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Extending the Genuine Savings estimates with natural capital and poverty at the regional and national level in Italy

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A B S T R A C T

Efforts to improve the Genuine Savings, a widely accepted index to assess the weak sustainability of an economy's development, have led to the creation of a broad body of literature that aims to produce more robust macroeconomic indicators for policy decision making. However, the various approaches to natural capital welfare accounting results in conflicting indicators of change. It is also the case that the inclusion of natural and social capital components is still scant. This paper addresses this gap by extending the traditional Genuine Savings methodology by including some natural capital components (e.g. flood protection, water purification) and the poverty dimension through a deontological approach. Although not offering a silver bullet solution, our approach proposes a pluralist and pragmatic improvement from 'weak' towards 'stronger' sustainability indicators. Results highlight the availability of data and information produced by different initiatives including the United Nations System of Environmental-Economic Accounting guidelines. The empirical application provides Genuine Savings estimates for Italy from 2006 to 2012 and from 2012 to 2015, shedding the light on the importance of natural capital and social considerations at national and regional level.

1. Introduction

A pertinent question of our time is "Are a country's resources managed equitably and sustainably both for present and future generations?". The awareness that a well-performing economy and society should be both as efficient as is feasible and as equitable as possible is now more widely accepted. The conventional measure of economic growth, the gross domestic product (GDP), is a useful but not sufficient indicator of an economy's progress in terms of economic welfare/well-being. Growing inequality in income and wealth is a global concern and the question of how to convert a country's wealth into a performance metric or collection of indicators is a prominent topic in economics and policy analysis. Policies that aim to reduce inequalities and poverty also improve sustainability but require more comprehensive metrics than GDP, and a wider view and integration with national/international performance indicators and Systems of National Accounts (SNA). Moreover, a renewed concern regarding economic divergences between countries, interregional disparity, and the necessity to track development paths has made clear the urgent need to assess economic performance and social progress more comprehnensively.

The Genuine Savings (GS), also known as Adjusted Net Savings (ANS), is a well-known indicator for providing policymakers with a measure of sustainable development. The GS has faced criticism for being either an insufficient measure due to the difficulty in calculating changes in human, natural, and social capital components on which it is based (in addition to the man-made or produced capital); or for being a single indicator to assess a country's 'weak' sustainable development when compared to a 'stronger' sustainability and more comprehensive dashboard approach. However, as a measure of weak sustainability, it has the merit of fitting well with established national income estimation practices and relies on data that allow consistent international comparability.

The restricted form of the GS indicator makes its possible extension a policy relevant topic for further investigation. For example, while the

Abbreviations: ANS, Adjusted Net Savings; GS, Genuine Savings; ES, Ecosystem services; PG, Poverty Gap; PH, Poverty Headcount; SEEA-CF, System of Environmental Economic Accounting - Central Framework; SEEA-ES, System of Environmental Economic Accounting - Ecosystem Accounting; SNA, System of National Accounts.

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depreciation of fixed capital can be estimated using the well-established accounting rules provided by the System of National Accounts (SNA), a substantial body of theoretical and empirical research seeks to enhance the estimates of the human and natural capital components alongside the more intangible social capital asset.

This paper provides an expansion of GS computation focusing on natural capital and the inclusion of poverty as a valuable starting point for further debate on social and welfare dimensions of macro indicators. In the case of natural capital, the paper deploys the development of natural capital accounting initiatives and recent guidelines (UN United Nations, 2021b; La Notte et al., 2017) for the GS methodology (World Bank, 2023b). Poverty is linked to GS by adopting an additional deontological ethical perspective. Our argument for this pluralist (utilitarian and deontological) approach is that sustainable development is a normative concept and in all its forms requires the adoption of some combination of rules/social contracts. Poverty alleviation is usually linked to the acceptance of a minimum standard of living rule sufficient to meet basic human needs. This 'safety net' has been cast in deontological terms through various arguments about, among others, the need to enhance human capabilities (Sen, 1999), social justice concerns (Nussbaum, 2006) and on humanitarian grounds (Pringle and Hunt, 2015). The related concept of inequality linked to persistent relative poverty also raises instrumental (inefficiency costs) concerns (Stiglitz, 2012). Our extended indicator is empirically applied in Italy where GS estimates are provided at national and regional level.

Results highlight the significance of including natural and poverty dimensions in the context of sustainable development monitoring. Moreover, the regional analysis helps to investigate the heterogeneity of sustainability that could be hidden at the national scale.

The present paper makes novel contributions in two domains: i) conceptually, by associating the GS framework with the SEEA EA natural capital components and by including the poverty measure via an additional ethical perspective; ii) empirically, by applying the novel approach at the regional scale in Italy to reflect on the role of natural capital and poverty in the Italian sustainable development pathway.

The paper is structured as follows: Section 2 introduces the Genuine Saving, its link with the sustainable development concept and previous empirical studies; Section 3 explains the methodological framework used to estimates the GS; data and the empirical calculation are described in Section 4; Section 5 presents and discusses results and Section 6 concludes.

2. Genuine savings and previous applications

The complexity and multidimensionality of sustainability and challenges to capture all aspects in a single or a set of indicators have led to the development of several tools and many indicators, such as the Adjusted Net Savings, comprehensive wealth measures (Hamilton and Clemens, 1999; Dasgupta and Mäler, 2000; Arrow et al., 2012). However, their use has remained largely academic despite efforts to revise GDP or supplement the System of National Accounts (SNA) with satellite accounts to inform national-level economic decision-making.

The Genuine Saving (GS) was the first widely accepted adjustment to national accounts. Its theoretical foundation is well established and rooted in economic theory and utilitarian philosophy. The GS is an index of weak sustainability that assumes substitutability across different forms of capital. It aims to measure the "genuine" savings, that is the value of the change in wealth linked to not only produced capital but also other forms of capital such as natural, social and human capital in a specified period of time. In other words, the GS is equal to the sum of net changes in all included capital stocks valued at their constant shadow prices.

The GS is built on the framework of green national accounting and the rearrangement of the Hartwick rule - invest non-renewable resource rents in other assets - (Hartwick, 1990; Hartwick, 1997), and aims to track a weak sustainable development path i.e., above or equal to zero. A persistently negative value of the GS signals unsustainable development and an insufficient rate of produced capital accumulation.

Moving from theory to practice, the SNA needs to be adjusted to include changes in other capitals (e.g., human, natural, social) to assess whether the overall capital stock of a country is increasing or decreasing. The first empirical estimates of Genuine Savings were computed by Pearce and Atkinson (1993). Today, the World Bank publishes annual estimates of comprehensive savings for over 100 countries[1] (World Bank, 2023b).

Several studies have expanded the Genuine Savings to include other measures. For example, recent papers focus on the inclusion of natural and human capital and others have applied different methods to compute each component of GS and compared their results with the World Bank estimates (Ferreira and Moro, 2011; Qasim et al., 2020; Biasi et al., 2019).

Ferreira and Moro (2011) compute the GS index for Ireland over the period 1995–2005. They use official Irish sources and a methodology which differs from the World Bank version. For example, they limited the use of international averages and estimates, and the depreciation of marketable natural resources is based on the net present value method of resource rent.[2] They expand the valuation of environmental degradation by including estimates of external costs from sulfur dioxide (SO2) and nitrogen oxides (NOx) emissions in addition to PM10 and CO2 emissions. They find that their estimates are smaller than the World Bank values and, contrary to the World Bank estimation, they show that Ireland experienced negative or close to zero genuine savings from 1995 to 1997 and a positive and increasing GS in more recent years.

Qasim et al. (2020) improve GS estimates for New Zealand from 1950 to 2015 by using a longer time series of data and adding additional dimensions. They include the rents from forest depletion that play a vital role in considering the sustainability of the New Zealand's economy, as the forestry industry contributes to an average of 3.4 % of GDP annually (about $4.8 billion in 2017). Their results show that New Zealand's GS has been positive over their data time series; but they also highlight a decline in forest volume due to land use changes for dairy farming and agriculture, which resulted in a reduction in the GS.

Biasi et al. (2019) proposed an extended version of the Italian Genuine Saving to capture water and soil losses and report that they represent significant proportions of regional and national GS (about 1 % of GDP at national level and between 5 and 33 % of GDP at the regional level).

These studies, it can be argued, have made the World Bank and Genuine Savings' adjustments more policy relevant since they use more reliable and updated regional and national data sources and methodologies. At the same time, these studies are dated, and other further extensions are possible. The current paper aims to deploy the wealth of data produced by the SEEA EA studies (UN United Nations, 2022) and Italian Statistics Office. To the best of our knowledge, the inclusion of ecosystem services accounting estimates and the poverty measure in relation to the GS is novel and offers a promising line for future 'sustainability 'macroeconomic indicators.

3. Methodology

The Genuine Savings is linked with economic wealth theory and its foundations. Hamilton and Clemens (1999) developed the formal model that was revised by Dasgupta and Maler in 2000 and by Asheim and Weitzman in 2001. Pearce and Atkinson (1993), Hamilton et al. (1997), and later Hamilton and Clemens (1999) calculated the cross-country estimates of GS including man-made capital, depletion of natural

[1] https://datacatalog.worldbank.org/search/dataset/0037653

[2] The resource rent is the difference between the price at which an output from a natural resource (e.g. oil, gas) is sold and its respective extraction and production costs

capital and investment in human capital.

