DE GRUYTER
OPEN

Acta Universitatis Bohemiae Meridionalis, Vol 19, No 1 (2016), ISSN 2336-4297 (online)

Sustainability Evaluation of the European Union based on the Ecological Footprint

Magdaléna Drastichová[1]

Abstract: *Recent production and consumption activities impose a heavy burden on the Earth's current and future capacity. Therefore, it is inevitable to deal with the impacts of the economic activities on the natural resources which determine our future well-being and the survival by itself. The indicators reflecting impacts of regions and countries on the available resources are used in this Paper to operationalize the sustainable development concept. The Ecological Footprint, Total Biocapacity and their components are investigated in the European Union (EU) and its countries and the EU region is compared with the other regions of the world. The additional three developed countries – Norway, Switzerland and the United States (US), were included in the sample together with the EU countries to enable extended comparisons. The aim of the Paper is to evaluate sustainability in the EU and its countries by means of the Ecological Footprint and the available biocapacity and to detect the relations between the countries' EF and their standard of living and human development level. Concerning the regions, the highest Ecological Footprint per capita is typical of North America followed by the EU region. The Northern countries show largest biocapacities and are thus the largest resource creditors. The worst results in the Ecological Footprint – biocapacity relations analysis are typical of Cyprus, Belgium, Netherlands and Italy. The cross-section regression models confirmed that, at least, in the sample of the developed countries the positive relations between the Ecological Footprint on the one hand and the standard of living / state of the human development on the other hand exist.*

Keywords: Sustainable Development ·Sustainability · Ecological Footprint · Biological Capacity · European Union

JEL Classification: C21 · Q51 · F56

1 Introduction

Current production and consumption activities impose a heavy burden on the Earth's capacity in the present times as well as in future. Sustainability, a nebulous but attractive concept, poses a guiding question for every activity, i.e. if this can continue. This means that activities such as production, consumption, and the related exhaustion of natural, physical or other forms of capital, with an unlimited time horizon, can be regarded as sustainable. Consumption is the process by which goods are, at last, provided to final use by people. It is at the end of the line of economic activities which starts with an evaluation of available resources and proceeds through production and distribution of goods. The effect of this consumption, including depletion of resources and generation of waste as well as enhancement of human survival and flourishing, determines the resource base for the future economic activities (Goodwin et al., 2008). Since for the analysis the cross-section data are only available the term "sustainability" is often used instead of or together with "sustainable development" (SD). The term sustainability can also be used to determine state, however, the level of the Ecological Footprint (EF) and its relations to the available biocapacity are the result of the previous development and they also determine the sustainability of the development in the future and thus the SD. Every human activity uses biologically productive land and/or fishing grounds which is reflected in the EF.

SD is a global challenge which requires a progressive transformation of economies (Hediger, 2006), specifically substantial changes in production processes and lifestyles in compliance with the idea that the global development cannot be only understood from the economic point of view (FEEM, 2011). According to the most quoted definition of the World Commission on Environment and Development (WCED, 1987), SD is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Although this term is still vague there is an emerging political consensus on the desirability of SD (Daly, 1996). SD is amongst the main policy priorities worldwide (FEEM, 2011). Already in 1997 SD became a fundamental objective of the European Union (EU) and in 2001 the EU Sustainable Development Strategy (EU SDS) was launched (European Commission, 2015).

According to the European Environment Agency (2015), the total EF for the EU-28 countries increased rapidly during the 1960s and 1970s, and has remained relatively constant since the 1980s. However, the region's total biocapacity has changed very little since 1961. It is therefore needful to investigate the recent state of the EU's impact on resources

[1]Ing. Magdaléna Drastichová, Ph.D., VŠB-TU Ostrava, Faculty of Economics, Department of Regional and Environmental Economics, Sokolská třída 33, 701 21 Ostrava, Czech Republic, e-mail: magdalena.drastichova@vsb.cz

DOI: 10.1515/acta-2016-0008

together with the achieved standard of living and the state of human development_and compare this region with the other regions of the world. In this Paper the footprint / biocapacity methodology is used to measure the sustainability and SD aspects whereas the EF is the basic composite index which can reflect the fundamental aspects of the SD of regions or countries. The aim of the Paper is to evaluate sustainability in the EU and its countries by means of the Ecological Footprint and the available biocapacity and to detect the relations between the countries' EF and their standard of living and human development level.

