

Is Italy on the Pathway for Achieving Sustainable Development Goals?



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Abstract In this paper, we investigate the current well-being and the future sustainability of Italy. A general equilibrium model is used to estimate the future evolution according to different scenarios in which selected policies are identified in order to evaluate their potential contribution to the SDG achievement. We provide evidence that in a scenario *business-as-usual*, Italy will not improve significantly its level of well-being. However, with a set of policies specifically targeted in 2030, the Italian sustainability would increase remarkably especially if all policies were implemented simultaneously.

1 Introduction

On 25 September 2015, the General Assembly of the United Nations adopted the 2030 Agenda for Sustainable Development, accompanied by a list of 17 objectives and 169 targets (Sustainable Development Goals, or SDGs) covering all domains of human life and the planet, and which will have to be achieved by all countries of the world by 2030.

However, the lack of awareness and commitment on the 2030 Agenda and the SDGs can hinder the transitioning towards sustainable development. Monitoring and measuring SDGs is therefore crucial to guarantee accountability among policy makers and stakeholders with respect efforts made in sustaining SDG achievement.

The paper introduces a novel methodology that can guide policymaking throughout this task offering a synthesis of past and current performance of a country with

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21 respect to SDGs and giving some insight on its future evolution. The current wellbe-
22 ing and future sustainability of Italy is analyzed using the APPS Index. This approach
23 is based on 28 indicators representative of 16 SDGs. The future sustainability assess-
24 ment uses a macro-economic model, enhanced with social and environmental dimen-
25 sions, and produces future projections for selected SDG indicators and 45 countries
26 and macro-regions up to 2030 under a reference scenario and considering several
27 sustainable development policies. Country performances in each SDG is evaluated
28 depending on the gap between the indicator values and specific SDG targets; the
29 APPS Index is a synthetic measure of country distance from achieving all SDGs and
30 offers, therefore, an assessment of country wellbeing and sustainability levels.

31 The paper is organised as follows. In Sect. 2, political and institutional implications
32 of 2030 Agenda for Italy are discussed. Section 3 presents the current well-being of
33 Italy according to the APPS Index, while Sect. 4 shows the evolution of the same
34 index in a business-as-usual scenario. In Sect. 5, the effects on sustainability of a
35 set of specific policies for SDGs are analysed. Some final remarks follow in the
36 concluding Sect. 6.

37 2 Agenda 2030 for Italy: Political and Institutional 38 Framework

39 In the past two years, the attention to the 2030 Agenda has significantly grown in
40 Italy. In 2017, the global progress towards the SDGs was discussed during the UN's
41 annual High-Level Political Forum (HLPF). In this context, Italy presented his own
42 National Strategy for Sustainable Development (NSDS)¹ and the respective actions
43 that the Government is going to undertake in order to achieve SDGs. The presentation
44 of the Voluntary National Review² during the HLPF has represented a crucial step
45 in the development of new reform strategy with a long-term perspective.

46 In fact, following the 2030 Agenda, the Italian Strategy identifies a multi-
47 dimensional framework based on five main areas of intervention: People, Planet,
48 Prosperity, Peace and Partnership (5Ps). The first four domains are basically covered
49 at domestic level, while the latter is designed for a coordinated effort at international
50 level. With this respect, the Italian government has also approved the “Three-year
51 Strategic and Planning Document” of the Italian Development Cooperation in which
52 both structure and targets of the 2030 Agenda have been directly incorporated in the
53 macro-areas of intervention. Consistently, the Italian Parliament has also approved an
54 overall increase of financial resources devoted to Official Development Assistance in
55 order to allow Italy to contribute to the implementation of the “external dimension”
56 of the Agenda.

57 Overall, the ambition of the Italian NSDS is to guarantee the fast recovery towards
58 the pre-crisis socio-economic prosperity conditions. The main targets are: reducing

¹To read the full report see <https://sustainabledevelopment.un.org/memberstates/italy>.

²To date, 44 countries has presented their own strategy at the HLPF.

59 poverty, inequality, and unemployment (particularly among youth and women), while
60 ensuring at the same time an environmentally sustainable economic development. A
61 specific area of intervention is related to those actions able to enhance competitiveness
62 and technology favouring the shift of Italian production system towards the “fourth
63 industrial revolution” based on innovative and sustainable technologies.

64 Regarding NSDS’ governance, the Italian Prime Minister has the role to coordi-
65 nate and manage the strategy with the support of the Ministry for the Environment,
66 Land and Sea for the domestic dimension and the Ministry of Foreign Affairs for
67 the international one. At the same time, the Ministry of Finance has to guarantee
68 coherence between NSDS actions and formal political economy decisions and to
69 coordinate models for defining objectives in line with SDGs targets.

70 In this framework, it is important to note that with the publication of the 2017
71 Economic and Financial Document (spring), according to a law recently approved
72 (L.163/20169), new indicators for measuring equitable and sustainable well-being
73 (BES) has been introduced besides GDP and other “traditional” economic and finan-
74 cial variables in the economic planning analysis. This is an important novelty: Italy
75 is in fact the first European country to include such variables in its official economic
76 planning documents. The equitable and sustainable well-being variables selected are:
77 (i) average disposable income, (ii) inequality indicator, (iii) labour force participation
78 rate, (iv) emissions of CO₂ and other global warming gases. Particularly significant
79 for the quality of life of citizens and society as a whole are the past and future trends
80 of these indicators.

81 The Italian National Institute of Statistic (Istat) has been working to guarantee the
82 availability of data and indicators in line with those selected by Expert Group on
83 Sustainable Development Goal Indicators (IAEG-SDGs) to monitor SDGs achieve-
84 ment. Starting form 2016, Istat has released several indicators, mainly based on the
85 previous BES project launched in 2011, to evaluate the current pattern of Italy within
86 the framework of 2030 Agenda.

87 The following chapter will present a novel methodology for assessing Italian
88 current wellbeing, considering a more restricted array of indicators with respect to the
89 BES ones, but offering projections for these indicators up to 2030 under a reference
90 scenario and some policy scenarios, therefore sketching some light on the Italian
91 perspectives on sustainable development. The methodology has been developed as
92 part of activities and projects carried out by ASviS³ with the aim to raise the awareness
93 of Italy about 2030 Agenda providing a quantitative assessment of the current and
94 future positioning with respect SDGs.

³The Italian Alliance for Sustainable Development (ASviS) was established on February 3rd, 2016, upon the initiative of the Unipolis Foundation and the University of Rome “Tor Vergata” with the aim to raise the awareness of the Italian society, economic stakeholders and institutions about the importance of the 2030 Agenda. ASviS brings together over 180 of the most important civil society institutions and networks, such as: associations, public and private universities and research centres.

3 Current Wellbeing in Italy

The level of current wellbeing in Italy is measured using an aggregate index (APPS Index) synthetizing 28 indicators covering 16 SDGs.⁴ Among the 45 macro-regions considered in the APPS framework, Italy is at the 14th position in the worldwide current wellbeing ranking⁵ (APPS Index: 56.9). Among EU28 countries, Italian performances exceed only Czech Republic, Spain and Greece one (Table 1).

Overall, Italy is still far from achieving SDGs (score 100) and maintains a substantial gap from Nordic countries, Sweden in particular, at the top of World and European ranking (Fig. 1). The SDG Index, recently published, shows a similar picture of global wellbeing (SDSN-Bertelsmann Stiftung 2017). The Italian result is mainly due to the performance in the economic dimension (−55% with respect to Sweden), and in the environmental one (−24% with respect to Sweden), whereas the gap in the social pillar is marginal (−16% with respect to Sweden).

In order to move close to Sweden level of wellbeing, Italy need to focus on improving indicators relative to economic growth and employment (SDG 8) which, at the moment, obtain a score of 0 and 7. The good result in terms of GDP per employed (score 87) is not sufficient to reach a good score in SDG 8 (score 31). The restraint of public debt is another priority in order to improve Italian wellbeing. The debt-to-GDP ratio in Italy is below the “unsustainable” threshold and implies a score of 0 in SDG 17.

