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Enriching the Italian Genuine Saving with water and soil depletion: national trends and regional differences

Abstract: National and international governments aim to promote the responsible management of the natural capital but measuring its contribution to economic growth is still a challenging exercise. The natural capital supports a plurality of environmental functions whereas the economic growth is frequently measured by aggregated indicators. In this paper, we propose an extended version of the Genuine Saving macro indicator to account for water and soil depletion. Further, as natural capital is spatially heterogeneous we estimate Genuine Saving for Italy for the period 2000-2015 at the regional level. Whilst the case study produces specific results for Italy the methodological framework is broadly applicable to other states. The Italian comparison shows that soil and water provide an absolute change of roughly 1% of the GS but average relative regional variations are between 5 and 33% of GDP, showing that the geographical scale of sustainability analysis is a crucial element for responsible management of national assets. The methodological contribution suggests that the Genuine Saving can support policy makers in developing targeted policies for sustainable growth.

Keywords: Adjusted net savings, Beyond GDP, Loss of soil, Regional sustainability.

JEL code: E01, Q56, R11.

1. Introduction

The need of measuring the performance of nations has been historically fulfilled by GDP as an indicator of economic activities. Nowadays, the focus on the multiple dimensions of nations' performance requires a shift from GDP towards more comprehensive indicators (Ciommi et al 2017). GDP has been unable to properly take into account the environmental and social impact of economic growth; these aspects have a central role in societal progress, and constitute a central issue in the concept of sustainability (Stiglitz et al. 2010).

After the publication of the Bruntland commission report (WEDC, 1987), the idea of sustainability, as well as the problems related to its measurement have been at the center of the public debate. A rich academic literature discusses the normative and methodological problems posed by this challenge; more specifically, the concrete measurement of sustainability is still an open question and several scholars contributed to the elaboration of different approaches (i.e. weak versus strong sustainability). Since the concept itself is complex and multidimensional, it is hard to capture all its relevant aspects in a single indicator or even a set of indicators. Due to this, a plethora of different tools are now available (Atkinson et al., 2014).

39 The economic literature has been dominated by the idea that the ability to satisfy the needs of
40 present/future generations (WCED, 1987) crucially depends on the preservation (or even the
41 increase) of the economic, natural, social and human capital. This rather basic consideration has
42 been very fruitful, leading to the advancement of an influential strand of literature, whose main
43 focus is on the components that “produce” human well-being (Polasky et al. 2015). In that
44 perspective, a proper assessment of sustainability starts from the definition of the elements that
45 constitute the “productive base” of human well-being and wealth. The eventual erosion of these
46 endowments undermines the ability to support intra- and inter-generational development.
47 Accordingly, the measurement of sustainability requires to monitor and evaluate changes in capital
48 assets to test the ability to sustain well-being. A non-declining wealth has to be preserved over time;
49 this is a necessary condition for sustainable development (Dasgupta et al., 2001).

50 The Genuine Savings (GS) is a sustainability indicator also called Adjusted Net Savings or
51 Adjusted Investments (Pearce and Atkinson, 1993; Hamilton and Clemens 1999; Hamilton and
52 Atkinson 2006) that links social welfare theory, capital stock management and well-being. It
53 measures “true” savings, that is, the changes in total wealth, accounting for the variation in
54 produced capital, natural capital and human capital that occurs in a period of time (e.g. a year); a
55 persistently negative value of the index signals an unsustainable development path and an
56 insufficient rate of produced capital accumulation. The main advantage of this indicator is that it is
57 directly comparable with GDP being expressed in monetary terms. A major disadvantage is the
58 need to monetize social and environmental assets. Stiglitz et al. (2010) observe that a desirable
59 feature of sustainability indicators is their ability to signal unsustainable pathways in current trends.
60 We claim that Genuine Saving fulfills this role but still needs a greener vision to better account for
61 environmental damages.

62 The effort in measuring sustainability trends is confirmed by the production of different national or
63 macroregional levels indicators (such as the Inclusive Wealth initiative (UNEP 2012, 2014); Better
64 Life Index for 362 Regions (OECD 2014), World Bank GS for more than 100 countries (World
65 Bank, 2006, 2011)). The World Bank GS only accounts for depletion of natural capital due to
66 subsoil resources, forests exploitation and CO2 emission. While these resources are important it is
67 easy to sustain that also water and soil are critical assets for sustainable development. According to
68 the World Bank estimates, EU Members States and many other developed countries present a
69 positive GS results, however relevant natural and social assets are neglected (Schepelmann et al.,
70 2010).

71 The definition of World Banks GS has been extended and tailored for specific countries reflecting
72 the richness of data on air pollutants or other assets (e.g.: Ferreira and Moro, 2011, 2013 for Ireland,

73 Mota and Martins, 2010 for Portugal and Hanley, 2015 for a review). Brown et al. (2005) and
74 Hanley et al. (1999) propose measurements of subnational GS (respectively for Queensland and
75 Australia, and Scotland), showing that important divergences in national and regional sustainability
76 paths might be masked by the World Bank indicator. Clark and Lawn (2008) revise benefits and
77 challenges of sub-national indicator and Biasi and Rocchi (2016) present a first attempt to derive
78 sub-national GS estimates for Italy. At the best of our knowledge, none of these previous studies
79 include water and soil depletion as components of the natural capital in the GS.

80 The main aim of this paper is twofold: determining the Genuine Savings for the Italian regions and
81 extending the World Bank empirical specification to include soil and water management. Data
82 availability is the criteria followed to incorporate these natural assets in the national and regional
83 GS indicator. The paper contributes methodologically to enhance the specification of sustainability
84 indicators and empirically presents the sustainability trends of Italian nation and regions over a
85 fifteen years-time period. This spatial and temporal specification of the GS offers a promising
86 policy instruments to improve environmental management at both at the local and the national level.
87 Complementary to Ciommi et al (2017), our GS regional analysis shows how unsustainable pathways
88 can occur at sub-national level and a variety of factors that can play a role.

89 The paper is structured as follows: Section 2 describes the theoretical model of the GS and the
90 empirical specification used by the WB in its calculation; Section 3 describes the data used for
91 physical and monetary accounting in our estimates. Section 4 presents and discusses the results.
92 Section 5 concludes.

93
94

95 **2. The Genuine Savings**

96 The GS was initially proposed by Hamilton and Clemens (1999) but the intellectual roots dated
97 back to Weitzman (1976) (see Pearce 2002; Fleurbaey, 2009). Weitzman (1976) shows that the
98 current Net National Product (NNP), under certain conditions, can be considered a measure of the
99 present value of future consumption where the capital also includes natural resources. Solow (1974)
100 raises awareness on the role of limited natural resources for growth and intergenerational equity;
101 based on the assumption of perfect substitution between capital-labour and natural resources, he
102 states that current generation can “consume” exhaustible resources as long as it adds to the stock of
103 reproducible capital. Building on this and relying on the Hartwick rule (1977), Solow (1986) shows
104 that reinvesting natural resource rents can help maintaining capital stock constant over time,
105 providing a rule of thumb for policy makers to preserve consumption possibilities in
106 intergenerational terms. The principle of “weak sustainability” shapes the Genuine Savings

107 indicator and initially Pearce and Atkinson (1993), Hamilton and Clemens (1999) and Atkinson and
108 Hamilton, (2007) discuss the implications of using sustainability measurements.

109 From a theoretical point of view, the Genuine Savings indicator is based on the Hicksian definition
110 of income as the maximum amount that can be consumed in one period without compromising the
111 ability to afford the same level of consumption in the following period (Hicks, 1946). The indicator
112 is built on the framework of the green national accounting, together with a rearrangement of the
113 Hartwick rule (Hartwick, 1990) and it requires that the depletion of exhaustible natural resources
114 should be offset with investments in other forms of capital to preserve the total stock of wealth and
115 well-being over the long run.

116

117 Four types of adjustments are necessary to transform the standard savings, as measured in national
118 accounting, into “genuine savings”. Figure 1 represents the main steps to calculate the National
119 savings (that is gross national income less private and public consumption) plus the public
120 investment in education (private investments in education are excluded), minus the consumption of
121 fixed capital, the natural resource extraction (natural capital includes oil and natural gas, mineral
122 and forest depletion) and environmental degradation (air pollutants) all valued in monetary terms.