2 Literature Review

Singh et al. (2009) describe methodologies for Sustainability Assessment and provide an overview of various sustainability indices applied in policy practice. Composite indicators are defined as an innovative approach to evaluating SD. The authors classified the indicators to measure the SD into a number of groups while the EF was included in the group of Eco-system-based Indices.

One way of quantifying the total human pressure on the natural environment is to calculate humanity's environmental footprint (Hoekstra and Wiedmann, 2014), or so called Footprint Indicators. The common feature of all environmental footprints is that they quantify the human appropriation of natural capital as a source or a sink (e.g Giljum et al., 2011). The Footprint Indicators can measure the use of one particular resource, such as Water, Land, Material Footprint, or in relation to the sink function of the environment, the so called Carbon Footprint can be measured (see Tukker et al., 2014). The EF as an aggregate environmental indicator (Segnestam, 2002) covers more aspects together in one composite indicator. The EF concept was introduced by Rees and Wackernagel (1994). The EF indicator serves as one of the primary guides for the evaluation if the examined subjects operate at a sustainable level. This evaluation is moreover enabled by the comparison of the EF with the available biocapacity and its components. The EF is a method for estimating the biologically productive area necessary to support current consumption patterns, given prevailing technical and economic processes (Holmberg et al., 1999). Thus the EF is a measure of the demand which human activities put on the biosphere. Concretely, it measures the extent of biologically productive land and water area required to produce all the resources an individual, a population, an activity, a region, or all of humanity consume, and to absorb the waste they generate, given prevailing technology and resource management practices (Global Footprint Network, 2015b). Subsequently, this area can be compared with biocapacity, which is the amount of productive area that is available to generate these resources and to absorb the waste. Both are measured in global hectares (gha) whereas a gha represents a hectare with world average productivity. By comparing human impact with the planet's limited bioproductive area, this method tests a basic ecological condition for sustainability (Holmberg et al., 1999).

Hoekstra and Wiedmann (2014) emphasised that within the context of Earth 's limited natural resources and assimilation capacity, the current environmental footprint of humankind is not sustainable. They also concluded that to reduce humanity's environmental footprint toward a sustainable level, it is necessary to reach consensus on footprint caps at different scales. Footprint caps need to be related to both production and consumption. The various components of the environmental footprint of humanity must be reduced to remain within planetary boundaries. The EF is of high policy relevance because it indicates the overall resource demand of the relevant actor / unit compared to resources available (European Environment Agency, 2015). Although a huge number of indicators / indices and frameworks have been developed to measure SD from the various points of view, the EF concept is the fundamental one and can help answer the basic question if the economy operates at the sustainable level. The evaluation is straightforward, i.e. if the EF exceeds the available biocapacity, the ecological overshoot occurs. Moreover, the deeper aspects of sustainability can be detected by the examination of the EF component indicators and the relations between the EF and well-being / human development indicators.

In the EU the Sustainable Development Indicators (SDIs) were developed to monitor the EU SDS and other set of indicators was created to monitor the Europe 2020 Strategy, i.e. the Europe 2020 Indicators. Both sets are constructed according to the framework based on sustainable development themes (see Segnestam, 2002) and include a large number of indicators which are interconnected. These sets enable detailed SD evaluation, but not so straightforward, when different indicators show different trends of development. Also the *Beyond GDP* initiative at the EU level focused on developing indicators comparable to Gross Domestic Product (GDP), but more inclusive of environmental and social aspects of progress, helps to monitor the SD in the EU. The indicators are classified into four groups, i.e. Enlarged GDP, Social Indicators, Environmental Indicators and Well-Being. The EF is included in the Environmental Indicators and the proxy for human development used in this Paper, namely HDI, is included in two groups, i.e. Social Indicators and Well-Being (European Commission, 2016). At the international level, the framework based on sustainable development themes was used to construct the Millennium Development Goals (MDGs adopted in year 2000) and the subsequent Sustainable Development goals (SDGs adopted in 2015) which built on the MDGs (see Segnestam, 2002). The above mentioned EU's strategies are in compliance with these goals and a part of the indicators included are based on them. Thus, the EU is aimed at achieving the SD goals adopted at the international level, but it is also focused on the specific SD issues related to its own economy and in its Member States.