The average environmental performance stems from an intensive use of water resources (SDG 6) with respect to renewable ones (30%); this figure corresponds to

Table 1 Current wellbeing in EU28: APPS Index and economic, social and environmental pillars

EU28	APPS Index	Economy	Society	Environment
Sweden	80.3	57.9	89.5	80.4
Finland	73.2	43.3	93.4	65.1
Germany	71.2	51.6	92.6	67.8
RoEU	64.6	37.6	79.3	65.7
Benelux	63.7	38.3	89.8	50.2
France	63.4	24.5	83.5	61.0
UK	62.1	35.2	74.6	59.7
Poland	57.7	38.0	69.0	59.3
Italy	56.9	26.2	75.5	61.5
Czech_Rep	56.3	43.7	77.4	54.7
Spain	49.6	32.8	75.2	47.6
Greece	44.8	18.3	66.0	50.9

⁴See Appendix I for an extensive description of APPS framework.

⁵See Appendix II (Table 8) for the complete country ranking of current wellbeing and 2030 sustainability.

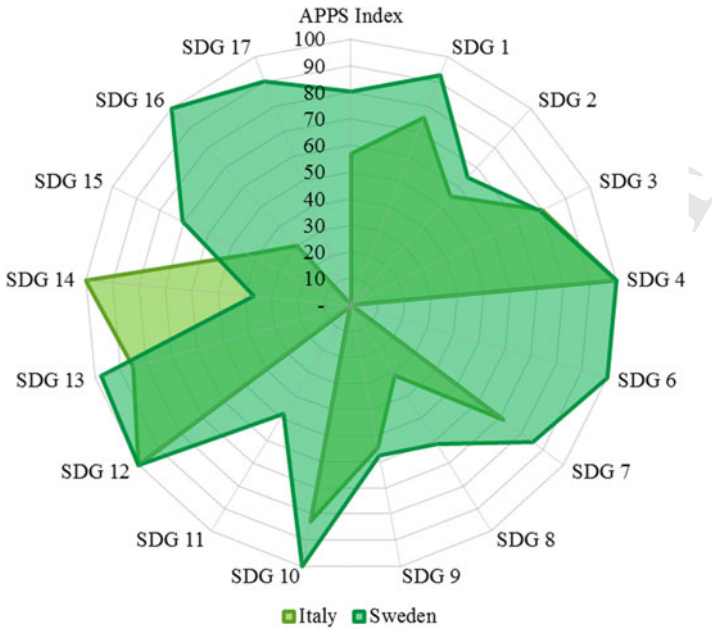


Fig. 1 Gap from achieving SDGs. Italy versus Sweden.

117 the “unsustainable” threshold. In addition, Italy has a high CO2 intensity in the resi-
 118 dential and transport sectors (SDG 11) and an average result in SDG 15 (endangered
 119 terrestrial area, forest share and protected animal and plant species). It is worth to
 120 notice that Italy overcomes Sweden on SDG 14 which measures the share of pro-
 121 tected marine areas (11% in Italy compared to 9% in Sweden) and the two countries
 122 have a sustainable material productivity (SDG 12).

123 Social indicators perform good, being in proximity of Sweden score (−16%).
 124 The only exception is SDG 16, which accounts for a corruption perception markedly
 125 higher than the Swedish one.

126 4 Future Sustainability in the Business-as-Usual Scenario

127 In order to assess the Italian perspectives in terms of future sustainability, we adopted
 128 a business-as-usual reference scenario, not envisioning any policy changes after 2015.
 129 The reference scenario reproduces historical trend from the base year up to 2015; for
 130 the period 2016–2030, the Shared Social Economic Pathway 2—SSP2—scenario
 131 (O’Neill et al. 2017) is used as a source for GDP, population, employment and

Table 2 Sustainability in 2030 in EU28: APPS Index and economic, social and environmental pillars

EU28	APPS Index	Economy	Society	Environment
Sweden	82.3	51.6	95.4	79.2
Finland	71.3	36.0	94.6	64.2
Germany	70.2	46.0	95.3	61.7
UK	67.4	36.0	90.9	53.6
France	66.4	33.7	92.5	54.4
RoEU	66.5	33.8	87.9	60.0
Benelux	64.1	37.7	94.7	46.6
Poland	61.5	35.7	79.5	57.1
Czech_Rep	60.7	46.7	87.1	53.0
Italy	60.0	29.7	84.3	54.9
Greece	53.5	28.2	84.6	44.0
Spain	53.0	28.1	89.4	38.3

132 emission⁶ trends for all countries excluding Italy (see Appendix I for more infor-
 133 mation). Among SSPs, SSP2 is the “Middle of the road” scenario with the trends of
 134 main socio-economic variables similar to the one observed in past decades: moderate
 135 GDP and population growth, further improvements in energy efficiency and a less
 136 intensive use of natural resources. In building the reference scenario for Italy, we
 137 opted for more updated figures on GDP growth from International Monetary Fund
 138 and Oxford Economics, on population growth from the Ageing report (EC 2015) and
 139 on emissions from Oxford Economics.

140 Under this scenario, Italy will experience a slight increase of wellbeing in 2030
 141 (+5% wrt 2015 levels), mainly imputable to improvements in the economic (+13%)
 142 and social (12%) pillars; the environmental dimension records a small worsening
 143 (−11%). Overall, Italy loses a position in the global ranking of sustainability, and
 144 also in the EU28 one (Table 2).

145 Figure 2 allows understanding what generates higher sustainability levels in 2030:
 146 SDG 8 improves compared to 2015 due to higher annual GDP per capita growth and
 147 GDP per employed. This is coupled with a better performance in social indicators:
 148 poverty (SDG 1) and malnutrition (SDG 2) prevalence reduce; healthy life expectancy
 149 (SDG 3) and equality (SDG 10) improve. On the contrary, it is interesting to observe
 150 that there are downsides of economic growth in the environmental pillar. Although
 151 CO2 intensity in residential and transport sectors (SDG 11) increase only marginally,
 152 the Greenhouse Gas (GHG) emissions and energy intensity rises in the industrial
 153 sectors. This leads to a lower score in SDG 13, the worsening of environmental pillar
 154 performance, and move Italy farther from the target abatement subscribed in the Paris
 155 Agreement.

⁶SSP database provides emissions data for 5 macro-regions; these were downscaled to our 45 country aggregates.

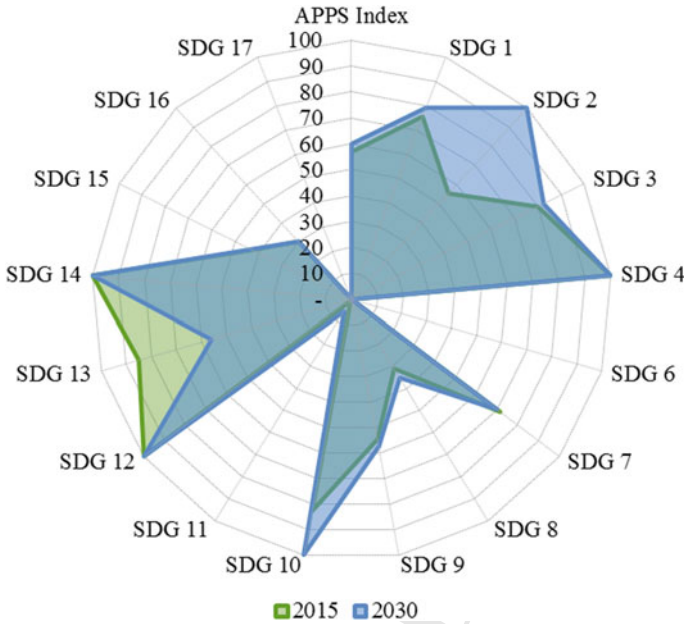


Fig. 2 Gap from achieving SDGs in 2015 and in 2030

5 Sustainability Under SDG Policies

The APPS framework is a useful tool to assess sustainability of a reference scenario, but also allows analysing the impacts of several sustainable development policies targeting economic, social and environmental dimensions. Among the numerous policies that Italy could implement in compliance to the SDGs, we had to select only the interventions whose implication can be analysed using a Computable General Equilibrium (CGE) framework. Table 3 lists the selected policies and the assumptions made in terms of expected impacts and costs for public finance.