123

124 **Figure 1. Definition of Genuine Saving [Source: The World Bank (2006)].**

125

126 All components are expressed as percentage of Gross National Income (GNI). Given the weak
127 sustainability assumption, different forms of capital (productive, natural and human) are perfect
128 substitutes and the Genuine Savings (GS) suggests that an economy is sustainable if its net savings
129 are non-negative. The negative value of the GS signals that current well-being is based on an
130 unsustainable mismanagement of resources (due to overconsumption or underinvestment). A
131 negative GS will lead to the erosion of total wealth implying future lower levels of wellbeing
132 (Pearce and Atkinson, 1993). Being able to provide suggestions on future implication of current
133 choices, the GS is a forward looking indicator that can be used for policy decision making (Stiglitz
134 et al., 2010, UNECE 2009).

135 Despite its popularity and promising features the GS presents drawbacks. First, the World Bank GS
136 (Bolt et al., 2002), includes only a small subset of natural components such as depletion of minerals,
137 metals, forests and environmental pollution (carbon dioxide and particulate matter emission).
138 However, other crucial resources such as water, soil and, in general, biodiversity are missing. The

139 World Banks needs to provide meaningful cross-country comparisons and, as a consequence, it
140 must focus on homogeneous and comparable data, rather than broader measurement of natural
141 capital assets.

142 Second, as a national aggregated indicator, the GS can hide unsustainable development pathways at
143 regional or local level. This can be a serious issue when the aim is to monitor relative
144 overconsumption/underinvestment. The natural capital includes spatially heterogeneous resources
145 (Fisher et al 2009): the sustainability of the aggregate is not necessarily based on the sustainable
146 progress of its parts, so that the choice of the geographical scale for measurement is not neutral for
147 the final results. Hanley et al. (1999) disentangle the GS for the United Kingdom and show that
148 overall positive GS masks a negative performance for Scotland. Moreover, even though the
149 sustainability challenge is a global issue, “political actions and the potential to change development
150 paths is predominantly a regional, national or even local privilege. For this reason it remains
151 imperative to measure whether sub-global entities – particularly nations, but also sub-national
152 jurisdictions [...] – are developing sustainably” (UNECE 2009). Then, monitoring long-terms
153 trends in sustainability with measurement tailored at the subnational level may provide useful
154 information to support policy decision making.

155 The paper extends the Hanley et al. (1999)’s approach presenting the GS estimates for NUTS2
156 regions in Italy over time including water and soil depletion. In our opinion, however, the approach
157 presented in the paper is applicable across countries that provide regional gross savings..

158

159 **3 Data and methods: the traditional components of the Genuine Savings**

160 According to Atkinsons et al. (2014) the standard GS in a given year of an economy can be defined
161 as follows:

$$\begin{aligned} \text{Standard GS} = & \text{Gross Savings} - \text{Depreciation of fixed Capital} \\ & + \text{Public investments in Education} \\ & - \text{Depletion of Energy Resources} - \text{Depletion of Minerals} \\ & - \text{Net Depletion of Forests} - \text{CO2 Damages} - \text{PM Damages} \end{aligned} \quad \text{Eq 1}$$

162

163 Following the World Bank (Bolt et al. 2002) empirical implementation as in eq. 1 Biasi and Rocchi
164 (2016) suggest to measure the GS for Italian regions. In this paper we also propose to include soil
165 and water degradation as per eq. 2 and to compare national and regional trends.

$$\begin{aligned}
\text{Extended GS} = & \text{Gross Savings} - \text{Depreciation of fixed Capital} \\
& + \text{Public and Private investments in Education} \\
& - \text{Depletion of Energy Resources} - \text{Depletion of Minerals} \\
& - \text{Net Depletion of Forests} - \text{CO2 Damages} - \text{PM Damages} \\
& - \text{Damages of soil sealing} - \text{Damages of water losses and degradation}
\end{aligned}
\tag{Eq. 2}$$

166

167 Furthermore, the prices for subsoil depletion (energy and minerals) and pollution damages (PM10)
168 are calculated considering alternative source of data, mimicking the challenges in calculating the
169 GS when multiple source of information are available. The price of minerals is based on two
170 different estimates of unit rents and extraction costs and the PM10 costs account both for high and
171 low Value Of a statistical Life Year (VOLY). The objective is to use all the estimates available at
172 national and regional levels for all considered assets in 2000, 2005, 2010 and 2015. This allows to
173 provide GS estimates at the regional level under an optimistic and pessimistic scenario.

174 The National Office of Statistics provides the National Accounts figures (ISTAT, 2017) to
175 determine the Net National Savings and disaggregate them at the regional level¹. Regional public
176 and private expenditures in education are included², as a proxy for investments in human capital.

177 Subsoil depletion is accounted for as oil and natural gas extraction rent. The physical quantity of
178 natural capital extracted is monetized using international market prices minus extraction costs. Data
179 on quantity extracted are provided by the Italian Ministry of Economic Development; the value of
180 the unit rent for natural gas and oil is estimated by the World Bank for Italy. As the paper aims to
181 test the impact of data availability on GS measure, we present an alternative approach which
182 employs international market price for oil (British Petroleum, 2016) and cost of oil production
183 (development costs) as elaborated by Nomisma Energia (2012). These alternative sources of data
184 present higher cost of oil extraction and consequently, a lower unit rent for oil with respect to WB
185 estimates. Both values will be presented in the empirical application.

186 CO2 and PM10 emissions are the air pollutants included in the standard measures of GS. Ispra
187 (2019) provides regional CO2 emissions for the period considered. CO2 is valued at 37 \$ per ton as
188 estimated by OIRA (2017) and we account for the incremental damages of CO2 emission over the
189 time span. Regional PM10 emissions are derived by the National Inventory of Pollutants (ISPRA,

¹ The ratio of regional investments over national investments are used to disaggregate the national figure, according to the methodology described by (Biasi and Rocchi 2016).

² Following the World Bank approach, we consider expenditures in education as a proxy of human capital formation. As detailed in eq. 1 and 2 the WB framework includes only public expenditures whereas our extended indicator captures private and public investments in education.

190 2019) while estimates of economic damages are based both on low and high Value Of Life Years
191 (VOLY) as provided by EEA (2014).

192

193 **3.1 Complementing the GS with Soil data**

194 Complementing the GS with soil and water degradation is one objective of the paper but data
195 availability is a constraint and our approach is to rely on available information. Soil sealing
196 represents the main source of biodiversity loss and also causes soil degradation. The physical data
197 on soil sealing are provided by ISPRA – Soil monitoring network. The network accounts for
198 artificial land cover in the period 1956 to 2015 and previous studies report the impact of soil sealing
199 in Italian regions (Munafò et al 2013). Based on this data, we compute the regional average soil
200 consumption in hectares over time as the percentage of regional area of “arable land” transformed
201 into artificial surfaces in a given period³.

202 As the soil sealing produces a loss of agriculture values already included in the gross saving and
203 data on costs of soil erosion are not available, the monetary estimates of damages due to soil sealing
204 are obtained considering the loss of CO₂ sequestration potential (as a proxy of regulating services).
205 As detailed information on the nature of soils sealed are not available the lost carbon sequestration
206 potential is assumed to be the same for each hectare of soil. Following Sallustio et al. (2015), this
207 value is set to 58.1 Mg C /ha for a conservative estimate. The same cost of carbon provided by
208 OIRA (2017) is used to monetize the sealing of soil⁴. The mean economic loss of soil is
209 approximately 4800 euro/ha over the period considered.

210

211 **3.2 Complementing the GS with Water data**

212 Given the availability of regional data two dimensions of water depletion are included in the
213 analysis: 1) water quality degradation due to urban and industrial pollution; 2) quantity of potable
214 water lost (that is, water abstracted and then wasted due to inefficient distribution systems)⁵. The
215 National Office of Statistic (ISTAT 2006, 2009) provides physical data for both dimensions.

³ Despite this assumption might appear too simplistic, it is supported by the evidence that the expansion of urban area and the increase in soil sealed from 1990 to 2008 in Italy occurred at the expense of arable land (mainly cropland -approximately the 75%-, and orchards- less than 12%). Other natural areas (e.g., forests) are marginally involved in this process (Marchetti et al., 2012).