Economic and social development, or human well-being, can be approximated with UNDP's widely recognized HDI (UNDP, 2014). This index is composed of three Dimension Indices reflecting three dimensions of HDI: Life Expectancy Index reflecting long and healthy life, Education Index reflecting knowledge and Gross National Income (GNI)

Index reflecting a decent standard of living. The first index is based on Life Expectancy at Birth, the second combines the Mean Years of Schooling and Expected Years of Schooling and the third is based on GNI per capita (UNDP, 2014). Thus, it is necessary to go beyond GDP when measuring well-being, which means that the HDI seems to be more appropriate indicator than GDP to reflect human development and social aspects of the development.

Finally, some lacks and aspects of critique of the EF concept need to be mentioned. To avoid exaggerating human demand on nature, the EF includes only those aspects of resource consumption and waste production for which the Earth has regenerative capacity, and where data exist that allow this demand to be expressed in terms of productive area. The typical example is that freshwater withdrawal is not included in the EF, although the energy used to pump or treat it is. EF accounts reflect past resource demand and availability, but they do not predict the future. Thus, while the EF does not estimate future losses caused by present degradation of ecosystems, if persistent this degradation will likely be reflected in future accounts in the form of biocapacity losses. Footprint accounts also do not indicate the intensity with which a biologically productive area is being used, nor do they reflect specific biodiversity pressures. Finally, the EF is a biophysical measure; it does not evaluate the social and economic dimensions of sustainability (Ewing et al., 2010). According to Pearce (2013) the footprint analysis does not really measure people's overuse of the planet's resources at all. If anything, it underestimates it. The damaging environmental effects of the ways of the area use, i.e. soil erosion and the overuse of water reserves, are not measured, only the extent of this area is. This is especially related to soils and water reserves and thus, to the *Cropland Footprint* and *Grazing Land Footprint* (explained more in detail in subsection 3.2). The reasons especially lie in the missing data sets.

Nevertheless, it can be still claimed that the EF concept is meaningful to reflect the fundamental aspects related to SD while it should be appropriately combined with other indicators to reflect all relevant SD aspects. Firstly, it is appropriate to combine the Footprint Indicators with the well-being or human development indicators because the Footprint Indicators are predominantly focused on the environmental pillar of the SD, while the latter reflect the economic and social or all three SD dimensions. The other composite indices and so called decoupling indicators should also be combined with the EF analysis to reflect the important SD aspects. As to the first, the World Bank has developed a composite indicator known as Adjusted Net Saving (ANS) which is a macro level index of SD building on the concepts of green national accounts. The ANS measures the true rate of savings in an economy after taking into account investments in human capital, depletion of natural resources and damage caused by pollution (World Bank, 2012). In this indicator, all three SD dimensions are included and the environmental one includes both resource depletion and damages to the environment. However, the ANS values are generally affected by pricing methods used to estimate economic values of the natural resource and environmental damages and therefore the assessment can be subjective to some extent. Therefore, the evaluation based on the combination of the EF and ANS seems to be meaningful. The analysis of the EU countries according to the ANS and its component indicators was carried out in Drastichová (2014). Secondly, Decoupling Indicators are a special case of the SD indicators, whose issue of interest is not the change in one single trend but the relationship of two trends. These indicators show the strength of the link, or the so called coupling, between the economic and the environmental variable. In relation to SD, the aim is to achieve the decoupling of these two variables, so that continued economic growth does not lead to a further increase in environmental degradation (Eurostat, 2015). In terms of the EU SDIs the Resource Productivity, defined as the ratio between GDP and Domestic Material Consumption, is the fundamental macroeconomic decoupling indicator. This can also be combined with the EF to extend the SD evaluation.

3 Methods

3.1 Data

To obtain data on EF per capita in 2011 (global hectares (gha) per person) and Biocapacity per capita in 2011 (gha per person) as well as their component indicators the Results from the National Footprint Accounts: NFA 2015 Public Data Package, 2015 Edition Global Footprint Network (2015a) were used. The NFAs measure the ecological resource use and resource capacity of nations. The majority of the additional data used in this Paper are also included in this Package whereas original HDI data are 2011 values from United Nations Development Programme (UNDP, 2014) and Population data are from the Food and Agriculture Organization of the United Nations. Data on the National Footprint Accounts (Global Footprint Network, 2015a) include Gross domestic product (GDP) data in the form of 2011 values from the International Monetary Fund World Economic Outlook Database, published in October 2014. However, for the calculations carried out in this Paper where GDP per capita data are needed, the more recent database, i.e. International Monetary Fund, World Economic Outlook Database, published in April 2015 was used to obtain GDP based on purchasing-power-parity (PPP) per capita in current international dollar in 2011. This is due to the fact that the result of Global Footprint Network (2015a) does not include data from Malta and Luxembourg. However, the effort was made to elaborate the cross-section analysis for as many countries of the EU as possible. Using the more recent data, all the EU-28 countries were included.

