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## NATIONAL SUSTAINABILITY INDEX AS A TOOL FOR EVALUATING THE IMPLEMENTATION OF SUSTAINABLE DEVELOPMENT GOALS IN POLAND IN 2010-2019

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**ABSTRACT:** The paper presents the assessment results of the implementation of Poland's national sustainable development goals from 2010 to 2019. For this purpose, a synthetic index (National Sustainability Index) was designed using taxonomic methods. The study sought answers to the following questions: What is Poland's general level of accomplishment of sustainable development goals? What were the dynamics of changes in respective years? Which plans require special attention and actions in the coming years? Considering the possible range of the NSI, a significant improvement in accomplishing Poland's national sustainable development goals was observed in the surveyed years. Nevertheless, some areas still need intervention at the decision-making level, contributing to further balancing Poland's economic growth and development paths. The analysis's added value is the synthetic measure designed based on 76 specific indicators and the evaluation of sustainable development in Poland over ten years.

**KEYWORDS:** sustainable development goals, taxonomic methods, synthetic index, Poland, dynamic analysis

## Introduction

It has been 35 years since the concept of sustainable development (SD) was incorporated into the international public debate. The new economic doctrine was summarised in the first sentence of the Brundtland Report 1987 – “Our Common Future” as a *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (United Nations, 1987).

Some critics claim that it was only a coined slogan that could be followed up by the first ‘green’ political fractions and leaders of the Third World countries in which facing social and economic problems was a priority. The formula was unclear, but details could be left for later. Nevertheless, it was indisputably the rise of the concept of sustainable development (Bâc, 2008; Bartlett, 2006; Benton, 1994).

The number of publications tackling the topic of sustainable development increased significantly over the past 20 years. Associated papers mainly focused on: the essence and origin of the concept (Lawn, 2001; Strange & Bayley, 2008; Waas, 2011; Janousková et al., 2019; Ruggiero, 2021; Bellantuno et al., 2022); barriers to and conditions for its implementation (Nasibulina, 2015; Raszkowski & Bartniczak, 2019; Mio et al., 2020; Berchin et al., 2021; Otamendi-Irizar et al., 2022; Bonnedahl et al., 2022); planning, including formulating sustainable development strategies at various management levels (United Nations, 2015; Wang et al., 2015; Allen et al., 2016; Grainger-Brown & Malekpour, 2019; Qu et al., 2020; Guan et al., 2021; Zhou et al., 2022); promoting best practices and models in implementing SD (Charrouf & Guillaume, 2009; Häikiö, 2014; Ross, 2018; Bin Mohd Yusof & Ariffin, 2020; Baba Ali et al., 2021; Gusheva et al., 2022) and relationships between sustainable development and various socio-economic concepts and phenomena (Bina, 2013; Olsson et al., 2014; Kasztelan, 2017; Corona et al., 2019; Dogaru, 2020; Belmonte-Ureña, 2021; Panchal, 2021; Zargartalebi, 2021; Rodríguez-Antón et al., 2022). Much attention was also devoted to monitoring and evaluating the implementation of sustainable development goals (SDG) (Radojicic et al., 2012; Waas et al., 2014; Bujanowicz-Haraś et al., 2015; Gujjarro & Poyatos, 2018; Mair et al., 2018; Megyesiova & Lieskovska, 2018; Barbier & Burgess, 2019; Popović, 2019; Raszkowski & Bartniczak, 2019a, b; Bova & Śleszyński, 2020; Lafortune et al., 2020; European Commission, 2021; Guan et al., 2021; Adrangi & Kerr, 2022; Gunnarsdottir et al., 2022).

The above summary shows that issues related to sustainable development remain a constant concern for science, policy and economic practice, and one of the critical areas of research is tools for assessing the achievement of SD goals. A comprehensive system for evaluating the related measures

must be created to implement the assumptions of sustainable development at various decision-making levels. The multiple dimensions of sustainable development goals described using various indicators necessitate applying a synthetic tool to allow a precise evaluation of progress in the journey towards sustainable development.

This paper aims to satisfy these needs. The study evaluated the accomplishment of Poland's national sustainable development goals from 2010 to 2019. The National Sustainability Index (NSI) was designed and empirically verified using taxonomic methods. The analyses responded to the following questions: What is Poland's general level of accomplishment of sustainable development goals? What were the change dynamics in respective years? Which SD goals require special attention and activity in the coming years? The added value of the analyses is that a comprehensive tool was created for evaluating SD in Poland, which was preceded by selecting as many as 76 specific indicators representing all 17 sustainable development goals. Secondly, the study covered 2010 to 2019, so this is the widest time perspective considering previous analyses in this scope.

The paper is organised as follows. The starting point will be a literature review on the goals, methods of measurement, and results of evaluating sustainable development, focusing on previous studies in this area conducted in Poland. The following chapter describes research methods, including designing the national sustainability index. The next section of the study presents the synthetic index results to evaluate national sustainable development goals in Poland and identifies potential directions for further research. The final part presents conclusions from the analyses.