For each one of the above described policies, we analyse the impact on Italian sustainability in 2030 with respect to the reference scenario. Finally, we observe the outcome of the simultaneous implementation of all these policies.

5.1 Paris Agreement (NDC_COND_Policy)

GHG emission reduction target for Italy is in line with EU28 conditional NDC: -40% by 2030 with respect to 1990. In order to meet this target, EU28 countries participate to the EU-ETS, a trade system of emission permits that allows an efficient

Table 3 Sustainability policies proposed for Italy

Policy	Description	Modelling
Paris Agreement (NDC_COND_Policy)	The policy implies the compliance with the conditional Nationally Determined Contribution (NDCs) of GHG emission mitigation subscribed as part of Paris Agreement	NDC implies for EU28 a 40% reduction of GHG emissions with respect to 1990 by 2030 though the trade of emission permits in the Emission trading Scheme (EU ETS). All other countries achieve their mitigation targets taxing CO2 emissions
National Energy Strategy 2017 (NES_Policy)	The policy includes the compliance with NDC in reducing GHG emissions subscribed under Paris agreement; the achievement of EU target of 30% energy consumption from renewable sources; the reduction of energy consumption by 20% (between 2010 and 2030) and by 30% (between 2021–2030)	Government invests yearly 2.35 billion € from 2017 to 2030 to meet the energy efficiency target by 2030; subsidies to the production of energy from renewables rise annually by 4%
Youth and female employment (OCC&FG_Policy)	The program “Garanzia Giovani” aims at effectively reducing by 2030 the young population that is not studying, not training and not employed (NEET). Policies aiming to rise female employment include: the provision of social security services, ad hoc fiscal measures, support to women entrepreneurship and other similar actions	Increase of youth employment: 429 thousand Increase of female employment: 1.5 million These two polices determine 148,000 additional employed people between 2018 and 2030 (on average +0.8% every year). “Garanzia Giovani” is financed with European funds. The policy on female employment implies an investment of 11 billion € between 2017 and 2022
Industry 4.0+Digital Agenda (IND4.0&BL_Policy)	The Plan Industry 4.0 aims to stimulate collaboration between research centres and firms. The Digital Agenda plan to extend the access to fast broadband connection (higher than 100 Mbps) to 100% of population by 2030	Technological progress in industrial sector will rise by 2% annually. Annual government investment of 3 billion € from 2017 to 2030
Quality Education (QIST_Policy)	This policy wants to stimulate human capital accumulation by investing in education: (1) quality of learning; (2) dispersion control; (3) permanent learning	Annual increase of 0.5% of total factor productivity in all economic sectors from 2020 on. Rise of government expenditure in education by 1% every year from 2017 to 2030



Fig. 3 Gap from achieving SDGs, 2030 baseline versus 2030 NDC_COND Policy

171 allocation of abatement efforts. In the non-Eu28 countries, NDCs are met through
 172 direct taxation of CO₂ emissions.

173 The effect of this policy on the overall Italian sustainability in 2030 is moderate
 174 (+1.7% with respect to 2030 reference scenario). The highest improvements can be
 175 observed in the environmental pillar, +7.2%, and, interestingly, the economic dimension
 176 is not penalised (+2.2%). The social dimension remains almost unchanged.

177 The most affected goal is SDG 13, which directly considers the compliance to the
 178 Paris Agreement, +29% with respect to the 2030 reference scenario (Fig. 3). Despite
 179 this policy leads to the highest score in the indicator “Compliance to Conditional
 180 INDCs”, and a slightly lower one in “equitable and sustainable emissions per capita”
 181 (95 compared to 85 of the reference scenario), the overall performance in SDG 13
 182 remains below 100, because another indicator pertaining this SDG (concentration
 183 of emissions from agriculture, forestry and land use change—LULUCF), although
 184 improving, is far from sustainable threshold (score 22). Furthermore, the mitigation
 185 policy stimulates the use of renewable resources (+55%) in electricity production
 186 which lead to a +2.8% in SDG 7 score.

187 The marginal improvement of economic sustainability is mainly due to the chosen
 188 recycling scheme of carbon taxation revenues. In our simulation, these lead to pri-
 189 mary surpluses and, consequently, interest payments and debt reduction. The related
 190 indicator (SDG 17) remains unchanged, given that the debt-to-GDP ratio, even if

191 reduced, is well below the “unsustainable” threshold. Moreover, the lower deficit
 192 stimulates GDP growth (SDG 8: +1.7%).

193 5.2 National Energy Strategy (NES_Policy)

194 The National Energy Strategy (NES) includes three different policies on energy
 195 and environment: GHG emission reduction, the increase of renewable share in total
 196 energy consumption and an overall reduction of energy consumption. The outcome
 197 of this policy in terms of sustainability (1.3%, Fig. 4) is positive and comparable
 198 with the Paris Agreement one, but economic and social dimensions shows some
 199 discrepancies from the previous case.

200 On one side, the two goals targeted by the policy, i.e. GHG emission mitiga-
 201 tion (SDG 13) and energy consumption reduction and renewable share (SDG 7),
 202 improve respectively by 25% and 43%. In particular, in SDG 13, emissions are in
 203 line with NDCs, the gap from equitable and sustainable emissions per capita remains
 204 unchanged with respect to the NDC_COND_Policy and the concentration of emis-
 205 sions from AFOLU is slightly higher than in the previous scenario because the NES
 206 impacts more energy intensive sectors and stimulates agricultural production. Italy
 207 achieves full sustainability also relatively to renewable share target (SDG 7). SDG 11

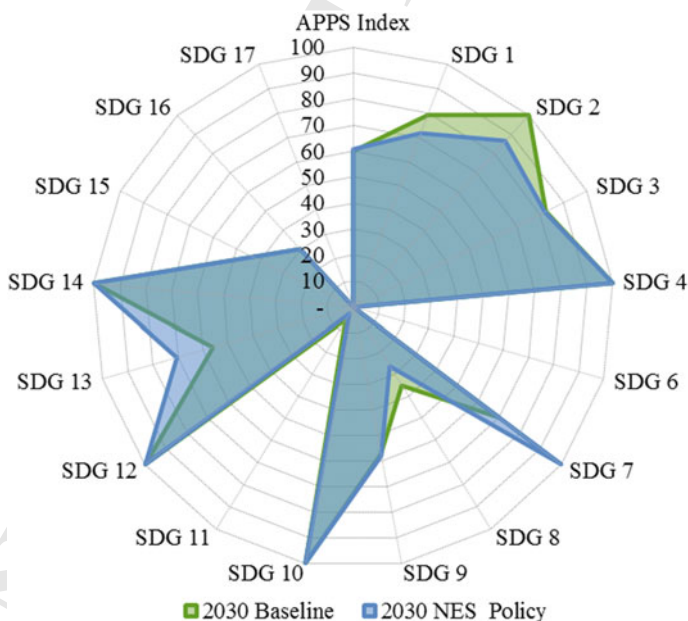


Fig. 4 Gap from achieving SDGs, 2030 baseline versus 2030 NES_Policy

(emission intensity) shows an opposite trend which deteriorates due to a contraction of energy consumption faster than emission reduction.

On the other side, there are some drawbacks on the economic and social dimensions. The NES policy is more costly than Paris Agreement policy and determines some negative externalities on the economy. Namely, GDP per capita growth slows down compared to the reference scenario (-0.6% yearly) and also of GDP per employed, determining a drop of SDG 8 score (-24%). The worsening of economic pillar conditions social sphere: -9.5% (SDG 1), -13.5% (SDG 2) and -0.5% (SDG 3). It is worth to notice that these are small variations in the absolute value of indicators that remain very close to full sustainability level in 2030 (1.4% of population below extreme poverty line, 0.9% undernourishment prevalence and 73 years of healthy life expectancy at birth).

5.3 *Quality Education (QIST_Policy)*

Public investments to boost the quality of education lead to a 2.8% rise of overall sustainability (Fig. 5). Under this policy, the driving indicators are the economic ones given the positive correlation between the quality of human capital and the all factor productivity of the system (0.5% yearly). Economic sustainability increases by 46.7%, social one by 1.5% and environmental one by 4%. More in detail, the rise of GDP per employed and GDP per capita growth propel SDG 8 score (+76.9% wrt reference scenario).