3.2 Methodology

For the analysis in this Paper, the footprint and biocapacity methodology is applied to measure the sustainability / SD in the EU and its countries. Moreover, the cross-section analysis is used to detect relations between the standard of living measured by GDP per capita, and the human development level measured by HDI, both as the explanatory variables, and their impact on resources measured by the EF as the explained variable.

To explain the EF methodology in detail it is important to introduce its component indicators. The EF calculations have so far included land for energy supply, food, forest products, and the built environment, degraded areas, and sea space for fishing. For the waste side the land needed for sequestering CO_2 is included in the EF. Particularly, the components of the EF include the following ones. Cropland is the most bioproductive of all the land-use types and consists of areas used to produce food and fibre for human consumption, feed for livestock, oil crops, and rubber. The *Cropland Footprint* includes crop products allocated to livestock and aquaculture feed mixes, and those used for fibres and materials. Recent Cropland Footprint calculations have not yet taken into account the extent to which farming techniques or unsustainable agricultural practices may cause long-term degradation of soil. This is due to lack of globally consistent data sets. Forest land provides for two competing services. Firstly, it is the *Forest Product Footprint,* which is calculated based on the amount of lumber, pulp, timber products, and fuel wood consumed by a population on a yearly basis. Secondly, it is the *Carbon Footprint*, which represents the carbon dioxide emissions from burning fossil fuels in addition to the embodied carbon in imported goods. The Carbon Footprint component is represented by the area of forest land required to sequester these carbon emissions and recently it represents the largest portion of humanity's Footprint. The *Fishing Grounds Footprint* is calculated according to estimates of the maximum sustainable catch for a variety of fish species. The *Grazing Land Footprint* is determined by grazing land which is used to raise livestock for meat, dairy, hide, and wool products. The *Built-Up Land Footprint* is calculated based on the area of land covered by human infrastructure: transportation, housing, industrial structures, and reservoirs for hydro-power. Moreover, built-up land may occupy what would previously have been cropland (Global Footprint Network, 2015a). Ecological Footprint generally refers to the EF of consumption.

There are three complementary indicators created by means of the EF per capita and available biocapacity per capita which serve for sustainability assessment of the countries and regions:

$$Biocapacity\ Deficit/\ Reserve = Biocapacity - EF \quad (1)$$

$$Number\ of\ Countries\ required = \frac{EF}{Biocapacity} \quad (2)$$

$$Number\ of\ Earths\ required = \frac{EF}{Earth{-}Biocapacity} \quad (3)$$

where: EF – Ecological Footprint.

The first and second indicators are simply expressed as the difference (Eq. 1) and ratio (Eq. 2) of the EF and biocapacity of the individual country / region whereas the last indicator compares the EF of a country / region with the biocapacity of the world. While the EF represents the demand side and the biocapacity the supply side, the deficit occurs if the EF is higher than biocapacity in compliance with Eq. 1. This country works as a resource debtor. Regarding the remaining two ratio indicators, the deficit which reflects the debtor´s position is represented by the indicator higher than 1. Number of Earths required represents the number of Earths needed if everyone in the world lived the average lifestyle of a resident in this country. Number of Countries required indicates how many times the country's biocapacity is needed in order to provide for the country's consumption Footprint (Global Footprint Network, 2015a).