## Literature review

Over a few dozen years, the sustainable development goals evolved from a one-factor goal of sustainable use of animal and plant resources, through the Millennium Development Goals (MDG) focusing on poverty, to the present comprehensive and universal SD goals (Kasztelan et al., 2021).

In the initial period of agricultural management, people were fully aware of the limited regeneration of natural resources. At that time, the main issue was ecological sustainability aiming to ensure rational use of natural resources and natural environment protection (Lele, 1991). The global Millennium Development Goals, established at the UN Summit in 2000, included eradicating extreme poverty and hunger, achieving universal primary education, and promoting gender equality (Asadullah & Savoia, 2018). Based on the MDG experience, in 2015, the United Nations Organization adopted,

under the so-called Agenda 2030, a new set of sustainable development goals (SDG) (United Nations, 2015).

At the heart of the Agenda 2030 for Sustainable Development there are five critical themes known as the 5P's: people, planet, prosperity, peace and partnerships, making up 17 Sustainable Development Goals (Table 1) and their 169 specific targets that should be the guiding principles for all regions, including developed and developing countries over the next 15 years (Muff, 2017). The transition from MDG (2000-2015) to SDG (2015-2030) reflects the latest evolution of the sustainable development discourse. Close compliance between global and national frameworks of sustainable development can be seen as proof that global goals have a (specific) impact at the national level and, at the same time, that sustainable managing development through objectives is effective (de Jong & Vijge, 2021).

Along with the evolution of sustainable development goals, a question arose about measuring the progress and efficiency of the undertaken activities. Reliable, correctly selected, and current data concerning SD is a significant element for shaping development strategies and using instruments to boost changes in that respect. Creating a uniform and, at the same time, a comprehensive set of indicators for evaluating the progress towards sustainable development is a difficult task due to the complexity of the concept itself. Most authors agree that the hands should be based on strict criteria, should be repeatable, generally acceptable and easily understandable (Balmford et al., 2005; Cornescu & Adam, 2014). Mair et al. (2018) indicated that the indicators of sustainable development, despite their defects, provide an opportunity for qualitative analysis, so they can play a helpful role in implementing SDG.

Progress measurement is an integral part of the EU's Sustainable Development Strategy. In order to ensure consistency of methods and comparability of countries, the indicators are calculated by Eurostat, based on primary data from national statistics. In some instances, the indicators reported by respective countries can differ from those presented in Eurostat's database (Urbaniec, 2015).

Radojicic and Isljamovic (2012), based on 11 SG indicators that, in their opinion, are essential, and using the I-distance method, designed a synthetic measure of sustainable development for 27 countries of the European Union. The outcomes of their study show that in 2009 Sweden and Denmark were countries that were the most advanced in implementing sustainable development. New EU member states, such as Latvia, Hungary, Estonia, Lithuania and Slovakia, ranked at the other end.

**Table 1.** Sustainable development goals

Goal 1	No Poverty
Goal 2	Zero Hunger
Goal 3	Good Health and Well-being
Goal 4	Quality Education
Goal 5	Gender Equality
Goal 6	Clean Water and Sanitation
Goal 7	Affordable and Clean Energy
Goal 8	Decent Work and Economic Growth
Goal 9	Industry, Innovation and Infrastructure
Goal 10	Reduced Inequality
Goal 11	Sustainable Cities and Communities
Goal 12	Responsible Consumption and Production
Goal 13	Climate Action
Goal 14	Life Below Water
Goal 15	Life on Land
Goal 16	Peace and Justice Strong Institutions
Goal 17	Partnerships to achieve the Goal

Source: author's work based on (United Nations, 2015, p. 14).

In 2015, the team under the management of B. Bujanowicz-Haraś (2015) published the evaluation results of the level of sustainable development for 28 EU countries from 2011 to 2013. The study's authors designed a synthetic measure based on Hellwig's development model. This method allowed a comprehensive evaluation of the studied phenomenon based on which the member states were assigned to four uniform groups according to similarities in the level of development. Group I, with the highest level of sustainable development, included Sweden, Luxembourg, Slovenia, Denmark, Austria and Finland. By contrast, group IV was Portugal, Bulgaria, Romania and Hungary.

Guijarro and Poyatos (2018) used the Goal Programming model to design a synthetic SDG indicator capable of overcoming some limitations related to the application of arithmetic and geometric means. The model was used for evaluating the level of sustainable development in EU-28, placing Austria and Luxembourg at the top while Greece and Romania at the bottom of the ranking.

Popovic et al. (2019) also assessed sustainable development in the EU. By using ward's clustering method, the EU countries were assigned to four relatively uniform groups based on 37 indicators. The first group (cluster 1) consisted of highly-developed European countries making a uniform, best-performing group in terms of sustainable development indicators (health care, biggest investment in research and development, information technology and environmental protection). The two poorest countries in the EU – Romania and Bulgaria – were assigned to the second cluster and placed at the very bottom of the ranking, leaving behind in terms of economic, social and environmental indicators of sustainable development. The third cluster was composed of Eastern European countries, and the fourth comprised countries of Southern Europe and Ireland. According to the presented study outcomes, Central European countries were in a better position than those from Southern Europe as the latter featured a higher percentage of the population at the risk of poverty, higher rate of unemployment, lower increase in GDP per capita, as well as poor results in the information technology sector and environmental protection.

