How Big Is "Ecological Footprint" of the Polish Economy?

Małgorzata Stachowiak, post-graduate
Interdepartmental Environmental Protection Study, University of Warsaw
Jerzy Śleszyński, professor
Department of Economics, University of Warsaw

1. Introduction

Each person's needs are compromised directly or indirectly thanks to various components of the environment. These are: air of appropriate quality, clean water, healthy agricultural crops and various raw materials used as production inputs and turned into products of the appropriate use value. The amount, quality, and structure of needs are shaped by the wealth of nations, the level of individual incomes, tradition, culture, customs, and other factors.

Phenomena and tendencies that exist in the consumption and production spheres raise concern of environmental economists and environmentalists. Rich consumption societies are constantly urged to buy more and more new goods, which in turn stimulate further production. Production processes are still characterised with a relatively high intensity of raw materials used per one unit of the product.

Exploitation of the environment is constantly increasing because the sum of needs of the constantly growing number of population is increasing. These processes cannot be rapidly stopped but they have to be submitted to control and measurement and they have to be modified in accordance with the ecological, technological, economic and social criteria. The most suitable for implementation of this task is the strategy of sustainable development, and among its instruments environmental pressure indicators should be take into account.

Ecological Footprint (EF), being something like "ecological trace left in the environment by a human being" is an example of such an indicator. Physical amount—in this case land surface—is used for assessment of the natural resources management. EF has been defined by the creators of the concept, Wackernagel and 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" (Borgström Hansson, Wackernagel, 1999).**

Every domestic economic activity has an impact on global ecosystem because it uses the resources and services taken away from the natural environment. 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, to calculate the EF (van den Bergh, Verbruggen, 1999):

- built-up areas,
- arable land,
- meadows and pastures,
- forests,
- so-called energy lands,
- sea.

Built-up area, devoid of the natural components, is treated as already "consumed," i.e. the area where biological production is no more possible. This category includes municipal and communication areas (roads, airports, cities, etc.) Currently the surface of built-up land *per capita* oscillates around 0.06 ha (Bello et al., 1999) but the share of this category in land utilisation patterns is constantly increasing.

Arable land, meadows and pastures are ecosystems characterised with a relatively high production efficiency, used for production of basic goods consumed by humans. They cover the area of 4.82 billion hectares, which translates into approximately 0.85 ha of this category of land use *per capita*. Smeets and van Vuuren (2000) have proposed the following formula for calculating the surface necessary for a given population for meeting the needs related to consumption of agricultural and consumption goods:

$$\text{land use} = \sum_{c} \left(\frac{\text{production}_{\text{loc, c}}}{\text{productivity}_{\text{loc, c}}} + \frac{\text{import}_{\text{c}}}{\text{productivity}_{\text{imp, c}}} - \frac{\text{export}_{\text{c}}}{\text{productivity}_{\text{exp, c}}} \right) \quad [1]$$

Land use constitutes the "net ecological footprint" expressed in hectares. The "c" subscript indicates various production categories. The variables "production," "import," and "export" relate to the economy of a given country and are expressed in tonnes per year. The variables "$\text{productivity}_{\text{loc}}$" and "$\text{productivity}_{\text{exp}}$" equal the volume of the domestic crops and are expressed in tonnes per year. Productivity of imports is equal to the average global efficiency of ecosystems or to the production capacity of the region of origin of a given good.

Forests cover the area of 5.1 billion ha (0.9 ha *per capita*). In the EF analysis they are treated as the source of timber which is used in construction industry, wood, and paper industry and as a raw material in power sector. Wackemagel and Rees (1996) have used the following formula for describing forest areas used by a given population (source: www.rprogress.org/resources/nip/ef/ef_can93.xls.sit):

$$\text{forest area} = \sum_{x} \frac{\text{production}_{x} \cdot \text{input intensity}_{x}}{\text{forest productivity}} \quad [2]$$

The subscript "x" (in the formula 2) stands for the production category that can be expressed in tonnes, m^2 or m^3. Input intensity (in m^3/t, m^3/m^2 or m^3/m^3) stands for the amount of material used per unit of production of a given product. Productivity characterises production possibilities of 1 ha of forest and is expressed in m^3/ha/year.