The wealth of an economy, W, at time *t* can be expressed as the sum of a comprehensive set of assets (man-made capital, human capital, natural capital) evaluated at their shadow prices. Considering the aim of this analysis, formally we can write the wealth of an economy as follows:

$$W_t = k_t K_t + \mu_t H_t + \lambda_t N_t \quad (1)$$

where K is the man-made capital, H is the human capital and N is the natural capital and k, μ, λ are their respective shadow prices.

The capital assets contribute to the societal well-being (V) which, using a Ramsey-Koopmans formulation, $V_t = \int_t^{\infty} U(C_s, Z_s) e^{-\rho(s-t)} ds$ where C_t is the consumption level and Z_t represents the minimum level of consumption (or poverty line).[3] It can be shown that under certain assumptions - constant population, stationary technology - the change in W under constant prices, or Genuine Savings (GS), equates to the change in societal well-being:

$$\frac{dV_t}{dt} = GS_t = k_t \frac{dK_t}{dt} + \mu_t \frac{dH_t}{dt} + \lambda_t \frac{dN_t}{dt} \quad (2)$$

Eq. (2) states that the value of changes in comprehensive wealth has the same sign as the corresponding change in inter-generational well-being. Conceptually, the GS indicates whether a country is saving for future generations by summing up total annual changes in a country's natural, human, social and fixed capital. If the sum of these values is positive, then the societal welfare is increasing, and this contributes to sustainable development. If the value is negative the current generations may be depleting resources and the future development may be unsustainable. In other words, the GS is an indicator to assess an economy's sustainability by defining wealth as the value of the net change in the whole range of assets that are important for development (produced assets, natural resources, human resources, social assets).

The units and terms used in the computation of the GS have policy traction in the sense that they are commonly understood and accepted in financial circles. However, there are drawbacks and the GS's limits have long been debated even by its creators. For some analysts the main limit is the scarcity of available data which hampers the production of a theoretically sound index. Other critics of GS point out that it is an incomplete measure of changes in natural capital and an imprecise measure of changes in human capital (Daly and Posner, 2011; Howarth and Kennedy, 2016).

Referring to natural capital, the World Bank GS computation preserves its essential and original methodology accounting for only a few natural resource depletions (World Bank, 2023b). However, in recent years the attention paid to natural capital and ecosystem services has exponentially increased. Initiatives like the INCA (Integrated system for Natural Capital Accounting), KIP INCA (Knowledge Innovation Project on Integrated System for Natural Capital Accounting) and LISBETH (LInking accounts for ecosystem Services and Benefits to the Economy Through bridging) promoted by European Commission offer theoretical and practical improvements allowing for better integration of natural capital and ecosystem services into the SNA (La Notte et al., 2017).

In the last decade the System of Environmental Economic Accounting Central Framework (SEEA-CF) and the SEEA Ecosystem Accounting (SEEA EA) were developed. The SEEA-CF accounts focus on the stocks and changes in productive assets such as minerals, timber, and land, while the SEEA-EA framework measures ecosystem assets and their associated goods and ecosystem service flows in relation to the well-being society and economy. The SEEA-EA includes physical (extent, condition, services) accounts and suggests monetization of these effects. In other words, the ecosystem accounting system is developed for multiple aims: i) to record and explore relationships and track changes in ecosystems extent (e.g. size) and condition; ii) to measure the interaction between ecosystems and the economy.

In 2021, the INCA project released the first pilot estimates for multiple ecosystem services (pollination, crop and timber provision, water purification, flood protection, carbon sequestration and recreation) for the EU but nowadays policy uses are still limited. Turner et al. (2019) noted that monetary quantifications in SEEA applications are still problematic, but a dashboard of indicators compiled as Complementary Account Network is a pragmatic approach to mainstream ecosystem measurements in decision-making.

The natural capital and the value of ecosystem services are linked. According to Turner et al. (2015), the environment can be viewed as stocks of natural capital assets that provide flows of ecosystem services linked to the economy and human well-being which are valued in utilitarian units. In other words, ecosystem services are biophysical flows from natural capital stocks from which humans derive benefits, including provisioning, regulating, and cultural services (Fisher and Turner, 2008; UN United Nations, 2014; Potschin et al., 2016).

Accordingly, one way to measure the value of natural capital that provides ecosystem services is to predict the value of the flow of services through time generated by the natural capital and compute a present value of these flows (UN United Nations, 2012 page 200–201). The Net Present Value (NPV) approach is applied in this paper to account for the natural capital proxy by water purification and flood control ecosystem services which are classified as regulating ecosystem services.

Formally, the value of natural capital (N) at the end of a period t - that will plug in Eq. (1) - is computed using the NPV as follows:

$$N_t(EA) = \sum_{i=1}^{i=S} \sum_{j=t}^{j=t+T} \frac{ES_t^{ij}(EA_t)}{(1+r)^{(j-t)}} \quad (3)$$

where ES_t^{ij} is the value of ecosystem service *i* in year j as expected in period t generated by a specific ecosystem asset EA_t, S is the total number of ecosystem services, *r* is the discount rate, and T is the lifetime of the asset (UN United Nations, 2021b).

For the regional and national GS estimates, we use the NPV approach for ecosystem services valuation to assess the change in natural assets over time.

Fig. 1 summarises the main steps to compute the GS indicator at national and regional level highlighting the estimate of natural components using the natural capital accounting framework.

Shifting focus onto the minimum level of consumption (or poverty line), we highlight that the traditional GS does not account for social disparity or poverty. According to Thiry and Cassiers (2010), the lack of a distribution component is due to the theoretical framework on which GS is based and how the societal wellbeing function is formulated. It focuses attention on a representative individual rather than the whole community. They also state that it is a common feature of other social well-being functions which do not provide any type of mechanism that attributes different weights to different interests and stakeholders.

This paper provides a starting point for further debate about poverty and sustainability in the GS analysis. There are, of course, challenges with the approach we suggest, so we must be clear about some of them.

Inequality is often linked to economic inefficiency and extreme inequality leads to poverty (Stiglitz, 2012). Poverty is defined as the condition experienced by people who have insufficient resources to access goods and services necessary for a minimal or socially acceptable living standard.

The impact of poverty is multi-dimensional with effects (usually negative) on individual wellbeing, economic activity, crime levels, education, healthcare and social conduct. Previous economic studies confirm that poverty is linked with productivity and environmental degradation (UN United Nations, 2021a); these interconnections affect

[3] The definition of the social well-being function has adapted to be a hybrid of discounted utilitarianism and deontology by including the minimum level of consumption.

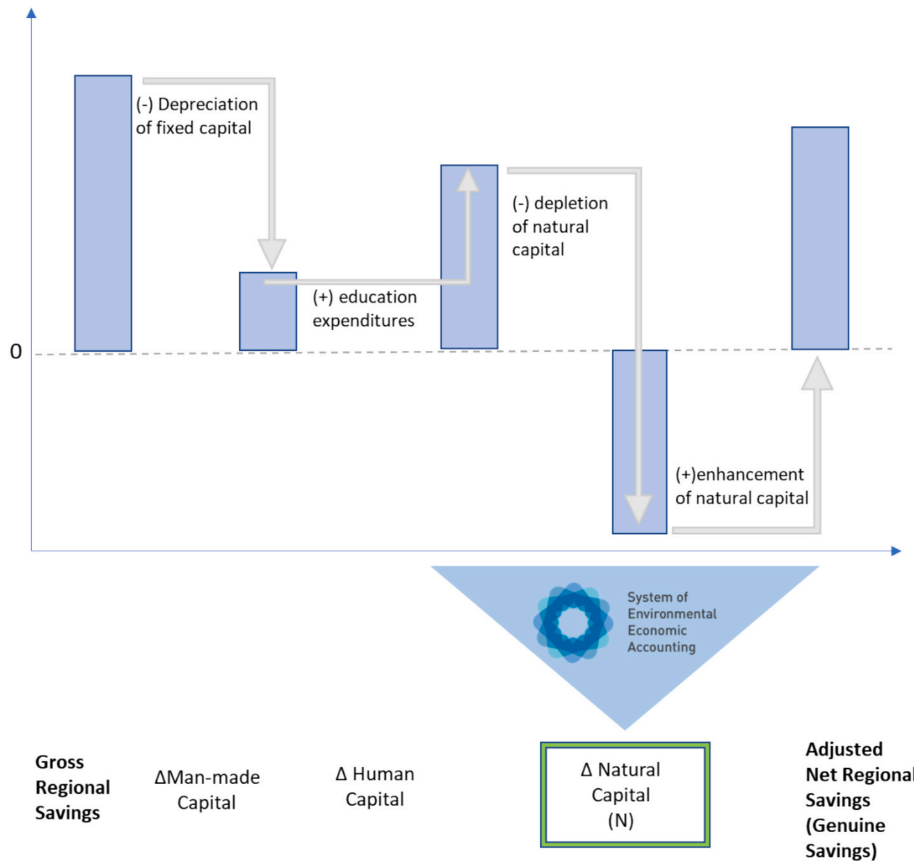

Fig. 1. Computation of extended Genuine Savings at regional level.

the sustainability of development in a region, country, or the world. Poverty has a direct negative effect on the well-being of society, and this provides a strong deontological case to justify the introduction of a measure of it, within an indicator such as the GS.

We provide two possible alternatives for linking together poverty and the Genuine Savings indicator. The first is the use of a dashboard approach (Turner et al., 2019) in which the GS is complemented by poverty indicators over time such as the number of people with an income lower than the poverty line (according to the WB definition is 60 % of median income).

