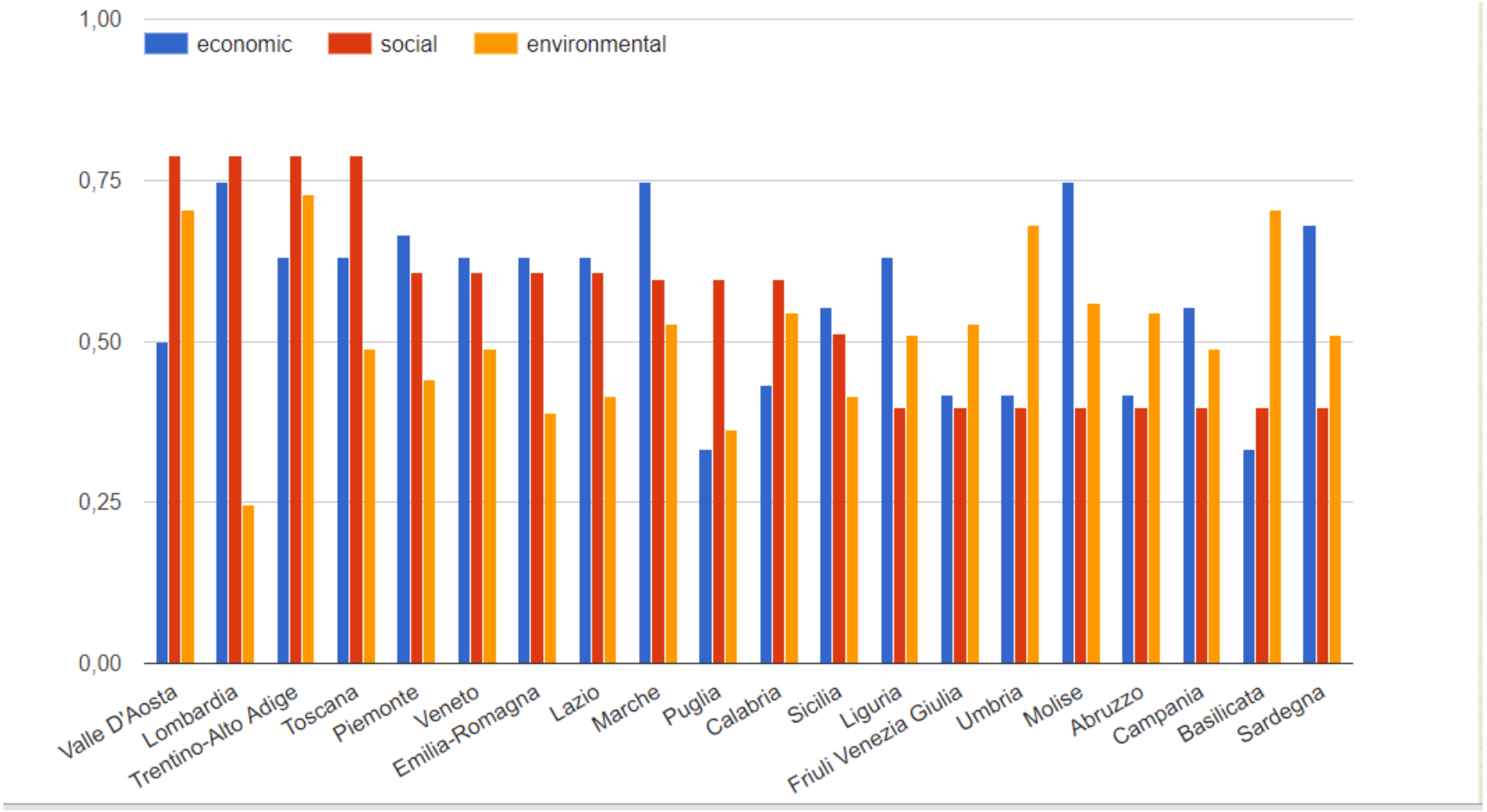
INDICATORI ECONOMICI

INDICATOR	CODE	R.U.	GAIN/COST	WEIGHT
ANNUAL GROWTH RATE OF REAL GDP PER PERSON EMPLOYED	E_PILEMP	%	GAIN	25
UNEMPLOYMENT RATE	E_UNEMPL	%	COST	23
RESEARCH AND DEVELOPMENT COSTS AS A PERCENTAGE OF GDP	E_RESPIL	%	GAIN	14
KNOWLEDGE WORKERS	E_KNOWLE	%	GAIN	7
AVERAGE INCOME AVAILABLE PER CAPITA	E_INCOME	€	GAIN	18
RATE OF CHANGE IN FAMILY INCOME PER CAPITA FOR THE POOREST 40% OF THE POPULATION	E_FARMRED	%	GAIN	13

