

The SDGs Indicators for the Statistical Analysis of Land and Water Resource Protection

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Abstract. The evolution of the concept of sustainability and the availability of new statistical information requires constant checks on the set of indicators so that they accurately carry out the task of representing well-being in our society. The Sustainable Development Goals refer to several domains of development related to environmental, social, economic, and institutional issues. For the environmental sustainability is particularly interesting territorial protection and the water resource issues and how statistical indicators can be helpful for urban planning and decisions support systems. The numerous data available have been analysed at regional level through multivariate statistical methodologies (Totally Fuzzy and Relative method) capable of synthesizing the multiple information to assess the current situation in the different Italian regions. The presence of multiple data updated to 2019 allows researchers to develop a holistic approach to the evaluation of the policies of government of the territory in place and to monitor the progress of subsequent policies of intervention of the Italian government.

Keywords: Water discomfort · Ecological development · Sustainable development goals

1 Introduction

At the heart of the United Nations 2030 Agenda of great importance is the theme of sustainable development in the economic, social and environmental dimensions. Among the many objectives are those concerning urgent ecological measures to combat climate change, to protect the oceans, seas and marine resources and to manage forests by combating desertification.

Clean water is an essential resource for human health, agriculture, energy production, transport and nature. Also, if it is under multiple pressures. Currently, only 40% of

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Europe's surface water bodies achieve good ecological status. In addition, even though EU countries have managed to reduce selected pressures, the status of our freshwater bodies remains unsatisfactory [1].

In Europe, in 2000, with the adoption of the Water Framework Directive, an integrated ecosystem-based approach to managing water was introduced. Public safety and health objectives were persued by the Drinking Water, Bathing Water and Floods Directives [2]. While the directives tend to be very specific, the importance of water in relation to biodiversity and marine policies is pursued through the EU biodiversity strategy to 2020 [3] and the priority objectives of the Seventh Environment Action Europe's waters are affected by pressures from pollution, overabstraction and physical changes.

Hydromorphology is considered a key parameter, because interaction between water, morphology, sediments and vegetation creates habitats that determine the river's ecological status. Hydromorphological pressures are one of the main reasons that surface water bodies fail to achieve good ecological status.

What is Italian evaluation of protection, and the water resource issues? How is it possible to evaluate it?

The Sustainable Development Goals refer to various development domains relating to environmental, social, economic and institutional issues [4]. This paper deals with analyzing the relationships between the domains of the Sustainable Development Goals (SDGs) and the statistical indicators relating to the protection of the territory and of the water resource.

The numerous data available were analyzed at regional level using multivariate statistical methodologies (Totally Fuzzy and Relative method) capable of synthesizing the various information to evaluate the current situation in the various Italian regions. The presence of multiple data updated to 2019 allows for the development of a holistic approach to the evaluation of the local government policies in place and the ability to monitor the progress of the subsequent intervention policies of the Italian government.

2 The Statistical Indicators of the Sustainable Development Goals Report (SDGs)

2.1 SDGs Project

The "Sustainable Development Goals" indicate what changes the nations and peoples of the world are committed to achieving, by virtue of a global consensus, obtained through a long, complex and difficult process of international and interdisciplinary dialogue and collaboration.

The 2030 Agenda consists of 17 objectives that refer to different development domains relating to environmental, social, economic and institutional issues, outlining a global action plan for the next 15 years. The 17 objectives are divided into 169 Targets (sub-objectives) that refer to different domains of economic, social and environmental development; the United Nations Inter Agency Expert Group on SDGs (UN-IAEG-SDGs) in 2017 proposed a system of over 230 indicators necessary for their monitoring, which constitute the reference framework worldwide [5].

It is a highly complex system of indicators that includes both consolidated indicators available for most countries, and indicators that are not currently produced or that have

not yet been precisely defined at an interactional level. Starting from 2018, Istat makes available, every six months, many indicators for Italy and publishes the "SDGs Report. Statistical information for the 2030 Agenda in Italy".