The second approach, the deontological GS, GS_t^D,(from a Greek word, *deon*, 'duty'), implies the adjustment of the indicator by quantifying the poverty measure in monetary term. Similar to the several contributions on the moral status of economic systems (see Paul et al., 1985; Pearson et al., 2012), in our deontological setting, sustainable development includes a moral duty such as the Rawlsian maximin criterion (Rawls, 1974) which provides a buffer/safety net against ongoing poverty. Therefore, a financial allocation and incentives such as cash transfer programmes, vouchers and subsidies to households must be implemented in order to ensure that individual' incomes is at least at the poverty line. In other words, G_P is the government expenditure for poverty alleviation.

Omitting the subscript t, the deontological GS, $\widehat{GS^D}$, is formally defined as:

$$\widehat{GS^D} = \frac{GS^D}{k} = \frac{dK}{dt} + p^H\frac{dH}{dt} + p^N\frac{dN}{dt} + p^D\frac{dD}{dt} \tag{4}$$

where D is the deontological capital to ensure minimum standard of living, and p^D is its shadow price, and $p^H = \frac{\mu}{k}$ and $p^N = \frac{\lambda}{k}$. We assume that the portion ϕ of G_P goes to pure consumption by the poor, and $(1-\phi)$ goes to investment to the accumulation of deontological capital, $\gamma_t\frac{dD_t}{dt}$.

Hence:

$$p^D\frac{dD_t}{dt} = (1-\phi)G_P \tag{5}$$

Given the change in produced capital in monetary term as:

$$\frac{dK_t}{dt} = F(K,N) - C - G_P \tag{6}$$

and by plugging (5) and (6) to (4), we have (omitting the subscript t),

$$\widehat{GS^D} = F(K,N) - C - G_P + p^H\frac{dH}{dt} + p^N\frac{dN}{dt} + (1-\phi)G_P \tag{7}$$

In practice, the cash flow for poverty intervention (G_P) needs to be quantified. Among the alternative quantification approaches (Adato and Hoddinott, 2007; Attanasio et al., 2009) here we will rely on the Poverty Gap (PG) and Poverty Headcount (PH) for quantifying the cash flow for avoiding poverty. This is the most pragmatic approach available for most Offices of National Statistics. Since Italy is a regionalized state, we determine for each region the spending for avoiding poverty multiplying the poverty gap by the number of poor people. This aggregated amount of money is multiplied by $(1-\phi)$ and added to the gross savings to compute the GS^D.

The Poverty Gap is the amount of money by which each individual falls below the poverty line.[4] In other words, the PG represents how much money would be necessary to allow poor people to reach at least the level of the poverty line.

In this application the PG per equivalent adult is computed following the World Bank guideline (World Bank, 2023a). Formally, the PG per

[4] The poverty line is defined by the World Bank as 60 % of the median households' income

equivalent adult can be expressed as follows:

$$PovertyGap = \sum_{i=1}^{M} (z_i - y_i) I(z_i, y_i) a_i \quad (8)$$

where i identifies the households, $z_i$is the poverty line for the i household, y_i is the disposable household income equivalent, $I(z_i, y_i)$ is a dummy variable that equals 1 if the household is poor, a_i is the equivalised household size and M is the number of total households.

The Poverty Headcount (PH) is the ratio between the number of poor people and the total population; it identifies the share of a population whose income is less than the poverty line.

$$\text{PovertyHeadcount} = \frac{N_p}{P} \quad (9)$$

where N_p is the number of the poor and $P = \sum_{i=1}^{M} a_i$ is the total population.

The poverty line for each region, based on the PG and PH estimates, is computed considering 60 % of median equivalent disposable household income following the World Bank definition.

Fig. 2 summarises the main steps to compute the deontological GS^Dindicator at national and regional level highlighting the estimate of social components using the poverty gap.

4. Data and calculations

To compute the GS, we start comparing the World Bank's guideline and the Biasi et al. (2019) sources and methods for then expanding the GS calculation by including components of natural capital (ecosystem services) and a poverty measure.

Appendix A includes the details of each component, the methodological reference and data source.

The Net National Saving is obtained from the Italian National Office of Statistics (ISTAT) and is disaggregated at regional level following Biasi and Rocchi (2016). Due to the unavailability of regional Net Savings data, they derived this measure by leveraging the strong correlation observed between Net Savings and Net Investment. We follow the same approach and the available regional Net Investment figures are used to derive the regional ratio. Regional public and private expenditures in education are included using statistics made available by ISTAT.

Data on CO_2 emission[5] are calculated by Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA, 2010) and valued with the cost of carbon[6]; PM Damage is estimated as the Willingness to Pay (WTP) to avoid mortality and morbidity attributable to particulate emissions and it is costed as suggested by the World Bank. Data on PM emission disaggregated on regional basis are derived from Biasi et al. (2019).

Ecosystem services are monetized following the INCA outputs (e.g. cost-based approaches) and the NPV is determined to assess the change in natural assets over 2006–2015. Firstly, the Net Present Value is computed using a 4 % discount rate on the constant flow value over 100 years for 2006, 2012 and 2015.[7] Secondly, the change in natural asset is estimated using the difference between the natural stocks for the years of analysis (2012 and 2015).

Using the ecosystem services valuation framework, energy resources are considered for provisioning ecosystem services from which people derive benefits by extracting them from nature. The depletion of energy resources is computed using oil and gas extraction. Data on quantity extracted and the value of unit rent[8] are provided respectively by the General Directorate for Energetic Resources of the Italian Ministry of Economic Development and the World Bank.

For the regulating ecosystem services, water purification and flood control the quantification of yearly flow is already spatially available in the INCA project website where it was extracted with geographic information system.[9]

Flood control is the capacity for reducing or retaining runoff water and protect downstream infrastructure and residents from flooding. Several ecosystems such as wetlands, forest, cropland and urban area have the ability to reduce the speed of runoff water during heavy rain or store water temporarily in the soil. The physical accounts of flood control are based on a spatially explicit modelling of the water retention capacity of different ecosystem types located in floodplains (e.g. urban, cropland, grassland, forest, wetlands) and an assessment of the infrastructure and residential areas that are at risk is considered in the model outputs (Vallecillo et al., 2020). The monetary accounts are based on avoided damage costs meaning the costs that would have been occurred in absence of the protective functions of ecosystems. The damage costs are based on a function developed for Italy considering different economic assets, for example, road, buildings, agriculture (La Notte et al., 2017 page 76).

Water purification is the self-purifying capacity of rivers and lakes, wetlands and soils, and groundwater systems at removing excess nutrients and pollutants. In INCA for the physical estimates, the eutrophication sustainability threshold is used as an indicator to guarantee a minimum standard for good ecological status for rivers and lakes. The monetary accounts are based on replacement costs (e.g. artificial constructed wetland) which will be needed if water purification service is lost (La Notte et al., 2017).

For the poverty adjustment, the Poverty Gap (PG) and PH indicators at regional level are based on income and living conditions survey provided by the Italian Statistics Office (ISTAT) for 2006, 2012 and 2015. The total value of poverty by regions relies on own data elaboration of the PG and PH using the EU SILC survey data.

For the portion of government expenditure for poverty alleviation that goes to investment in the accumulation of deontological capital, the value of $(1 - \phi) = 0.08$ is used as the gross savings rate in Italy was 6.7 % in 2012 and 8.3 % in 2015 (ISTAT, 2024).

5. Results

We first present the ecosystem assets estimates and the value of adjustments for natural capital which enable the calculation of Genuine Savings with changes in natural capital denoted as GS^N. Subsequently, the GS^N linked with the poverty measure both at national and regional level is introduced. For this, we refer to the deontological GS, denoted as GS^D, while the unadjusted Genuine Savings as GS^U.

5.1. GS and SEEA EA

While some components of the GS came from the SNA, others are computed using a set of country's available data sources (See Appendix A). Our empirical analysis indicates that the SEEA EA natural capital estimates can be a valid standardised way to compute accurately the changes in natural asset to be included in the GS indicator.

Tables 1, 2 and 3 show the value of provisioning (oil and gas extraction) and regulating (flood control and water purification)

[5] From 1990 to 2006, the CO2 emission are interpolated for the following years; ENEA (2010) includes regional emissions from agriculture, manufacture, transport sector and household

[6] CO_2 cost is derived by Sartori et al. (2014) and considering the Office of Information and Regulatory Affairs report (2013).

[7] Following Vandermotten et al. (2021) the chosen discount rate is 4 % which is the average of the standard European benchmark discount rate which is 3–5 %.