The improved economic sustainability stimulate social indicators with a reduction of extreme poverty (-8.9% wrt baseline scenario) and higher healthy life expectancy (+1.5% wrt baseline scenario).

The implemented policy is lacking in controlling side effects of economic growth with an environmental policy and the absence of a lower energy efficiency determine a negative impact on environmental indicators and specifically on SDG 13 (-16.8% wrt reference scenario) considering a rise of gaps from NDC emission reduction targets (+34.5%) and from equal and sustainable emission per capita (+8%).

5.4 *Youth and Female Employment (OCC_FG_Policy)*

The government investments in order to reduce youth and female unemployment have similar effects of the above described policy on education, although more contained. The narrow expansion is due to design of this policy that assume a rise of employed population, but a constant productivity. However, overall sustainability is higher (+0.5%) (Fig. 6) synthetizing two divergent effects: the improvement of economic and social indicators (respectively +9% and +0.3%) and the worsening of environmental pillar (-9.8% wrt the reference scenario). The rise of occupation and

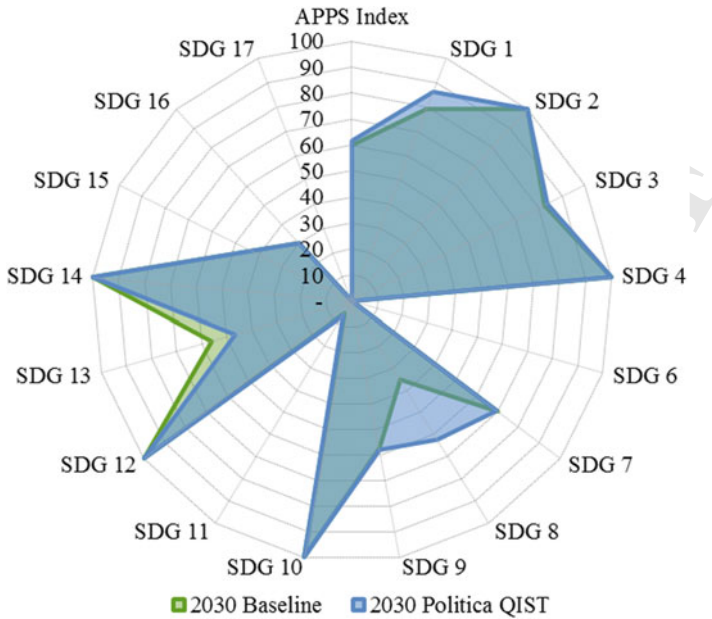


Fig. 5 Gap from achieving SDGs, 2030 baseline versus 2030 quality education policy (QIST_Policy)

244 GDP growth rate more than compensate the slight reduction of GDP per employed.
 245 Overall SDG 8 score increase by 14%.

246 The higher score obtained in social sustainability depends on a 2.2% contraction
 247 of poverty prevalence due to higher GDP per capita. As mentioned above, the higher
 248 economic growth stemming from this policy leads to a lower level of environmental
 249 sustainability with no mitigation policies are put in place. The score of SDG 13
 250 decreases by 6%, as effect of a widening gap from the targets of the 3 underlying
 251 indicators, and SDG 11 drop by 1.8% denoting a small rise in emissions intensity in
 252 residential and transport sectors.

253 5.5 Industry 4.0 and Digital Agenda (IND4.0&BL_Policy)

254 Government investment aiming at improving cooperation between industrial and
 255 research sectors and spreading the access to fast broadband connection brings upward
 256 Italian sustainability level (+5.2%), but highlight the trade-offs among pillars (Fig. 7).

257 The economic pillar, stimulated by higher productivity especially in the industrial
 258 sector, gains 75.5%, social one 2.1% and the environment drops by 12.9%. The
 259 economic sustainability is dragged by SDG 8 (+93.1%), i.e. strong GDP growth,

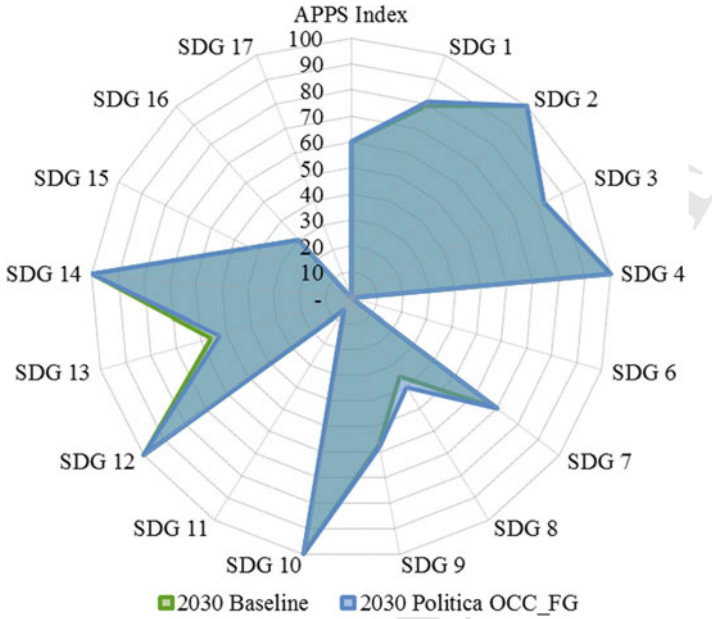


Fig. 6 Gap from achieving SDGs, 2030 baseline versus 2030 youth and women employment policy (OCC_FG_Policy)

260 and by a subsequent improvement of debt-to-GDP ratio. This affects also social
 261 indicators, i.e. poverty prevalence reduces by 17.9%.

262 The economic expansion has some environmental drawbacks especially on SDG
 263 13 (−53%) with a rise of 100% of the gap from Paris mitigation targets and a distancing
 264 from equal and sustainable emission per capita (+31.5%). Only the concentration
 265 of emissions from AFOLU declines due to the competitive advantage of industrial
 266 sector that depress agriculture.

267 It is worth to mention that, as effect of the policy, we assume generalised higher
 268 total productivity in the entire industrial sector. Therefore, the negative impact on
 269 the environmental pillar might be overestimated whereas high-tech, clean energy and
 270 tertiary sectors benefit more of technological change opportunities due to their lower
 271 emission intensity.

272 5.6 Overall Policy for Sustainable Development

273 This final section analyses the effects on Italian sustainability following the simul-
 274 taneous implementation of all policies described above.

275 Our results denote a strong rise of overall sustainability (+17%) with an increase of
 276 economic (+120%), social (+2.4%) and environmental (+5.7%) pillar scores (Fig. 8).

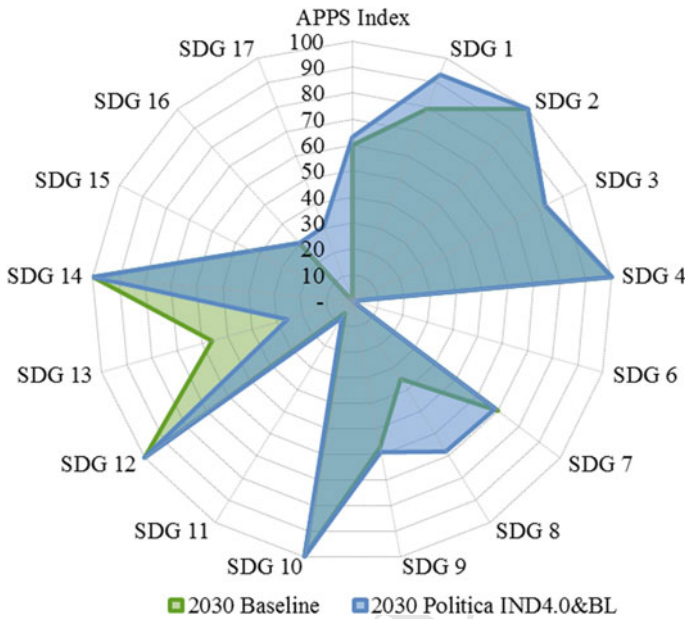


Fig. 7 Gap from achieving SDGs, 2030 baseline versus Industry 4.0+Digital Agenda (IND4.0&BL_Policy)