We briefly describe the 17 Sustainable Development Goals (SDGs): No Poverty; Zero Hunger; Good Health and Well-Being; Quality Education; Gender Equality; Clean Water and Sanitation; Affordable and Clean Energy; Decent Work and Economic Growth; Industry, Innovation and Infrastructure; Reduce inequalities; Sustainable Cities; Responsible Consuption and Production; Climate Action; Life Below Water; Life on Land; Peace, Justice, and Strong Institution; Partnership for the Goals.

3 Statistical Indicators for the Protection of the Territory and Water Resources

3.1 SDGs Indicators

The Italian National Recovery and Resilience Plan (NRRP) is part of the Next Generation EU (NGEU) program, the 750-billion-euro package, about half of which is made up of grants, agreed by the European Union in response to the crisis pandemic. The main component of the NGEU program is the Recovery and Resilience Facility (RRF), which has a duration of six years, from 2021 to 2026, and a total size of 672.5 billion euros (312, 5 grants, the remaining 360 billion loans at subsidized rates).

The Plan is developed around three strategic axes shared at European level (digitization and innovation, ecological transition and social inclusion) and 6 missions. The subject of territorial safety also finds space in the Mission, with prevention and restoration interventions in the face of significant hydrogeological risks, the protection of green areas and biodiversity, and those relating to the elimination of water and soil pollution, and the availability of water resources.

The Sustainable Development Goals [5] refer to various development domains relating to environmental, social, economic and institutional issues. In particular, the Goals considered for the purposes of the analysis for the protection of the territory and of the water resource are shown in Table 1.

Table 1. Goals, indicators, measures and data source.

Goal	Indicators	Measures	Data source
Goal 6.1.1:	Percentage of population benefiting from safely managed drinking water services	Irregularities in water distribution	(Istat, 2020, percentage values)
Goal 6.1.1:	Percentage of population benefiting from safely managed drinking water services	Water supplied per capita	(Istat, 2018, litres per capita per day)
Goal 6.3.1:	Percentage of civil and industrial wastewater treated safely	Urban wastewater with secondary or advanced treatment	(Istat, 2018, No. of plants)
Goal 6.3.1:	Percentage of civil and industrial wastewater treated safely	Coverage of the public sewerage service	(Istat, 2018, percentage values)
Goal 6.4.1:	Change in efficiency in the use of water resources	Efficiency of drinking water distribution networks	(Istat, 2018, percentage values)
Goal 11.3.1:	Ratio of land use rate to population growth rate	Sealing and land use per capita	(Ispra, 2019, m2 per inhabitant)
Goal 11.7.1:	Average percentage of the urbanized area of cities that is used as public space, by sex, age and people with disabilities	Incidence of urban green areas on the urbanized surface of cities	(Istat, 2019, m^2 per 100 m^2 of urbanized surface)
Goal 15.3.1:	Share of degraded land out of the total land surface	Soil waterproofing by artificial cover	(ISPRA, 2019, percentage values)
Goal 15.3.1:	Share of degraded land out of the total land surface	Fragmentation of natural and agricultural land	(ISPRA, 2019, percentage values)

3.2 SDGs Index and Their Italian Distribution

Let's carry out a first analysis by territorial division for the different sets:

- **Set 1: Protection of water resources**
  - Water supplied per capita
  - Efficiency of drinking water distribution networks
  - Irregularities in the distribution of water
  - Coverage of the public sewerage service

- **Set 2: Protection of the territory**

  – Waterproofing and land use per capita
  – Soil waterproofing by artificial cover
  – Fragmentation of the natural and agricultural territory
  – Incidence of urban green areas on the urbanized surface of cities

From an initial analysis of the indicators for the protection of water resources, Italy is among the European countries in the Mediterranean area that use the most groundwater, springs, and wells; these represent the most important freshwater resource for drinking water use on the Italian territory (84.8% of the total withdrawn). The infrastructural situation remains critical in some areas of the country, mainly due to the presence of physical losses (deterioration of the systems, breakages in the pipes, defective joints, etc.) and to a minimum part of physiological and administrative losses (unauthorized connections, measurement errors of the counters).