By contrast, Raszkowski and Bartniczak (2019b) examined the level of implementation of the concept of sustainable development in countries of Central and Eastern Europe from 2010 to 2016. Their survey relied on 66 indicators monitoring the accomplishment of the global sustainable development goals; for each of the analysed countries, the value of the synthetic measure of sustainable development (SMD) in respective years. The situation of all the countries was found to have improved in the analysed period. Nevertheless, none of the surveyed countries was included in the group featuring an advantageous situation in that area. Slovenia and the Czech Republic were close to achieving this in 2016, but ultimately, they remained in the moderate group together with Estonia, Hungary, Slovakia, Poland, Lithuania, Latvia and Croatia. The worst situation throughout the analysed period was noted in Bulgaria and Romania.

Good data and clear indicators are necessary for every country to evaluate its position, devise ways to achieve its goals and track progress (Lafortune et al., 2020). A theoretical description of each indicator accentuates its pros and cons, highlighting that no indicator is perfect and can provide a complete picture of sustainable development. Therefore, to evaluate sustainable development aptly, various indicators should be analysed. The respective countries were left with the freedom to shape their national sets of sustainable development indicators in compliance with the standard framework.

Progress at a global and regional level is evaluated using a set of so-called global indicators (SDG indicators). Values for the whole world and its regions are calculated by international organisations, mainly based on official statistics from respective countries. At the national level, in place of global indica-

tors, governments can use their own sets of hands, allowing the monitoring of areas and problems that are the most important for the specific country. Such a solution was adopted in Poland. Indicators for national priorities were made available for the first time in 2018. Due to development works, the set was updated and linked more closely with the national priorities related to SDG (Statistics Poland, 2022a).

Previously, the progress of Poland in its journey towards sustainable development was primarily recorded in reports prepared by Statistics Poland (GUS). The first of them was issued in September 2020 on the fifth anniversary of adopting Agenda 2030. The publication referred to progress in accomplishing goals and tasks agreed upon at the international level. The analysis relied on indicators adopted by international bodies for monitoring how common challenges were handled. Changes in Poland (compared with the EU) were analysed using hands selected by Eurostat for evaluating the implementation of the EU's priorities related to sustainable development. The report only allows a general, partial analysis (Statistics Poland, 2022b). In 2021 the second edition of the information was issued with the scope limited to inclusive economic growth, including eliminating regional and social inequality. It was a synthetic report, so the issues presented therein and the scope of their analysis did not exhaust the complex and multifaceted topic of inclusive growth (Statistics Poland, 2022c).

Also, Teneta-Skwiercz (2018) presented a selective approach to measuring sustainable development. The author evaluated four subjectively selected SD indicators, i.e., the risk of permanent poverty, the productivity of resources, renewable energy share in the gross final energy consumption and the level of confidence towards public institutions. She used two types of analysis: static for international comparison between the member states of the European Union pertaining to the year 2015, and dynamic – years from 2008 to 2015 or from 2008 to 2016 for Poland. Based on international comparisons, she concluded the low position of Poland in terms of all the analysed indicators compared with other EU member states. By contrast, studies conducted at the national level identified positive trends in the value of the analysed indicators.

Raszkowski and Bartniczak (2019) presented the results of analyses of selected indicators used for monitoring the implementation of sustainable development goals at the national level. The survey covered the period from 2010 to 2016. Research methods comprised dynamic analysis, i.e., individual indicators of dynamics. In addition, the mean rate of respective changes in time was determined. To conclude, the authors mentioned above perceived SD implementation status in the surveyed years as satisfactory. For 57 out of 73 analysed indicators, the direction of expected change was determined as

positive, which implies that the country was on the right path towards sustainable development.

In contrast, Rybak and Włodarczyk (2021) analysed the implementation of sustainable development goals only to the extent of available and clean energy in Poland, that is, based on: dependence on energy imports by product, energy efficiency, renewable energy share in the gross final energy consumption by sector, and final energy consumption in households per capita. This allowed identifying the current implementation level of the goals and forecasting the achievement of the adopted goals by 2030.

Dziekański et al. (2021) examined spatial differentiation of development relationships, natural environment and ecology in Polish districts using a synthetic measure. The selection of 40 variables was determined by the available data from Statistics Poland about the period from 2010 to 2019. The results of the analyses point to a positive correlation between the measure of district development and the quality of the natural and ecological environment. A higher level of a district's growth is associated with a lower rate of its natural habitat.

The above-presented analyses were predominantly based on the evaluations of changes in the selected indicators in time, while every hand was considered individually. Secondly, sustainable development assessments in Poland were based mainly on indicators describing global goals, which allowed the authors to conduct international comparative analyses. Considering the limitations above and thus an existing research gap, a comprehensive assessment of sustainable development in Poland relied on a synthetic index based on indicators for national SD priorities (Statistics Poland, 2022d).