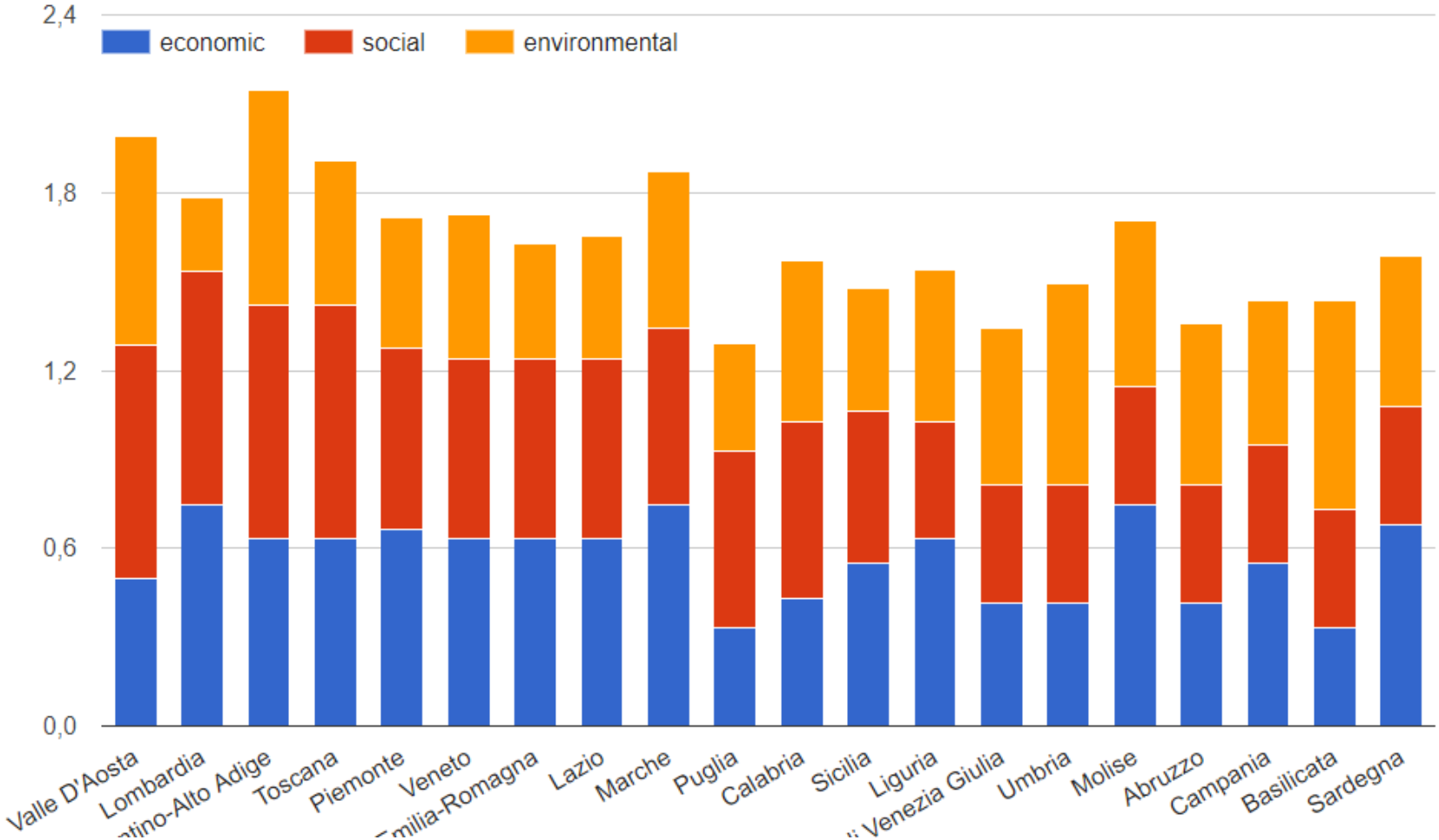
INDICATORI SOCIALI

INDICATOR	CODE	R.U.	GAIN/COST	WEIGHTS
INDIVIDUAL INCIDENCE OF RELATIVE POVERTY	S_RELPOV	%	COST	34
STANDARDIZED PROPORTION OF PEOPLE AGED 14 OR OVER WHO DECLARE THEY CURRENTLY SMOKE	S_SMOKE	%	COST	12
EARLY EXIT FROM THE EDUCATION AND TRAINING SYSTEM	S_ABOUND	%	COST	14
RELATIONSHIP BETWEEN THE EMPLOYMENT RATES OF WOMEN AGED 25-49 WITH AT LEAST ONE CHILD OF PRESCHOOL AGE AND WOMEN WITHOUT CHILDREN	S_WOWORK	%	GAIN	14
PERCENTAGE OF THE POPULATION THAT HAS BEEN SUBJECTED TO PHYSICAL, PSYCHOLOGICAL OR SEXUAL VIOLENCE IN THE PREVIOUS 12 MONTHS	S_VIOLEN	%	COST	24
