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SYNTHETIC SUSTAINABLE DEVELOPMENT INDICATORS: PAST EXPERIENCE AND GUIDELINES

Abstract: In the paper an overview of selected synthetic indicators of sustainable development will be followed by a presentation of historical case studies on Ecological Footprint, Total Material Requirement, and Index of Sustainable Economic Welfare. All these indicators were calculated for Poland in the past. Critical discussion of indicators helps to understand all difficulties associated with the measurement and interpretation of the results. The author suggests that synthetic indicators generate important statistical information supplementary and complementary to the Gross Domestic Product. Another objective of the paper is to stress that any extension of the national accounts methodology towards an integrated system of economic and environmental accounts, as it is supported recently by the EU, should be accompanied by a number of country studies on related synthetic indicators.

Keywords: sustainable development, synthetic sustainability indicators.

1. Introduction

Recently, a lot of new statistical measures and methods have appeared in the literature to monitor interdependences of socio-economic system and natural environment. Synthetic indicators pretend to describe by a single number this extremely complex and multidimensional phenomenon. In particular, synthetic indicators of sustainable development are an ambitious attempt to formulate an aggregated evaluation of almost all effects of sustainability strategy, the strategy which tends to harmonize economy with social problems and with natural environment. Unfortunately, synthetic indicators are often treated with suspicion and rarely applied on the Polish ground.

Synthetic indicators can be divided into two major groups: the first includes indicators presented in monetary values, and to the second group belong indicators presented in physical or standardized units. Indicators from the first group usually refer to the economic category of welfare. Indicators from the second group, mostly, are concentrated on the measurement of an anthropogenic environmental impact. In the paper a brief overview of selected synthetic indicators is followed by a presentation of results from just three historical Polish case studies on Ecological Footprint, Total

Material Requirement, and Index of Sustainable Economic Welfare. All selected studies on sustainability indicators need updating but deliver an interesting material for a preliminary evaluation of synthetic indicators with regard to their ability to monitor and support national policy stimulating sustainable development.

In the paper, critical discussion on indicators' structure and components helps to understand some difficulties associated with an ongoing modification of measurement and interpretation of the results. In spite of some strengths and weaknesses of synthetic indicators, the paper suggests that they generate important statistical information which is supplementary and complementary to the Gross Domestic Product. Another objective of the paper is to stress that country studies on synthetic indicators should: firstly, accompany the EU set of indicators monitoring sustainability strategy and, secondly, follow an extension of the national accounts methodology towards an integrated system of economic and environmental accounts.

2. Ecological Footprint

Ecological Footprint (EF) was the first synthetic sustainability indicator in physical units taken into account worldwide. Physical amount – in this case land surface – was used for an assessment of the natural resources management [Wackernagel 1994]. EF has been defined by the creators of the concept, M. Wackernagel and W.E. Rees, as "the total area of biologically productive soil surface (including the sea) necessary to compromise consumption needs of a given population and to assimilate waste generated by this population" [Rees, Wackernagel 1994; Borgström-Hansson, Wackernagel 1999].

EF can be estimated through recalculation of economic activities motivated with compromising human needs into ecological functions expressed in terms of the area. The following categories of resources are in question, according to the original methodology, in an attempt to calculate the EF [Van den Bergh Joeren, Verbruggen 1999]: built-up area, arable land, meadow and pasture, forest, so-called energy land. The most recent development tends to include in the analysis also water use and consumption.

This section presents estimates of the EF indicator for the Polish economy in the period 1955–1997 [Stachowiak, Śleszyński 2002]. The original concept has been actually applied [Bello et al., 1999; Smeets, van Vuuren 2000] with only negligible modifications, however, adopting direct and country specific land productivity coefficients wherever it was possible. Calculation of EF was possible but also troublesome because of not always available domestic productivity coefficients.

The results of the original estimates indicated that EF *per capita* was increasing at the beginning of the analysed period from 2.094 ha per person in 1955 to 3.525 ha per person in 1988. After 1988, the area used by one statistical Pole was rather decreasing and in 1997 amounted to 2.503 ha per person. It was mainly due to changes in structure and amount of the consumed goods, changes in the volume of harvests and small but stable, although diversified in pace, increase of population number.

The largest share in EF can be attributed to energy land. During the analysed period it oscillated between 56.9 and 78.0%. Changes in the value of land surface used by the average Pole varied primarily in accordance with the volume of energy generated in the country. Consequently, maximum and minimum values of EF were observed in the years with the highest and the lowest energy consumption (1988 and 1955, respectively). Moreover, there are similarities in the trend of changes of EF and energy land. In both cases, during the years 1955–1988, increase in the use of environment was observed, and after 1988 this use was decreasing, which was due to the general changes in energy intensity of the national economy.

Carrying capacity of the environment has been defined at the beginning as land surface per one inhabitant of a given country. In this study it was calculated by dividing the area of Poland (in ha) by the population number. Next, the existing carrying capacity of environment (after taking into account the standard 12% "deduction" for biodiversity protection) was compared with "ecological footprint," which allowed to estimate the possible ecological deficit or surplus.

The results for Poland indicated that including energy land in the analysis led to the conclusion that Poland was not able to provide ecological services necessary for fulfilling self-sustainability based needs of the statistical Pole (Table 1). In the entire period, carrying capacity of the environment has been calculated at the level of 0.71–1.00 ha per person, and EF at the level of 2.094–3.525 ha per person.

Omitting energy land in the calculations, however, allowed for an opposite conclusions: during the years 1955–1988 ecological deficit was estimated at the level of only 0.008–0.136 ha per person, and since 1990 ecological surplus has been observed in the amount of 0.005–0.133 ha per person. Therefore, it was strongly emphasized that in this concept the values of EF and energy intensity of the national economy are very closely, someone may say too much, correlated.