The volume supplied per capita increases with the growth of the resident population and in the territories where there is a greater concentration of non-residential uses. In the municipal drinking water distribution networks, 215 L per inhabitant are supplied daily in 2018 (Table 2), about 5 L less than in 2015.

The efficiency of municipal drinking water distribution networks has been steadily worsening since 2008: the share of injected water reaching end users was 58.0% in 2018 (0.6 percentage points less than in 2015). Efficiency is declining for more than half of the regions. The most critical situations are concentrated above all in the regions of the Centre (51.3%) and the South (52.1%).

In 2018, 10.4% of families complained of irregularities in the water supply service in their home. In the North, the percentage of families reporting inefficiencies reaches minimum values (3%); in the Centre, almost one in ten families (10.6%) complains of irregularities, while in the South this percentage rises to 21.2%.

About nine out of ten inhabitants (87.8% of residents) in 2018 are connected to the public sewerage system, regardless of the subsequent purification treatment. There are 7.3 million residents not connected to the public sewerage system. The area with the greatest coverage of the sewerage service is the North (90%).

Table 2. Indicators for the protection of water resources by territorial division (year 2018)

Territorial distribution	Water supplied per capita	Efficiency of drinking water distribution networks	Irregularities in the distribution of water	Coverage of the public sewerage service
North	238	65.7	3.0	90.0
Centre	190	51.3	10.6	85.5
South	199	52.1	21.2	86.3
Italy	**215**	**58.0**	**10.4**	**87.8**

Fonte: our elaboration on SDGs.

The degradation of the territory, understood as the loss of ecological functionality, is monitored through the dynamics of land consumption, which Italy has committed to eliminating by 2030 with the National Strategy for Sustainable Development (2017). The "consumed" soil is that occupied by urbanization and made waterproof by artificial coverings (soil sealing). However, an excessive fragmentation of open spaces is also a degradation factor, since the barriers constituted by buildings and infrastructures interrupt the continuity of ecosystems, making even unoccupied but not large enough spaces ecologically inert and unproductive. Furthermore, in a fragile territory like the Italian one, soil consumption is also a significant factor of hydrogeological risk and deterioration of the landscape.

The per capita waterproofing and land use index in 2018 increased for the fifth consecutive year, resulting in 357 m^2 per inhabitant (Table 3). The soil sealed by artificial coverings is equal to 7.1% of the national territory (8.5% in the North, 6.5% in the Centre, 5.9% in the South). However, the goal of zero land use is not yet within reach.

According to Ispra estimates, 44.3% of the Italian natural and agricultural territory has a high or very high degree of fragmentation. A joint representation of the variations in fragmentation and soil sealing over the last two years summarizes the recent trends in soil consumption and their impact on the environment and landscape.

Another goal for 2030 is to provide universal access to safe, inclusive and accessible public green spaces, especially for women and children, the elderly and people with disabilities. In 2018, the incidence of urban green areas on the urbanized surface of cities was 8.5% in Italy with slightly higher values in the North and lower in the South.

Table 3. Indicators for the protection of the territory by territorial division (year 2018)

Territorial distribution	Waterproofing and land consumption per capita	Waterproofing of the soil from artificial cover	Fragmentation of the natural and agricultural territory	Incidence of urban green areas on the urbanized surface of cities
North	409	8.5	43.8	11
Centre	389	6.7	47.5	7.8
South	426	5.9	43.3	5.5
Italy	**357**	**7.1**	**44.3**	**8.5**

Fonte: our elaboration on SDGs.

4 A Multidimensional Approach for the Identification of the Areas

4.1 The Fuzzy Approach

The development of fuzzy theory initially stems from the work of Zadeh [6] and subsequently was conducted by Dubois and Prade [7]. The fuzzy theory develops starting

from the assumption that each unit is not univocally associated with only one but simultaneously with all the categories identified on the basis of links of different intensity (degrees of association).