## Research methods

Designing a synthetic index is a complex task with several alternative stages affecting the quality and reliability of the outcome. The main problems in this approach refer to selecting a theoretical framework, access to data, selecting the most representative indicators and processing them for comparison and aggregation purposes. The stages of designing a synthetic measure are broadly described in the scientific literature (Organisation for Economic Co-operation and Development, 2008; Piotrowska & Roszkowska, 2011; Mazziotta & Pareto, 2013; Piwowarski et al., 2018).

Recently, synthetic indices have been a response to the emergence of Agenda 2030. These were, for example, SDG indices designed by the Sustainable Development Solutions Network (Diaz-Sarachega et al., 2018). This solution assumes that sustainable development goals are aggregated using the arithmetic of the mean only, which is a compensatory technique. In con-



trast, experts recommend non-compensatory aggregation (Guzowska & Kryk, 2020; Petkovová et al., 2020).

Within the research framework, the synthetic NSI index was designed based on the following algorithm (Mazziotta & Pareto, 2013):

- 1) Defining the phenomenon for measurement. The definition of a notion should clearly explain what is measured by the synthetic index. The phenomenon subject to size will be the sustainable development of Poland from 2010 to 2019.
- 2) Selecting the set of individual indicators. The synthetic index was designed based on indicators for national sustainable development goals available on the National Reporting Platform – SDG (Statistics Poland, 2022d). The guiding principle was to use as many indicators as possible for which complete data about the period from 2010 to 2019 was available. Ultimately, 76 individual indicators were selected for analysis (Annex 1). Their values ( $X_i$ ,  $j=1, 2, \dots, m$ ) for respective years ( $Y_i$ ,  $i=1, 2, \dots, n$ ) were presented as an observation matrix (1):

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix}. \quad (1)$$

- 3) Standardisation of individual indicators. This step ensures that the indicators are comparable. Standardisation is required prior to data aggregation since indicators in the data set often come with different units of measure. Therefore, it is necessary to standardise the indicators by transforming them into bare, dimensionless quantities. Another reason for standardisation is that certain indicators (so-called stimulants) can be positively correlated with the measured phenomenon (positive ‘polarity’). In contrast, others (so-called destimulants) can be negatively correlated (negative ‘polarity’). Standardisation ensures that the increase in standardised indicators corresponds to a rise in the synthetic index. This operation can be performed in several ways. One of them is the min-max method (known as the ‘zero unitisation method’ in Poland) used in this study (Petkovová et al., 2020; Kryk & Guzowska, 2021):

- for stimulants:

$$Z_{ij} = \frac{x_{ij} - \min(x_{ij})_i}{\max(x_{ij})_i - \min(x_{ij})_i} \quad (2)$$

- for de-stimulants:

$$z_{ij} = \frac{\max(x_{ij})_i - x_{ij}}{\max(x_{ij})_i - \min(x_{ij})_i} \quad (3)$$

where:

$z_{ij}$  – the normalised value of the  $j$ -th variable in the  $i$ -th year

$x_{ij}$  – the initial value of the  $j$ -th variable in the  $i$ -th year.

The selected method was the only one to fulfil all the seven postulates formulated with reference to the use of normalisation formulas (Jarocka, 2015). Diagnostic features standardised as described above assume values in the range [0; 1]. The closer the value to one, the better the situation in terms of the analysed feature, and the closer to zero, the worse the situation is.

- 4) Aggregation of normalised indicators. All the components are combined into one or more composite indicators (synthetic indices). Here, the normalised variables provided the basis for calculating the median (formulas (4) and (5)) and standard deviation (6) for each surveyed year. The median was determined according to the formula (Strahl, 2006; Grzebyk & Stec, 2015):

$$Me_i = \frac{z_{(\frac{m}{2})i} + z_{(\frac{m}{2}+1)i}}{2}, \quad (4)$$

for an even number of observations, or:

$$Me_i = z_{(\frac{m}{2}+1)i}, \quad (5)$$

for an odd number of observations, where:

$z_{i(j)}$  – the  $j$ -th statistical ordinal for the vector  $(z_{i1}, z_{i2}, \dots, z_{im})$ ,  
 $i = 1, 2, \dots, n$ ;  $j = 1, 2, \dots, m$ .