[8] The value of unit resource rent (constant) is the average of unit rent for the period of analysis

[9] Q GIS (version 3.16), a free and open-source cross-platform desktop geographic information system, is used

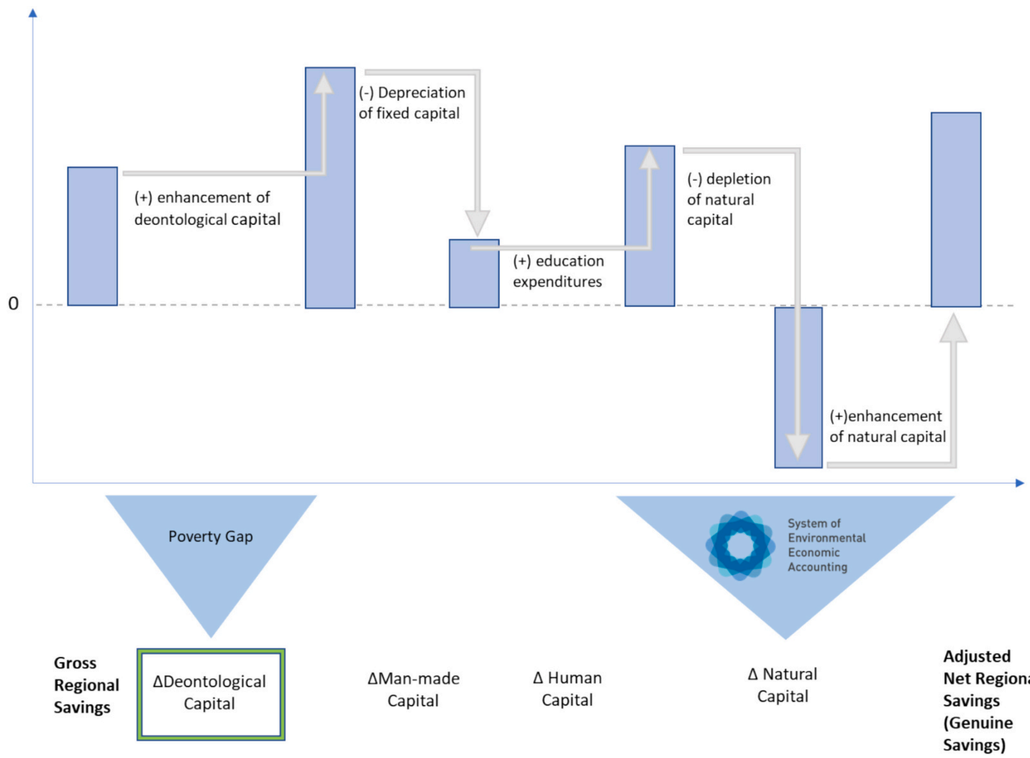

Fig. 2. Computation of deontological Genuine Savings at regional level.

Table 1
Value of natural capital adjustment for oil and gas provision ecosystem service.

	Oil and gas adjustment		
	Million €		
Region	2006	2012	2015
Abruzzo	13.87	8.62	5.00
Basilicata	228.35	267.25	315.03
Calabria	4.16	2.03	1.53
Campania	0.06	–	–
Emilia Romagna	45.35	59.75	34.43
Friuli Venezia Giulia	–	–	–
Lazio	0.00	0.00	–
Liguria	–	–	–
Lombardia	7.17	4.31	5.24
Marche	17.55	21.16	8.87
Molise	18.67	12.87	15.47
Piemonte	4.54	5.10	2.10
Puglia	76.10	61.80	48.27
Sardegna	–	–	–
Sicilia	66.35	66.86	48.11
Toscana	0.23	0.24	1.25
Trentino Alto Adige	–	–	–
Umbria	–	–	–
Valle d'Aosta	–	–	–
Veneto	0.52	0.44	0.34

Table 2
Value of natural capital adjustment for flood control ecosystem services.

	NPV of flood control*			Natural capital adjustment	
	Million €			Million €	
Region	2006	2012	2015	Δ2006–2012	Δ2012–2015
Abruzzo	458.63	465.68	469.2	7.05	3.52
Basilicata	90.98	90.02	89.55	−0.95	−0.48
Calabria	34.96	34.97	34.97	0.01	0.01
Campania	127.84	135.48	139.3	7.64	3.82
Emilia Romagna	1683.69	1668.66	1661.15	−15.03	−7.51
Friuli Venezia Giulia	989.5	1018.95	1033.68	29.45	14.73
Lazio	992.16	1005.22	1011.74	13.05	6.53
Liguria	312.97	311	310.02	−1.97	−0.98
Lombardia	2505.69	2518.36	2524.69	12.66	6.33
Marche	156.16	155.13	154.62	−1.03	−0.52
Molise	17.91	17.74	17.65	−0.17	−0.08
Piemonte	1605.71	1596.48	1591.87	−9.23	−4.62
Sicilia	11.17	11.46	11.61	0.3	0.15
Toscana	2310.95	2324.74	2331.64	13.8	6.9
Trentino Alto Adige	3846.48	3880.37	3897.31	33.89	16.95
Umbria	406.91	428.83	439.79	21.91	10.96
Valle d'Aosta	469.29	459.66	454.85	−9.62	−4.81
Veneto	1927.5	1939.57	1945.6	12.07	6.04

* 4 % discount rate on the constant flow value over 100 years.

ecosystem services for 2006, 2012 and 2015 and the respectively changes over time. The trend analysis maps whether the natural capital (proxied by our ecosystem services) is enhanced or depleted through time. For the regulating ecosystem services, changes in NPV values served to adjust the GS. Findings reveal that seven regions (Basilicata, Calabria, Campania, Emilia Romagna, Molise, Puglia, Sicilia) experienced a decline in natural resources respectively from 2012 to 2015.

5.2. GS and poverty

Once the GS is expanded with components of the natural capital the process progresses by testing the inclusion of the poverty dimension.

Following the dashboard approach, Table 4 reports the number of poor people and the GS (adjusted for the natural capital), GS^N.

Findings reveal that the Italian GS^N as a percentage of GDP[10] rose from 2.3 % to 3 % between 2012 and 2015, amounting to an increase

[10] GDP amounts respectively to 1,624,358.7 and 1, 655, 355 million € in 2012 and 2015

Table 3
Value of natural capital adjustment for water purification ecosystem service.

	NPV of water purification*			Natural capital adjustment	
	Million €			Million €	
Region	2006	2012	2015	Δ2006–2012	Δ2012–2015
Abruzzo	2206.16	2275.87	2310.73	69.71	34.85
Basilicata	1224.48	1191.08	1174.38	−33.4	−16.7
Calabria	3271.43	3174.07	3125.39	−97.36	−48.68
Campania	2009.28	1930.79	1891.55	−78.49	−39.25
Emilia Romagna	4997.22	5017.41	5027.5	20.18	10.09
Friuli Venezia Giulia	6683.22	6706.98	6718.86	23.76	11.88
Lazio	2949.8	2993.75	3015.72	43.95	21.97
Liguria	3502.32	3504.69	3505.88	2.37	1.18
Lombardia	12,414.7	12,559.3	12,631.7	144.66	72.33
Marche	1169.9	1197.56	1211.39	27.66	13.83
Molise	567.53	567.2	567.04	−0.33	−0.16
Piemonte	14,169.9	14,277.8	14,331.7	107.88	53.94
Sicilia	2419.95	2266.01	2189.04	−153.94	−76.97
Toscana	6949.47	6997.28	7021.18	47.81	23.9
Trentino Alto Adige	13,224.9	13,470.1	13,592.7	245.24	122.62
Umbria	1400.87	1448	1471.56	47.12	23.56
Valle d'Aosta	4907.34	4991.73	5033.92	84.39	42.19
Veneto	6538.79	6542.98	6545.08	4.19	2.1

* 4 % discount rate on the constant flow value over 100 years.

government to invest in social policies which would boost the sustainable development of the country/regions. Findings support the idea that integrating the social dimension into the GS helps capturing the relationship between economic growth and societal performances proxy by the poverty gap (Table 6 in Appendix B includes more details about the poverty line, poverty gap and poverty headcount for each region for 2012 and 2015[11]).

Fig. 5 reports the increase of the Poverty Gap with almost 1 point (+0.8) from 2006 to 2012 and + 0.4 from 2012 to 2015.

National totals for Italy show a notable rise from €37,879.28 million to €49,783.31 million for GS^N and from €42,144.53 million to €54,661.26 million for GS^D. This result could be already informative for policy decision making but a finer sustainability outlook can be drawn from the regional analysis.

In all regions, GS^D exceeds GS^N, highlighting a proximity to the sustainable development target when deontological criteria are applied. For instance, in Campania, GS^N increased from €3453.81 million (2006–2012) to €7072.50 million (2012–2015), while GS^D could rise from €4010.68 million to €7547.74 million during the same periods if poverty alleviation policies were implemented. Similarly, Lombardy shows a moderate increases, with GS^N rising from €7246.00 million to €7774.55 million, and GS^D from €7808.18 million to €8613.52 million.

Figs. 6 and 7 represent the $GS^N$and GS^D as a % of regional GDP from 2006 to 2012 and from 2012 to 2015; they help to appreciate the significant adjustments needed to reduce poverty and verify the number of regions which would gain an improvement. For instance, considering the time from 2006 to 2012, Lombardia stands out with the highest savings, although the noticeable gap between $GS^N$and GS^Dsuggests that poverty alleviation could make a substantial contribution to sustainability. Marche, Calabria and Trentino Alto Adige also show relatively high savings, with a smaller reducing poverty impact. In contrast, Liguria, Molise, and Valle d'Aosta exhibit minimal or negative savings, suggesting unsustainable development. The overall increase from GS^N to GS^D across regions emphasizes the critical role of poverty alleviation in

Table 4
The dashboard approach for GS and poverty.