⁴ Each ton of carbon is equal to 3,67 ton of carbon dioxide.

⁵ Physical data on water losses in 2000 refers to data provided by ISTAT (2006) for the year 1999; quantity in 2010 refers to data provided for 2008 by ISTAT (2009). For water pollution, data on 2000 are calculated through linear interpolation based on available data (ISTAT, 2009); also in this case data for 2010 refers to

216 Urban and industrial pressures are responsible for water quality degradation and per-capita unit of
217 organic loading is the quantity of attention in this paper. In physical terms, wastewater is an input to
218 the water system, since it contributes to water return flows from the economy to the environment
219 (directly or indirectly through treatment), and may be available for other uses within the economy;
220 nonetheless, degradation has an impact in terms of sustainability, since these flows are
221 characterized by lower quality with respect to abstracted water (UN, 2012). The monetization of the
222 per-capita unit is estimated as 14.56 Euro per unit of organic load (equivalent inhabitant) as derived
223 by Pulselli et al. (2006)⁶.

224 As water losses due to inefficient water supply network can have different interpretations our choice
225 is supported by the following considerations. According to UN's System for Environmental-
226 Economic accounting for Water (UN, 2012), leaks from pipe have to be considered as "return
227 flows" from the economy to the environment. Leakages from water supply networks may contribute
228 to recharge aquifers; at least part of these losses can turn out to be a resource for the water system
229 and become available for abstraction in the future (UN, 2012). On the other hand, it must be
230 observed that wasted potable water requires long natural hydrologic process (or expensive artificial
231 treatment) before the availability for use of the resource is restored to its initial level both in terms
232 of quantity and quality.

233 Leaks of potable water may support the refill of aquifers; but water after leakages is not equivalent,
234 in terms of quality, to drinking water. This problem has crucial implications, as drinking water
235 supports human beings and quality of life. In Italy, groundwater is the main source of potable water
236 and contributes to approximately 84% of total water abstraction as it requires less treatment due to
237 higher quality with respect to surface water (ISTAT, 1999). Persistent potable water leakage
238 problems prompt an increase abstraction from aquifers and depletion of subsoil water which can
239 alternatively support ecosystems and biodiversity. Further, "unnecessary abstraction may have
240 negative hydromorphological consequences and may cause higher concentrations of pollution in the
241 originating water body from which the water is abstracted" (EU, 2015). Finally, drinking water
242 leakages generate inefficiency that cannot be neglected in a macroeconomic perspective of
243 sustainability (i.e. waste in terms of electricity for abstraction, additional environmental pressure for
244 treatment, use of chemicals etc.). Including wasted potable water in the GS indicator provides (at
245 least partially) a measure of pressures and damages on water resources due to unrealized measures
246 (investments) to avoid leakages (EU, 2015).

value provided by ISTAT for the year 2008. We assume that drinking water losses due to inefficiency in the water distribution system require many years to return into the system.

⁶ The authors consider the cost of treatment of wastewater in a standard purification plant.

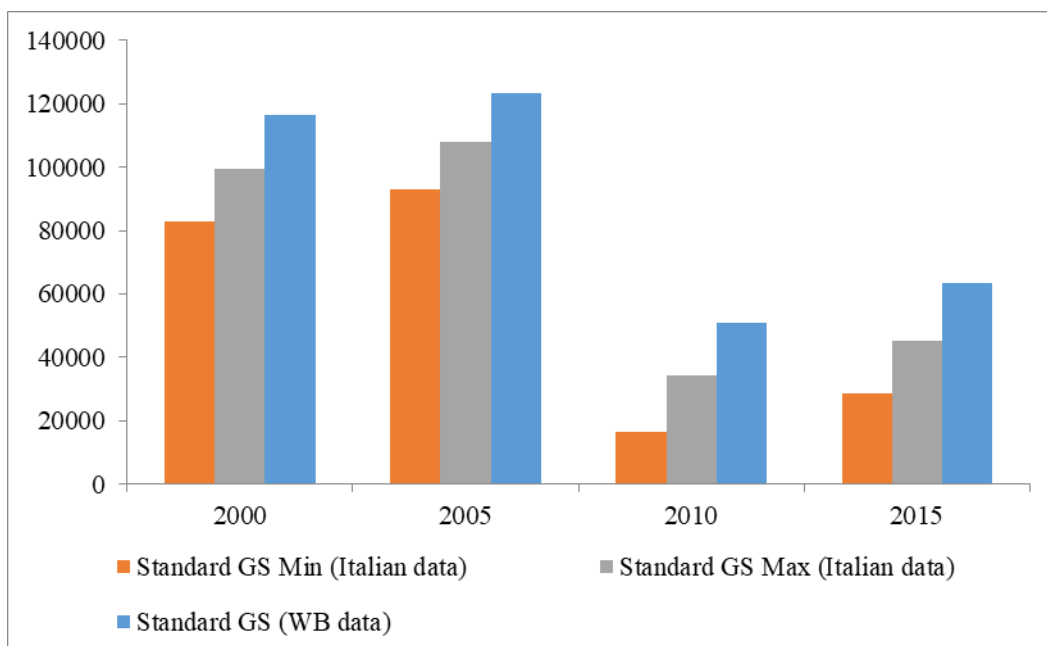
247 Data on water supplied and received, and percentage of dispersion at the regional level are provided
248 by the National Office of Statistics and the monetization of these losses is obtained multiplying the
249 quantity dispersed by the average regional Federconsumatori estimates of typical domestic water
250 consumption fees(1999, 2005, 2008,2015)⁷.

251

252 4. Results

253 Results firstly describe at the national level the benefits of enhancing the GS with soil and water
254 data and subsequently regional GS analysis is presented. Estimates with and without different
255 natural assets are reported to appreciate the contribution of the missing components. The national
256 GS is calculated following two approaches: theWB approach and a revised national estimates at low
257 (Min) and high (Max) values for oil and gas rents and PM10 damages. Figure 2 contrasts our
258 estimates for the standard World Bank GS calculation for the period 2000-2015.

259



260

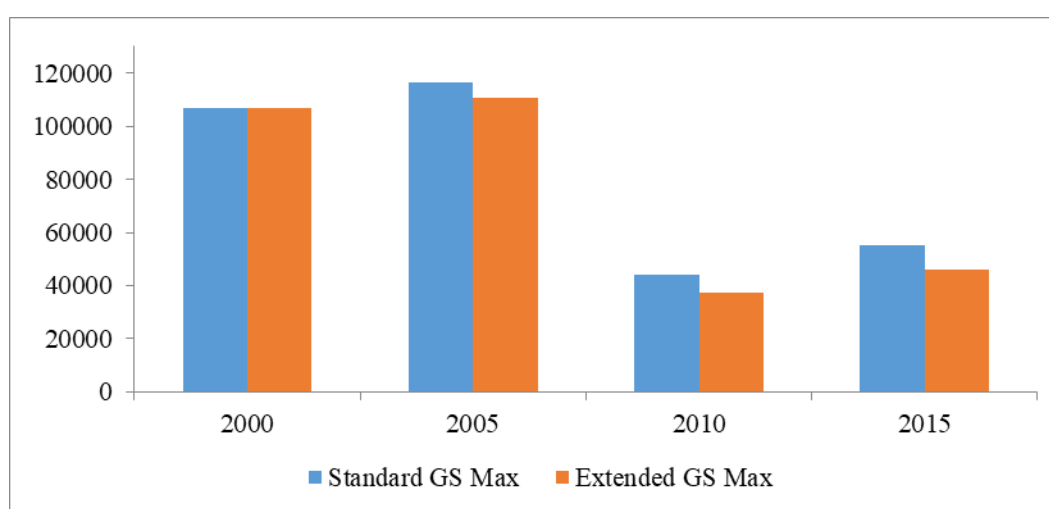
261 **Figure 2. Genuine Saving using WB and national data for Italy (values in millions of euro Euro)**

262 Results are comparable although our estimates appear slightly more conservative than the WB.
263 Over time, Italy presents a positive (but decreasing) GS, with a modest recovery in 2015. The
264 wealth trend is unequivocally the same, results show a steady reduction of the value of the index

⁷ Federconsumatori collects data on domestic tariffs in major Italian cities; based on this information we compute the average tariff at the regional level; alternatively, we impute the national average if local data are not available. We are aware that this is a rough approximation of the value of water lost; however, the aforementioned survey is the only systematic assessment of the “price” of this potable water all over the country.