Energy land is defined as the area of forest necessary for absorption of excessive CO_2 released as a result of combustion processes or, alternatively, as the area of land necessary for production of biological substitutes of fossil fuels at the level equal to current energy consumption.

In the first approach it is assumed that non-renewable assets of fossil fuels will remain in the near future the main source of energy. In order to calculate the energy land using this method, it would be necessary to calculate the amount of CO_2 which can be absorbed by one hectare of forest and the volume of emissions of this gas related to generation of a given portion of energy. According to the Intergovernmental Panel on Climate Change (www.rprogress.org/resources/nip/ef/ef_can93.xls.sit), 1 ha of newly planted forest can on average absorb annually 1.42 t of carbon. According to the Panel, emission factor for solid fossil fuels amounts to 26 t of C per TJ of generated energy, for liquid fuels 20 t C/TJ, and for gas—15.3 t C/TJ. After dividing 1.42 by the subsequent emission factors we obtain the following values: 55, 71, and 93 GJ/ha/year, respectively. They relate to 1 ha of EF for energy land. In case of hydropower plant, 1 ha of EF is equal to 1000 GJ of generated energy.

The second approach, i.e. production of the substitute, takes into account the possibility of using the reserves of fossil fuels as well as the necessity of giving up their use because of environmental protection reasons (e.g. limiting the greenhouse effect). Energy is treated as a potentially renewable resource, with renewability depending on CO_2 disposal. In order to calculate energy land in this way, Wackernagel and Rees (1996) have applied the following formula:

$$\text{energy area} = \frac{\text{energy consumption}}{\text{substitute production}} \qquad [3]$$

Ethanol is considered to be the best renewable substitute of fossil fuels. Thanks to the conversion technology it is possible to produce ethanol from natural resources at the level of 80 GJ/ha/year; in case of methanol the conversion indicator is less beneficial and amounts to 17–30 GJ/ha/year (National Renewable Energy Laboratory, 1992; Ferguson, 1999). In this way we also find out how to calculate EF of energy land, but this time as a surface which would have to be cultivated in order to generate the appropriate amount of energy.

Calculations related to fish consumption are based on the assumption that productivity of the sea is the same everywhere on the Earth. Due to lack of data related to production efficiency of the marine ecosystem it is calculated in the way of dividing the current global fish harvest by the surface of fish harvesting areas. The resulting value is treated as the maximum production capacity of the sea ensuring "sustainable" use of this ecosystem. In fact, the calculated value may be much lower, because in case of open access fishing the fish stock may be overexploited and many species are endangered with extinction.

2. Ecological Footprint estimates

For the last few years the Ecological Footprint (EF) has been viewed as a useful indicator of sustainable development and has been used in many studies. The calculations were carried out for 52 countries first time in 1996 by Wackernagel and Rees with the team (Bello et al., 1999). The analyses were performed for the national total consumption values based on the average, global productivity of ecosystems. Environmental capacity was calculated summing up all the available categories of land use (including the sea) per one inhabitant of a given country. The resulting outcomes (in ha *per capita*) are listed in Table 1.

As can be seen from the data below, the amount of land "consumed" by one inhabitant greatly differs among the countries (from 0.5 ha *per capita* in Bangladesh to 10.3 ha *per capita* in USA). It is due to the following factors: consumption level, population density, local productivity of ecosystems. Only thirteen countries have *ecological footprint* that is smaller or equal to the average global environmental capacity. On the other hand, thirty five countries need more natural resources than the amount available within their borders.

At the global scale, EF was calculated at the level of 2.8 ha *per capita*, while the environmental capacity amounts to 2.1 ha *per capita*. Thus, there is not enough land surface on Earth for compromising the consumption needs of all human beings and at the same time preserving all types of natural ecosystems for protection of biodiversity and absorbing excessive emissions of carbon dioxide.

Table 1.