Region	GS^N (million €)		Poor people		
	From 2006 to 2012	From 2012 to 2015	2012	2015	%Δ2012–2015
Abruzzo	77.52	1492.45	256,654	246,237	−4.06 %
Basilicata	39.38	13.16	102,684	93,889	−9.37 %
Calabria	1201.38	1533.26	370,124	391,115	5.37 %
Campania	3453.81	7072.50	1,159,184	1,120,807	−3.42 %
Emilia Romagna	2960.37	3162.05	671,342	748,115	10.26 %
Friuli Venezia Giulia	−187.11	1260.19	211,029	171,149	−23.30 %
Lazio	4470.84	4544.98	1,105,730	1,287,997	14.15 %
Liguria	−247.37	1325.02	289,753	301,180	3.79 %
Lombardia	7246.00	7774.55	1,549,885	1,689,350	8.26 %
Marche	1242.66	1378.07	263,840	205,005	−28.70 %
Molise	- 48.72	281.79	53,565	62,807	14.71 %
Piemonte	2318.40	3684.63	838,245	721,579	−16.17 %
Puglia	2184.59	1973.52	684,524	686,498	0.29 %
Sardegna	978.52	852.67	306,514	338,093	9.34 %
Sicilia	3108.09	4353.52	929,980	1,108,041	16.07 %
Toscana	2634.24	2969.83	607,250	603,775	−0.58 %
Trentino Alto Adige	2940.10	1853.17	176,944	175,090	−1.06 %
Umbria	576.75	646.16	138,902	150,315	7.59 %
Valle d'Aosta	−135.82	494.95	18,830	18,757	−0.39 %
Veneto	3065.64	3116.83	803,172	756,416	−6.18 %
Italy	37,879.26	49,783.31	10,538,151	10,876,215	**3.11 %**

from €37,879.26 million to €49,783.31 million (Fig. 4). Additionally, there was a 3 % increase in the total number of individuals living in poverty, suggesting a worsening in the social conditions.

At the regional level, results demonstrate a complex relationship between GS and poverty reduction across Italian regions. Puglia and Sardegna present a reduced $GS^N$and an increased in poverty. Basilicata and Trentino Alta Adige experienced a reduction in the GS^N (although still positive) but a reduction in poverty. Lazio, Molise, Emilia Romagna and Sicilia report higher GS than the others but the poverty increased more than 10 %, raising concern for the resilience of the societal wellbeing.

Turning to the deontological GS, Table 5 compares the GS^N and the deontological GS (GS^D), the latter represents the miss-opportunity of the

[11] The authors acknowledge that the poverty line is based on regional average income and the use of it in the computation of poverty gap could result in a different value of social adjustment if the absolute poverty line is adopted, for more details see Madden (2000) and Notten and Neubourg (2011).

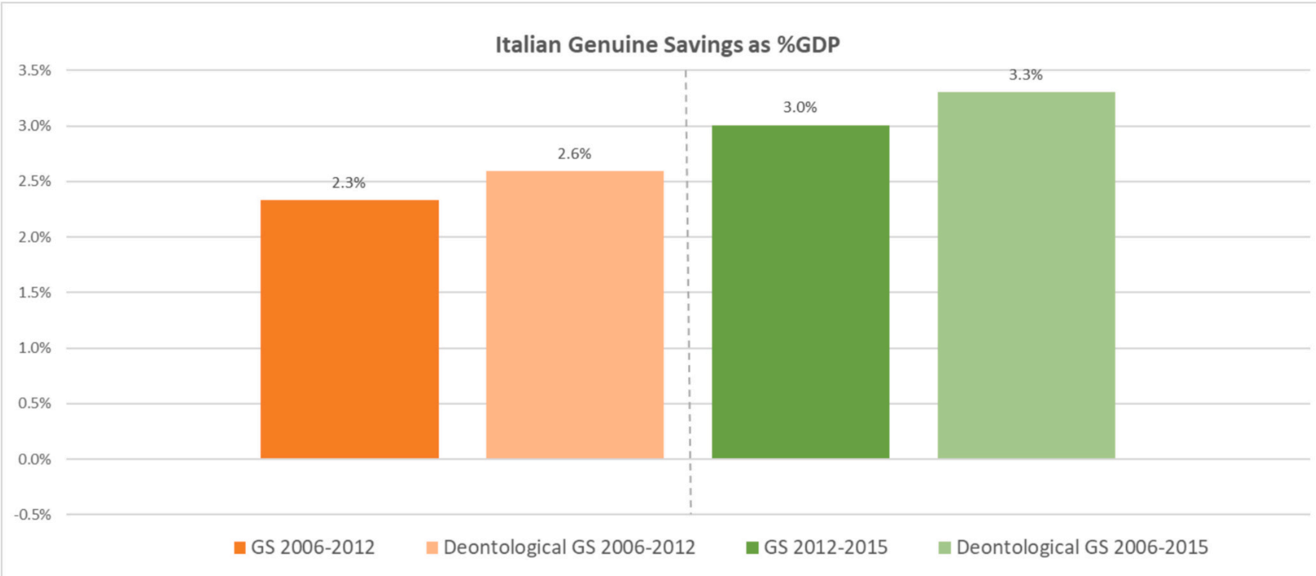

Fig. 4. The GS^N and GS^D as percentage of GDP in Italy from 2006 to 2012 and 2012 to 2015.

Table 5
The $\boldsymbol{GS^N}$ and deontological GS^D comparison.

	GS^N(million €)		GS^D(million €)	
Region	From 2006 to 2012	From 2012 to 2015	From 2006 to 2012	From 2012 to 2015
Abruzzo	77.52	1492.45	171.09	1603.73
Basilicata	39.38	13.16	81.32	50.14
Calabria	1201.38	1533.27	1366.55	1683.59
Campania	3453.81	7072.50	4010.68	7547.74
Emilia Romagna	2960.37	3162.05	3226.49	3498.91
Friuli Venezia Giulia	- 187.11	1260.19	- 111.22	1328.48
Lazio	4470.84	4544.98	4928.34	5152.56
Liguria	- 247.37	1325.02	- 137.86	1464.44
Lombardia	7246.00	7774.55	7808.18	8613.52
Marche	1242.66	1378.06	1351.89	1471.70
Molise	- 48.72	281.79	- 30.66	309.28
Piemonte	2318.40	3684.62	2687.16	3996.73
Puglia	2184.59	1973.52	2472.42	2295.70
Sardegna	978.52	852.67	1091.46	989.54
Sicilia	3108.09	4353.52	3488.49	4865.24
Toscana	2634.25	2969.84	2884.68	3231.55
Trentino Alto Adige	2940.10	1853.17	3007.30	1923.13
Umbria	576.75	646.16	623.60	720.92
Valle d'Aosta	- 135.82	494.95	- 128.92	502.10
Veneto	3065.64	3116.84	3353.57	3412.24
Italy	37,879.28	49,783.31	42,144.53	54,661.26

shaping economic sustainability. From 2012 to 2015 similar trends than the previous period 2006–2012 are reported although it is worth noting the significant improvement that Lazio and Campania could have made if their investment in poverty alleviation policies would manage to meet sustainable targets.

In summary, the deontological GS approach highlights the significant effect of the adjustment of the regional and national GS for poverty and the crucial need to consider social and welfare aspects in the analysis of sustainability and relevant indicators over time.

Following the dashboard approach and considering for example the change in the last period 2012–2015, the decision makers will get a set of information: while the percentages show the change in the number of impoverished individuals, with red signifying a deterioration of socio-economic situations, the GS^N, represented by colours from dark to light in Fig. 8, highlights that darker colour regions enhance their sustainability routes. The performance of regions aligns with the results in Tables 7 and 8, but interpretation for policy decision-making depends on prioritizing between poverty alleviation and development.

We claim that the expansion of the GS provides a finer understanding of development pathways and the preference for the dashboard and deontological genuine saving relies on a multi-dimensional consideration of decision-makers' need, data availability and time and resource available.

6. Discussion

Accurate estimates of the GS provide useful information to support sustainable development policies under the weak sustainability assumption. However, the indicator has a number of drawbacks that our paper addresses. Our approach supports the integration of micro and macro data on Net Savings as recommended by Stiglitz-Sen-Fitoussi Commission (Stiglitz et al., 2009). Data from the survey on income and living condition (EU-SILC), standard international accounts, SEEA CF (e.g. savings, ecosystem asset) and SEEA EA are jointly used to expand the GS calculation.

McLaughlin et al. (2024) call for an increased dialogue between the World Bank and the United Nations, given the disparity in outcomes between the wealth measures they champion. Our results demonstrate that a link between the latest ecosystem accounting estimates (SEEA EA compliant) and the GS indicator is possible and provides informative evidence for decision-makers. Moreover, our analysis also reports how the relationship between the GS and poverty measure can be outlined in a dashboard or incorporated in the GS if a deontological ethics (duty/contracts) is followed.

The number of applications of the SEEA guidelines is steadily growing worldwide and the wealth of data for the thematic accounts varies by location, with North America and Europe having the most extensive sets of accounts from energy to water accounts including air emission (CO2 and PM), environmental protection and management expenses and material flow. Our approach reveals that this data can be embedded in the GS calculation and produce a more refined indicator of sustainability.

At the same time, the attention and data available for the statistics on income and living conditions are well-consolidated and our approach reveals the possibility to include the social adjustment of the GS through

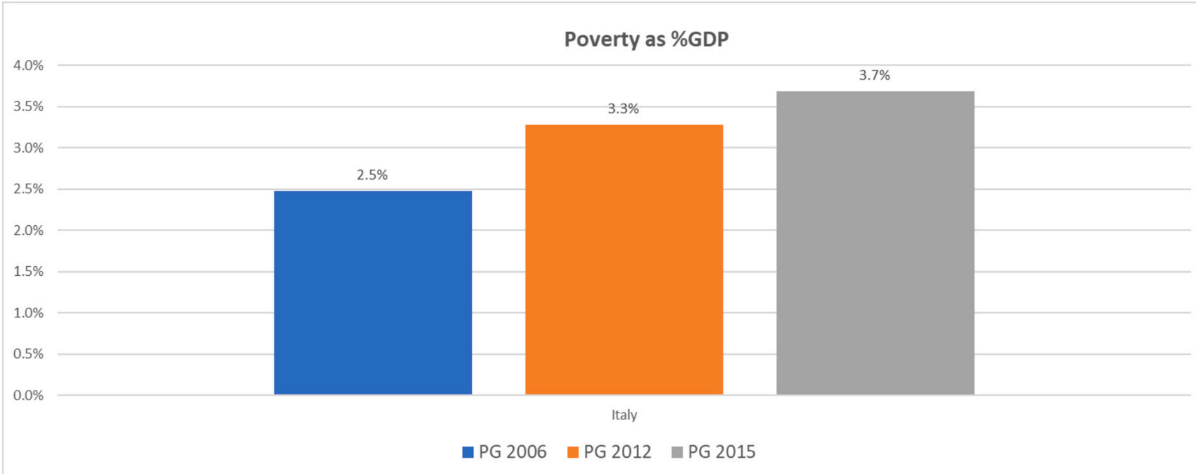

Fig. 5. The national Poverty Gap as percentage of GDP in 2006, 2012, 1015.