The EF concept, in general, allows for calculating the area of the surface used directly or indirectly while applying given production patterns. It is the surface necessary for using and processing natural resources which are indispensable for consumption sustaining a person, a society, or any given population. It seems to be easy to calculate and easy to interpret. Thus, it is not surprising that the concept gained many enthusiasts and, equally, many critics [Bello et al. 1999; Borgström-Hansson, Wackernagel 1999; Barrett et al. 2000; Moffatt 2000].

It should be stressed that the use of EF as an indicator of sustainable development should be associated with an extensive listing of its obvious limitations [Śleszyński 2009]. The indicator's specificity implies that it comprises only the selected problems and aspects of human impact on the natural environment. Moreover, it does not provide sufficient information on economic aspects of development of a given population.

Table 1. EF, carrying capacity of the environment, and ecological deficit/surplus for Poland (hectares *per capita*)

Year	EF including energy land	EF excluding energy land	Carrying capacity of the environment	Minus 12% for biodiversity	Ecological deficit (including energy land)	Ecological surplus (+) or deficit (–) (excluding energy land)
1955	2.094	0.902	1.13	1.00	−0.964	0.098
1960	2.553	0.954	1.05	0.92	−1.503	−0.034
1965	2.485	0.894	0.99	0.87	−1.495	−0.024
1970	2.755	0.851	0.96	0.84	−1.795	−0.011
1975	3.194	0.936	0.91	0.80	−2.284	−0.136
1980	3.334	0.857	0.87	0.77	−2.464	−0.087
1985	3.104	0.732	0.84	0.74	−2.264	0.008
1988	3.525	0.776	0.83	0.73	−2.695	−0.046
1989	3.197	0.720	0.82	0.72	−2.377	0.000
1990	2.611	0.587	0.82	0.72	−1.791	0.133
1991	2.467	0.606	0.82	0.72	−1.647	0.114
1992	2.548	0.715	0.81	0.72	−1.738	0.005
1993	2.542	0.646	0.81	0.71	−1.732	0.064
1994	2.450	0.648	0.81	0.71	−1.640	0.062
1995	2.445	0.606	0.81	0.71	−1.635	0.104
1996	2.580	0.613	0.81	0.71	−1.770	0.097
1997	2.522	0.651	0.81	0.71	−1.712	0.059

Source: [Stachowiak, Śleszyński 2002].

In particular, EF is very often calculated for the inhabitants of a specific country or an administrative area, which, according to C.J.M. van den Bergh Joeren and H. Verbruggen [1999], is not the right approach. It is related to the fact that any borders are of geopolitical and cultural, and not of environmental character. They often divide natural areas of closely related ecosystems. Therefore, it would be more justified to calculate EF for natural regions, separated on the basis of watersheds, climate zones, soil zones, etc.

The authors cited above have also turned attention to the fact that specific regions of the Earth are characterised with a high diversity of natural conditions (soil, climate, land diversification, hydrology), what has a direct impact on placement of dwelling areas (e.g. differences in population density of coastal areas and deserts). It is obvious that the regions with more favourable natural conditions will have higher population density, therefore the value of the accessible ecological surface *per capita* there will be lower.

Moreover, the countries with the territory situated in the area with natural conditions favourable for humans are characterised with high level of socio-economic development, which implies high EF. It need not mean, however, that the societies living in these areas are far from the implementation of the principles of sustainable development, in spite of the existing ecological deficit. Most often it results from high population density rather than from extensive exploitation of natural resources.

Aggregating the separate components of EF in one comprehensive indicator is another issue raised in many studies [Van den Bergh Joeren, Verbruggen 1999; Smeets, van Vuuren 2000]. Aggregating means summing up the areas having various ecological functions, constituting different categories of environmental pressure. This means that various consumption categories are assigned the same weight regarding the impact on environment. In fact, this impact is highly diversified (e.g. the area used for construction of buildings is more impacted than this using the land for agriculture).

The most controversial is the category of energy land which has been described as the green and biologically active surface needed to absorb excessive amount of carbon dioxide released as a result of combustion processes. According to the assumptions of the authors of EF, sustainability of development will be reached at the point where CO_2 emissions will not exceed the assimilation capacity of photosynthetic ecosystems (e.g. around 1.42 t C/ha/year). According to C.J.M. van den Bergh Joeren and H. Verbruggen [1999], reduction of emissions to this level is not possible or recommended neither from technical nor ecological point of view.

Moreover, EF analysis seems to suggest that the only way of decreasing the amount of CO_2 in the atmosphere is increasing forested areas, which, in fact, is one of the most expensive options. Additionally, in calculations of energy area some factors are not taken into account, for instance, scarcity of the resources like fossil fuels and emissions of other pollutants resulting from fossil fuels combustion (for instance, NO_x and SO_x lead to acidification of the environment). According to the critics, it leads to the significant underestimation of the indicator.

Another simplification used in the analysis of EF is reducing a given type of ecosystem to only one function or role that is played by this ecosystem in the natural environment. Thus, the forest is viewed as the source of timber used in paper industry and as energy-generating resource plus, potentially, as a carbon sink. Other functions of the forest, although very important from the nature and human beings' point of view are simply omitted.

In conclusion of methodological considerations, it is worthwhile to notice that EF indicator is helpful in the process of increasing ecological awareness. EF indicator allows for a better understanding that we are a part of the global ecosystem and supports an "only one Earth" education. It shows, in a very specific way of land, interrelations between the society and economy, and the environment. It can be calculated at the local level and for an individual household, which stresses the role of small communities and individuals constituting active participants of socio-economic environment who can have their important role in achieving sustainable development.