Ecological Footprint for selected 52 countries

Country	Population	Ecological footprint [ha *per capita*]	Carrying capacity of the environment [ha *per capita*]	Ecological deficit or surplus [ha *per capita*]
Argentina	35 405 000	3.9	4.6	0.7
Australia	18 550 000	9.0	14.0	5.0
Austria	8 053 000	4.1	3.1	–1.0
Bangladesh	125 898 000	0.5	0.3	–0.2
Belgium	10 174 000	5.0	1.2	–3.8
Brazil	167 046 000	3.1	6.7	3.6
Canada	30 101 000	7.7	9.6	1.9
Chile	14 691 000	2.5	3.2	0.7

Country	Population	Ecological foot-print [ha *per capita*]	Carrying capacity of the environment [ha *per capita*]	Ecological deficit or surplus [ha *per capita*]
China	1 247 315 000	1.2	0.8	–0.4
Columbia	36 200 000	2.0	4.1	2.1
Costa Rica	3 575 000	2.5	2.5	0.0
Czech Republic	10 311 000	4.5	4.0	–0.5
Denmark	5 194 000	5.9	5.2	–0.7
Egypt	65 445 000	1.2	0.2	–1.0
Ethiopia	58 414 000	0.8	0.5	–0.3
Finland	5 149 000	6.0	8.6	2.6
France	58 433 000	4.1	4.2	0.1
Germany	81 845 000	5.3	1.9	–3.4
Greece	10 512 000	4.1	1.5	–2.6
Hong Kong	5 913 000	5.1	0.0	–5.1
Hungary	10 037 000	3.1	2.1	–1.0
Island	274 000	7.4	21.7	14.3
India	970 230 000	0.8	0.5	–0.3
Indonesia	203 631 000	1.4	2.6	1.2
Ireland	3 577 000	5.9	6.5	0.6
Israel	5 854 000	3.4	0.3	–3.1
Italy	57 247 000	4.2	1.3	–2.9
Japan	125 672 000	4.3	0.9	–3.4
Jordan	5 849 000	1.9	0.1	–1.8
Korea	45 864 000	3.4	0.5	–2.9
Malaysia	21 081 000	3.3	3.7	0.4
Mexico	97 245 000	2.6	1.4	–1.2
Holland	15 697 000	5.3	1.7	–3.6
New Zealand	3 654 000	7.6	20.4	12.8
Nigeria	118 369 000	1.5	0.6	–0.9
Norway	4 375 000	6.2	6.3	0.1
Pakistan	148 686 000	0.8	0.5	–0.3
Peru	24 691 000	1.6	7.7	6.1
Philippines	70 375 000	1.5	0.9	–0.6
Poland	38 521 000	4.1	2.0	–2.1
Portugal	9 814 000	3.8	2.9	–0.9
Russian Federation	146 381 000	6.0	3.7	–2.3
Singapore	2 899 000	6.9	0.1	–6.8
South Africa	43 325 000	3.2	1.3	–1.9
Spain	39 729 000	3.8	2.2	–1.6
Sweden	8 862 000	5.9	7.0	1.1

Country	Population	Ecological footprint [ha *per capita*]	Carrying capacity of the environment [ha *per capita*]	Ecological deficit or surplus [ha *per capita*]
Switzerland	7 332 000	5.0	1.8	–3.2
Thailand	60 046 000	2.8	1.2	–1.6
Turkey	64 293 000	2.1	1.3	–0.8
Great Britain	58 587 000	5.2	1.7	–3.5
USA	268 189 000	10.3	6.7	–3.6
Venezuela	22 777 000	3.8	2.7	–1.1
World	5 892 480 000	2.8	2.1	–0.7

Source: Bello et al., 1999.

3. Critical comments on EF

The EF concept allows for calculating the area of the surface used directly or indirectly while applying a given technology. It is the surface necessary for using and processing natural resources which are indispensable for sustaining a person, a society, or any given population. 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).

EF is often calculated for inhabitants of the specific countries, which, according to van den Bergh and Verbruggen (1999) is not the right approach. It is related to the fact that state 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 the specific regions of the Earth are characterised with high diversity of natural conditions (soil, climate, land diversification, hydrology), which 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 must not mean, however, that the societies living in these areas are far from 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 Vuuren et al., 1999; van den Bergh et al., 1999). Aggregating means summing up the areas playing various ecological functions, constituting different categories of environmental pressure. This means that various consumption categories are assigned the same weight regarding impact on environment. In fact, this impact is highly diversified (e.g. the area used for construction of buildings is less destructive than using the land for agriculture).