In turn, the following formula was used for calculating the standard deviation:

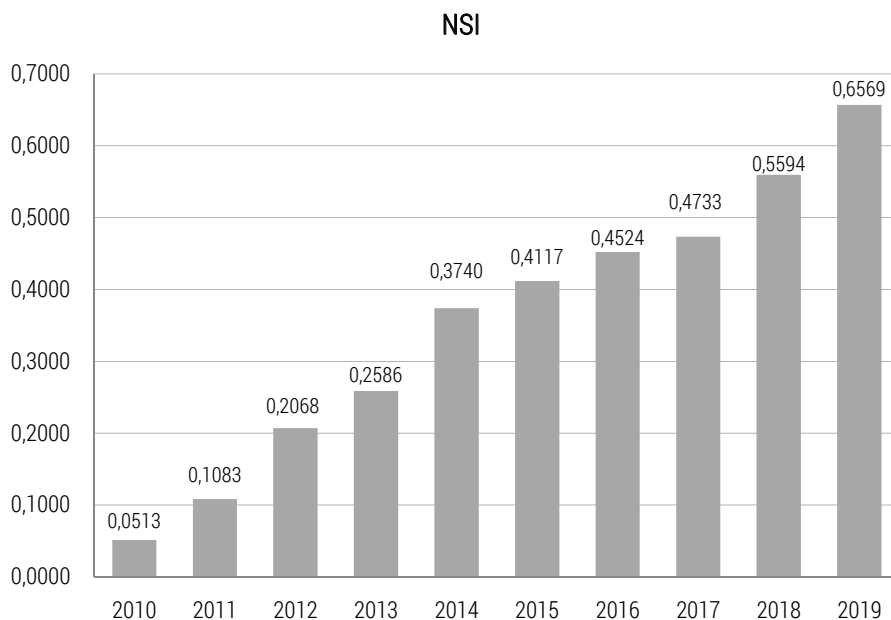
$$Se_i = \sqrt{\frac{1}{m} \sum_{j=1}^m (z_{ij} - \bar{z})}. \quad (6)$$

Finally, based on the median and standard deviation, NSI's were designed for each year:

$$NSI_i = Me_i(1 - Se_i). \quad (7)$$

## Results of the research

Figure 1 presents the results of calculations of the national sustainability index (NSI) for Poland from 2010 to 2019 (CI). In the surveyed period, a dynamic increase was observed in the level of sustainability of socio-economic processes in Poland, notably during the past two years. This means that the implementation of the national SD priorities accelerated. Last year the NSI was 0.6569, which should be considered a very good result in view of the range of this index (0-1).



**Figure 1.** NSI levels in Poland in 2010-2019

Source: authors' work.

Table 2 presents the evaluation of changes in specific indicators from 2010 to 2019. Out of 76 hands, clearly positive changes were observed concerning 52 (68.4%), 15 indicators (19.7%) should be given a negative evaluation, and for nine (11.9%), a detailed review is impossible due to significant variations in their values in the surveyed period.

**Table 2.** The changes in the assessment of indicators for national priorities of sustainable development in Poland in 2010-2019

Changes	Indicators for national priorities SD
positive	$x_1; x_2; x_3; x_6; x_7; x_8; x_9; x_{10}; x_{11}; x_{14}; x_{15}; x_{17}; x_{18}; x_{19}; x_{20}; x_{21}; x_{25}; x_{26}; x_{27}; x_{28}; x_{29}; x_{30}; x_{31}; x_{25}; x_{26}; x_{27}; x_{28}; x_{29}; x_{30}; x_{31}; x_{33}; x_{34}; x_{36}; x_{37}; x_{38}; x_{39}; x_{40}; x_{41}; x_{42}; x_{43}; x_{44}; x_{46}; x_{47}; x_{48}; x_{49}; x_{51}; x_{52}; x_{53}; x_{55}; x_{56}; x_{59}; x_{60}; x_{66}; x_{67}; x_{70}; x_{71}; x_{74}; x_{76}$
negative	$x_5; x_{12}; x_{13}; x_{16}; x_{23}; x_{24}; x_{32}; x_{35}; x_{50}; x_{62}; x_{63}; x_{68}; x_{69}; x_{73}; x_{75}$
ambiguous	$x_4; x_{22}; x_{45}; x_{54}; x_{57}; x_{61}; x_{64}; x_{65}; x_{72}$

Source: authors' work.

A deep dive analysis of sustainable development goals and selected indicators for national priorities led to the following conclusions:

1. As regards the accomplishment of **Goal 1**, all the specific indicators ( $x_1$ ,  $x_2$  and  $x_3$ ) significantly improved in the surveyed period;
2. The highest progress for **Goal 2** was observed with reference to the value of export of agri-food products per capita ( $x_6$ ) and the percentage of the length of public roads with a hard, improved surface in urban areas ( $x_8$ ). However, unfavourable changes in recent years have been recorded for the share of income from hired work and self-employment other than work on a farm in the income of rural households ( $x_5$ ) and for agricultural and food quality ( $x_4$ );
3. Within **Goal 3**, an exceptionally positive evaluation should be given to the decrease in the number of deaths due to diseases of the circulatory system ( $x_{11}$ ), an increase in the number of physicians ( $x_{15}$ ) and a related decrease in self-reported unmet need for medical examination and care ( $x_{17}$ ). In turn, still, a lot should be done about the number of deaths due to diabetes mellitus ( $x_{13}$ ) and malignant neoplasms ( $x_{12}$ );
4. With reference to **Goal 4**, a significant decrease in the unemployment rate was noted among basic vocational school leavers ( $x_{19}$ ), an increase in the percentage of foreign students studying in Polish higher education institutions in Poland ( $x_{20}$ ) and in the percentage of children aged 3-5 covered by pre-primary education ( $x_{21}$ ). Until 2018, changes in the percentage of young people, not continuing education were satisfactory, but one year later, this indicator was considerably worse;
5. Under **Goal 5** a low level of accomplishment of national SD priorities was noted. Insofar as a positive change was observed for the number of children aged 1-2 covered by different kinds of institutional care ( $x_{25}$ ), changes in the gender employment gap and the gender pay gap were definitely negative ( $x_{24}$ ,  $x_{23}$ );