Positive feature of EF is that the impact of human consumption on ecosystems is expressed in the form of one digit. It allows seeing the evidence of pressure exert on the natural resources supply of which is highly limited (e.g. natural areas unchanged by humans or biodiversity). Moreover, thanks to its simplicity, EF is comprehensible for the public, which can greatly contribute to limiting the pressure on the environment through life style changes. This feature is also useful for the politicians. Being aware of the value of ecological deficit, they can take the relevant steps in order to set the level of exploitation of environmental resources in agreement with the idea of sustainable development.

EF is extremely popular and plays an important role in professional and non-governmental comparative studies. In spite of reservation it is also a good starting point for an international debate on synthetic measures of the crucial relationship: society and economy versus natural environment. Most likely, Carbon Footprint (CF) focused on CO_2 emissions will be soon an indispensable element of climate policy and an indicator monitoring transformation processes to the low-carbon economy. Nevertheless, EF, being a very specific synthetic indicator, should be regarded always as a complementary measure and for a policy purpose used together with other indicators of sustainable development.

3. Total Material Requirement

In the Total Material Requirement (TMR) methodology the analysis concentrates on material flows. The basic issue is an identification of material inputs absorbed by the economy. As a rule, the acquisition of a specific amount of resource – to become later a direct input – involves a significant disturbance of the state of the environment [von Weizsäcker et al. 1997]. The most critical issue remains the distinction between direct and indirect inputs [Schmidt-Bleek 1994; Adriaanse et al. 1998]. Some changes reflect the most simple and quantitative effects of the abstraction of the useful resource. In contrast, the other and disturbing transformations result from the manner of acquisition and the efficiency of this process. Thus, the indirect inputs, in fact, are the external effect of the abstraction of useful inputs.

Under the TMR concept, the purpose of direct input category is to aggregate direct material consumption in the economy. On the other hand, the category of "hidden flows" is to reflect the size of indirect inputs which are a burden on the environment, although they are not present on the market and usually do not bring benefits. If indirect inputs are very large, this means that a given type of economic activity should be recognized to be excessively material-intensive, irrespective of the fact that the direct input may be small and provide tangible benefits. If, as a result of this, the total material requirement is high, it is also an indication that the exploitation of the resource is not efficient, since it consumes too much material and degrades the environment what is in contradiction with the principles of sustainable development.

Interestingly, accumulated hidden material flows continue to be represented in the literature and in this paper by the conceptually abridged term mass rucksack.

However, in publication in Polish we used the expression "ecological ballast." This term was proposed as one representing best the meaning of the material quantity, defined by weight, which is a total burden on the environment as a result of man's specific economic activity.

The collection of the statistical data for the three years made it possible to perform a very preliminary assessment of the trends which occurred in the Polish economy over the period 1992–1997 [Mündl et al. 1999; Schütz et al. 2002]. For the main indicators, it was found that TMR and Direct Material Input (DMI) grew. However, there was a positive gradual change in the value of indicators of the efficiency of using material inputs acquired from the environment.

The TMR/GDP indicator, expressed in kg per 1 USD of the Gross Domestic Product (GDP), fell in the period under study. It is interesting to note that the analogous indicator for direct inputs, i.e., DMI/GDP (kg per 1 USD of GDP), showed even a more distinct improvement. The measures GDP/TMR and GDP/DMI can be obtained by reversing the formula for the indicators discussed above. Then, it can be said that from 1992 to 1997, due to systemic changes in the economy, one tonne of material inputs generated an increasingly larger value of GDP.

Table 2. Material inputs in the Polish economy in 1992–1997

Item	1992	1995	1997
TMR (million t)	1,065	1,109	1,226
– domestic TMR	938	910	946
– imported TMR	127	199	280
TMR *per capita* (t)	27.7	28.7	31.7
DMI (million t)	492	533	541
– domestic DMI	453	481	479
– imported DMI	39	52	62
DMI *per capita* (t)	12.8	13.8	14.0
Mass rucksack (million t)	573	576	685
– domestic mass rucksack	485	429	467
– imported mass rucksack	88	147	217
Mass rucksack *per capita* (t)	14.9	14.9	17.7
TMR/GDP (kg/USD)	12.63	8.78	8.57
DMI/GDP (kg/USD)	5.83	4.22	3.78
GDP/TMR (USD/t)	79	114	117
GDP/DMI (USD/t)	171	237	264
DMI/TMR (%)	46	48	44

Source: [Mündl et al. 1999].

These positive trends cannot, however, conceal the real distance between the Polish economy and the substantially more efficient economies of the other analysed countries. Thus, in 1992 for instance, the levels of the indicators TMR/GDP for Germany, the Netherlands and the USA only slightly exceeded 3 kg per 1 USD of GDP, i.e., they were almost four times lower than the Polish indicator for the material intensity of GDP. The case was similar with the indicator GDP/TMR, which in Germany in 1992 was also several times greater than the Polish indicator for resource productivity.

In general, analysis of the size of material inputs in different sectors of the economy (not represented in the table above) confirmed the overall growing trend for TMR [Mündl et al. 1999; Śleszyński 2000]. It should be noted that over the period under study there were only minor changes in the most weighty category of domestic energy carriers. The direct inputs were 202 million t in 1992, almost 205 million t in 1995 and slightly more than 205 million t in 1997. In contrast, the level of mass rucksack related to domestic energy carriers fell: from 262 million t in 1992 to 236 million t in 1997.