265 over the period considered; it is worth noticing that as previously mentioned, it is well known that
266 the sustainability performance of developed economies may be overvalued in WB estimates of the
267 index, mainly due to problems in data quality.

268 Figure 3 shows the impact of considering also soil and water components in the estimate of GS as
269 the value of the index shows a further decrease. Considering the optimistic scenario (max GS), at
270 the country level, the inclusion of soil and water depletion generates a reduction of approximately
271 4% with respect to the “standard” calculation of GS in 2000 and 2005, 15.12% in 2010 and 16.97%
272 in 2015⁸. These findings support the idea that expanding the empirical framework of the index has a
273 non-trivial impact on final results, leading the GS indicator to better reflect the sustainability
274 performance of countries.



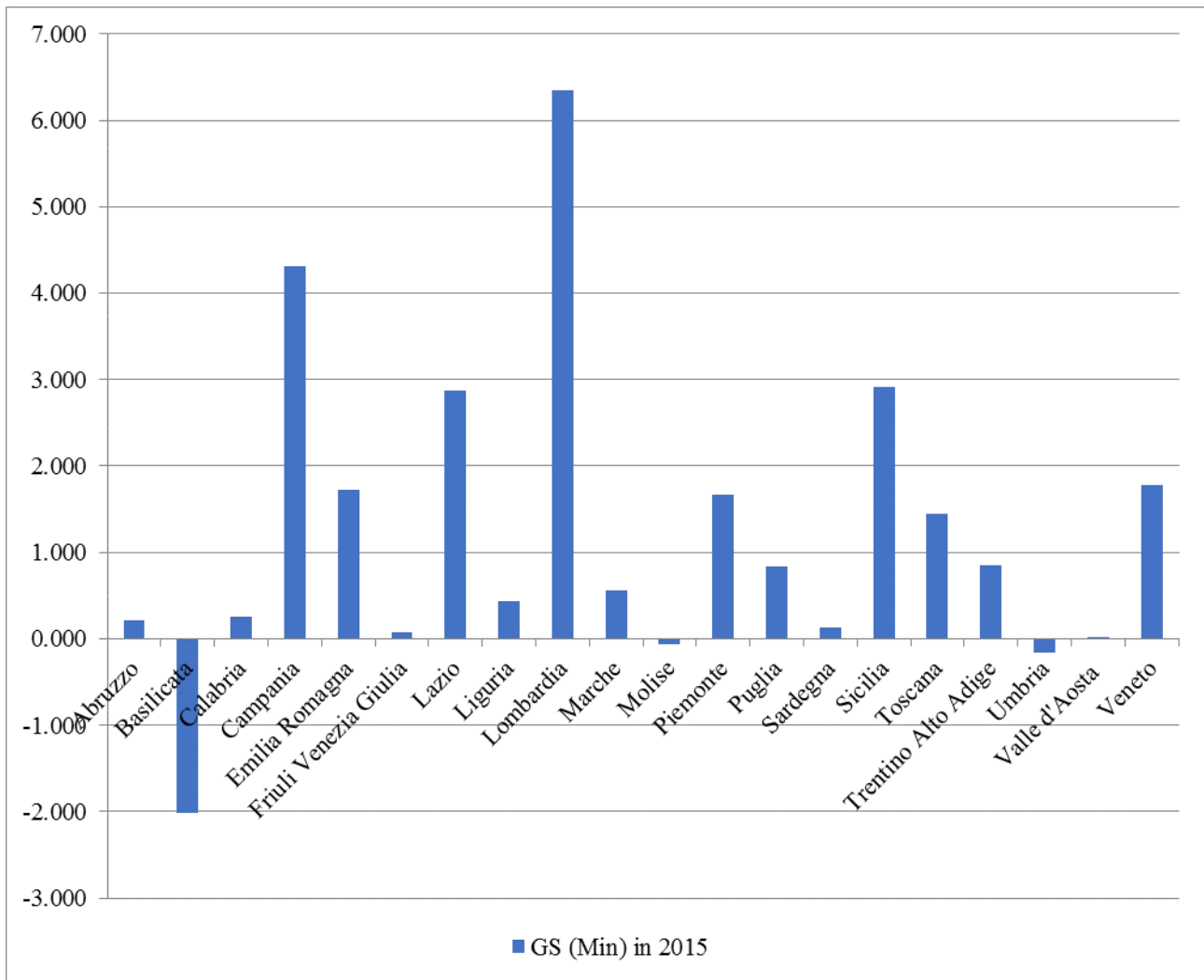
275

276 **Figure 3 Extended Genuine Saving with soil and water components for Italy (values in Euro)**

277 Figure 2 and 3 show a clear decline in GS from 2000 to 2010 and a modest improvement in 2015;
278 however the regional analysis can contribute to understand the dynamic of changes. The spatial
279 disaggregation of the standard and extended GS (with or without water and soil components) we
280 claim is an important step in enhancing the information provided by the indicator.

281 Figure 4 reports the regional values of standard GS in millions of euro in 2015 and shows that in
282 absolute terms Campania, Lombardia, Lazio and Sicilia show the highest performance, while other
283 regions, as for example Friuli-Venezia Giulia, Abruzzo, Molise and Calabria are very close to zero.
284 A better comparison which captures economic and geographical differences is the amount of
285 savings measured as a percentage of regional GPD as reported in Tab1.

8 For the “pessimistic scenario” estimation (min GS), the reductions with respect to the WB estimates of the GS become 6% in 2000 and 2005 and 40%,32.9% in 2010 and 2015. The considerable impact registered in 2010 is the result of a combined effect: the increase of soil and water depletion and, mostly, the considerable reduction in standard net savings due to the macroeconomic downturn.



286

287 **Figure 4 Regional Genuine Saving in 2015 for Italy (millions of Euro)**

288

289

290

291 For the four years considered (2000, 2005 2010 and 2015) Table 1 reports the standard estimates of
 292 regional Genuine Savings according to minimum and maximum values. All Italian regions, except
 293 Basilicata, pass the GS weak sustainability test in 2000 and 2005. Basilicata reports a persistent
 294 negative GS since 2005 due to oil and natural gas production. The region hosts the largest onshore
 295 field in the South of Europe and presumably the rest of Italian regions benefits from this activity but
 296 there is not a formal compensation of this wealth depletion. In the more optimistic scenario, the
 297 value of the Basilicata GS in 2015 is equal to -5.13% (over regional GDP); in the pessimistic
 298 scenario, the index falls dramatically to -15.86%. This result signals that the region is over
 299 consuming its wealth; or, that is not recovering this loss with investments in other forms of capital
 that could compensate for the current depletion of its natural capital. This implies that the

300 development path of the region is not sustainable and this can lead to future lower levels of well-
 301 being⁹.

302 In 2010, Emilia Romagna, Liguria and Sardegna presented a GS close to the threshold, in 2015
 303 Molise and Umbria were close to zero which suggests that attention is needed in managing the total
 304 capital of critical areas.