The first measurement based on the fuzzy set theory, named TF (Totally Fuzzy), was suggested by Cerioli and Zani [8]. This logic can be applied to both continuous and ordinal variable cases. However, in the latter case, the maximum and minimum values can be determined by assuming the value of the lowest category as minimum and the highest as maximum.

Cheli and Lemmi [9] have proposed a generalization of this approach, called *Totally Fuzzy and Relative* (TFR). This method is also called "totally relative" because the value of the membership function is entirely determined by the relative position of the individual in the distribution of the population. The fuzzy TFR approach consists in defining the measurement of an individual's *degree of belonging* to the totality fuzzy, included in the interval between 0 (with an individual who does not demonstrate a clear belonging) and 1 (with an individual who demonstrates a clear belonging). Mathematically, such a method consists of the construction of a function of membership to "the fuzzy totality of the poor" which is continuous in nature, and "able to provide a measurement of the degree of poverty present within each unit". Supposing the observation of k indicators of poverty for every family, the function of membership of i-th family to the fuzzy subset of the poor may be defined thus:

$$f(x_{i.}) = \frac{\sum_{j=1}^{k} g(x_{ij}).w_j}{\sum_{j=1}^{k} w_j} \quad i = 1, \ldots, n \tag{1}$$

The values w_j in the function of membership are only a *weighting system*, as for the generalization of Cerioli and Zani, whose specification is given:

$$w_j = \log\left(1/\overline{g(x_j)}\right) \tag{2}$$

Theoretically when $\overline{g(x_j)} = 1$ all units demonstrate the j-th symptom and the corresponding weight w_j results equal to zero; when $\overline{g(x_j)} = 0$ then w_j is not defined, or rather X_j is not an appropriate indicator for that collective.

The weighting operation is fundamental for creating synthetic indexes, by the aggregation of belonging functions of each single indicator. An alternative, by Betti, Cheli and Lemmi [10] starts from the conjoint use of the coefficient of variation as the first component of the set of weights, with the correlation coefficient, as the second component. The new set of weights, that is proposed for continuous variables, considers two factors, described in the following multiplicative form:

$$w_j = w_j^{(a)} * w_j^{(b)} \tag{3}$$

where:

$$w_j^{(a)} = \frac{\sigma_j}{\mu_j} \tag{4}$$

is given from the coefficient of variation of X_j

$$w_j^{(b)} = 1 - \frac{\sum_{l \neq j} \rho(X_j, X_l)}{\sum_{l=1}^{k} \rho(X_j, X_l)} \tag{5}$$

is given from the complement to one of the ratio between the sum of all correlation coefficients, left out the j array, and the whole sum of correlation coefficients referring to X_j. For further analyses please refer to other works [11, 12].

The indices were grouped into several sets characterized by different situations in the different components considered (Set 1 Protection of the water resource; Set 2 Protection of the territory). The Total Fuzzy and Relative method was applied to the data of all the Italian regions, obtaining a value of the individual weights wi, which varies according to the level of importance in determining the quality of the situation.

4.2 The Results Deriving from the Application of the Totally Fuzzy and Relative Approach

Once the sets of indicators for the 2 considered components were identified, the minimum, maximum and average values were found for each indicator of the different sets (Table 4). The indicators have been transformed in such a way that high values are significant for regional situations of poor health, conversely low values are significant for favourable conditions that do not require public intervention.

Table 4. Results of the application of the TFR method in relation to the distribution function and the weights of the various indices.