A gradual growth was observed for most categories of domestic material inputs; in 1995–1997 it was, however, very slight or stopped, even to fall in some categories. The situation of such input categories as the hidden flow for domestic mineral production and the disturbed land surface was different. In 1995–1997, too, inputs rose very substantially for these categories. In the last period, the quantities of imported direct inputs and mass rucksack grew. This is true primarily for energy carriers, metals and minerals, but also for processed products of forestry and the mass rucksack for agricultural production.

It is difficult to give an unambiguous answer regarding the structure of the Total Material Requirement. Analysis of the proportion of direct inputs in TMR may suggest that their trend was hardly favourable, particularly in the last period. In 1995, the DMI/TMR ratio was 48%; and in 1997 it was lower, i.e. 44%. This means that mass rucksacks carry increasing "weight" in affecting the size of the Total Material Requirement. Indeed, in 1992 and 1995 the hidden flow *per capita* was 15 million t, to grow in 1997 to as much as 18 million t.

The examination of the structure of the direct material inputs from the point of view of their division into domestic and imported ones showed a tendency of domestic inputs per capita to remain at a constant level of 24–25 t. Imports, which played a lesser role than domestic inputs throughout the period, increased their proportion from 12 to 21% in TMR *per capita*.

Throughout the period under study, energy carriers kept their leading share in the structure of TMR. In TMR *per capita*, all the time, energy carriers kept their share of 12–13 t. The shares of other categories were similarly stable, with the exception of metals and minerals; these had a decisive effect on an increase in TMR *per capita*, by growing from 3 t in 1992, to 5 t in 1995, and then to 6 t in 1997.

Quite recently, Central Statistical Office in Poland started to publish information on direct material inputs. The evaluation is limited, so far, to direct domestic material inputs only. The assessment of domestic material consumption (DMC) is available in our statistical yearbooks starting from the year 2000 (see Table 3) together with an indicator of productivity which simply calculates the ratio GDP/DMC. An improvement and increase in productivity is sure but the trend seems to be rather weak and has a tendency to stabilise around 380 EUR of GDP per one tonne of direct domestic material input.

Table 3. Domestic material consumption and its productivity for Poland 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Domestic material consumption (DMC) in thousand tonnes	564 980	522 954	499 756	515 314	551 134	558 071	572 096	642 107
Productivity of domestic material consumption (GDP/DMC) in EUR per kg	0.32	0.35	0.38	0.38	0.37	0.38	0.40	0.38

Source: [Central Statistical Office 2012].

Certainly, there is also a list of critical remarks on TMR methodology. First, material flows measured in units of weight may never reflect all important aspects of environmental impact. For instance, toxicity and radiation of material inputs remain completely outside this analysis. A similar objection applies to environmental or social consequences of any site-specific abstraction of materials. Second, hidden material flows calculation needs hidden flow coefficients and they can be hardly recorded for many domestic activities without troublesome and time consuming empirical studies. Third, hidden flow coefficients for imported good need even more rich data base stemming from numerous adjustments, which are activity patterns determined and country specific. Fourth, the TMR methodology cannot be perfect because of arbitrarily driven decisions to what extent our intervention in the environment changes its material composition and, therefore, needs a detailed hidden flows calculation. All of this is necessary to assess correctly how many kg of commercially useless material (transformed or lost in the environment, because of careless or inefficient abstraction) falls on material unit of direct input absorbed by the economy.

On the other hand, the analysis of material flows gained an international recognition and became an object of statistical assessment on the national level. Many international statistical bodies are interested to collect data on material balances, in the national and international context. Mostly, they want to avoid methodological controversies and, so far, focus their published reports on direct and domestic material inputs (for instance, DMC in Poland) which are easier to assess and do not include hidden flows which, by the definition, are rather difficult to verify.

It is very likely that in the near future material flows composed of direct material inputs will be included on a regular basis to the satellite national accounting systems in Europe. Nevertheless, in the distant future, it is also quite possible that a progress in hidden flows assessment will allow for an international comparison of TMR indicators.

4. Index of Sustainable Economic Welfare

Index of Sustainable Economic Welfare (ISEW) has been developed out of the concern that Gross Domestic Product (GDP) is not an adequate indicator for a current welfare neither the achievement of sustainability defined as the capacity to provide non-declining future welfare. The main critiques have been, for instance, that GDP is very much misleading decision makers because it does not take into account the value of non-market goods and activity, the welfare effects of income inequality, and the welfare loss due to environmental degradation into account. Additionally, GDP considers "defensive expenditures" (to large extent private or social costs of recovery or restitution of original environmental quality, state of health, etc.) wrongly as contributions to welfare.

The idea of ISEW was supposed to provide a remedy for these shortcomings in order to provide a more reliable monetary indicator of welfare and sustainability. The authors of ISEW wanted to compromise economic, environmental and social aspects of sustainable welfare. The environmental part exists in the index represented by the costs associated with the present pollution and long-term environmental damage. The most obvious economic components of ISEW are consumption and capital growth. Distribution of income has been adopted as the direct representation of a social aspect of welfare.

On the basis of information on hitherto calculations of ISEW for other countries, particularly for the United States of America [Daly, Cobb 1989], Scotland [Moffatt, Wilson 1994], Sweden [Jackson, Stymne 1996] and Austria [Stockhammer et al. 1997], the adequate available data were collected and the index for Poland was calculated. The structure of data presentation proposed by the authors of the first ISEW calculus, i.e. H.E. Daly and J.B. Cobb, was employed and some of the critics and modifications to methods of calculation introduced by followers were taken into account. The results were published several times in Poland and abroad, and the last effective research covered the period between 1990 and 2003 [Gil, Śleszyński 2003; Prochowicz, Śleszyński 2005, 2006].