6. As regards the accomplishment of **Goal 6**, all the specific indicators ( $x_{27}$ ,  $x_{28}$  and  $x_{29}$ ) significantly improved in the surveyed period;
7. With reference to **Goal 7**, the primary energy efficiency of GDP significantly decreased ( $x_{30}$ ), the renewable energy share in the gross final energy consumption increased ( $x_{31}$ ), and the share of average monthly spending on energy carriers in the total household spending also declined ( $x_{33}$ ). By contrast, unfavourable changes were observed with regard to national energy security ( $x_{32}$ );
8. The general trend of changes in implementing national sustainable development priorities under **Goal 8** looks positive, except for the level of expenditures on innovation activities in enterprises ( $x_{35}$ );
9. Considerable progress was achieved in accomplishing the national priorities for **Goal 9**, although a slight decrease in the share of net revenues from sales of new or improved products in total net revenues from sales in industrial enterprises ( $x_{45}$ ) was noted;
10. On the one hand, decreasing inequality for **Goal 10** denoted positive changes in eliminating differences in gross value added per person employed at the regional level (NUTS 2) ( $x_{49}$ ) and decreasing inequality of income ( $x_{51}$ ), while on the other hand – increased differences in the level of income between rural and urban population ( $x_{50}$ );
11. With reference to six out of eight specific indicators describing the degree of accomplishment of **Goal 11**, decisively positive changes were observed in the surveyed period. However, the percentage of the urban population living in adequate housing conditions ( $x_{54}$ ) and the share of municipal waste for specific processing in relation to the volume of waste generated ( $x_{57}$ ) have not improved permanently;
12. National priorities making up **Goal 12** were accomplished with various effects. Resource productivity ( $x_{60}$ ) considerably improved with slightly less progress in decreasing the domestic material consumption (DMC) per capita ( $x_{61}$ ). By contrast, a definite regression was recorded for increasing the organic production area ( $x_{63}$ ) and for the circular material use rate ( $x_{62}$ );
13. Regarding the accomplishment of **Goal 13**, significant variations in the dynamics of greenhouse gas emissions, including CO<sub>2</sub> emissions ( $x_{64}$ ,  $x_{65}$ ), were observed in the surveyed period. By contrast, significant achievements were recorded for obtaining geothermal energy ( $x_{66}$ );
14. **Goal 14**, due to an information gap, was described by one indicator only – the proportion of fish stocks within biologically sustainable levels ( $x_{67}$ ), which noted a significant increase from 2010 to 2019;
15. National priorities making up **Goal 15** were implemented to a varying degree. Slight progress was achieved in increasing the share of forest

land ( $x_{70}$ ), while actions undertaken for decreasing the share of devastated and degraded land requiring reclamation in total area ( $x_{69}$ ) and changes in the Farmland Bird Index ( $x_{68}$ ) should be given a negative evaluation;

16. For **Goal 16**, an improvement was recorded in ensuring security ( $x_{71}$ ) and using ICT (information and communications technology) for state governance and communication with its citizens ( $x_{74}$ ). By contrast, it is difficult to unambiguously evaluate changes in legislation quality ( $x_{72}$ ) that were subject to variations in the surveyed period. However, public institutions' effectiveness ( $x_{73}$ ) should be perceived as clearly negative;
17. Concerning **Goal 17**, measured by official development assistance (ODA) as a proportion of gross national income ( $x_{76}$ ), a positive change was noted in the baseline year.

It should be highlighted that the use of a synthetic index allowed a legible assessment of the national sustainable development priorities from 2010 to 2019. On the other hand, analysing each global goal and specific indicators making up the NSI allowed identifying the strengths and weaknesses of sustainable transformation processes in Poland.

During the survey, certain limitations occurred, which to some extent, set potential directions for further research. The index was designed based on 76 indicators, even though as many as 125 sustainable development indicators were initially identified. This is due to the existing information gap concerning other indicators. The system solutions aimed at improving the efficiency of collecting data on respective indicators might boost the comprehensive evaluation of sustainable development measures. Furthermore, the latest available data on most specific indicators comes from 2019, so it is impossible to conclude what changes occurred in 2020-2021. It was a time of extraordinary challenges associated with the necessity to combat the pandemic of COVID-19, and they have certainly affected the achievement of the national SD priorities.