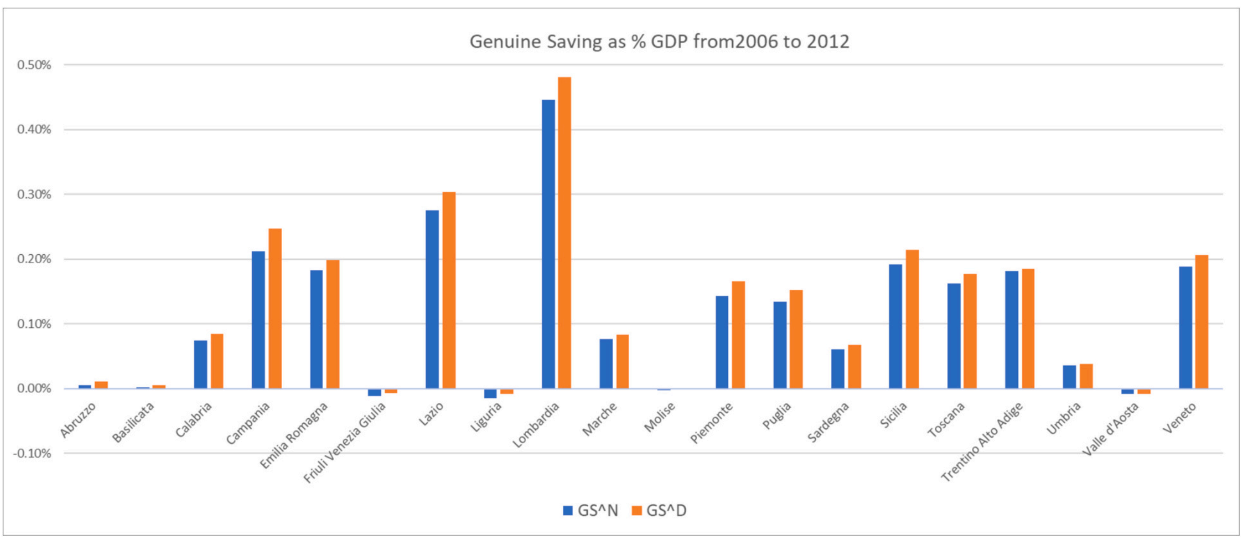

Fig. 6. Comparison of regional $GS^N$and GS^Das %GDP from 2006 to 2012 within the deontological approach.

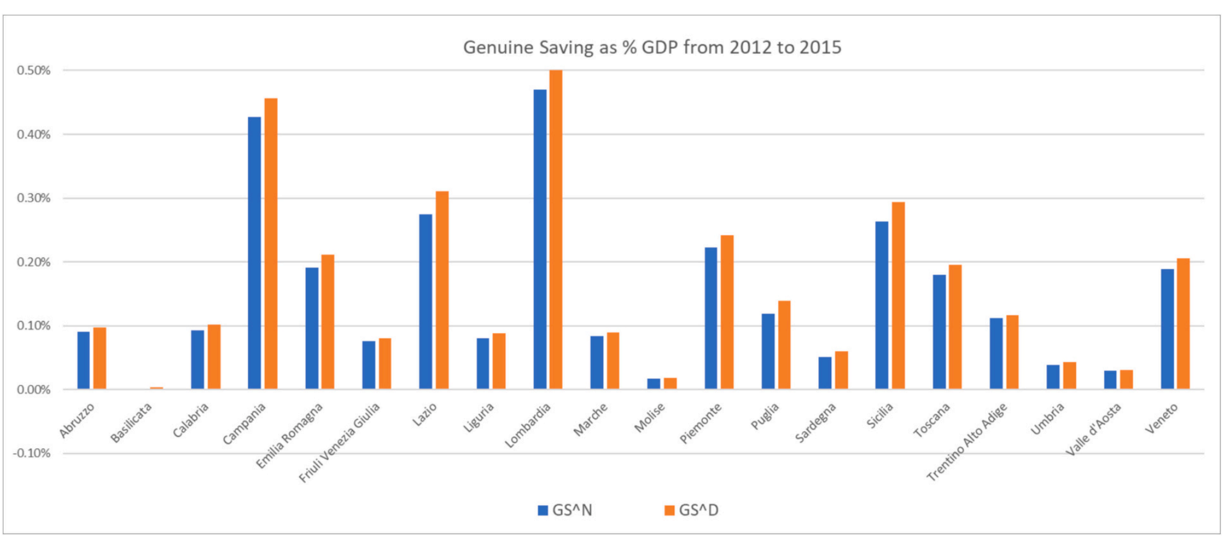

Fig. 7. Comparison of regional $GS^N$and GS^Das %GDP from 2012 to 2015 within the deontological approach.

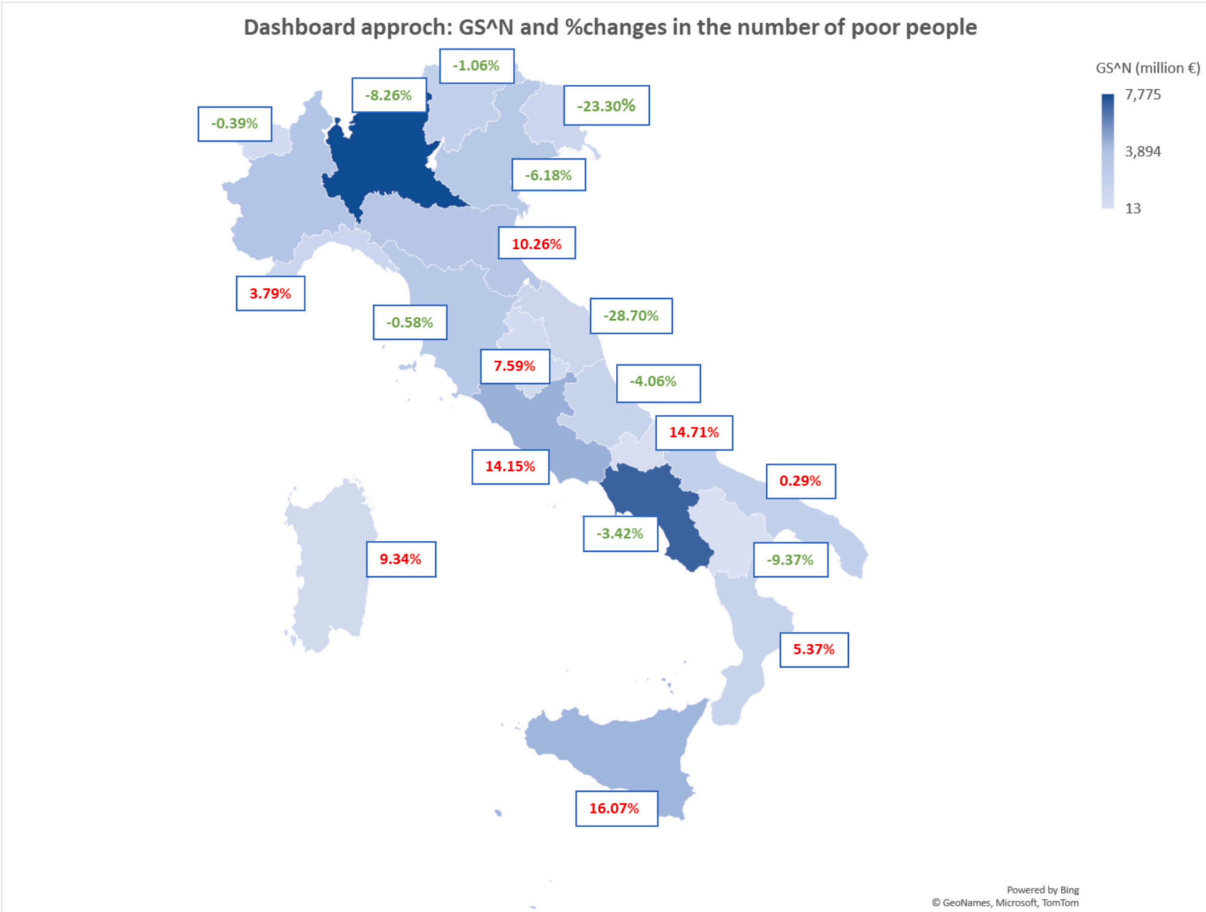

Fig. 8. Dashboard approach: GS^N and % changes in the number of poor people.

the poverty measure. Ravallion (2016) reveals that social consequences of unsustainable development starts to emerge, and the poverty is an important indicator to consider for long-term development pathways. Furthermore, the minimum level of consumption (or poverty level) will support a deontological approach to sustainable pathway strategies.