In the study, the most significant modification, when compared to the original ISEW, was the method of weighting ISEW. Weighting by the inequality coefficient has been applied to the entire value of the index after Austrians [Stockhammer et al. 1997] and not to the individual consumption only as H.E. Daly and J.B. Cobb [1989] did. It has been argued that in a society with significant income distribution inequalities not only individual income but also other categories which are important for welfare and sustainability are strongly influenced by inequality consequences.

In this context, an inequality coefficient works as a "penalty" to the total value of ISEW.

The sustainable economic welfare index (ISEW) was computed by adding values of categories that increase welfare and subtracting values of categories that decrease welfare, and – depending on a sign, by adding or subtracting values of categories that alter the welfare by net value (Table 4). In this way a result was reached – an unweighted ISEW. In order to receive original ISEW, results for each year were adjusted (weighted) by distributional inequality index (DII).

In result, it turned out that ISEW for Poland in 1990–2003 indicated a certain degree of volatility. The lowest values of ISEW were observed in 1990, when Poland still experienced the economic crisis. Up to 1992, we could observe a dynamic growth then slowing down and progressing again in succeeding years, which eventually shows back a new and more moderate tendency started in 2000. Sustainable economic welfare showed a clear upward tendency after the transformations of the system in 1990–1992. In 1997–2000 ISEW begun to increase dynamically again. The index grew rather slowly in the remaining years of the analysed period.

Growing stratification in welfare of the society in the 90s was clearly reflected on the graph (Figure 1). Different course of ISEW curve results from a change in personal income stratification compared in relation to its position in 2003. This trend, initiated after 1992, resulted in a growing gap between ISEW and weighted ISEW, especially in the period 2000-2003.

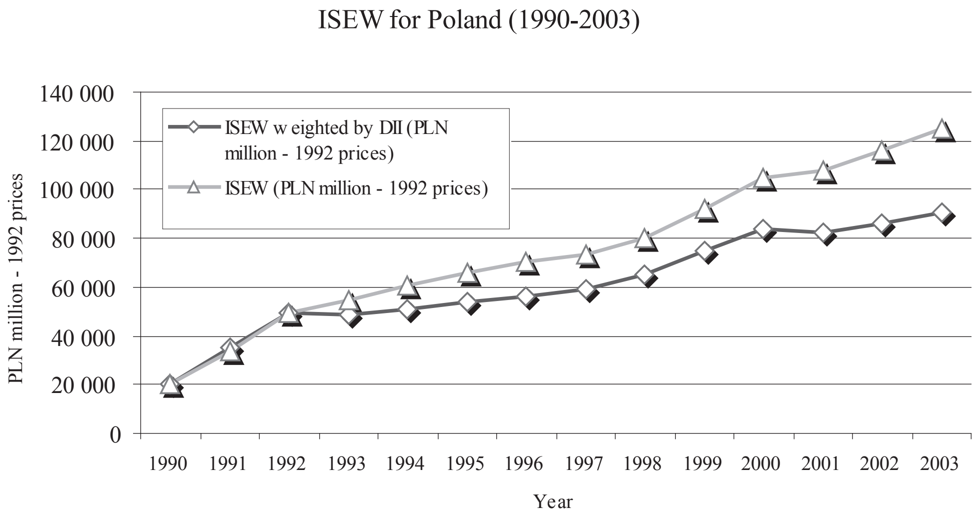

Figure 1. ISEW and impact of distributional inequality index (DII) on ISEW

Source: [Prochowicz, Śleszyński 2005].

Analytical research needs to address the question which categories participated in the upward and downward tendencies of the index (see Table 4 to identify components). The most extensive component of ISEW is individual consumption. Services from domestic labour is the second factor determining the value of ISEW. Public expenditures on health and education and net capital growth – but positive only after 1998 (!), can be considered as two next categories which values supported the positive result of ISEW, especially in recent years.

The remaining positive elements of total ISEW (except net change in international position after 1996) are of rather small and stable volume between 1990 and 2005. Since 1996, net change in international position of Poland contributes to ISEW with a negative value what is an alarming signal for the trade and foreign investment policy.

The categories that most negatively influence welfare have certainly contributed with their potential volume to it. In particular, those that included cost of commuting, cumulated long-term environmental damage, consumer expenditures on durable goods, cost caused by ozone layer depletion, cost of air pollution, and depletion of non-renewable resources. Exactly two first categories contributed most substantially to the total value of ISEW while next four remained on the lower level and stable in the entire period.

The dynamics of categories with much less potential to influence negatively the value of ISEW was very much differentiated. Defensive private expenditures on health and education grew very quickly all the time while cost of automobile accidents slowed down after rapid growth until 1998. The remaining categories which were negative in the sum did not diminish much the value of ISEW.

Categories like net capital growth and change in net international position turned out to be somehow special. These categories as being positive in some years and negative in others contributed to significant irregularities of ISEW value. Strong fluctuations are result of deep and structural changes, so called shock therapy, in the domestic economic system. In particular, only the beginning of 90s was the period when the capital declined. On the other hand, international position of Poland in the period 1996–2003 contributed to ISEW in a very negative way.

It seems, from the data analysis, that the most recent stagnation in ISEW could be attributed, in order of potential, to categories like: losses caused by commuting and road accidents, long-term environmental damage, expenditures on consumer durables, losses due to ozone layer depletion, change in net international position, depletion of non-renewable resources. Moreover, growing welfare inequalities penalized the value of ISEW at the end of recorded period much more significantly than before.

As concerns methodology of ISEW, there are quite a lot of positive opinions and statements on ISEW, Genuine Progress Indicator (GPI) and related indexes. The commentators demonstrate that these alternatives to GDP are theoretically sound but, in order to be broadly accepted, require the continuous development of more robust valuation methods [Lawn 2003]. On the other hand, there are also researchers who agree that ISEW is not perfect in too many aspects.