## Conclusion

No universal method for designing composite indices exists. In any case, their design depends on the specific application, contains formal elements, and includes expertise in the particular phenomenon. Nevertheless, composite indices have apparent advantages that can be condensed into a one-dimension measurement of the specific phenomenon, a straightforward interpretation of a set of multiple individual indicators, and a simplified data analysis.

The added value of the survey is that it was the first comprehensive evaluation of national sustainable development priorities from 2010 to 2019 using a specially designed NSI. The informational value of the index and the analysis of specific indicators should contribute to improvement in the monitoring, planning and implementation of sustainable development goals in Poland.

In response to research questions formulated in this paper, it should be noted that from 2010 to 2019, the level of sustainability of socio-economic processes in Poland dynamically increased, which was undeniably reflected in the degree of accomplishment of SD goals. The NSI considerably improved from 2010 to 2012, in 2014 and during the two final years covered by the assessment (2018-2019).

In contrast, analysis of changes in specific indicators implies that many areas still need intervention. The main challenges for the coming years include: for goal 2 – ensuring food quality and food security and increasing diversity of income sources among rural area population; for goal 3 – decreasing the number of deaths due to malignant neoplasms and diabetes mellitus and increasing the number of nurses and midwives; for goal 5 – increasing gender equality; for goal 7 – ensuring energy security of the state; for goal 8 – increasing expenditures on innovation activities in enterprises; for goal 10 – eliminating differences in the socio-economic development of urban and rural areas; for goal 11 – improving the dwelling conditions for the urban population; for goal 13 – effective reduction of greenhouse gases concentration in the atmosphere; for goal 15 – protecting biodiversity, and for goal 16 – improving legislation quality and application of the law, enhancing the effectiveness of public institutions and better use of public resources.

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## Anex 1. List of sustainable development indicators used to construct the NSI

SD goal	Variable	Indicator	Unit	Stimulant/ Destimulant
Goal 1	$x_1$	Relative poverty rate	%	D
Goal 1	$x_2$	Gross real disposable income of households per capita	2008=100	S
Goal 1	$x_3$	Number of dwellings per 1000 population	dwellings	S
Goal 2	$x_4$	Percentage of samples of agro-foodstuffs with inappropriate commercial quality	%	D
Goal 2	$x_5$	Share of income from hired and self-employed off-farm work in the income of rural households	%	S
Goal 2	$x_6$	Value of agri-food exports per capita	zł	S
Goal 2	$x_7$	Share of agri-food goods in total Polish exports	%	S
Goal 2	$x_8$	Percentage of the length of public roads with improved hard pavement in the urban areas	%	S
Goal 3	$x_9$	Expected healthy life years for men	years	S
Goal 3	$x_{10}$	Expected healthy life years for women	years	S
Goal 3	$x_{11}$	Number of deaths due to cardiovascular disease per 100,000 population	persons	D
Goal 3	$x_{12}$	Number of deaths due to malignant neoplasms per 100,000 population	persons	D
Goal 3	$x_{13}$	Number of deaths due to diabetes per 100,000 population	persons	D
Goal 3	$x_{14}$	Number of deaths due to chronic respiratory disease per 100,000 population	persons	D
Goal 3	$x_{15}$	Number of doctors per 10,000 population	persons	S
Goal 3	$x_{16}$	Number of nurses and midwives per 10,000 population	persons	S
Goal 3	$x_{17}$	Percentage of persons age 16 and older who reported that their needs for health care services were not met	%	D
Goal 3	$x_{18}$	Number of screening tests for early detection of colorectal cancer per 10,000 population	units	S
Goal 4	$x_{19}$	Unemployment rate of vocational education graduates according to Labour Force Survey (LFS)	%	D
Goal 4	$x_{20}$	Percentage of foreign students studying at Polish universities in Poland	%	S
Goal 4	$x_{21}$	Children aged 3-5 covered by preschool education	%	S
Goal 4	$x_{22}$	Young people not continuing their education	%	D
Goal 5	$x_{23}$	Gender pay gap	%	D
Goal 5	$x_{24}$	Employment gap between men and women (aged 25-54)	percentage points	D
Goal 5	$x_{25}$	Children aged 1-2 covered by different forms of institutional care	%	S
Goal 5	$x_{26}$	Employment rate of women with the youngest child up to 5 years of age according to LFS	%	S