PERCENTAGE OF INDIVIDUALS USING THE INTERNET	S_INTERN	%	GAIN	2

RISULTATI


1,00
0,75
0,50
0,25
0,00
economic
social
environmental
Valle D'Aosta
Lombardia
Trentino-Alto Adige
Toscana
Piemonte
Veneto
Emilia-Romagna
Lazio
Marche
Puglia
Calabria
Sicilia
Liguria
Friuli Venezia Giulia
Umbria
Molise
Abruzzo
Campania
Basilicata
Sardegna

RISULTATI


2,4
1,8
1,2
0,6
0,0
economic
social
environmental
Valle D'Aosta
Lombardia
Toscana
Piemonte
Veneto
Lazio
Marche
Puglia
Calabria
Sicilia
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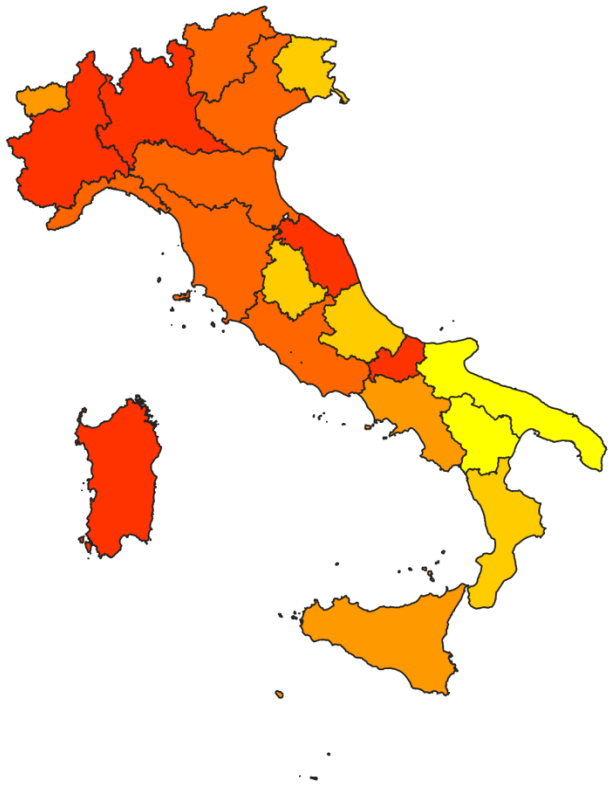
MAPPA DELLA SOSTENIBILITA' ECONOMICA