One of the most damaging critiques on ISEW [Neumayer 1999] suggests that the weakest elements are: arbitrarily assessed and accumulated costs of long-term environmental damage, arbitrarily defined scope and interpretation of defensive expenditures, simplified assumption that a more equal society is more apt to secure non-declining future welfare. Some elements like net profits from education or technical advances are not considered with care.

The literature [Neumayer 1999; Lawn 2003] allows for summarizing several technical advices how to improve ISEW. The Neumayer's proposals following below should be discussed and eventually elaborated for a practical modification of the ISEW methodology:

– in valuing non-renewable resources depletion, the resource rent method should be based on national extraction, while replacement costs needs estimates on national consumption,
– the costs of climate change and ozone depletion should not accumulate yearly because there is no reasonable theoretical basis for doing so and the effect this has on the cost of long-term environmental damage is very large indeed,
– in adjusting consumer expenditure for income inequality, the Atkinson index rather than a more crude method of adjustment based on Gini coefficients should be used (to precise how much more utility extra consumption gives the poor compared to the rich),
– classifying expenditures as defensive needs more caution because it is always rather difficult to argue a form of expenditure is fully defensive and some, such as education, do not seem to accord with the notion at all,
– some new categories should also be taken under consideration (as contributing to the welfare with plus or with minus): (+) value of volunteer work, (–) cost of crime, (–) cost of family breakdown, (–) loss of leisure time, (–) cost of underemployment, (–) cost of unemployment, (–) costs of overwork.

It may be critically concluded that with different assumptions (about weighting of income distribution, the corrections for the depletion of no-renewable resources and long-term environmental damage, and the inclusion of the positive effects of human capital formation and technical progress, etc.) one will get a very different picture of a society's welfare and achievement of sustainability. However, such a discussion is also a positive incentive to look for a reasonable improvement in ISEW and other related indicators instead of saying that macroeconomic, single-number sustainability indicators are questionable.

Certainly, ISEW itself needs substantial modification as it was clarified above in detail. However, there is still present among experts a strong belief that synthetic indicators are the best media for decision-makers and for the public to communicate on general trends of the national sustainable development. Moreover, an alternative macroeconomic indicator should always accompany GDP in the media to prevent too myopic and too optimistic evaluation.

Table 4. Index of Sustainable Economic Welfare 1990–2003 for Poland

A		Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
B	+	Consumer expenditures (personal consumption)	57 788	66 481	70 955	75 249	80 799	86 586	95 013	102 296	107 297	113 605	124 293	127 551	132 207	136 498
C	+	Services from domestic labour	10 945	19 537	24 946	28 085	29 369	30 397	31 731	33 330	34 445	35 712	41 246	42 978	42 041	43 452
D	+	Services from consumer durables	2 351	2 952	3 162	3 211	3 301	3 266	1 087	1 149	1 227	1 335	1 202	1 247	1 261	1 292
E	+	Services from streets and highways	166	168	144	167	195	265	381	402	352	354	341	300	276	364
F	+	Public health and education expenditures	6 552	5 099	5 327	5 202	5 620	5 977	7 879	8 249	8 431	9 016	9 482	9 928	10 131	11 047
G	–	Consumer durables expenditures	4 054	4 268	4 682	5 092	5 129	5 075	5 433	5 747	6 136	6 677	6 009	6 235	6 306	6 459
H	–	Defensive private expenditures on education and health	477	804	1 129	1 438	1 599	1 612	1 758	1 961	1 979	2 092	2 208	2 202	2 278	2 402
I	–	Cost of commuting	10 977	12 515	13 029	13 609	14 624	15 619	17 279	19 406	21 102	23 686	25 020	26 849	28 117	30 094
J	–	Cost of automobile accidents	560	678	754	778	689	746	893	1 118	1 335	1 488	1 494	1 458	1 423	1 407
K	–	Cost of water pollution	1 214	1 107	1 021	930	939	891	860	840	827	786	738	709	672	642
L	–	Cost of air pollution	6 653	6 219	5 851	5 685	5 554	5 113	5 137	4 788	4 188	3 853	3 389	3 440	3 251	3 132
M	–	Cost of noise pollution	62	63	74	110	225	259	318	409	647	269	290	295	147	153
N	–	Loss of wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O	–	Loss of farmland	20	30	23	39	30	29	39	34	51	42	43	39	34	36
P	–	Depletion of non-renewable resources	3 331	3 601	3 871	4 384	5 307	5 180	5 011	5 045	4 298	4 107	4 385	4 172	4 027	4 079
Q	–	Cost of long-term environmental damage	1 445	2 860	4 268	5 725	7 110	8 541	10 100	11 590	12 997	14 336	15 624	16 915	18 254	19 587
R	–	Cost of ozone layer depletion	4 777	4 928	5 078	5 232	5 331	5 435	5 467	5 486	5 504	5 515	5 526	5 536	5 548	5 555
S	+	Net capital growth	−23 130	−23 311	−14 467	−14 678	−14 758	−14 408	−13 210	−10 954	−4 403	5 429	3 768	2 224	6 423	9 981
T	+	Net change in international position	−1 008	−409	−1 025	634	2 814	2 605	−46	−4 573	−8 548	−10 857	−10 950	−8 857	−6 263	−4 024
		ISEW before applying distributional inequality index	20 095	33 442	49 263	54 852	60 803	66 188	70 539	73 475	79 738	91 744	104 657	107 521	116 017	125 063
U	x	Distributional inequality index (%)	98.1	95.5	100.0	112.2	119.1	122.4	126.3	124.5	122.8	123.0	124.9	130.0	134.8	138.4
		ISEW (PLN million – 1992 prices):	20 490	35 006	49 263	48 870	51 034	54 070	55 867	59 007	64 946	74 615	83 805	82 683	86 090	90 367

In conclusion, synthetic indicators expressed in monetary terms are not perfect but very useful because allow for a long-term and meaningful analysis and comparison of national economies due to their sustainability and welfare. It is possible that any new indicator, similar to Genuine Progress Indicator which is just a modified ISEW, will take over and attract more public attention than ISEW. Nevertheless, synthetic indicators are a necessary supplement to GDP. In addition and for sure, the set of indicators which is recently proposed to monitor EU sustainable development strategy should also include carefully selected synthetic indicators.