277 The economic pillar benefits from technological advancement and higher pro-
 278 ductivity due to the combined impulse of policies targeting Industry 4.0+Digital
 279 Agenda, Youth and female employment and Education. The score of SDG 8 strongly
 280 rises (+101.1%) and determines a drop of poverty incidence (+17.1% in SDG 1) and
 281 a rise of healthy life expectancy at birth (SDG 3: +1.7%). The economic growth,
 282 jointly with lower emission intensity due to mitigation policies, turns into a better
 283 performance in SDG 9 (+8.3%). Also SDG 17 benefits from this policy mix; the
 284 debt-to-GDP ratio shows huge improvement getting close to the sustainable level.
 285 All considered policies implies some costs, in terms of higher public expenditure or
 286 investments that are however more than compensated by the high economic growth.
 287 Therefore, a virtuous mechanism working in two direction kicks off: the debt-to-
 288 GDP ratio drops due to higher GDP at the denominator and higher fiscal revenues
 289 and debt decumulation at the numerator.

290 The implementation of National Energy Strategy and of Paris Agreement allows
 291 stemming detrimental effects of economic growth on the environment. In addition
 292 to the above mentioned reduction of carbon intensity in the productive sector, the
 293 spread of renewable energy sources leads to achieve sustainable level in SDG 7.
 294 These factors more than compensate the worsening performance of SDG 13, due to
 295 the rise of GHG emissions. It is worth to mention that Italy achieves its NDC trading
 296 emission permits in the EU-ETS: the Country is net buyer being more convenient to
 297 purchase permits and preserve the economic expansion, than curbing emissions.

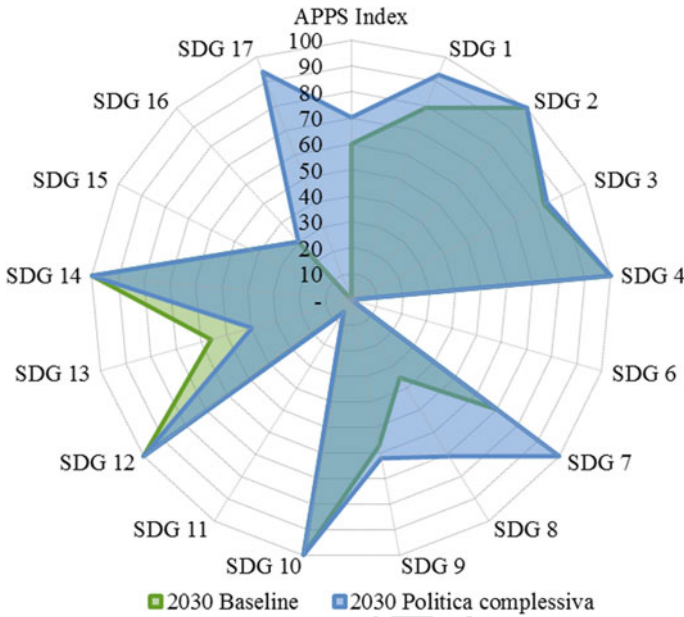


Fig. 8 Gap from achieving SDGs, 2030 baseline versus overall policy for sustainable development (SD_Policy)

298 Finally, the analysed package of policies leaves unchanged the score of some
 299 SDGs, e.g. SDG 6 (water use) and SDG 11 (emission intensity in the residential and
 300 transport sectors). Therefore other specific interventions targeting these indicators
 301 should be included in the policy mix to achieve a higher level of sustainability and
 302 proximity to 2030 SDGs.

303 6 Conclusion

304 Despite the important progress made in last years, Italy is still far to show a sustainable
 305 path towards the SDGs.

306 Current well-being, estimated through the APPS Index, is significantly lower than
 307 in other European countries. At the same time, in a business-as-usual scenario, these
 308 conditions are expected to improve marginally and therefore in 2030 Italy will not
 309 able to achieve the ambitious targets of 2030 Agenda.

310 However, in this paper we have shown that specific and overarching policy designs
 311 can be effective in improving levels of well-being, even if our results should be
 312 judged carefully because the use of a macroeconomic model implies a simplified
 313 representation of economic system and of policy interventions.

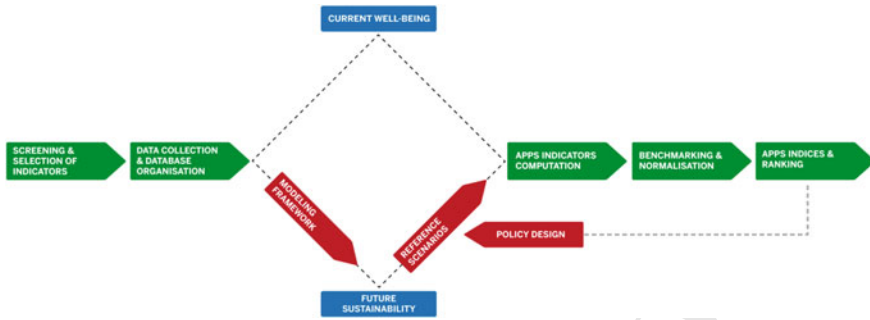


Fig. 9 APPS methodological framework

Nevertheless, several results are still significant. In particular, the main value-added of our analysis is the identification of potential trade-offs and interactions among sustainability targets that call for a careful policy planning. Not all policies are additive; negative interactions are common especially between economic and environmental pillars, when the uncontrolled rise of production can harm environmental sustainability, but also positive feedback, as in the case of climate policy revenues that help improving the score of economic indicators. In such complex context, it is important to adopt a holistic approach and consider coherent policy interventions.

Appendix I: APPS Framework Description

APPS (Assessment, Projection and Policy of Sustainable Development Goals) framework aims at offering a comprehensive assessment of current well-being and future sustainability based upon 28 indicators related to the 17 Sustainable Development Goals.⁷

The current well-being assessment is provided for 139 countries, and it is measured as the overall performance in 16 SDGs (APPS Index).

The future sustainability evaluation sheds some lights on the evolution of SDG indicators up to 2030, under different socio-economic and policy scenarios. On this purpose, historical records of SDG indicators and empirical analyses are combined with a Computable General Equilibrium (CGE) model.

The multi-step APPS methodological framework is synthetized in Fig. 9.

⁷The 2030 Agenda for Sustainable Development adopted by the UN General Assembly on September 2015 (UN 2015) set 17 Sustainable Development Goals (SDGs) to be achieved worldwide by 2030 by means of a global strategy.

335 A. Current Well-Being

336 A.1 Screening and Selection of Indicators

337 Each SDG is structured into Targets. The 169 Targets proposed by the United Nations
338 Open Working Group serves to monitor the actual achievement in quantifiable terms
339 of the SDGs under the different perspectives involved. Progresses over time and
340 compliance with SDG Targets can be measured using indicators. The current list
341 of indicators, adopted in July 2017 by the UN General Assembly, considers 232
342 indicators (UN 2017).

343 The multi-step feature of APPS framework implies further constraints to indicator
344 selection in addition to the usual requirements on **relevance** in measuring the SDG
345 they refer to and **connection with a specific quantitative SDG Target**. Indeed, APPS
346 indicators need to have good **country coverage** because the well-being assessment
347 is worldwide and the comparability of the results of aggregation procedure requires
348 excluding countries with missing values for at least one of APPS indicators. In
349 addition, APPS indicators are at **country level**. Furthermore, the most stringent
350 constraint in selecting APPS indicators comes from the sustainability assessment
351 methodology: drawing the future path of SDG indicators depends on identifying
352 their determinants (empirical analysis on the historical data and evidences from the
353 literature), and, at the same time, depicting future evolution of these determinants. A
354 macro-economic model can offer a coherent scenario-dependent representation of the
355 future; therefore our approach relies on linking SDG indicators to macro-economic
356 variables from a macro model. The lack of any **empirical evidence connecting SDG
357 indicators with one or more endogenous variable in our model** determined its
358 exclusion from APPS set of indicators.