Taking into account the new set of natural capital and poverty measures, we calculate the expanded GS (GS^N *and* GS^D) for Italy and its regions from 2006 to 2012 and 2012–2015. The findings shed light on the reduced sustainability for many Italian regions when managing their natural capital.

Multiple factors can explain this trend including energy and land use policies developed in the last decades. For example, in the last 20 years, there has been a persistent and constant decrease in exploration and production of permits for natural resources. The quantity of production of oil and gas was 16 billion in 1996 and about 3 billion in 2018 (Grandi et al., n.d.). At the same time the Italian hydrocarbon industry is active and based in regions where the depletion of natural resources is particularly critical such as Abruzzo, Basilica, Puglia and Emilia Romagna.

Furthermore, in the period 2006 to 2012, the conversion of land from agriculture to urban is estimated to be on average of 77 km^2 per year leading to soil sealing, increase in flooding and heat waves, loss of green areas, biodiversity and ecosystem services (ISPRA, 2022). The regions that report a decreased value of the assessed ecosystem service are southern regions (Basilicata, Campania, Calabria, Sicilia) but also central and northern regions as Emilia Romagna, Liguria, Piemonte and Val d'Aosta. Furthermore, our analysis supports the hypothesis that the escalation of severe flooding due to heavy rainfall, like in Emilia Romagna -see a recent editorial in Nature (2023) on the topic -, might be caused by underinvestment in natural capital such as land-use changes and urbanisation.

The regional analysis of poverty also reveals severe differences among regions overtime, but we are not in a position to confirm the north-south disparity pointed out by Putnam et al. (1993). Contrary to widespread belief, Lombardia and Campania emerge as the most promising areas, whereas Emilia Romagna has embarked on perilous developmental trajectories concerning sustainability objectives.

Naturally, it might be possible that using the absolute level of poverty or including population growth in the GS we could draw different reflections for the Italian regions (Cutillo et al., 2022; Asheim et al., 2023) but our approach includes a subsistence level of consumption in the utility function and theoretically derived the deontological Genuine Savings. The results of poverty are presented as deontological GS^D as well as with a dashboard approach to signal the need to develop further approaches for incorporating poverty into macro indicators. We acknowledge that our inclusion of poverty in the GS is still experimental and further research is needed to associate poverty with a wider dimension of the social capital.

7. Conclusion

The idea of sustainable development has been established as an overarching policy objective to drive policy decision making. This paper makes several contributions to GS theoretical and empirical literature aiming to get accurate sub-national accounting measures for regional and national welfare and policy analysis.

First, we extend the GS framework including the SEEA EA for expanding the inclusion of natural capital components from which monetary estimates are available. Second, we propose and empirically assess the impact of poverty on the GS indicator by using the dashboard and the deontological approach. The former is used to complement the GS results; the latter sheds light on the moral duty to alleviate poverty by including a monetary compensation rule in the GS computation. Finally, we provide revised region-level estimates of GS in Italy complemented with poverty consideration.

The estimates of natural capital should be considered experimental and indicative rather than definitive as only a minority of terrestrial ecosystem services (only oil and gas provision and flood and water ecosystem services) could be included. Methodological and empirical constraints still exist. For the natural capital component, a key priority is to expand the assessment and valuation of ecosystem services to have a more comprehensive estimate of the natural capital. Furthermore, several statistics necessary for a more holistic accounting of capital stocks (e.g. social capital) are either non-existent or have not yet been generated.

For example, our paper highlights the challenges to include poverty in the GS as well as the lack of a clear link between the latest SEEA EA findings and the World Bank GS computation. At the theoretical level, our results do not account for endogenous population fluctuations and shadow pricing based on scarcity and option values which are left for future research. We also urge more studies on poverty and how it relates to possible losses of social capital in the theoretical welfare economy model as well as actual implementation. Finally, our argument is not that the proposed pluralist extended computation of GS is a 'silver bullet 'measurement for sustainability, but that in its 'improved' form it can be a useful starting point in any future 'strong' sustainability debate.

CRediT authorship contribution statement

Valentina Di Gennaro: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Silvia Ferrini:** Writing – review & editing, Supervision, Conceptualization. **Robert Kerry Turner:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Valentina Di Gennaro reports financial support was provided by the Tuscany Region PEGASO scholarship for the join PhD programma in Economics at the University of Siena, Pisa and Florence.

Data availability

Data will be made available on request.

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Appendix A. Genuine Saving methodological comparison

Component	World Bank (2023a)	Biasi et al. (2019)	Current study
Gross National Saving	Difference between Gross National Income (GNI) and public and private consumption, a standard item in the system of national accounts.	The National Office of Statistics provides the National Accounts Figures to determine the Net National Savings (Available at: http://dati.istat.it)	Recomputed according to Biasi et al. (2019), recomputed
Consumption of fixed capital	The replacement value of capital used up in the process of production, also a standard item in the system of national accounts.	The National Office of Statistics provides the National Accounts Figures to determine the capital consumption (Available at: http://dati.istat.it)	Same as Biasi et al. (2019)
Human capital			
Education	As a lower-bound first approximation, the calculation includes current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment.	Public and private expenditures in education are included as a proxy for investments in human capital also at regional level.	Same as Biasi et al. (2019)
Natural capital			
Ecosystem services	NA	NA	Flood control and water purification ecosystem services using the NPV approach (UN United Nations, 2021a). Flow are from INCA data source (Data Catalogue | INCA Platform (europa.eu)) for 2006, 2012 and 2015. For monetary valuation details refer to La et al., 2021, La Notte et al., 2017 and Vallecillo et al., 2020
Energy depletion	Energy depletion is the ratio of the value of the stock of energy resources to the remaining reserve lifetime. It covers coal, crude oil, and natural gas.	Subsoil depletion is accounted for as oil and natural gas extraction rent. The physical quantity of natural capital extracted is monetized using resource rent method. Data on quantity extracted are provided by the Italian Ministry of Economic	Subsoil depletion is accounted for as oil and natural gas extraction rent. The physical quantity of natural capital extracted is monetized using the value of the constant unit rent for natural gas and oil estimated by the World Bank for Italy. The average unit rent of the

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Component	World Bank (2023a)	Biasi et al. (2019)	Current study
		Development; For the monetary valuation two approaches are tested: 1) the value of the unit rent for natural gas and oil is estimated by the World Bank for Italy. 2) using international market price for oil (British Petroleum, 2016) and cost of oil production (development costs) as elaborated by Nomisma Energia (2012).	years of analysis sis used. Data on quantity extracted are provided by the Italian Ministry of Economic Development;
Net forest depletion	Net forest depletion is unit resource rents times the excess of roundwood harvest over natural growth.	NA	NA
Mineral depletion	Mineral depletion is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime. It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate rock;	NA	NA
Damages of soil sealing	NA	The regional average soil consumption in hectares over time as the percentage of regional area of "arable land" transformed into artificial surfaces in each period multiplied by 4800 euro/ha (corresponding to the monetary estimates of damages due to soil sealing obtained considering the loss of CO2 sequestration potential).	NA
Damages of water losses and degradation	NA	Water quality degradation due to urban and industrial pollution and the quantity of potable water lost (water abstracted and then wasted due to inefficient distribution systems) are included.	NA
GHG	Damages due to carbon dioxide emissions from fossil fuel use and the manufacture of cement, estimated to be US$ 30 per ton of CO_2 (the unit damage in year 2014 U.S. dollars for CO_2 emitted in the year 2015) times the number of tons of CO_2 emitted.	ENEA (2010) provides regional CO2 emissions for the period considered. CO_2 is valued at 37 $ per ton as estimated by Office of Information and Regulatory Affairs (2013) accounting for the incremental damages of CO_2 emission over the time span	ENEA (2010) provides regional CO2 emissions for the period considered. CO_2 is valued at Euro 25 per ton as suggested by Sartori et al., 2014 in .10 page 63.
POL	Damages due to exposure of a country's population to air pollution, including ambient concentrations of particulates measuring less than 2.5 μm in diameter (PM2.5), indoor concentrations of air pollution in households cooking with solid fuels, and ambient ozone pollution. Damages are calculated as forgone labor output due to premature death from pollution exposure;	Regional PM10 emissions are derived by the National Inventory of Pollutants (ISPRA, 2019) while estimates of economic damages are based both on low and high Value Of Life Years (VOLY) as provided by ENEA (2010).	Same as Biasi et al. (2019); authors assume that carbon emission belongs to the region of the emitter, not the suffering region, following the World Bank methodology
Welfare and social issues			
Poverty	NA	NA	Poverty measure is computed using the Poverty Gap multiplied by the number of poor people using the poverty headcount and population. The Poverty Gap and Poverty Headcount relies on EUSILC data survey (data on income and living condition provided by the Italian Statistics Office (ISTAT) for 2006, 2012 and 2015.)