5. Problems around sustainability indicators

Any discussion on sustainability indicators needs prudence, common sense and critical background resulting from some obvious and known facts. We are living in a changing (natural, economic and social) environment. Stability is just a short break in a sequence of critical events (mostly evolutionary and rarely revolutionary). Sustainability is a cultural term associated with our human civilization, in the same way as weed, waste, car, sculpture, philosophy, empathy and many other "civilized" terms. There is no one unconditional reference point which is perfect or valid forever, also in environmental sciences. Signpost arrow may turn around what is sometimes very clear in any scientific discovery and quite common in our social life. Therefore, quantified social targets change and political targets' life is extremely short, probably until next election. All these arguments need consideration and sustainability indicators should reflect them as much as possible.

The term of sustainability is firm, popular and should not be substituted. However, the most instructive term for our promising indicators is adaptation and in many instances it expresses even better than sustainability what we want, what we should and what we can do. Ecological adaptation, so far, guaranteed sustainability of life on the Earth and radical progress of the human being. Adaptive resource management, as it was formulated by C.S. Holling and C.J. Walters [Holling (Ed.) 1978; Walters 1986], is environmentally, socially and economically justified. Therefore, adaptation should be reflected in all modes, aspects and systems of sustainability indicators.

This concept is not new and it exists in some official proposals. Something like an active management demand is present in a framework for structural environmental indicators elaborated by OECD and adapted in the European Union to its policy and documents. The framework for environmental indicators considers three aspects of their use: Pressure-State-Reaction. Talking about acidification, for instance, we should know numbers describing the real pressure created by identified emissions. We should also know how looks like the state of the environment in reaction to that impact in all environmental media – air, water, soil. But, finally, we should also monitor what kind of action was the decided reaction to the pressure and environmental impact question. So to speak, observation of bad things happening and calculation of environmental damages is not enough. Indicators have one more crucial thing to do: monitor effectiveness of an adaptive policy towards sustainable state of the environment.

The informative and adaptive role of sustainability indicators for the public, experts and decision-makers can be summarized in three points. First of all, it is expected that they will correspond to the reference points or critical values stemming from empirical science and being reliable information on available sustainable space. Medicine or biology and many other empirical sciences, are in a position to say something concrete about critical loads, safety levels or limits which should be incorporated into the reasoning whether human activity goes already beyond the capacity of our natural systems.

Second, quite often our knowledge is not complete, perfect and precise and in these circumstances indicators can serve only as signpost arrow showing a safe direction for human activities and actions. An important difference is that a signpost saying "go this way" will not inform how much we approach the final limit and to what extent we can still develop our activity.

Third, another role of sustainability indicators stems from official documents which reflect declaration of political will to lessen anthropogenic pressure, stimulate new production and consumption pattern, and improve the quality of life. In this context, sustainability indicators can only check the distance between quantified targets stemming from policy objectives or from social opinion on real-life situation. Very likely, what makes this last approach less reliable, they measure the distance to a pretty normative and political target or even to some numbers stemming from wishful thinking or unrealistic needs.

Having in mind these three characteristics, it makes sense to underline quite significant differences between environmental, economic and social indicators for sustainability [Śleszyński 2011]. Because of their empirical basis, environmental indicators are the most reliable with regard to reference point and critical value, especially when information originates from the positive model-case of renewable resources use or from ecological and medical sciences. Environmental indicators are also a confident signpost arrow for environmental pressure reduction where less means almost always better, in spite of the cost factor which should be never forgotten. In addition, discretional targets and strange ideas almost do not exist among environmental indicators, except some bizarre opinions expressed by green extremists.

Economic indicators create more problems in their reference to sustainability. Unfortunately, economic reference values are of rather unique and historical validity. There is nothing like a universal and perfect check level for inflation, unemployment, internal or external debt, which could be used as an absolute reference point for a critical evaluation, as it may happen in the case of lead content in food or chemical and biological characteristics of potable water. Moreover and quite often, economic indicators can act as a very simplified signpost arrow. Somebody should be very careful because they may be connected with the growth of production and consumption volume indicating, without a necessary check, that more means always better. This situation becomes even trickier with regard to the official economic policy objectives. Very often they are just unrealistic and incidental targets too much dependent on rather myopic economic perspective, political life cycle, and populism.

Social indicators pretending to monitor real sustainable policy are the most difficult task. They are damned to the situation where reference points are fuzzy, extremely diversified or almost non-existing. Some obvious and widely accepted pillars of our social life like democracy, human rights, equality, dignity, independence, create a headache when somebody wants to reflect them in an indicator form with a pathetic ambition to say: what is and what is not sustainable from the society point of view. Moreover, social indicators are also rather weak as a signpost arrow. It is enough to say that they are extremely and heavily dependent on cultural or religious status. Certainly, what can be easily accepted in an orthodox catholic environment will be refused somewhere else, and what is good and traditional for hunters in Africa will be simply forbidden and prosecuted in Europe. However, what should be still observed with a growing care and anxiety is the tendency among politicians to declare strongly homogeneous social targets pretending them to be perfectly universal. This threatening tendency started in Agenda21 and is still built on hardly reflexive normative thinking.