Indicators	Minimum	Maximum	Mean	gmean	Weight w_j
- Water supplied per capita	152	446	235	0.4	0.8
- Efficiency of drinking water distribution networks	0.0	1.0	0.6	0.6	0.5
- Irregularities in the distribution of water	0.7	39.6	10.0	0.3	1.3
- Coverage of the public sewerage service	2.7	24.0	10.6	0.4	0.8
- Waterproofing and land use per capita	2.1	562	6.3	0.6	0.6
- Soil waterproofing by artificial cover	240	12.0	410	0.4	0.8
- Fragmentation of the natural and agricultural territory	1.2	66.7	39.2	0.5	0.6
- Incidence of urban green areas on the urbanized surface of cities	0.0	1.0	0.5	0.5	0.7

For each set of indicators, the fuzzy value and the relative values connected to it have been calculated. Of particular interest is the analysis of the weights w_j which indicate the relevance of the indicator on the set considered. As already specified, high values of this indicator denote a strongly discriminating condition in determining the result. In our case the values of the weights of the indicators relating to the irregularity in water distribution ($w_j = 1.3$), those relating to the quantity of water supplied, the coverage of the sewerage service and the waterproofing of the soil are particularly discriminating. from artificial roofing ($w_j = 0.8$). Conversely, the weights of the indicators relating to the inefficiency of the drinking water distribution networks appear less discriminating ($w_j = 0.5$).

As a result of the application, we have classified the Italian regions based on fuzzy values, obtaining the classification shown in Table 5. We recall that high values are significant for regional situations of water or territorial degradation which therefore require national interventions.

Table 5. Composition in absolute values and percentages of the provinces by belonging to the fuzzy classes

Fuzzy value	Number of regions		%	
	Water protection	Territory protection	Water protection	Territory protection
0.0–0.2	2	0	10%	0%
0.2–0.4	9	6	45%	30%
0.4–0.6	6	7	30%	35%
0.6–0.8	2	5	10%	25%
0.8–1.0	1	2	5%	10%
Total	**20**	**20**	**100**	**100**

4.3 Spatial Distribution of Fuzzy Values

In this paper, the representation of the values attributed to the individual geographic areas, corresponding to the regions, occurs through cartograms, associated with "natural" interval classes, defined within the distribution.

Applying the *Total Fuzzy and Relative* method on the data of all Italian regions, as described in the previous paragraph, three synthetic indices were obtained (Table 5) that describe the territorial distribution of the indicators that are represented in the next Fig. 1.

It thus emerges that for the set related to the indicators related to the protection of the water resource most of the regions are in an average condition while 3 regions have strong deficiencies with fuzzy values between 0.6 and 1 (Calabria, Molise, Sicilia).

Regarding the indicators linked to the protection of the territorial resource, there is instead a greater equidistribution in all classes with the presence of 7 regions in

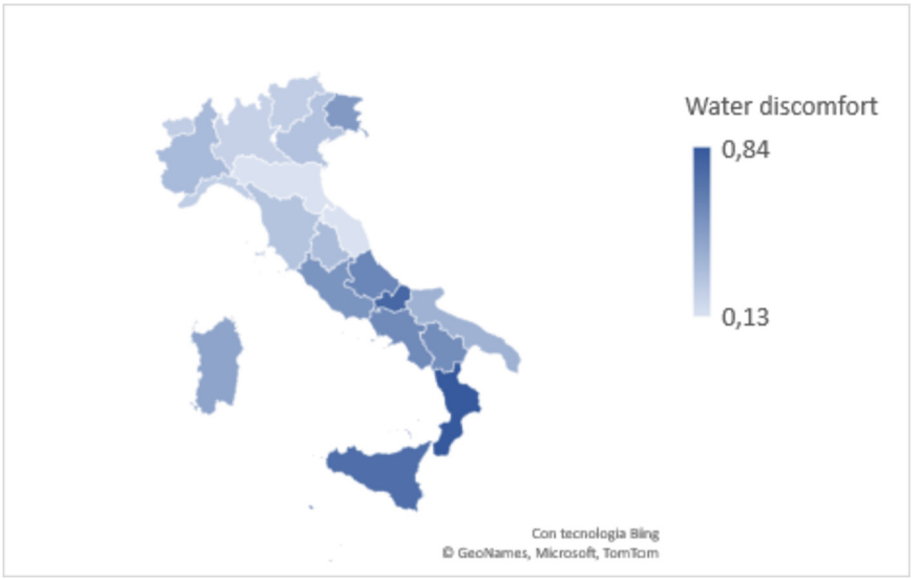

Fig. 1. Territorial distribution by region of the fuzzy values for *Water protection* assessed through indicators for the achievement of the Sustainable Development Goals Agenda 2030.