359 The final APPS screening considers 28 indicators covering 16 SDGs (All but
360 SDG 5—Achieve gender equality and empower all women and girls). Table 4 lists
361 the APPS indicators coupled with the related SDG and specific target they measure. AQ1









362 A.2 Data Collection and Database Organization

363 Data for all the indicators identified in the previous step have been gathered from
364 international databases. The huge amount of missing data prevented the creation of
365 a solid time series for APPS indicators. Thus, the current database focuses only on
366 the latest available data.

367 Table 5 reports the source used for each indicator and the number of countries
368 covered. Only 139 countries report data for all the indicators considered.





369 The same indicators and sources are used for the sustainability assessment. Given
370 that 2007 is the base year of our macro-economic model, for the sustainability assess-
371 ment we collected indicator values around 2007 and we further aggregated them
372 according to regional detail our model (see Sect. B1 for more details).

Table 4 APPS indicators and SDG targets

UN SDG	APPS indicator	SDG target
	Poverty headcount ratio at \$1.25 a day (PPP2005) (% of population)	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.25 a day
	Prevalence of undernourishment (% of population)	2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round
	Physician density (per 1,000 people)	3.c Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States
	Healthy Life Expectancy (HALE) at birth (years)	n/a
	Youth literacy rate (% of population 15–24 years)	4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy
	n/a	n/a
	Annual freshwater withdrawals, total (% of internal renewable water)	6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
	Access to electricity (% of total population)	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services
	Renewable electricity (% in total electricity output)	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix
	Primary energy intensity (MJ/\$PPP2011)	7.3 By 2030, double the global rate of improvement in energy efficiency
	GDP per capita annual growth (%)	8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries






(continued)

Table 4 (continued)

UN SDG	APPS indicator	SDG target
	GDP per person employed (\$PPP2011)	8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value
	Employment-to-population ratio (%)	n/a
	Manufacturing value added (% of GDP)	9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries
	Total energy and industry-related GHG emissions over sectoral value added (t of CO2e/\$PPP2011)	9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
	Research and development (R&D) expenditure (% of GDP)	9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending
	Palma ratio	10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average
	CO2 intensity of residential and transport sectors (t of CO2/t of oil equivalent energy use)	n/a
	Material productivity (\$PPP2011/kg)	12.2 By 2030, achieve the sustainable management and efficient use of natural resources

(continued)

Table 4 (continued)

UN SDG	APPS indicator	SDG target
	Net GHG emissions from agriculture, forestry and other land use (AFOLU) sectors per square metre of forest and agricultural land (t of CO ₂ e/sq. m)	n/a
	Compliance to Conditional INDCs	13.2 Integrate climate change measures into national policies, strategies and planning
	Gap from equitable and sustainable GHG emissions per capita in 2030 (t CO ₂ eq) ^a	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity, and, by 2020, protect and prevent the extinction of threatened species
	Marine protected areas (% of territorial waters)	14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
	Terrestrial protected areas (% of total land area)	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
	Forest area (% of land area)	15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally
	Endangered and vulnerable (animals and plants) species (% of total species)	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity, and, by 2020, protect and prevent the extinction of threatened species
	Corruption perception index	16.5 Substantially reduce corruption and bribery in all their forms
	Central government gross debt (% of GDP)	17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress

^aThe equitable and sustainable GHG emission per capita level in 2030 is computed as the ratio of the median GHG emission level in 2030 according to scenarios that will contain (with likelihood > 66%) the temperature increase below 2 °C by the end of the century, i.e. 42 GtCO₂ e (UNEP 2015), and the median estimate of world population in 2030 (UN 2015)

Table 5 APPS indicators, sources and coverage

APPS indicator	Sources	Countries coverage
Poverty headcount ratio at \$1.25 a day (PPP2005) (% of population)	World Development Indicators/Millennium Development Goals Database	171
Prevalence of undernourishment (% of population)	World Development Indicators/Millennium Development Goals Database	178
Physician density (per 1000 population)	World Health Organization	194
Healthy Life Expectancy (HALE) at birth (years)	World Health Organization	194
Youth literacy rate (% of population 15–24 years)	UN Educational, Scientific and Cultural Organization	197
Annual freshwater withdrawals, total (% of internal renewable water)	World Development Indicators	205
Access to electricity (% of total population)	World Development Indicators	245
Renewable electricity (% in total electricity output)	World Development Indicators	215
Primary energy intensity (MJ/\$PPP2011)	World Development Indicators	193
GDP per capita annual growth (%)	International Monetary Fund/World Development Indicators	225
GDP per person employed (\$PPP2011)	International Monetary Fund/World Development Indicators	205
Employment-to-population ratio (%)	World Development Indicators	207
Manufacturing value added (% of GDP)	World Development Indicators	185
Total energy and industry-related GHG emissions over sectoral value added (t of CO ₂ e/\$PPP2011)	World Development Indicators/International Monetary Fund/CAIT (WRI Climate Data Explorer)	177
Palma ratio	World Development Indicators	168
CO ₂ intensity of residential and transport sectors (t of CO ₂ /t of oil equivalent energy use)	International Energy Agency	179
Material productivity (\$PPP2011/kg)	World Development Indicators/International Monetary Fund/GMWD SERI/WU Global Material Flows Database	178

(continued)

Table 5 (continued)

APPS indicator	Sources	Countries coverage
Net GHG emissions from agriculture, forestry and other land use (AFOLU) sectors per square metre of forest and agricultural land (t of CO ₂ e/sq. m)	UN Food and Agriculture Organization/World Development Indicators	209
Compliance to Conditional INDCs	CAIT (WRI Climate Data Explorer)/World Development Indicators	183
Gap from equitable and sustainable GHG emissions per capita in 2030 (t CO ₂ eq) ^a	CAIT (WRI Climate Data Explorer)/World Development Indicators/UN (2015)	176
Marine protected areas (% of territorial waters)	Millennium Development Goals Database	238
Terrestrial protected areas (% of total land area)	Millennium Development Goals Database	226
Forest area (% of land area)	World Development Indicators	241
Endangered and vulnerable (animals and plants) species (% of total species)	International Union for Conservation of Nature	222
Corruption Perception Index	Transparency International	188
General government gross debt (% of GDP)	International Monetary Fund	184
Research and development (R&D) expenditure (% of GDP)	World Development Indicators	186

^aThe equitable and sustainable GHG emission per capita level in 2030 is computed as the ratio of the median GHG emission level in 2030 according to scenarios that will contain (with likelihood > 66%) the temperature increase below 2 °C by the end of the century, i.e. 42 GtCO₂ e (UNEP 2015), and the median estimate of world population in 2030 (UN 2015)

373 *A.3 Benchmarking and Normalization*

374 In order to compare country performance in different SDG indicators and to compute
375 some aggregate measures, it is necessary to bring all indicators to a common
376 measurement unit.

377 The **normalization procedure** required for transforming the raw data into a common
378 [0, 1] scale uses two different step functions depending on the indicator characteristics.
379

$$380 \quad f_a(x) = \begin{cases} 1 & x \geq \bar{x} \\ 0 & x \leq \underline{x} \\ \frac{(x-\underline{x})}{(\bar{x}-\underline{x})} & \underline{x} \leq x \leq \bar{x} \end{cases} \quad f_b(x) = \begin{cases} 1 & x \leq \bar{x} \\ 0 & x \geq \underline{x} \\ \frac{(\bar{x}-x)}{(\bar{x}-\underline{x})} & \bar{x} \leq x \leq \underline{x} \end{cases}$$



Fig. 10 Indicators pertaining aggregate index by pillar

382 For indicators belonging to the (a) category, country performance is unsustainable
 383 whenever its score is below a critical threshold value \underline{x} , whereas it is defined as
 384 sustainable whenever its score is above the threshold value \bar{x} . Indicators belonging
 385 to the (b) category have the opposite normalization process. In both cases, a linear
 386 interpolation between these two threshold values allows evaluating the intermediates
 387 scores.