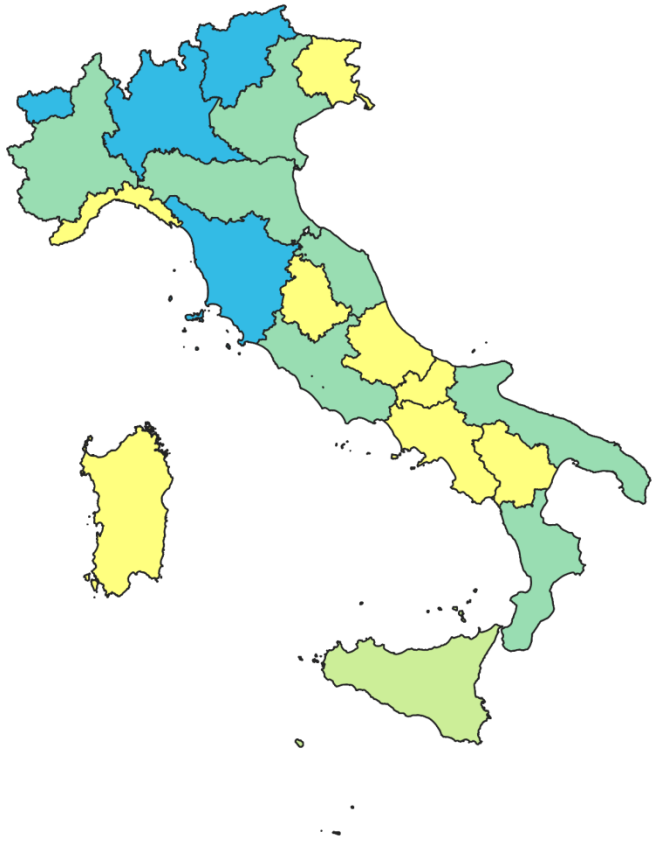
SustIdeal
- very low [43.19 - 48.89]
- low [48.89 - 54.58]
- medium [54.58 - 60.27]
- high [60.27 - 65.97]
- very high [65.97 - 71.66]

SocIdeal
- very low [0.40 - 0.48]
- low [0.48 - 0.55]
- medium [0.55 - 0.63]
- high [0.63 - 0.71]
- very high [0.71 - 0.79]

EcoIdeal
- very low [0.33 - 0.42]
- low [0.42 - 0.50]
- medium [0.50 - 0.58]
- high [0.58 - 0.66]
- very high [0.66 - 0.75]

EnvIdeal
- very low [0.25 - 0.34]
- low [0.34 - 0.44]
- medium [0.44 - 0.54]
- high [0.54 - 0.63]
- very high [0.63 - 0.73]
- geosustainability.shp
- Reg_2016_WGS84_g

MAPPA DELLA SOSTENIBILITA' SOCIALE



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MAPPA DELLA SOSTENIBILITA' AMBIENTALE