6. Conclusions

In spite of numerous proposals with large sets of sustainability indicators, there is also a critical need to construct and use synthetic (one-number) indicators. They should give a clear and unambiguous message often in an easily digested form. Moreover, the calculation upon which the synthetic indicator is based should have a firm scientific background and should be relatively easy to undertake. The paper concerns three exemplary approaches: Index of Sustainable Economic Welfare (ISEW), Total Material Requirement (TMR), and Ecological Footprint (EF). All of them have been estimated for the Polish economy some time ago and results with regard to the method are briefly commented in the paper.

EF of any defined population is the total area of biologically productive land and water occupied exclusively to produce all the resources consumed and to assimilate all the wastes generated by that population. In the paper EF estimates made for the Polish nation over 1955–1997 show that Polish footprint does not differ very much from western developed societies. However, it seems to be too large when compared to appropriate carrying capacity.

In the TMR methodology, the basic issue is the calculation of the total material input of the economy as a sum composed of direct and indirect material flows. The statistical data made it possible to perform a preliminary assessment of the trends occurred in the Polish economy over 1992–1997. It was found that TMR grew, however, there was a positive gradual change in the efficiency (TMR/GDP) of using material inputs acquired from the environment.

A number of attempts were undertaken to create a measure of sustainable management in the economy. One such an attempt is ISEW developed by H.E. Daly and J.B. Cobb Jr. It turned out that ISEW for Poland in the years 1990–2003 indicated a certain degree of volatility. Sustainable economic welfare showed a clear upward tendency after the transformations of the system started. The index grew rather slowly on the end of the analysed period. An effect obtained as a result of weighting ISEW by the welfare inequality index indicated a need to restrain from the optimism that accompanies the observations of growing various economic indicators which do not take into account an individual welfare of citizens.

Approaching a final part of the paper, it is high time to summarize some positive advices for a system of sustainability indicators:

– system of indicators must be a complex structure composed of structural indicators, indicators for local communities, and synthetic indicators,
– systematic indicators should be applied to each level of human activity, first of all national, regional, local,
– it is worth to remember that environmental indicators are more reliable than economic, and economic more reliable than social ones,
– regular monitoring and comparative studies on indicators should be an accepted national and EU norm.

In particular, synthetic indicators still need substantial modification and improvement. In spite of their critics indicating arbitrary and fuzzy elements of their assessment, synthetic sustainability indicators should always accompany GDP. This is the only acceptable way to avoid misunderstanding and wrong interpretation of GDP. European Union wants to monitor its "Sustainability Strategy" and scientists work hard to elaborate a set of structural indicators to cover all dimensions of the problem. However, indicators proposed to monitor EU sustainable development strategy should also include several synthetic indicators.

There are a lot of doubts and suspicions around synthetic indicators but to a large extent it results from too much optimistic and sometimes unrealistic expectation. Synthetic indicators have their clear drawbacks and limits and only knowing them well somebody may try to interpret them in a rational way. Nevertheless, it seems to be true that synthetic indicators are the best media for a survey and international communication on sustainable development.

Sustainability indicators are still elaborated, modified and improved. Despite of an undergoing research, there is also a place for some new initiatives. First proposal refers to a very serious and still existing data problem. This problem could be attacked easier after creation of a specialized international scientific data bases allowing for a calculation of indicators based upon specific coefficients. Wuppertal Institute for Climate, Environment and Energy and its commitment to material flows analysis makes a good example how such a data bank could be created and afterwards shared and used for an international cooperation and comparison studies.

The most recent phenomena of the economic crisis is calling for a reaction from the community of sustainability indicators' scientists. Some new and troublesome issues like sustainable banking, sustainable public finance, sustainable financial help of the EU, should be somehow measured and monitored, therefore, covered by new, specific, financial indicators.

Finally, I do also believe that individual research on sustainable indicators needs national coordination and calls for international collaboration. Something like international "joint implementation" in the field of sustainability measurement could initiate large comparative studies on sustainable development and its indicators. Unfortunately, our domestic empirical work of the past and some new research challenges are still rather neglected in the space of our policy.

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SYNTETYCZNE WSKAŹNIKI ROZWOJU TRWAŁEGO I ZRÓWNOWAŻONEGO – ZDOBYTE DOŚWIADCZENIA I ZALECENIA NA PRZYSZŁOŚĆ

Streszczenie: W artykule dokonano przeglądu wybranych syntetycznych wskaźników rozwoju trwałego i zrównoważonego, ze szczególnym zwróceniem uwagi na te, których rachunki zostały już w przeszłości przeprowadzone dla polskiej gospodarki: *Ecological Footprint*, *Total Material Requirement*, *Index of Sustainable Economic Welfare*. Przeprowadzona dyskusja wskaźników pozwala zrozumieć trudności związane z pomiarem i interpretacją wyników.

Wskaźniki syntetyczne są, zdaniem autora, właściwym sposobem uzupełnienia i dopełnienia informacji statystycznej dostarczanej przez Produkt Krajowy Brutto. Celem artykułu jest wskazanie, że rozbudowie metodyki rachunków narodowych w kierunku zalecanego przez Unię Europejską zintegrowanego systemu informacji ekonomicznej i środowiskowej towarzyszyć powinno prowadzenie krajowych prac nad syntetycznymi wskaźnikami.

Słowa kluczowe: trwały i zrównoważony rozwój, syntetyczne wskaźniki trwałości rozwoju.