388 The **benchmarking procedure** consists in defining the threshold values, \underline{x} and \bar{x} ,
 389 for each indicator described above and is the same in the well-being and sustainability
 390 assessment. In choosing the threshold levels we firstly looked at the 169 SDG targets,
 391 which are our preferred source whether it gives a quantitative target. When the targets
 392 are qualitative, as it happens in many cases, other sources were preferred such policy
 393 targets in OECD (target in EU of 3% R&D expenditure) or best practices.

394 Table 6 shows the threshold values used, respectively, for the normalization pro-
 395 cess of APPS indicators both in well-being and sustainability assessments.

396 **A.4 APPS Indices and Ranking**

397 APPS framework considers several aggregation steps in order to produce aggregate
 398 indices conveying more synthetic information to policymakers:

- 399 • SDG indices are the average value of indicator characterizing each goal;
- 400 • The APPS Index is the average of scores in each SDG;
- 401 • Indices by pillar are the average of SDG indices related to each sustainability pillar
- 402 (Figs. 3 and 10).

AQ2

Table 6 APPS indicators, normalization type and benchmarks

Indicator	Type	Lower bound	Upper bound
<i>Economy</i>			
GDP per capita growth (%)	A	0	3
GDP per person employed (\$PPP2011)	A	40,000	100,000
Public debt as share of GDP (%)	B	100	20
Employment-to-population ratio (%)	A	40	80
Manufacturing value added (MVA) as percent of GDP (%)	A	5	25
Gross domestic expenditure on R&D as share of GDP (%)	A	0.5	3
<i>Society</i>			
Population below \$1.25 (PPP) per day (%)	B	5	0
Population undernourished (%)	B	7	0
Physician density (per 1000 population)	A	2	3
Healthy Life Expectancy (HALE) at birth (years)	A	60	80
Literacy rate of 15–24 years old, both sexes (%)	A	90	100
Access to electricity (% of total population)	A	90	100
Palma ratio	B	2	1
Corruption Perception Index	A	2.7	8
<i>Environment</i>			
Proportion of total water resources used (%)	B	30	5
Share of electricity from renewables (%)	B	5	60
Rate of primary energy intensity (Mtoe/million\$PPP11)	B	10	3
Total energy and industry-related GHG emissions over value added (kgCO ₂ /\$PPP07)	B	2	1
CO ₂ intensity of residential and transport sectors over energy volumes (t of CO ₂ /toe)	B	2.5	0.5
Net GHG emissions in the AFOLU sector over total surface (t of CO ₂ e/sq. km)	B	100	0
Gap from equitable and sustainable GHG emissions per capita (t CO ₂ eq)	B	15	0
Proportion of terrestrial protected areas (%)	A	10	50
Proportion of marine protected areas (%)	A	5	20
Forest area (%)	A	5	60
Share of endangered and vulnerable (animals & plants) species (% of total species)	B	20	5
Direct Material Consumption over GDP (%)	A	0.5	2

B. Future Sustainability

B.1 Macro-Economic Framework

The indicators are calculated using the outputs of the **Intertemporal Computable Equilibrium System (ICES) model** (Eboli et al. 2010). ICES is a recursive-dynamic CGE model with World coverage based on the GTAP-E model (Burniaux and Truong 2002) and GTAP 7 database⁸ (Narayanan and Walmsley 2006).

AQ3

In the model, the economy of each country is characterised by n industries, a representative household and government. Industries minimize production costs and have nested Constant Elasticity of Substitution production functions that combine primary factors (natural resources, land, and labour), a capital and energy composite, and intermediates in order to generate the output. The “Armington assumption” introduces some frictions on the substitutability of inputs imported from different countries.

A regional household in each region receives income, defined as the service value of national primary factors (natural resources, land, labour, capital). Capital and labour are perfectly mobile domestically but immobile internationally; instead land and natural resources are industry-specific. Income of different agents is used to finance three classes of expenditure: private household consumption, public consumption and savings; the utility of private household consumption has a Constant Difference of Elasticities functional form.

A fictitious world bank collects savings from all regions and allocates investments in order to equalise the current rates of return.

Dynamics inside the ICES model are driven essentially by two sources: one endogenous and one exogenous. The first involves capital accumulation and foreign debt evolution governed by endogenous investment decisions. On the other hand, we make several exogenous assumptions concerning trends of population stock, labour stock, labour, land and total factor productivity over time in order to obtain a reference scenario in line with main economic indicators.

The **benchmark year** for indicators calibration is 2007, and the **time horizon** for the assessment is 2015–2030.

While the assessment of current well-being is provided for the 139 countries, projecting future sustainability requires some aggregation for the sake of computation. There are **45 countries/regions** considered in the model simulations (Fig. 11). The countries singled out are selected on the basis of their relevance for sustainability (high concern for social and environmental issues) as well as population size (covering 70% of World population). Each socio-economic system is then divided into 22 sectors providing commodities/services, chosen according to their contribution to sustainable development indicators.

⁸GTAP 7 database considers 113 macro-regions and 57 production sectors for the year 2007; for APPS project the world is aggregates it in 45 macro-regions and 20 production sectors.

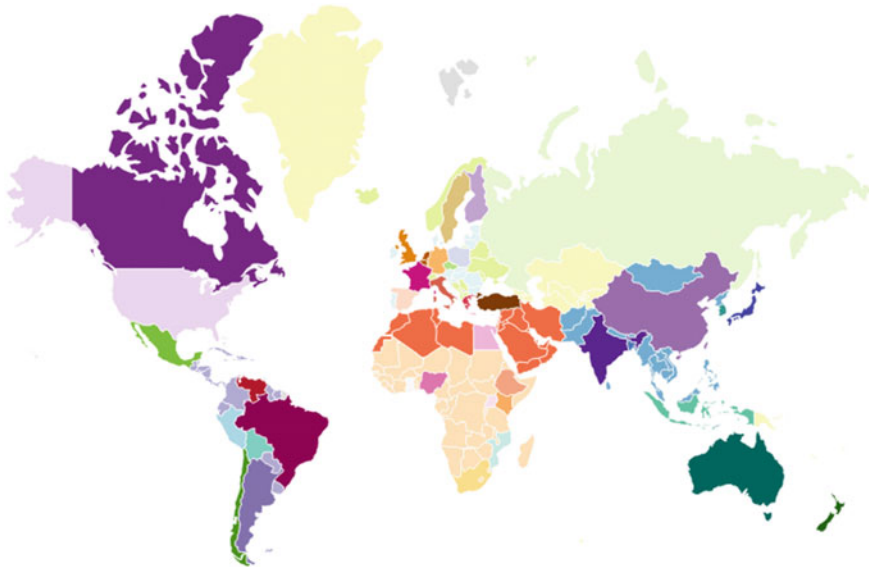


Fig. 11 APSS regional aggregation

441 *Extensions of ICES model*

442 In order to perform a sustainability analysis, we extended ICES to consider a more
 443 detailed sectoral aggregation and to better capture the behaviour of public sector.
 444 The new sectors are: Research and Development (R&D), Education, Health, and
 445 Renewable Energy Sources (RES). All of them were split from the original GTAP 7
 446 sectors according to the available international statistics which represent the world
 447 economy in the year 2007.

448 For the **R&D** sector, we used the indicator “R&D expenditure as percentage of
 449 GDP” from the World Development Indicators—WDI (World Bank) and the “share
 450 of R&D financed by Government, Firms, Foreign Investment and Other National”
 451 from the OECD Main Science and Technology Indicators for attributing R&D to the
 452 different economic agents.

453 A similar approach has been used for **Education and Health** sectors. Data on
 454 overall expenditure on health and education have been obtained from the WDI
 455 database (World Bank).

456 In order to regard separately the **RES**, namely wind, solar and hydro-electricity,
 457 they were split from the original electricity sector. The data collection refers to phys-
 458 ical energy production in Mtoe (Million tons of oil equivalent) from different energy
 459 vectors and for each GTAP 7 country/region. The data source is Extended Energy Bal-

460 ances (both OECD and Non-OECD countries) provided by the International Energy
461 Agency (IEA). We complemented the production in physical terms with price infor-
462 mation (OECD/IEA 2005; EC 2008; Ragwitz et al. 2007; GTZ 2009; IEA country
463 profiles and REN21). The explicit consideration of the RES sector implied some
464 modelling changes: the production function of electricity sector considers a new
465 nest allowing the inter-electricity substitution between RES and traditional fossil
466 electricity.