The most controversial is the category of energy land, which has been described as the soil 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 forest ecosystems (1.42 t C/ha/year). According to van den Bergh, Jaroen and Verbruggen (1999), reduction of emissions to this level is not possible neither from technical nor ecological point of view. Additionally, EF analysis seems to suggest that the only way of decreasing the amount of CO_2 in the atmosphere is increasing forested areas. Moreover, in calculations of energy land 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 (NOx and SOx lead to acidification of the environment). According to the critics, it leads to significant underestimation of the indicator.

Another controversial assumption used in the analysis of "ecological footprint" 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. Other functions of the forest, although very important from the point of view of nature and human beings, are simply omitted.

4. EF estimates for the Polish economy

This section presents estimates of the EF indicator for the Polish economy in the period 1955–1997. First, it should be stressed that up-to-date official publications give only general description of the methods and scope of data needed for EF estimation. They usually present only the resulting numbers and not input data and formulas used for calculations. Therefore, in this study, the two richest in explanations studies have been used: Smeets and van Vuuren (2000) and the study carried out by the group under supervision of Wackernagel (Bello et al., 1999). The original methodology has been actually applied with only negligible modifications, however, adopting direct and country specific productivity coefficients wherever it was possible.

Local productivity of ecosystems has been used for calculations, however, consumption of fish and seafood has been omitted. Energy "embodied" in internationally traded goods has not been taken into account. Ultimately, the following categories have been included in the calculations:

- built-up area;
- energy land;

- forest area (necessary for fulfilling the needs resulting from demand for wood and paper industry products);
- area of arable land, meadows and pastures (used for agricultural purposes and food production).

The basic source of data for Poland were the publications of the *Main Statistical Office* (statistical yearbooks on the Polish economy, foreign trade, environmental protection, agriculture and food production, 1946–1998, published by GUS), and for the world *Food Agricultural Organisation* (FAO Yearbooks: Production, 1956–1998, Vol. 10–52) and *International Energy Agency* (CO_2 emission from fuel combustion, 1971–1998, IEA). Individual elements have been aggregated into one indicator, which has subsequently been compared with the surface available to the statistical Pole within the country borders.

Table 2.

Aggregated EF for Poland during the period 1955–1997 (hectares *per capita*)

Year	Built-up area	Energy land	Forests	Cereals	Leguminous and industrial plants	Vegetables and fruits	Oil plants	Condiments and natural fibres	Animal-based products	Total—without energy land	Total—including energy land
1955	0.031	1.192	0.176	0.190	0.038	0.012	0.008	0.021	0.426	0.902	2.094
1960	0.039	1.599	0.146	0.157	0.058	0.015	0.003	0.023	0.513	0.954	2.553
1965	0.043	1.591	0.149	0.160	0.043	0.015	0.014	0.024	0.447	0.894	2.486
1970	0.048	1.904	0.159	0.127	0.037	0.016	0.012	0.022	0.430	0.851	2.755
1975	0.049	2.258	0.227	0.121	0.037	0.018	0.015	0.021	0.447	0.936	3.193
1980	0.050	2.477	0.151	0.125	0.033	0.018	0.025	0.022	0.432	0.857	3.333
1985	0.050	2.372	0.159	0.084	0.035	0.011	0.018	0.015	0.360	0.732	3.104
1988	0.051	2.749	0.143	0.089	0.028	0.013	0.018	0.017	0.417	0.776	3.525
1989	0.051	2.477	0.153	0.077	0.030	0.012	0.018	0.014	0.365	0.720	3.197
1990	0.051	2.024	0.101	0.062	0.028	0.012	0.009	0.009	0.316	0.587	2.612
1991	0.051	1.861	0.105	0.063	0.024	0.015	0.008	0.007	0.333	0.606	2.467
1992	0.051	1.833	0.154	0.076	0.029	0.018	0.018	0.012	0.357	0.715	2.548
1993	0.051	1.896	0.133	0.072	0.028	0.018	0.021	0.011	0.312	0.646	2.542
1994	0.052	1.802	0.134	0.079	0.027	0.017	0.023	0.010	0.306	0.648	2.450
1995	0.052	1.839	0.105	0.075	0.026	0.021	0.023	0.013	0.291	0.606	2.445
1996	0.052	1.967	0.114	0.086	0.027	0.026	0.018	0.013	0.277	0.613	2.580
1997	0.052	1.871	0.143	0.087	0.024	0.025	0.023	0.013	0.284	0.651	2.522