Before the analysis the biocapacity and EF factors should be shortly mentioned to explain the factors of their differences between the investigated regions and countries. The EF is driven by consumer habits and the efficiency of providing goods and services. The growing biocapacity deficit is defined as the situation when a population uses more biocapacity than can be supplied and regenerated in a year. It is driven by the combination of high consumption rates, i.e. consumption is growing more rapidly than improvements in efficiency, which leads to increase in people's footprint; and populations growing faster than the biosphere's capacity resulting in drop of biocapacity per person. Biocapacity as a supply side is expressed as the bioproductive area multiplied by its bioproductivy (per hectare) whereas these two are referred to as the biocapacity factors. Bioproductive area is the available area of cropland, grazing land, fishing grounds and forests. Bioproductivity per hectare is the area's productivity which depends on factors such as ecosystem's type, management and health, agricultural practices or weather and thus it can vary each year. Productivity can be advanced to achieve more biocapacity, however this is often at the expense of a larger EF. It means, energy-intensive agriculture and heavy reliance on fertilizer can increase yields, but it requires increased inputs and can generate more CO_2 emissions. The EF can be expressed *as population x consumption per person x footprint intensity,* whereas they represent the so called EF drivers. As to population growth, the growing number of consumers is a strong driver behind the growing EF. Moreover, population size also affects the biocapacity available to each person. Regarding consumption of goods and services per person, it is evident that different populations consume different quantities of goods and services, primarily based on their income level. Footprint intensity is the efficiency with which natural resources are turned into goods and services while the differences between products and of course between countries exist. (WWF et al., 2012)

Cross-Section Analysis

The cross-section model was created and the linear least-squares regression was applied to detect the relations between the Ecological Footprint and the HDI / GDP per capita. The countries included in the sample are the EU-28 together with Norway and Switzerland, which are the countries of the European Economic Area (EEA). Moreover, the US as a representative of the developed countries in North America region was included in order to compare the levels of sustainability. The applied formula to detect the relationship is as follows:

$$ln\, EF = a + b \times ln(HDI, GDP\ \ p.c.) + \mu_i, \tag{4}$$

where *EF* is Ecological Footprint in 2011 (gha per person), *HDI* is Human Development Index in 2011 and *GDP p.c.* is the Gross domestic product based on purchasing-power-parity (PPP) per capita in Current international dollar in 2011 dollar. Symbols a and b represent coefficients and ln represents the natural logarithm which is used to eliminate the effect of the different units of the variables. The assumptions of linear regression such as (1) statistical independence of the errors, (2) homoscedasticity (constant variance) of the errors, and (3) normality of the error distribution are proved with the suitable tests such as Breusch-Godfrey Serial Correlation LM Test for the first assumption, Breusch-Pagan-Godfrey, Harvey, Glejser and White test for the second one and the Jarque-Bera test for the third one.

4 Research results

The EF indicator represents a first step in the SD investigation and thus it is applied to the EU countries as well as to the overall EU. Moreover, to detect sustainability and SD the EF needs to be compared with the available resources.

4.1 Sustainability analysis in the EU and its countries using the Ecological Footprint

Firstly, the sustainability is evaluated using the comparison of the EU with the regions of the world for which data are available. Table 1 summarizes the results for the EF and its component indicators together with the population data of the seven regions and the overall world. It is evident that regarding the size of the region the population of EU is the fourth highest, i.e. it is in the middle of the group. The Cropland, Grazing, Carbon and Fish Footprints of the EU are the third highest in the group of the regions. In the Cropland, Forest Product and certainly Carbon Footprint North America reached the highest levels. Finally, in the Grazing Footprint Latin America, and in Fish Footprint the Other Europe, dominate. Forest Product Footprint of the EU is the second highest following the North America region. The Built up Land of the EU is the highest and it is, of course, followed by North America. The highest total EF is typical of North America. It is followed by the EU and Other Europe. On the contrary, the developing regions of Africa and Asia-Pacific reach the lowest EF levels, i.e. lower than 2 gha. The lowest levels of several EF's components are typical of Africa including Cropland, Carbon Footprints and Built up Land as well as the overall EF. Asia-Pacific reached the lowest level of Grazing Footprint and Middle East/Central Asia, of course, the lowest Forest Product Footprint and also Fish Footprint. All these results comply with the standard of living and the stage of development as well as the economic structures and production and consumption patterns of these regions.

Table 1 Population (mil.), Ecological Footprint and its components (gha per person) in the world and the regions, 2011

Region	Pop. (mil.)	CrF	GF	FPF	CF	FF	BL	TEF
World	6997.99	0.56	0.21	0.26	1.46	0.08	0.07	2.65
Africa	1009.35	0.401	0.155	0.292	0.291	0.052	0.051	1.242
Asia-Pacific	3842.4	0.445	0.065	0.165	0.915	0.075	0.081	1.751
EU - 27	502.2	0.946	0.227	0.504	2.098	0.113	0.146	4.086
Latin America	598.42	0.557	0.543	0.393	0.813	0.075	0.083	2.465
Middle East/Central Asia	398.25	0.631	0.142	0.152	1.408	0.041	0.055	2.457
North America	349.47	1.088	0.267	0.714	4.452	0.12	0.101	6.742
Other Europe	238.72	0.951	0.103	0.399	2.24	0.149	0.069	3.911

Source: Global Footprint Network (2015a)
Notes: Pop. (mil.) = Population (millions); CrF = Cropland Footprint; GF = Grazing Footprint; FPF = Forest Product Footprint; CF = Carbon Footprint; FF = Fish Footprint; BL = Built up Land; TEF = Total Ecological Footprint.