SD goal	Variable	Indicator	Unit	Stimulant/ Destimulant
Goal 6	x <sub>27</sub>	Population supplied with the water supply network with water that does not meet requirements	%	D
Goal 6	x <sub>28</sub>	Population using wastewater treatment facilities	%	S
Goal 6	x <sub>29</sub>	Industrial and municipal wastewater treated biologically, chemically and with enhanced nutrient removal as % of wastewater requiring treatment	%	S
Goal 7	x <sub>30</sub>	Primary energy intensity of GDP with climate adjustment	kg/euro (2005 prices)	D
Goal 7	x <sub>31</sub>	Share of energy from renewable sources in gross final energy consumption	%	S
Goal 7	x <sub>32</sub>	Ratio of total energy acquisition to global energy consumption	%	S
Goal 7	x <sub>33</sub>	Share of average monthly expenditure on energy carriers in the total expenditure of households	%	D
Goal 8	x <sub>34</sub>	Share of export of high-tech products in total export	%	S
Goal 8	x <sub>35</sub>	Outlays on innovative activities in enterprises in relation to GDP	%	S
Goal 8	x <sub>36</sub>	Global Competitiveness Index (GCI)	ranking position	D
Goal 8	x <sub>37</sub>	Employment indicator for persons aged 15 and more according to LFS	%	S
Goal 8	x <sub>38</sub>	Persons employed on the basis of an employment relationship in relation to the number of persons employed in the national economy	%	S
Goal 8	x <sub>39</sub>	Labour force participation rate	%	S
Goal 8	x <sub>40</sub>	Share of the long-term unemployed in the total number of the unemployed (20-64 years)	%	D
Goal 8	x <sub>41</sub>	Young people not in employment, education or training (aged 15-24)	%	D
Goal 8	x <sub>42</sub>	Share of people working in rural areas in the non-agricultural sector in the total number of people working in rural areas	%	S
Goal 9	x <sub>43</sub>	Global Innovation Index	ranking position	D
Goal 9	x <sub>44</sub>	Gross domestic expenditure on R&D in relation to GDP	%	S
Goal 9	x <sub>45</sub>	Share of net revenue from sales of new or improved products in total net revenue from sales in industrial enterprises	%	S
Goal 9	x <sub>46</sub>	Percentage of households using Internet access of at least 100 Mbps	%	S
Goal 9	x <sub>47</sub>	Share of revenues from export sales in net revenues of SMEs from sales of products, goods and materials	%	S
Goal 9	x <sub>48</sub>	Density of expressways and freeways per 1000 km <sup>2</sup>	km	S
Goal 10	x <sub>49</sub>	Differentiation of gross value added per 1 employed person at the regional level (NUTS 2)	%	D
Goal 10	x <sub>50</sub>	Ratio of average annual net disposable income per person in a rural to urban household	%	D
Goal 10	x <sub>51</sub>	Gini coefficient – index of income distribution	points	D

SD goal	Variable	Indicator	Unit	Stimulant/ Destimulant
Goal 11	x <sub>52</sub>	Exposure to excessive noise	% of population	D
Goal 11	x <sub>53</sub>	Average floor area of a dwelling per 1 person in cities	m <sup>2</sup>	S
Goal 11	x <sub>54</sub>	Percentage of the urban population living in housing with a leaking roof, damp walls, floors or foundations, or with rotting window frames or floors	%	D
Goal 11	x <sub>55</sub>	Share of alternative fuel buses in total number of buses serving urban transport	%	S
Goal 11	x <sub>56</sub>	Number of passenger transport services per 1 resident of urban areas	persons	S
Goal 11	x <sub>57</sub>	Percentage of municipal waste to be treated in a certain way in relation to the amount of waste generated	%	S
Goal 11	x <sub>58</sub>	National average exposure indicator for PM2.5	µg/m <sup>3</sup>	D
Goal 11	x <sub>59</sub>	Urban green area	m <sup>2</sup> per 1 inhabitant	S
Goal 12	x <sub>60</sub>	Resource productivity	euro/kg	S
Goal 12	x <sub>61</sub>	Domestic Material Consumption (DMC) per capita	tonns	D
Goal 12	x <sub>62</sub>	Material reuse rate	%	S
Goal 12	x <sub>63</sub>	Share of certified organic agricultural area in total agricultural area on farms	%	S
Goal 13	x <sub>64</sub>	CO <sub>2</sub> emission dynamics	2010=100	D
Goal 13	x <sub>65</sub>	Dynamics of greenhouse gas emissions	2010=100	D
Goal 13	x <sub>66</sub>	Geothermal energy extraction	TJ	S
Goal 14	x <sub>67</sub>	Percentage of fish stocks at biologically renewable levels	%	S
Goal 15	x <sub>68</sub>	Abundance index of common birds of the agricultural landscape	2000=100	S
Goal 15	x <sub>69</sub>	Share of devastated and degraded land requiring rehabilitation in total area	%	D
Goal 15	x <sub>70</sub>	Share of forest land area in the land area	%	S
Goal 16	x <sub>71</sub>	Percentage of people who think that life in Poland is safe	%	S
Goal 16	x <sub>72</sub>	Indicator of the quality of legislation	points	S
Goal 16	x <sub>73</sub>	Governance Performance Index	points	S
Goal 16	x <sub>74</sub>	Percentage of people using the Internet to interact with public administration to submit completed forms	%	S
Goal 16	x <sub>75</sub>	General government investment rate	%	S
Goal 17	x <sub>76</sub>	Official Development Assistance in relation to gross national income	%	S

Source: author's work based on [https://sdg.gov.pl/statistics\\_nat/](https://sdg.gov.pl/statistics_nat/) [09-02-2022].