305 **Table 1. Genuine Savings in Italian regions (as % of regional GDP), considering min and max estimates.**

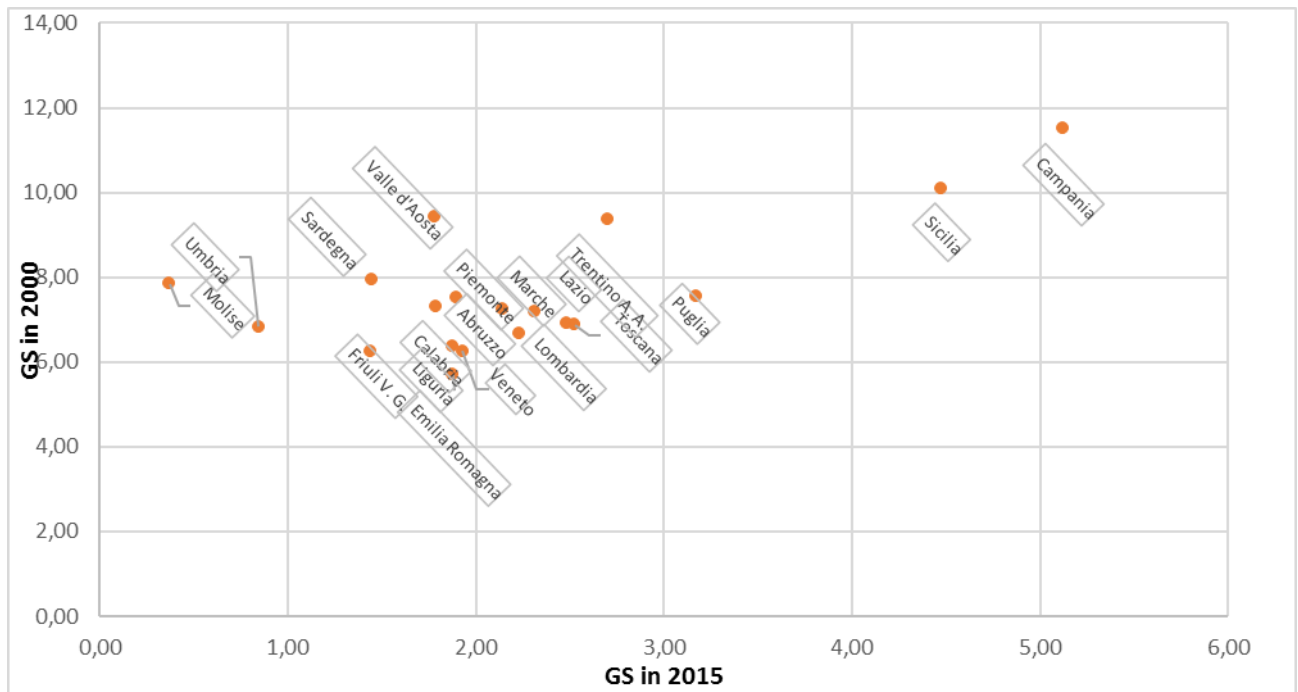
	2000		2005		2010		2015	
	Min	Max	Min	Max	Min	Max	Min	Max
Abruzzo	7.52%	9.78%	8.27%	9.45%	2.26%	3.43%	1.90%	3.91%
Basilicata	5.47%	9.87%	-3.63%	1.13%	-12.78%	-6.96%	-15.86%	-5.13%
Calabria	7.32%	11.48%	9.89%	11.36%	3.01%	4.95%	1.79%	4.74%
Campania	11.50%	13.03%	10.86%	11.89%	4.90%	6.15%	5.12%	6.37%
Emilia Romagna	5.69%	6.74%	5.61%	6.46%	0.61%	1.55%	1.88%	2.49%
Friuli Venezia Giulia	6.26%	7.74%	6.00%	7.19%	1.16%	2.26%	1.44%	2.64%
Lazio	6.93%	7.83%	6.21%	6.85%	1.79%	2.55%	2.48%	3.13%
Liguria	6.36%	7.55%	4.93%	6.03%	0.96%	1.89%	1.87%	2.56%
Lombardia	6.67%	7.40%	6.12%	6.74%	1.14%	1.86%	2.23%	2.74%
Marche	7.19%	8.49%	5.99%	7.10%	1.42%	2.56%	2.31%	3.49%
Molise	7.85%	11.43%	7.30%	9.89%	1.34%	3.34%	0.37%	3.79%
Piemonte	7.24%	8.57%	6.72%	7.64%	1.30%	2.41%	2.15%	3.26%
Puglia	7.56%	10.11%	7.51%	9.44%	2.46%	4.60%	3.18%	4.48%
Sardegna	7.95%	10.77%	7.86%	9.86%	0.52%	2.76%	1.45%	3.21%
Sicilia	10.10%	11.65%	8.98%	10.27%	2.87%	4.76%	4.48%	5.47%
Toscana	6.88%	7.96%	6.24%	7.23%	1.98%	2.83%	2.53%	3.35%
Trentino Alto Adige	9.37%	10.31%	9.63%	10.38%	2.65%	3.33%	2.70%	3.75%
Umbria	6.84%	9.00%	5.80%	7.41%	1.44%	2.78%	0.85%	3.08%
Valle d'Aosta / Vallée d'Aoste	9.42%	10.66%	7.47%	8.48%	1.52%	2.36%	1.78%	2.98%
Veneto	6.25%	7.50%	6.24%	7.26%	1.41%	2.35%	1.93%	2.89%

306
 307 Tab.1 confirms that Italian regions experienced a considerable reduction in the amount of Genuine
 308 Savings in the period 2000-2015. The main reason of this negative evolution is the persistent
 309 decline in the level of standard (economic) savings, that was amplified by the economic crisis,
 310 leading to negative net savings in the country, compensated by investments in human capital

⁹ The negative value of GS for Basilicata is mainly driven by the production of oil and natural gas in the area; indeed, Basilicata can be defined as a “resource rich” region with respect to the rest of the country. However, only a portion of these resources is actually *consumed* in the area, while a part of this natural capital is exploited elsewhere. In principle, this may determine the negative performance of the region, due to the structure of the index. Nonetheless, it is worth noting that Biasi and Rocchi (2016) apply a correction in order to account for this problem. When the natural capital component is rescaled for an “ecological balance of payment” (that is, considering the value of oil and gas produced and consumed in the area), the value of the index is still negative.

311 formation (especially in Southern regions, where public investments in education are generally
 312 higher when compared to other regions). Figure 5 presents the evolution of GS over time.

313



314

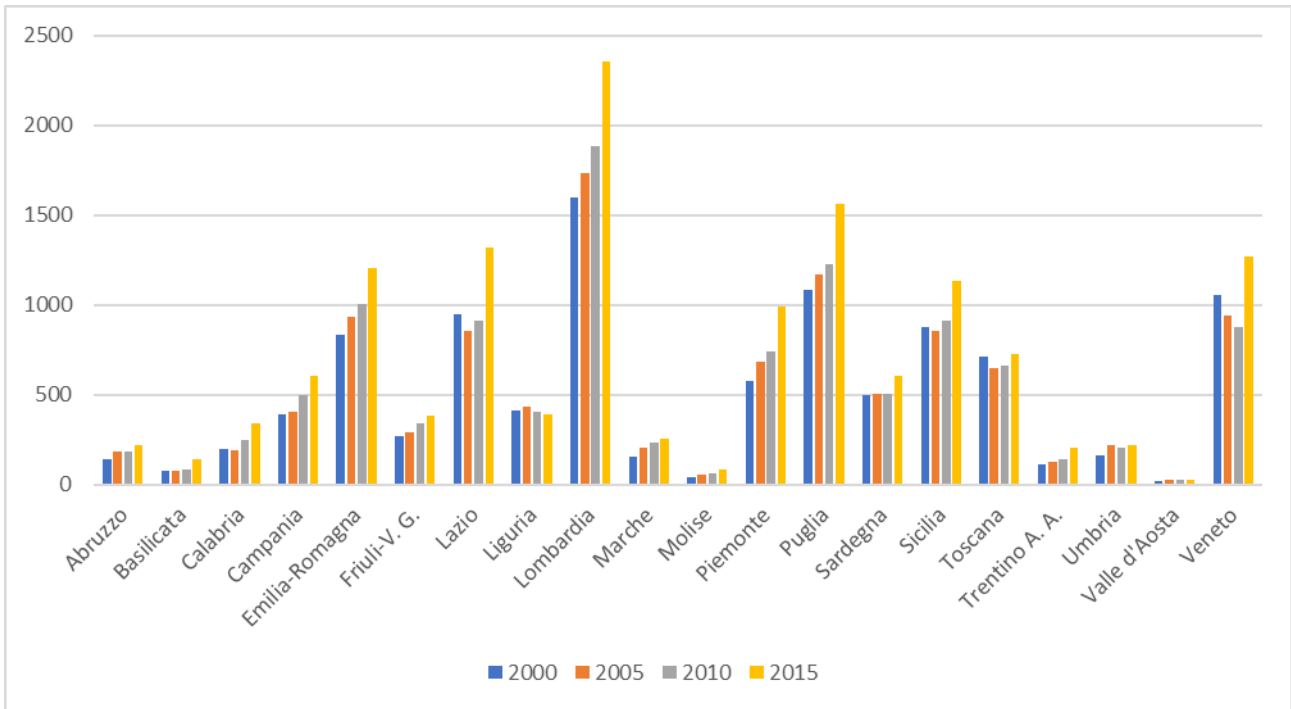
315 **Figure 5 GS as % of Italian regional GDP in 2000 and 2015.**

316 Regions with similar GS in 2000, as for example Molise and Puglia, present in 2015, a worsening
 317 position although the pace of changes differs. The temporal change in GS is another dimension of
 318 the indicator which needs to be considered by policy makers. Southern regions (especially
 319 Campania, Calabria, Puglia, Sicilia and Sardegna) present higher GS values in 2000 and 2015
 320 suggesting a more sustainable management of the total capital compared to the Northern regions.