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- Reg_2016_WGS84_g

MAPPA DELLA SOSTENIBILITA' GLOBALE

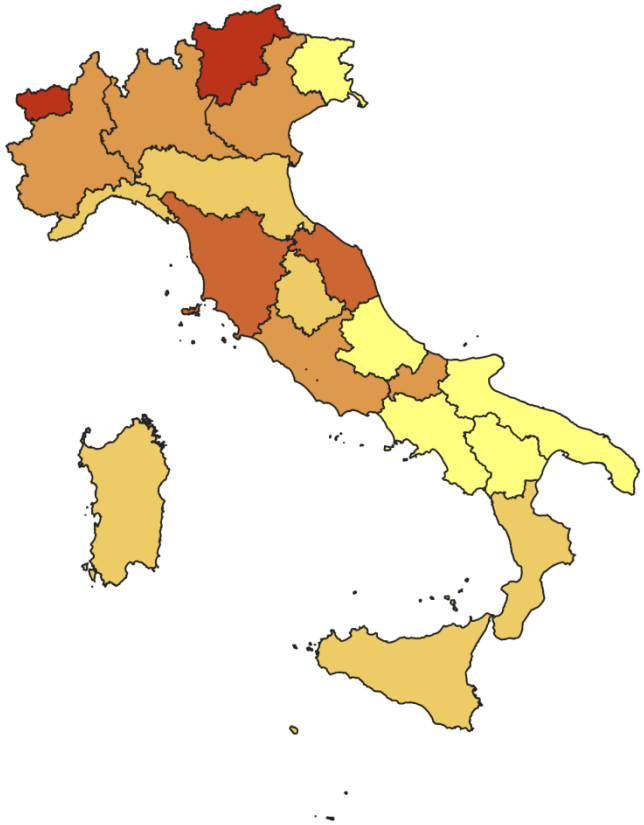

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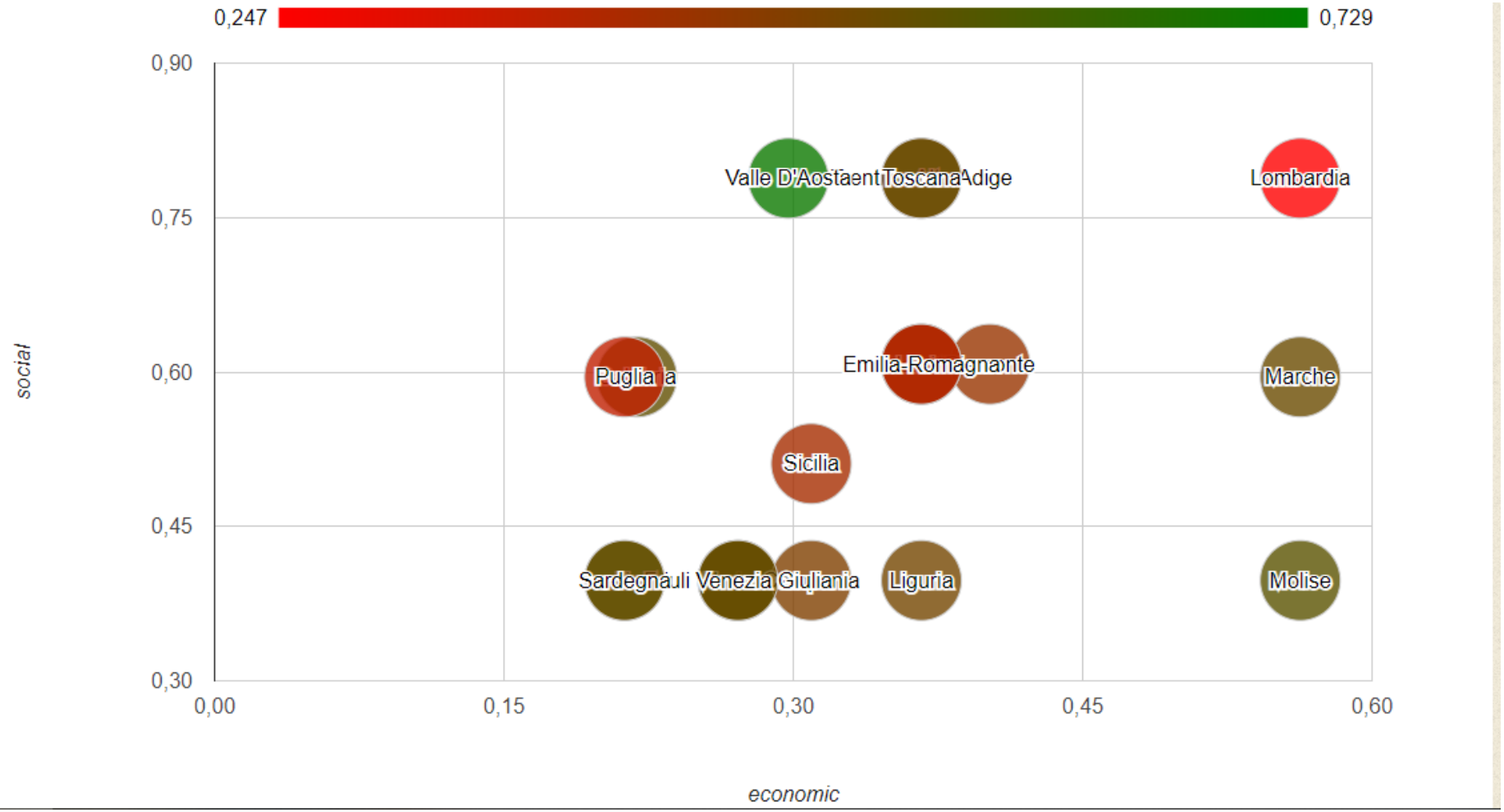
GRAFICO A BOLLE