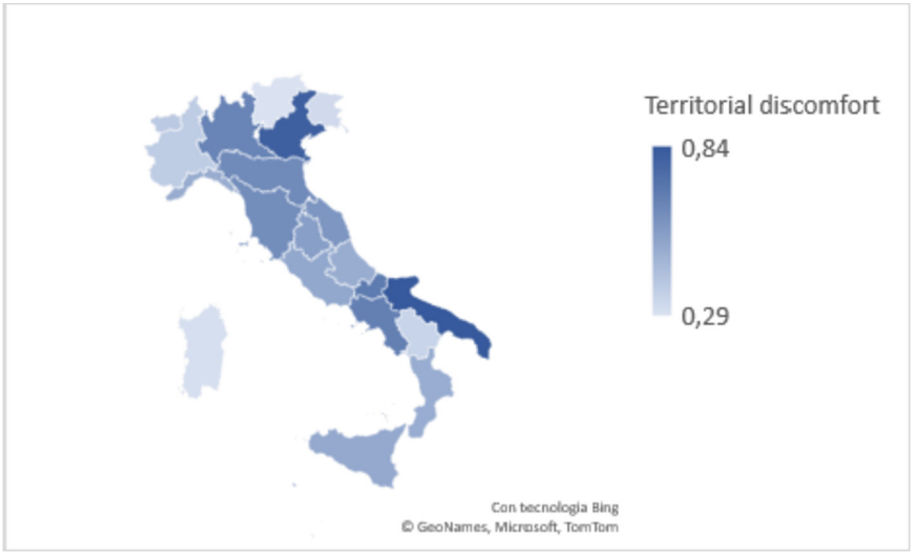

Fig. 2. Territorial distribution by region of the fuzzy values for *Territory protection* assessed through indicators for the achievement of the Sustainable Development Goals Agenda 2030.

conditions of territorial degradation (Fig. 2): Puglia, Veneto with very high degradation

values (close to 1), Molise, Campania, Lombardy, Emilia-Romagna and Tuscany with high values (between 0.6 and 0.8).

5 Conclusions

In continuity with the European Green Deal, the National Recovery and Resilience Plan represents an opportunity for further development in this area, providing for reforms and substantial investments for the promotion of circular economy solutions, the improvement of the capacity for efficient and sustainable management. of waste, the strengthening of the infrastructures for waste treatment and separate collection, the reduction of the Italian North/South gap.

Sustainability indicators are key tools to assess such integration, but initiatives are diverse and there is no agreed framework for the assessment of such interactions and feedbacks.

The results of the analysis conducted with the fuzzy method show a significant difference in the starting conditions between the different Italian regions.

While water protection policies once again show the gap between North and South, territorial protection highlights a different starting point between the Italian regions which is independent of this gap and appears more linked to more articulated regional differences.

It is certainly important and necessary to spend the huge resources made available by Europe within the required time frame (by 2026), but it is perhaps even more so to do so that they can multiply their effectiveness and become not mere expenses but effective investments capable to offset the debt that Italians have accepted to assume for the next few years with a view to restructuring the overall organization of the country and making it more resilient to increasingly frequent and unpredictable events that jeopardize the well-being achieved from a perspective of sustainability.

To do this, it seems to us that the analyses conducted show the need to allocate these resources not only through competitive tenders based on the criterion of the best response to the tender criteria, but also on the basis of the different starting conditions.

Territorial disparities do not resolve by themselves, as most of the experiences carried out in the world in development policies have now taught us, starting from the well-known ones of the United Nations [13–15] in what were once called least developed country up to those of the cohesion fund of the European Union [16].

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