321

322 Considering now the data available for the damages to single environmental components we can
 323 further detail the heterogeneity of Italian regions in terms of sustainability measures. The Northern
 324 regions such as Lombardia and Veneto present a higher level of CO2 emission when compared to
 325 the rest of the country. Among Southern ones, Sicilia and Puglia show a remarkable level of
 326 emissions; few regions report a (modest) reduction from 2005 onward (Figure 6)

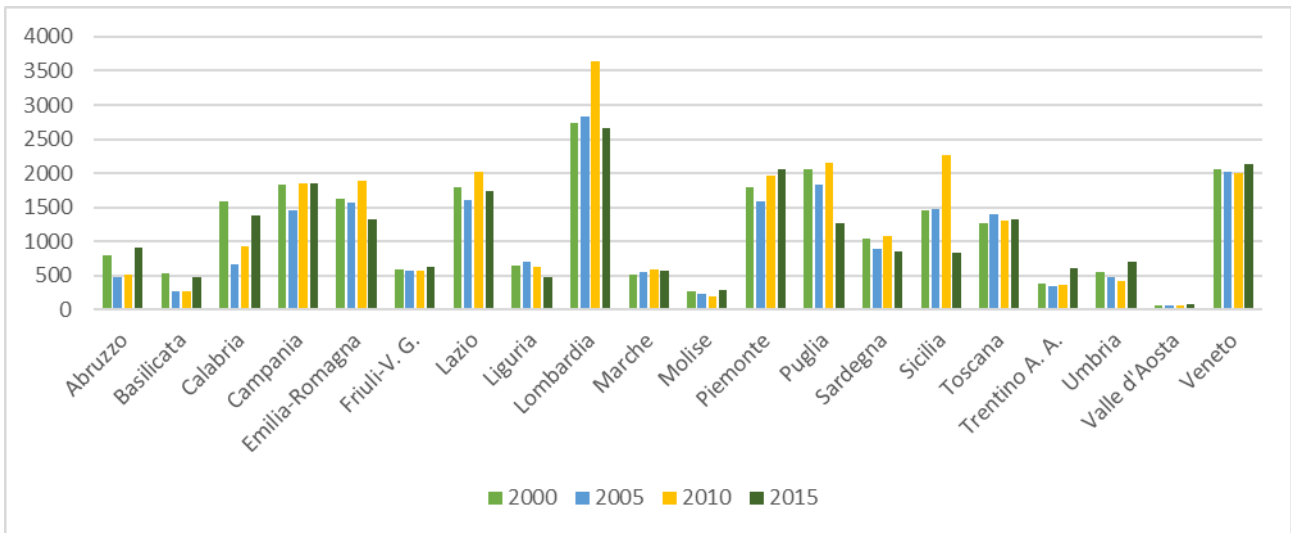
327



328

329 **Figure 6. Economic losses due to CO2 emission in Italian regions (millions of euro)**

330 In terms of air quality degradation due to PM10 emissions, the economic impact of pollution
 331 remains a serious issue despite the continuous reduction from 2000 to 2015, especially in regions
 332 such as Lombardia, Emilia Romagna, Puglia and Sicilia (Figure 7).



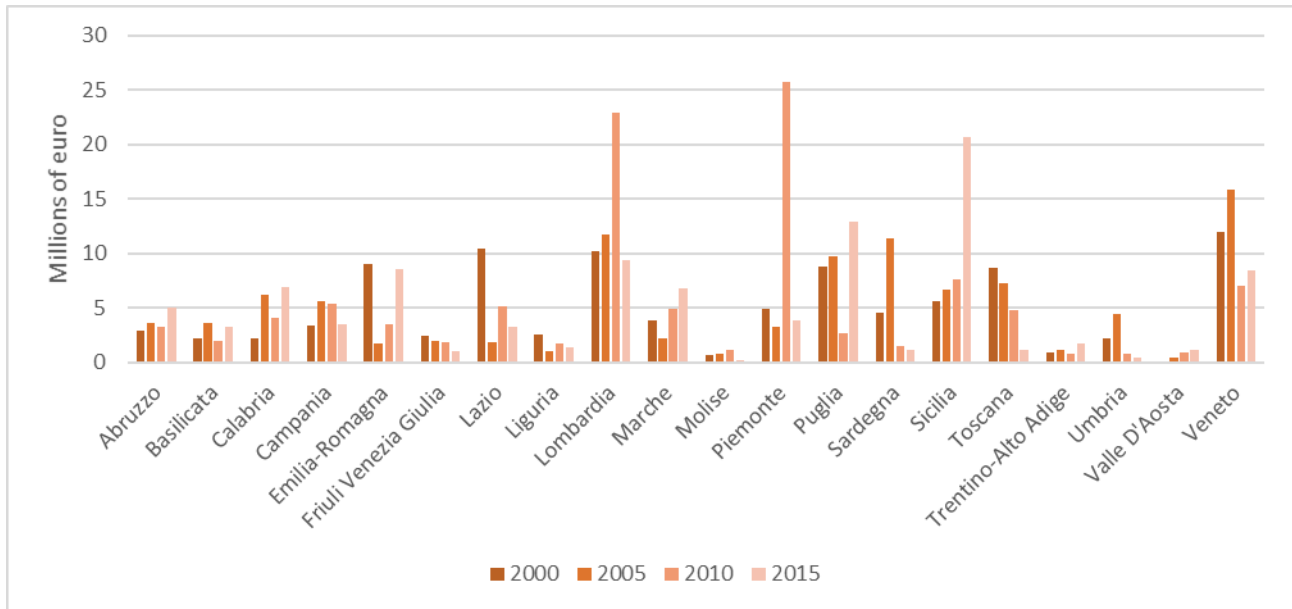
333

334 **Figure 7. Economic losses due to PM10 emission in Italian regions (millions of euro)**

335 Beside the analysis of air pollution in terms of CO2 and PM10 emissions, already included in the
 336 standard measures of the GS, we can provide also estimates of the damages to two further
 337 components of natural capital, i.e. soil and water. Figure 8 reports the loss of CO2 regulating
 338 service due to soil sealing. In 2010 the northern regions of Lombardia and Piemonte show the worst

339 performance although in 2015 other regions from the South (Sicilia and Puglia) follow a similar
 340 trend. Overall the soil sealing is not particularly pronounced in the period of study in the rest of the
 341 country.