467 Furthermore, starting from the ICES core model, we develop a model extension,
468 ICES-XPS (Delpiazzi et al. 2017), to specifically consider the **public actor**. Indeed,
469 in the original ICES model the government is part of a regional household but it
470 hasn't its own budget and its representation is limited to only consuming a frac-
471 tion of regional disposable income. In this extension, instead, we split the regional
472 household into the two main actors in the economy, i.e. the private household and the
473 government. The government revenues now derive from: taxes paid by private house-
474 hold and productive sectors, international transactions among governments (foreign
475 aid and grants) and transactions between the government and the private household
476 (net social transfers, interest payment on public debt to residents), and flows among
477 governments and foreign private households (interest payment on public debt to non-
478 residents). The government can use these revenues for public expenditure in goods
479 and services, savings or for reducing public debt.

480 *Indicator computation*

481 For evaluating future sustainability, APPS indicator values around 2007 are collected
482 for each country and introduced into the modelling framework. Their future trends
483 are linked to the dynamics of macro-economic variables in the model.

484 The Table 7 describes the modelling behaviour of APPS Indicators.

[AQ4]

485 **B.2 Reference Scenarios**

486 Building future socio-economic-environmental scenarios into a macro-economic
487 framework implies making assumptions on trends of some exogenous variables. The
488 APPS project uses as a reference source for scenarios those developed by the climate
489 change community and known as Shared Socioeconomic Pathways (SSPs) (O'Neill
490 et al. 2017). These are connected to different mitigation/adaptation challenges and,
491 more extensively, to sustainable pathways of future economic development. SSPs
492 provide references for future patterns of population, labour force and GDP growth.
493 Primary factor productivity, sector-specific efficiency, total factor productivity and
494 energy prices are then used in order to reproduce the trends of GDP, energy use,
495 emissions and value added shares.

496 Among Shared Socioeconomic Pathways (SSPs), we have for the moment devel-
497 oped the **SSP2 “Middle of the road” scenario**. The main features of this scenario
498 are:

Table 7 APPS indicators and dependent variables from ICES model

APPS indicator	Modelling behaviour
Poverty headcount ratio at \$1.25 a day (PPP2005) (% of population)	GDPPPP per capita and Palma ratio (regression)
Prevalence of undernourishment (% of population)	GDPPPP per capita, Palma ratio, urban population, agricultural production per capita and industrial VA share (regression)
Physician density (per 1000 population)	Private and public education expenditure (regression)
Healthy Life Expectancy (HALE) at birth (years)	Physician density, education expenditure per capita and electricity access (regression)
Youth literacy rate (% of population 15–24 years)	Public education expenditure per capita (regression)
Annual freshwater withdrawals, total (% of internal renewable water)	Domestic demand of water by agents: households, industry, agriculture (endogenous)
Access to electricity (% of total population)	GDPPPP per capita, electricity output, urbanisation and Palma ratio (regression)
Renewable electricity (% in total electricity output)	Supply of Electricity from Renewables and Total Electricity (endogenous)
Primary energy intensity (MJ/\$PPP2011)	Total Primary Energy Supply and Real GDP (endogenous)
GDP per capita growth (%)	GDP (endogenous) and Population (exogenous)
GDP per person employed (\$PPP2011)	GDP (endogenous) and Employed Population (exogenous)
Employment-to-population ratio (%)	Exogenous
Manufacturing value added (% of GDP)	Value Added in Manufacturing and GDP (endogenous)
Total energy and industry-related GHG emissions over sectoral value added (t of CO _{2e} /\$PPP2011)	Industrial Emissions and Value Added in the Industrial sector (endogenous)
Palma ratio	Sectoral VA, public education expenditure per capita, unemployment and corruption control (regression)
CO ₂ intensity of residential and transport sectors (t of CO ₂ /t of oil equivalent energy use)	Demand of Fossil Fuels and Emissions in Residential and Transport sectors (endogenous)
Material productivity (\$PPP2011/kg)	Material (mining) Use in Heavy Industry sector and GDP (endogenous)
Net GHG emissions from agriculture, forestry and other land use (AFOLU) sectors per square metre of forest and agricultural land (t of CO _{2e} /sq. m)	Emission in agriculture (endogenous), other emissions (exogenous)

(continued)

Table 7 (continued)

APPS indicator	Modelling behaviour
Compliance to Conditional INDCs*	GHG Emissions (endogenous)
Gap from equitable and sustainable GHG emissions per capita in 2030 (t CO ₂ eq)**	GHG Emissions (endogenous)
Marine protected areas (% of territorial waters)	Exogenous
Terrestrial protected areas (% of total land area)	Exogenous
Forest area (% of land area)	Land use in the Forestry sector (endogenous)
Endangered and vulnerable (animals and plants) species (% of total species)	Exogenous
Corruption Perception Index	Exogenous
General government gross debt (% of GDP)	GDP and government debt (endogenous)
Research and development (R&D) expenditure (% of GDP)	R&D Value Added and GDP (endogenous)

- 499 • similar trends of recent decades, but some progresses towards achieving develop-
500 ment goals;
501 • medium population growth;
502 • per-capita income levels grow at a medium pace on the global average; slow income
503 convergence; some improvements in the intra-regional income distributions;
504 • reductions in resource and energy intensity, and slowly decreasing fossil fuel
505 dependency.

506 Appendix II: Detailed Results

See Table 8.

Table 8 Current wellbeing (APPS 2015) and future sustainability (APPS Index 2030). APPS Index and ranking

Ranking 2030	Countries	APPS Index 2030	Δ ranking	APPS Index 2015	Ranking 2015
1	Sweden	82.3	0	80.3	1
2	Finland	71.3	0	73.2	2
3	Germany	70.2	0	71.2	3
4	Canada	69.6	5	62.8	9
5	New Zealand	69.4	-1	65.2	4
6	Australia	68.9	2	62.9	8

(continued)

507

Table 8 (continued)

Ranking 2030	Countries	APPS Index 2030	Δ ranking	APPS Index 2015	Ranking 2015
7	UK	67.4	3	62.1	10
8	RoEU	66.5	-3	64.6	5
9	France	66.4	-2	63.4	7
10	Russia	64.6	6	56.7	16
11	RoEurope	64.3	1	61.2	12
12	Benelux	64.1	-6	63.7	6
13	Japan	61.8	-2	61.2	11
14	Poland	61.5	0	57.7	14
15	Czech_Rep	60.7	2	56.3	17
16	Italy	60.0	-1	56.9	15
17	Indonesia	59.2	11	44.2	28
18	USA	58.2	1	55.0	19
19	South Korea	57.2	-6	59.7	13
20	Chile	57.2	-2	55.1	18
21	Brazil	56.6	-1	53.0	20
22	Argentina	56.6	-1	51.4	21
23	Venezuela	54.4	2	45.7	25
24	Greece	53.5	3	44.8	27
25	Spain	53.0	-2	49.6	23
26	RoMENA	50.2	4	41.8	30
27	RoLACA	49.3	2	42.4	29
28	Turkey	49.0	-4	47.8	24
29	Mexico	48.9	-7	49.7	22
30	Bolivia	47.7	3	37.2	33
31	Egypt	47.4	3	36.4	34
32	Peru	47.0	-1	41.5	31
33	RoW	45.6	-7	45.5	26
34	China	45.5	3	32.8	37
35	Bangladesh	42.0	4	31.0	39
36	Ghana	41.7	2	32.0	38
37	South Africa	41.4	-1	33.1	36
38	Ethiopia	40.2	3	29.8	41
39	Nigeria	38.7	-7	38.3	32
40	India	35.5	5	24.9	45
41	RoAfrica	34.5	-1	30.6	40
42	Mozambique	32.9	-7	34.4	35
43	RoAsia	32.6	-1	29.7	42
44	Uganda	30.6	0	26.6	44
45	Kenya	24.3	-2	27.0	43

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