Appendix B. Poverty line, poverty gap and poverty headcount

Region	2006			2012			2015		
	Poverty Gap	Poverty line	Poverty *Headcount*	Poverty Gap	Poverty line	Poverty *Headcount*	Poverty Gap	Poverty line	Poverty *Headcount*
	€	€	%	€	€	%	€	€	%
Abruzzo	268,642	8053.20	16 %	378,257.30	8798.88	20 %	451,941.20	8380.80	18 %
Basilicata	308,718.70	6469.60	14 %	362,472.70	7597.02	18 %	260,922.20	7360.94	16 %
Calabria	606,515.60	6635.28	20 %	680,475.00	7644.80	19 %	571,720.80	7622.28	20 %
Campania	1,181,724.00	6724.80	18 %	1,326,998.00	7386.80	20 %	1,044,137.00	7551.00	19 %
Emilia Romagna	1,102,782.00	10,373.54	17 %	1,050,496.00	11,684.03	15 %	1,255,145.00	12,374.80	17 %
Friuli Venezia Giulia	482,380.40	9571.20	16 %	791,114.60	10,955.10	17 %	763,069.90	11,548.97	14 %
Lazio	1,171,957.00	8609.40	18 %	1,779,294.00	10,200.60	20 %	1,822,031.00	10,000.80	22 %
Liguria	551,588.80	9029.70	17 %	892,761.50	10,627.50	19 %	1,087,862.00	11,199.60	19 %
Lombardia	1,500,593.00	10,002.72	16 %	1,491,745.00	11,682.75	16 %	1,912,003.00	12,272.40	17 %
Marche	601,636.50	9136.96	17 %	884,852.40	10,448.36	17 %	770,771.30	10,235.64	13 %
Molise	228,465.40	7351.98	17 %	269,773.30	7828.56	17 %	284,542.50	8146.75	20 %
Piemonte	767,565.90	9517.80	16 %	1,484,733.00	11,364.00	19 %	1,157,023.00	11,303.67	16 %
Puglia	592,996.60	6561.60	16 %	835,625.80	8033.20	17 %	838,888.80	8223.72	17 %
Sardegna	411,258.50	7833.64	17 %	409,930.40	8806.33	19 %	445,310.00	8555.40	20 %

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Region	2006			2012			2015		
	Poverty Gap	Poverty line	Poverty *Headcount*	Poverty Gap	Poverty line	Poverty *Headcount*	Poverty Gap	Poverty line	Poverty *Headcount*
	€	€	%	€	€	%	€	€	%
Sicilia	790,403.90	5766.60	18 %	940,760.80	6700.00	19 %	1,102,612.00	7113.81	22 %
Toscana	821,361.20	9669.90	14 %	1,113,420.00	11,071.20	16 %	1,040,312.00	11,240.40	16 %
Trentino Alto Adige	463,514.30	10,281.02	15 %	541,191.50	11,444.70	17 %	514,481.60	12,083.90	17 %
Umbria	473,497.80	8764.36	17 %	586,063.40	10,002.40	16 %	609,258.10	10,219.00	17 %
Valle d'Aosta	155,883.10	9864.33	13 %	210,732.40	11,161.71	15 %	219,185.50	11,583.60	15 %
Veneto	880,290.60	9339.60	15 %	1,057,469.00	10,899.60	16 %	1,054,440.00	11,160.33	15 %

Data own elaboration from on income and living condition survey provided by ISTAT.

Table 6 Poverty line, poverty gap and poverty headcount for 2006, 2012 and 2015.

The value of national PG amounts approximately to 38, 53 and 61 thousand million euros for 2006, 2012 and 2015.

Appendix C. From unadjusted GS (GS^U) to GS with changes in natural capital (GS^N) and deontological GS (GS^D)

Region	GS^U			Oil and gas adjustment			Water purification ES		Flood control ES		GS^N		
	2006	2012	2015	2006	2012	2015	Δ2006–2012	Δ2012–2015	Δ2006–2012	Δ2012–2015	2006	2012	2015
Italy	126,822	36,099	49,124	483	510	486	1848	924	443	221	–	37,879	49,783
Abruzzo	7244	9	1459	14	9	5	70	35	7	4	–	78	1492
Basilicata	864	447	398	228	267	315	- 136	- 68	- 4	- 2	–	39	13
Calabria	4003	1601	1733	4	2	2	- 397	- 199	0	0	–	1201	1533
Campania	21,755	3743	7217	0	–	–	- 320	- 160	31	16	–	3454	7073
Emilia-Romagna	5241	2999	3186	45	60	34	82	41	- 61	- 31	–	2960	3162
Friuli-Venezia Giulia	7742	- 404	1152	–	–	–	97	48	120	60	–	- 187	1260
Lazio	7068	4238	4429	–	–	–	179	90	53	27	–	4471	4545
Liguria	8318	- 249	1324	–	–	–	10	5	- 8	- 4	–	- 247	1325
Lombardia	12,005	6608	7459	7	4	5	590	295	52	26	–	7246	7775
Marche	2473	1155	1333	18	21	9	113	56	- 4	- 2	–	1243	1378
Molise	1941	- 34	298	19	13	15	- 1	- 1	- 1	- 0	–	- 49	282
Piemonte	10,495	1921	3485	5	5	2	440	220	- 38	- 19	–	2318	3685
Puglia	4625	2246	2022	76	62	48	–	–	–	–	–	2185	1974
Sardegna	1719	979	853	–	–	–	–	–	–	–	–	979	853
Sicilia	10,531	3802	4715	66	67	48	- 628	- 314	1	1	–	3108	4354
Toscana	5710	2383	2845	0	0	1	195	98	56	28	–	2634	2970
Trentino Alto Adige / Südtirol	2744	1801	1284	–	–	–	1001	500	138	69	–	2940	1853
Umbria	2267	295	505	–	–	–	192	96	89	45	–	577	646
Valle d'Aosta / Vallée d'Aoste	4373	- 441	342	–	–	–	344	172	- 39	- 20	–	- 136	495
Veneto	5705	3000	3084	1	0	0	17	9	49	25	–	3066	3117

Region	GS^N (million €)		G_P (million €)		$(1-\Phi)G_P$ (million €)		GS^D (million €)	
	2012	2015	2012	2015	2012	2015	2012	2015
Italy	37,879	49,783	53,316	60,974	4265	4878	42,145	54,661
Abruzzo	78	1492	1170	1391	94	111	171	1604
Basilicata	39	13	524	462	42	37	81	50
Calabria	1201	1533	2065	1879	165	150	1367	1684
Campania	3454	7073	6961	5940	557	475	4011	7548
Emilia-Romagna	2960	3162	3326	4211	266	337	3226	3499
Friuli-Venezia Giulia	- 187	1260	949	854	76	68	- 111	1328
Lazio	4471	4545	5719	7595	458	608	4928	5153
Liguria	- 247	1325	1369	1743	110	139	- 138	1464
Lombardia	7246	7775	7027	10,487	562	839	7808	8614
Marche	1243	1378	1365	1170	109	94	1352	1472
Molise	- 49	282	226	344	18	27	- 31	309
Piemonte	2318	3685	4610	3901	369	312	2687	3997
Puglia	2185	1974	3598	4027	288	322	2472	2296
Sardegna	979	853	1412	1711	113	137	1091	990
Sicilia	3108	4354	4755	6397	380	512	3488	4865
Toscana	2634	2970	3130	3271	250	262	2885	3232
Trentino Alto Adige / Südtirol	2940	1853	840	875	67	70	3007	1923
Umbria	577	646	586	934	47	75	624	721
Valle d'Aosta / Vallée d'Aoste	- 136	495	86	89	7	7	- 129	502
Veneto	3066	3117	3599	3693	288	295	3354	3412

(*continued on next page*)

(*continued*)

Region	GS^N (million €)		G_P (million €)		$(1-\Phi)G_P$ (million €)		GS^D (million €)	
	2012	2015	2012	2015	2012	2015	2012	2015

Region	N of poor people				Poverty gap pro poor (€)			G_P (million €)		
	2006	2012	2015	Δ2012–2015	2006	2012	2015	2006	2012	2015
Abruzzo	200,950	256,654	246,237	−4.06 %	3198	4557	5649	643	1170	1391
Basilicata	84,298	102,684	93,889	−8.57 %	4540	5105	4923	383	524	462
Calabria	403,950	370,124	391,115	5.67 %	5013	5578	4804	2025	2065	1879
Campania	1,057,893	1,159,184	1,120,807	−3.31 %	5029	6005	5300	5320	6961	5940
Emilia-Romagna	687,715	671,342	748,115	11.44 %	3967	4955	5628	2728	3326	4211
Friuli-Venezia Giulia	191,268	211,029	171,149	−18.90 %	3281	4495	4987	628	949	854
Lazio	970,260	1,105,730	1,287,997	16.48 %	4277	5172	5897	4150	5719	7595
Liguria	269,478	289,753	301,180	3.94 %	3426	4724	5787	923	1369	1743
Lombardia	1,486,606	1,549,885	1,689,350	9.00 %	4002	4534	6208	5949	7027	10,487
Marche	248,284	263,840	205,005	−22.30 %	3306	5175	5709	821	1365	1170
Molise	53,917	53,565	62,807	17.26 %	3046	4215	5472	164	226	344
Piemonte	676,340	838,245	721,579	−13.92 %	3396	5499	5407	2297	4610	3901
Puglia	653,853	684,524	686,498	0.29 %	3683	5256	5866	2408	3598	4027
Sardegna	270,198	306,514	338,093	10.30 %	4154	4606	5060	1122	1412	1711
Sicilia	869,499	929,980	1,108,041	19.15 %	4033	5113	5773	3506	4755	6397
Toscana	502,484	607,250	603,775	−0.57 %	3838	5155	5418	1929	3130	3271
Trentino Alto Adige / Südtirol	143,534	176,944	175,090	−1.05 %	3565	4747	4995	512	840	875
Umbria	141,128	138,902	150,315	8.22 %	2959	4216	6217	418	586	934
Valle d'Aosta / Vallée d'Aoste	16,349	18,830	18,757	−0.39 %	2941	4581	4765	48	86	89
Veneto	707,456	803,172	756,416	−5.82 %	3507	4481	4882	2481	3599	3693

Note: $(1-\phi) = 8\%$.

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