REGOLE DECISIONALI – «BACK ANALYSIS»

1: IF [(S_VIOLEN >= 3.2)] THEN AT MOST CLASS "very low" [1] [16, 14]
2: IF [(E_PILEMP <= -4.1)] THEN AT MOST CLASS "very low" [1] [15]
3: IF [(A_WATEFF <= 43.7)] THEN AT MOST CLASS "very low" [1] [18]
4: IF [(E_PILEMP <= -1.9)(S_WOWORK <= 78.2)] THEN AT MOST CLASS "very low" [1] [7, 15]
5: IF [(E_UNEMPL >= 13.3)] THEN AT MOST CLASS "low" [2] [15, 16, 17, 18, 19, 20]
6: IF [(E_PILEMP <= -1.9)] THEN AT MOST CLASS "low" [2] [10, 15, 14, 7]
7: IF [(S_SMOKE >= 22.5)] THEN AT MOST CLASS "low" [2] [16, 10, 6]
8: IF [(A_RENENE <= 19.1)(S_INTERN <= 63.6)] THEN AT MOST CLASS "low" [2] [8, 6]
9: IF [(S_VIOLEN >= 2.3)] THEN AT MOST CLASS "medium" [3] [1, 4, 6, 7, 8, 10, 12, 13, 14, 16, 18, 20]
10: IF [(A_RENENE <= 34.7)] THEN AT MOST CLASS "medium" [3] [3, 6, 7, 8, 13, 15, 17, 19, 20]
11: IF [(A_RENENE <= 47.3)] THEN AT MOST CLASS "high" [4] [1, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 19, 20]
12: IF [(S_INTERN <= 60.6)] THEN AT MOST CLASS "high" [4] [6, 10, 12, 15, 16, 17, 18, 19, 20]
13: IF [(E_PILEMP >= -0.9)] THEN AT LEAST CLASS "low" [2] [1, 3, 4, 5, 6, 8, 9, 11, 12, 13, 17, 19, 20]
14: IF [(S_INTERN >= 65.5)] THEN AT LEAST CLASS "low" [2] [2, 3, 4, 5, 13]
15: IF [(S_ABOUND <= 6.7)] THEN AT LEAST CLASS "low" [2] [10]
16: IF [(S_INTERN >= 65.5)] THEN AT LEAST CLASS "medium" [3] [2, 3, 4, 5, 13]
17: IF [(E_RESPIL >= 2.2)] THEN AT LEAST CLASS "medium" [3] [1]
18: IF [(E_PILEMP >= 2.1)] THEN AT LEAST CLASS "medium" [3] [12]
19: IF [(S_RELPOV <= 12.0)(S_VIOLEN <= 1.9)] THEN AT LEAST CLASS "medium" [3] [2, 3, 5, 9, 11]
20: IF [(S_VIOLEN <= 0.3)] THEN AT LEAST CLASS "high" [4] [2]
21: IF [(S_RELPOV <= 5.2)] THEN AT LEAST CLASS "high" [4] [5]
22: IF [(S_RELPOV <= 6.7)(S_VIOLEN <= 1.6)] THEN AT LEAST CLASS "high" [4] [9]
23: IF [(E_PILEMP >= 1.9)(S_INTERN >= 64.2)] THEN AT LEAST CLASS "high" [4] [11]
24: IF [(S_VIOLEN <= 0.3)] THEN AT LEAST CLASS "very high" [5] [2]
25: IF [(S_RELPOV <= 5.2)] THEN AT LEAST CLASS "very high" [5] [5]