Source: own calculations based on GUS, FAO.

The above listed data indicate 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 2.522 ha per person. It was mainly due to changes in structure and amount of the consumed goods, changes in the volume of harvests and 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 are 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 is observed, and after 1988 this use was decreasing, which was due to the general changes in energy intensity of the national economy.

Table 3.

Percentage share of the main product categories in the aggregated Polish EF

Year	Built-up area (%)	Energy land (%)	Forest (%)	Agriculture and food products (%)
1955	1.5	56.9	8.4	33.2
1960	1.5	62.6	5.7	30.1
1965	1.7	64.0	6.0	28.3
1970	1.7	69.1	5.8	23.4
1975	1.5	70.7	7.1	20.6
1980	1.5	74.3	4.5	19.7
1985	1.6	76.4	5.1	16.8
1988	1.4	78.0	4.1	16.5
1989	1.6	77.5	4.8	16.1
1990	2.0	77.5	3.9	16.7
1991	2.1	75.4	4.3	18.2
1992	2.0	71.9	6.0	20.0
1993	2.0	74.6	5.2	18.2
1994	2.1	73.6	5.5	18.9
1995	2.1	75.2	4.3	18.4
1996	2.0	76.2	4.4	17.3
1997	2.1	74.2	5.7	18.1

Source: own calculations based on GUS and FAO.

According to the data, the surface of forests, arable land, orchards and green areas necessary for meeting consumption needs of the Polish society indicated a decreasing tendency from 0.902 ha per person in 1995 to 0.651 ha per person in 1997. This is due to the changes in the volume and structure of the consumed goods and "space intensity" of production. In this case the highest share of EF can be attributed to the space used for consumption of animal-based products (43.6–55.0%), then wood products (15.3–22.0%), cereals (10.4–21.1%), leguminous and industrial plants (3.6–6.1%), vegetables and fruits (1.3–4.2%), oil plants (0.3–3.8%), and natural fibres and condiments (1.2–2.7%). Built-up areas constitute 3.4–8.0% of the analysed indicator.

Because of many controversies raised with aggregating individual categories that stand for the areas of various ecological functions into one indicator, the share of individual components of EF has also been calculated, excluding energy land.

Table 4.

Percentage share of the main product categories in the Polish EF (excluding energy land)

Year	Built-up area (%)	Forest (%)	Cereals (%)	Leguminous and industrial plants (%)	Vegetables and fruits (%)	Oil plants (%)	Condiments and natural fibres (%)	Animal-based products (%)
1955	3.4	19.5	21.1	4.2	1.3	0.9	2.3	47.2
1960	4.1	15.3	16.5	6.1	1.6	0.3	2.4	53.8
1965	4.8	16.7	17.9	4.8	1.7	1.6	2.7	50.0
1970	5.6	18.7	14.9	4.3	1.9	1.4	2.6	50.5
1975	5.2	24.3	12.9	4.0	1.9	1.6	2.2	47.8
1980	5.8	17.6	14.6	3.9	2.1	2.9	2.6	50.4
1985	6.8	21.7	11.5	4.8	1.5	2.5	2.0	49.2
1988	6.6	18.4	11.5	3.6	1.7	2.3	2.2	53.7
1989	7.1	21.3	10.7	4.2	1.7	2.5	1.9	50.7
1990	8.7	17.2	10.6	4.8	2.0	1.5	1.5	53.8
1991	8.4	17.3	10.4	4.0	2.5	1.3	1.2	55.0
1992	7.1	21.5	10.6	4.1	2.5	2.5	1.7	49.9
1993	7.9	20.6	11.1	4.3	2.8	3.3	1.7	48.3
1994	8.0	20.7	12.2	4.2	2.6	3.5	1.5	47.2
1995	8.6	17.3	12.4	4.3	3.5	3.8	2.1	48.0
1996	8.5	18.6	14.0	4.4	4.2	2.9	2.1	45.2
1997	8.0	22.0	13.4	3.7	3.8	3.5	2.0	43.6

Source: own calculations based on GUS, FAO.