342



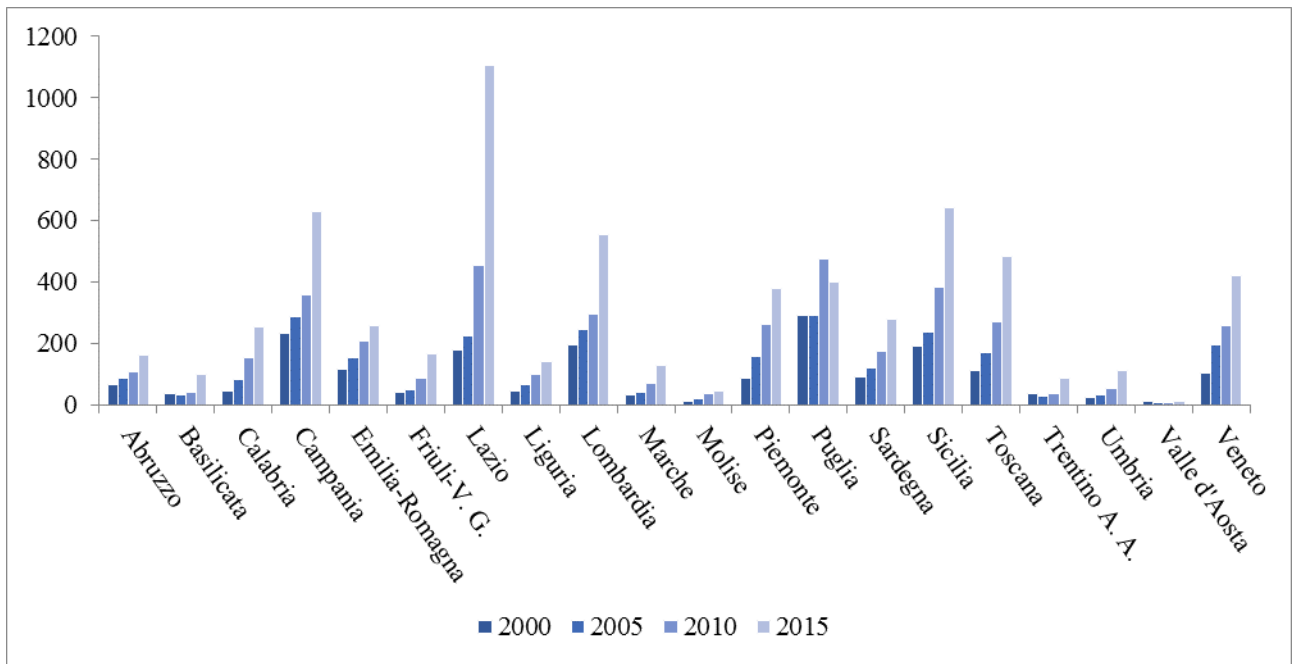
343

344 **Figure 8. Economic losses due to soil degradation in Italian regions (millions of euro)**

345 In general we can observe that industrial regions like Lombardia, Veneto and Emilia-Romagna
 346 present important impacts in term of pollutants (PM10 and water pollution) and soil sealing;
 347 contrary, they perform better in term of potable water losses (Fig. 9). In general the economic
 348 impact of water losses is more severe than soil disruption; in total water pollution and losses
 349 generates an economic loss of approximately 9000 million of euro in 2015 (that represents 0.56% of
 350 GDP). In this case, Southern regions perform worse. Puglia, Lazio and Sicilia have the most severe
 351 level of potable water losses (Fig.9). On the contrary in terms of water pollution Northern regions
 352 are still prevailing on the rest of the country (Fig.10).

353

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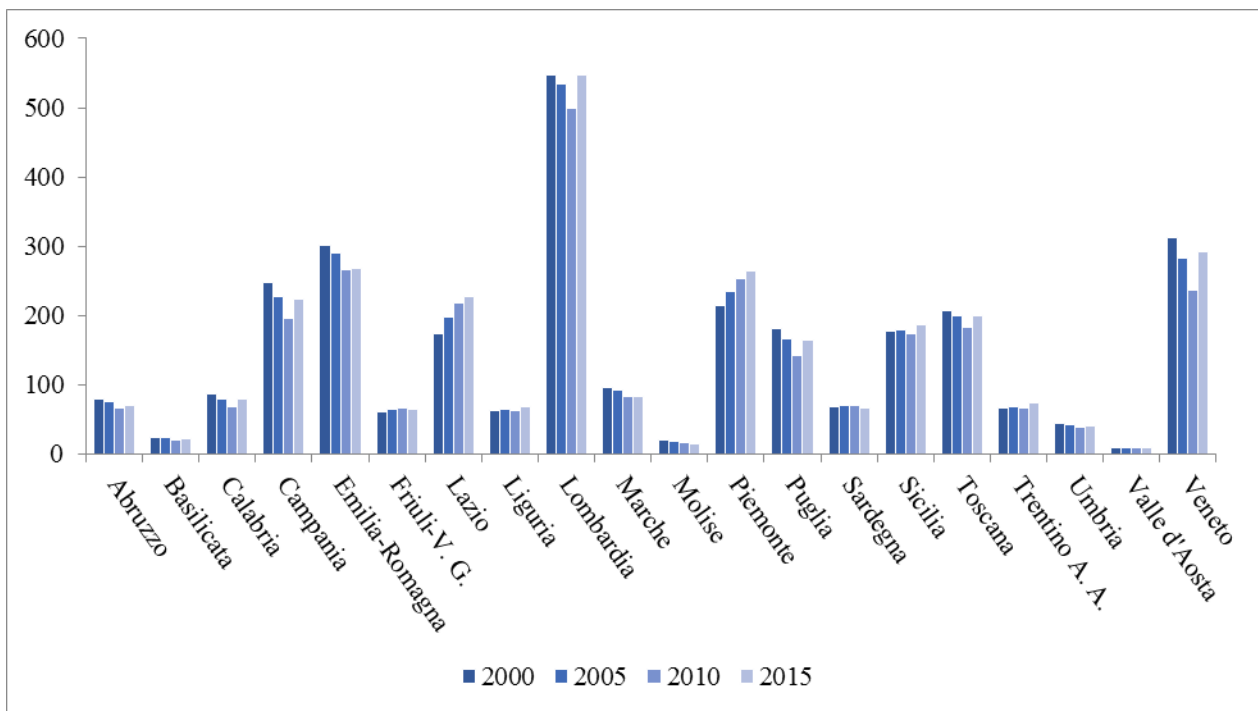


355

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Figure 9. Economic losses due to potable water losses in Italian regions (millions of euro)

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Figure 10. Economic losses due to water pollution in Italian regions (millions of euro)

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For 2015 figure 11 summarizes the regional economic losses due to PM, soil and water presenting the values in terms of regional GDP. Not surprisingly, when each figure is expressed in relative terms, the relative importance of economic losses due to air, soil and water components at the regional level is subject to a remarkable change with respect to absolute value.

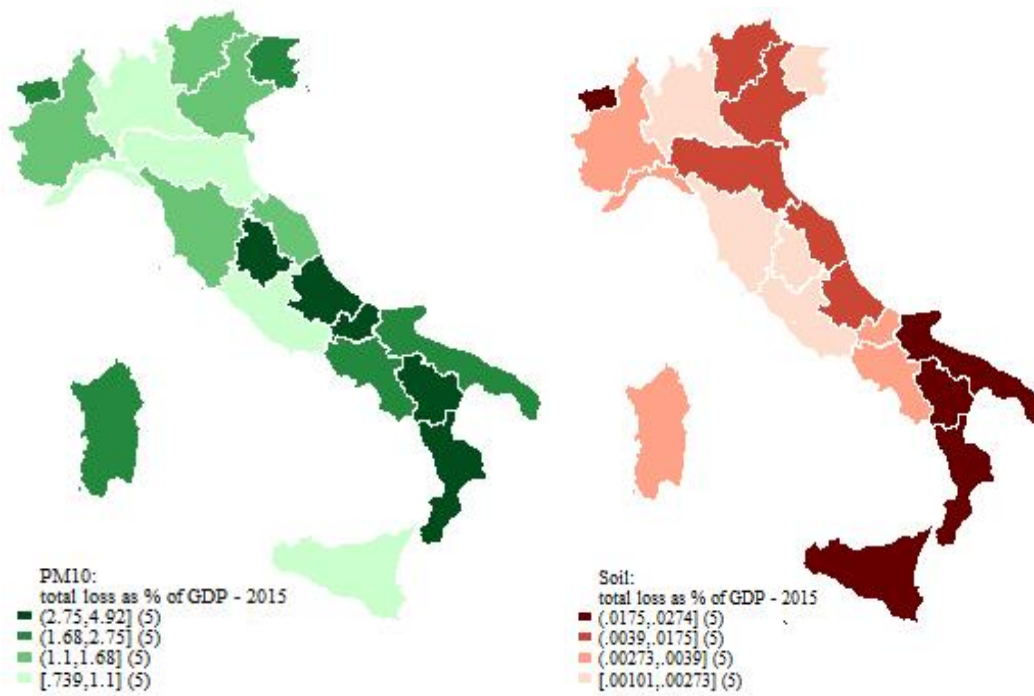
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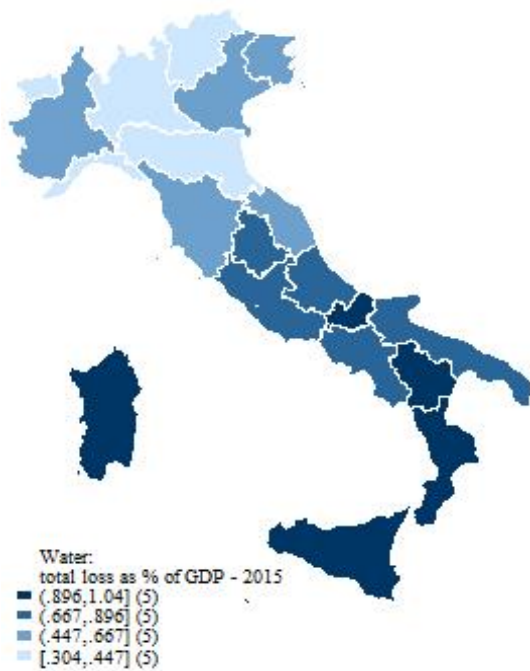
367 PM10

b) Soil sealing



368

369 a) Water total losses



370

371 **Figure 11. Economic losses due to PM10, soil and water losses in Italian regions (% of GDP)**