The resource stock per capita, i.e. natural capital / wealth of the countries and regions, which is used to meet the needs, is the other side of the coin and these aspects are summarized in Table 2. North America disposes of the highest Cropland per capita. Latin America has the highest available areas of Grazing Land and, of course, Forest Land. Other Europe disposes of the largest area of Fishing Ground and EU of the Built up Land. This result of the EU is not positive, because for the built up land the other parts of biocapacity are used which limits its usage for alternative purposes. In Africa the lowest areas of Cropland and Built up Land per capita are available; in Asia-Pacific this is typical of Grazing Land, in Middle East/Central Asia of Forest Land and Fishing Ground. The largest total biocapacity is indeed typical of Latin America whereas this region is still the highest creditor and disposes of the largest Biocapacity Reserve. Regarding the highest deficits, North America is followed by the EU and then by Middle East/Central Asia whereas the first region is the only region with the deficit higher than 2 gha. The other two regions reached the deficit higher than 1 gha. These results are in compliance with the natural conditions including climate of these regions.

Table 2 Biocapacity and its components (gha per person) in the world and the regions, 2011

Region	CrL	GL	FL	FG	BL	TB	D/R	NE	NC
World	0.56	0.21	0.73	0.15	0.07	1.72	-0.93	1.54	
Africa	0.343	0.333	0.424	0.095	0.051	1.246	0.004	0.722	0.997
Asia-Pacific	0.419	0.081	0.178	0.1	0.081	0.864	-0.886	1.018	2.026
EU - 27	**0.976**	**0.091**	**0.738**	**0.198**	**0.146**	**2.291**	**-1.795**	**2.375**	**1.783**
Latin America	0.742	0.741	3.456	0.287	0.083	5.309	2.844	1.433	0.464
Middle East/Central Asia	0.448	0.2	0.164	0.095	0.055	0.976	-1.48	1.428	2.516
North America	1.597	0.245	2.175	0.612	0.101	4.73	-2.012	3.92	1.425
Other Europe	1.044	0.262	2.885	0.775	0.069	5.035	1.124	2.274	0.777

Source: Global Footprint Network (2015a)
Notes: CrL = Cropland; GL = Grazing Land; FL = Forest Land; FG = Fishing Ground; BL = Built up Land; TB = Total Biocapacity; D/R = Biocapacity (Deficit) or Reserve; NE = Number of Earths required; NC = Number of Countries required.

Finally, Table 3 summarized the results of the EU in the component indicators, i.e. the differences between the relevant component biocapacity and footprint indicators according to Eq. 1. Although, there is still sufficiency of the Cropland and Fishing Grounds for meeting the needs, the Grazing and Forest Land, when also the role of forests to sequester the carbon emissions is taken into account (see section 2.2.), is not available to a sufficient extent. The Forest Land only suffices to cover Forest Product Footprint, but not the sum of this one and Carbon Footprint. The EU's Cropland is the third highest; however, the Grazing Land is the second lowest among the monitored regions (see Table 2). This is in compliance with the position of the EU as a creditor or debtor in particular component footprints. As a built up land the other parts of the bioproductive area are used and thus the differences between area available and footprint indicator are equal zero. This footprint component in the EU reached the highest level among the examined regions by which the negative effects on the bioproductive areas being used for this purposes are emphasised (see Tab. 1). However, it must be emphasised that the damages to environment are not adequately included in the Ecological Footprint concept, which is especially related to the Cropland Footprint. Thus, the impacts on this kind of area can be underestimated and the results would not be so positive after inclusion of these damages. The results for Carbon Footprint clearly show that it is necessary to continue in appropriate strategies to reduce greenhouse gas emissions in order to combat climate change.