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 has been calculated by dividing the area of Poland (in ha) by the population number, and the results are presented in Table 5. Next, the existing carrying capacity of environment (after taking into account the standard 12% "deduction" for biodiversity) was compared with "ecological footprint," which allowed to estimate the possible ecological deficit or surplus.

Table 5.

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: own calculations based on GUS and FAO.

5. Conclusions

The discussed results for Poland indicate that including energy land in the analysis leads to the conclusion that Poland is not able to provide half of ecological services necessary for fulfilling self-sustainability based needs of the statistical Pole. 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 allows 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, the values of EF and energy intensity of the national economy are very closely correlated.

Increase and drop of EF and ecological deficit during the analysed period in the Polish economy were induced primarily by changes in the amount of the consumed primary energy carriers. Therefore, in order to achieve EF reduction, it is necessary, first of all, to control energy consumption, and next, to control consumption of agriculture and food industry products and wood.

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—"only one Earth". It shows, in a very specific way, 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. This is also a good starting point for a future scientific research on creation of macroeconomic, synthetic measures of the crucial relationship: society and economy versus natural environment.

Concluding, 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. 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 or social aspects of development of a given population. Therefore, EF, being a specific and synthetic indicator, should be regarded as a complementary measure and for policy purposes always used together with other indicators of sustainable development.

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Abstract

How Big Is "Ecological Footprint" of the Polish Economy?

The ecological footprint concept was conceived by Wackernagel and developed by Wackernagel and Rees to estimate how much biologically productive space people use to sustain themselves. Ecological footprint calculations are based on two assumptions: first, it is possible to keep track of most of the wastes we generate; secondly, most of these resource and waste flows can be converted to a corresponding biologically productive area. Thus, ecological footprint of any defined population (from a single individual to a whole city or country) 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, using prevailing technology. Ecological footprinting takes into account arable land separated into cropland, pasture land, and forest.

Thus, ecological footprints give a direct comparison between nations regarding the level and patterns of consumption of their citizens. Just as important as the level of consumption is the ecological space which the nation has available. This determines how many people a nation can support at the current lifestyle without, on balance, appropriating ecological space from other nations. The ecological footprinting, for very pragmatic reason, should meet the following criteria: (1) the calculation procedure should be objective and scientifically sound, (2) indicators should have a clear interpretation and be understandable by non-scientists, (3) indicators should relate to clear policy objectives.

In the paper we present ecological footprint estimates made for the Polish nation within its border over 1955–1997. In this approach we managed to reach numbers comparable with other countries' studies. It appears that Polish foot-

prints do not differ very much from western developed societies. However, as usual in dynamic economies, they seem to be too large when compared to available ecological space.

The ecological footprint is one attempt at developing a biologically based ecological economics, which approximates reality better than many economic expansionist models. There are several advantages and limitations associated with the development of the ecological footprint concept. The major advantage of the ecological footprint concept over some other indicators like environmental space is that the former concept gives a clear, unambiguous message often in an easily digested form. The clarity of the message is an important function of any indicator for both policy makers and the general public. Next, the calculation upon which the ecological footprint is based is relatively easy to undertake and much of the data is available at different spatial scales.

Nevertheless, the presentation of ecological footprinting needs to be greatly improved. Ecological footprint is a static measure, it ignores technological change, it ignores underground resources, it is a stock measure and does not measure flows, it lacks measures of equity. The energy footprint aspect needs to be tackled by experts in the energy field. More work needs to be done on the vexed question of forest yield factors and sustainability. But despite of the many problems, there remains tremendous potential in the use of ecological footprints for estimating how many people each nation can support in a specified consumption and production patterns.