372 Complementing data in table 1 with water and soil data in table 2 we derive the extended regional
373 GS. On average regions present an additional impact in absolute terms of roughly 1% due to water
374 and soil losses, however considering the relative variation the impact is more significant. For
375 example Molise in 2010 presents a standard GS of 2.29% (min level in Table1) but after including

376 soil and water the GS drops to 1.50% with a relative impact of roughly 30%. These assets
 377 contribute significantly to express the sustainability of growth in the Italian regions. Table 2 shows
 378 that more Regions are closer to zero and at risk to fail the test of sustainability than in Table 1.

379 **Table 2. Extended Genuine Savings in Italian regions including water and soil (as % of regional GDP).**

	2000		2005		2010		2015	
	Min	Max	Min	Max	Min	Max	Min	Max
Abruzzo	6.90%	9.16%	7.67%	8.85%	1.69%	2.85%	1.15%	3.16%
Basilicata	4.82%	9.21%	-4.17%	0.58%	-13.35%	-7.53%	-16.91%	-6.17%
Calabria	6.81%	10.97%	9.35%	10.82%	2.32%	4.27%	0.73%	3.68%
Campania	10.91%	12.44%	10.33%	11.36%	4.35%	5.60%	4.29%	5.53%
Emilia Romagna	5.30%	6.34%	5.27%	6.11%	0.27%	1.21%	1.52%	2.14%
Friuli Venezia Giulia	5.89%	7.36%	5.66%	6.85%	0.71%	1.82%	0.80%	2.00%
Lazio	6.66%	7.57%	5.96%	6.61%	1.42%	2.18%	1.75%	2.40%
Liguria	6.06%	7.25%	4.64%	5.74%	0.61%	1.54%	1.44%	2.13%
Lombardia	6.37%	7.11%	5.86%	6.49%	0.91%	1.63%	1.92%	2.43%
Marche	6.75%	8.05%	5.64%	6.74%	1.03%	2.17%	1.77%	2.95%
Molise	7.23%	10.82%	6.69%	9.28%	0.53%	2.52%	-0.60%	2.82%
Piemonte	6.93%	8.27%	6.39%	7.31%	0.87%	1.98%	1.64%	2.75%
Puglia	6.72%	9.26%	6.80%	8.73%	1.56%	3.71%	2.36%	3.67%
Sardegna	7.29%	10.12%	7.21%	9.21%	-0.23%	2.01%	0.42%	2.18%
Sicilia	9.56%	11.11%	8.49%	9.78%	2.23%	4.13%	3.49%	4.49%
Toscana	6.48%	7.56%	5.85%	6.85%	1.55%	2.40%	1.91%	2.73%
Trentino Alto Adige	8.99%	9.94%	9.33%	10.08%	2.37%	3.05%	2.30%	3.35%
Umbria	6.45%	8.61%	5.42%	7.03%	1.01%	2.35%	0.14%	2.38%
Valle d'Aosta / Vallée d'Aoste	8.85%	10.08%	7.06%	8.07%	1.13%	1.96%	1.34%	2.54%
Veneto	5.87%	7.12%	5.88%	6.89%	1.06%	2.01%	1.46%	2.41%
Italia	6.90%	8.23%	6.44%	7.44%	1.23%	2.33%	1.78%	2.79%

380
 381 Figure 12 maps the 2015 regional extended GS for Italy. Two regions have a negative Genuine
 382 Savings and four regions are below 1%. However, it is worth noting that most of territories are very
 383 close to the threshold that signals unsustainability, according to the weak sustainability perspective
 384 of the indicator. The index provides a synthesis of the interaction between the economic
 385 performance and the management of natural resources; in general the economic slowdown is
 386 associated with a reduction both in the level of savings and in the pressure on resources, such as
 387 water and air pollution; this is the case for Italy, as it emerges in our data. On the contrary,
 388 expansive phases may boost the level of savings, with a positive impact on the index, but also
 389 environmental degradation is expected to increase. Monitoring this trends may offer useful insight
 390 in that respect.

391 The strength of these two contrasting forces is captured by the index, and will determine the overall
392 impact on long term sustainability. Contrasting results in Tab 1 and 2 we can appreciate the
393 importance of accounting for the degradation of natural capital and its components. For example,
394 Sardegna in 2010 presented a GS (Min) of 0.52% but once a wider set of natural components is
395 accounted for the GS in 2010 becomes -0.23 with a relative decrease of more than 144%. Other
396 regions present a more modest relative impact of the inclusion of additional natural resources on the
397 measurement of GS: for example in Campania in 2015 the (Max) GS without natural resources is
398 equal to 6.37% while the extended indicator is 5.53%. On average the worsening regional estimates
399 of GS due to the inclusion of soil and water depletion is between 5% and 33%.
400



401

402

Figure 12. Extended Genuine Saving for Italian regions in 2015 (% of GDP)

403

404

405

406 **5. Conclusion**

407 The pressure on natural resources and a broader attention on sustainable development goals stress
408 the importance to develop consistent and simple indicators. The Genuine Saving is a sustainability
409 indicator that can signal if a country is over consuming its wealth. As a comprehensive indicator of
410 wealth the Genuine Saving can play a promising role in supporting sustainable development
411 although drawbacks need to be addressed. This paper proposes an extended measure of Genuine
412 Saving that include soil and water degradation and tests its suitability to be implemented at the
413 subnational level (NUTS2 regions). to capture the heterogeneity of natural capital assets and
414 provide richer information to policy makers.

415 In the empirical application the paper estimates the amount of Genuine Savings for Italian regions
416 in the period 2000 - 2015, including the economic losses related to soil sealing, water pollution,
417 drinkable water dispersed. Results show a considerable reduction in the amount of Genuine Savings
418 across Italian regions in the period 2000-2010. According to our estimates several regions present
419 alarming performance in the weak sustainability test for 2010; nonetheless, only one region
420 (Basilicata) shows a value of the index that is persistently well below the sustainability threshold.
421 On average the negative impact of soil and water depletion is 1% of the regional GDP but the
422 spatial diversity of impacts is substantial. Central policy makers could use GS results to establish
423 across regions compensations to support the depletion of non-renewable assets that benefits the
424 whole nation but at the costs of threatening the sustainability of a single region (as in the case of oil
425 and gas extraction in Basilicata).

426 Tailoring the analysis at the regional level and accounting for the depletion of these important
427 natural capital assets, the Genuine Saving indicator can better reflect the trends in natural resource
428 management and help in detecting specific threats and priorities that should be considered to secure
429 a sustainable development path.

430 The methodological development of the indicator captures relevant natural capital assets that can
431 complete the picture of wealth captured by the standard World Bank Genuine Saving. For example,
432 soil sealing reduces the productive potential of land, and has also a negative impact on biodiversity.
433 Water quality and quantity impact productivity, other ecosystem services and human wellbeing well
434 beyond the dimension included in this analysis. The paper aims at improving the measurement of
435 national capital assets using available data for better assess the sustainability of development of sub-
436 national areas. Results show that the extended Genuine Saving might represent a promising macro
437 indicator that can complement non-monetary indicators like the OECD Better Life Index or the
438 Italian Equitable and Sustainable Well-being indicators.

439

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