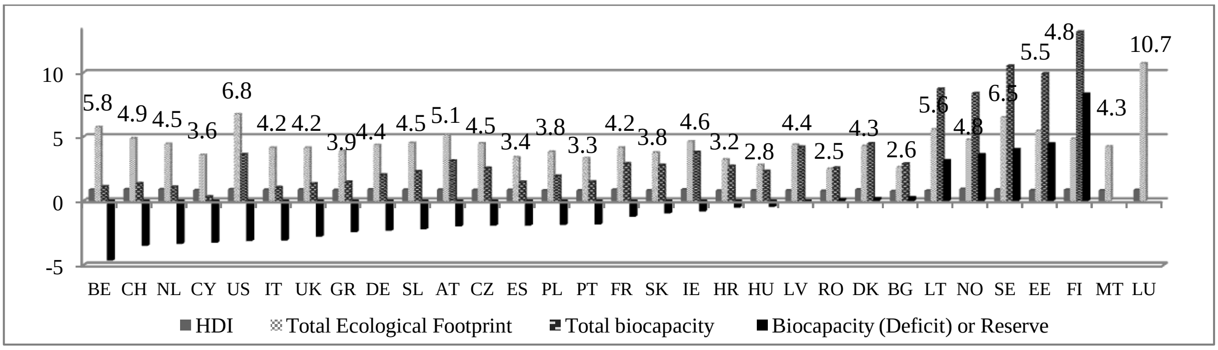
Table 3 Differences between the component biocapacity and footprint indicators, EU – 27, 2011

	CrL-CrF	GL-GF	FL-FPF	FL-(FPF+CF)	FG-FF
EU - 27	0.030073477	-0.136094584	0.234712664	-1.863635205	0.085364397

Source: Global Footprint Network (2015a), own calculation
Note: CrL = Cropland; GL = Grazing Land; FL = Forest Land; FG = Fishing Ground; CrF = Cropland Footprint; GF = Grazing Footprint; FPF = Forest Product Footprint; CF = Carbon Footprint; FF = Fish Footprint.

Next step is the analysis of the individual EU countries. As Figure 1 shows there are eight resource creditors among the EU countries. These are all Northern countries, i.e. developed EU countries such as Finland, Sweden and Denmark, together with Norway, two Baltic countries such as Estonia and Latvia, and also two least developed EU countries, i.e. Bulgaria and Romania. On the other hand, these countries, except Bulgaria and Romania, also showed the highest levels of biocapacity in the range from 4.5 gha in Denmark to even 13.2 gha in Finland. The last Baltic country Lithuania follows Denmark; its biocapacity was 4.2 gha. However, its EF was little bit higher, concretely 4.4 gha. Moreover, these countries, except (mainly) Bulgaria and Romania, also showed ones of the highest levels of the EF among the EU countries. Sweden showed the second highest EF after Luxembourg whereas these are the only EU countries with the EF higher than 6 gha. Such a high level is also typical of the US (see Figure 1). Two Baltic economies showed the EF higher than 5, concretely Latvia 5.6 and Estonia 5.5 gha. The remaining three Northern countries showed the EF higher than 4 gha. There are only three EU countries with the EF lower than 3 gha, i.e. Hungary (2.8), Bulgaria (2.6) and Romania (2.5). These countries also showed the lowest level of HDI and GDP per capita among the EU countries. Bulgaria and Romania are the only two EU countries with the high human development level, i.e. HDI lower than 0.8 (0.77 and 0.78 respectively), and the lowest levels of GDP per capita as well. There is a large number of the EU countries with the HDI between 0.8 and 0.9. The three Northern countries with large biocapacity areas as well as high EF levels, Norway, Denmark and Sweden, showed also very high HDI, i.e. Norway 0.94 and other two countries 0.9. Finland's HDI is little bit lower (0.88), however, this country has the highest available biocapacity and it is the highest EU creditor. Regarding these Northern countries, the sequence of GDP per capita is quite consistent with that of HDI. Norway is a country with the highest GDP per capita among the Northern countries and it is followed by Denmark, Sweden and finally by Finland.

Figure 1 HDI, EF, Biocapacity and Biocapacity Deficit / Reserve in the EU countries, Norway, Switzerland, and the US, 2011



Source: Global Footprint Network (2015a)
Note 1: HDI data are 2011 values from UNDP Human Development Reports, 2014;
Note 2: The countries are ordered according to Biocapacity Deficit / Reserve. Data description is related to the EF indicator.
Note 3: For Malta and Luxembourg, data on HDI in 2011 and data on EF in 2008 are only available.

As regards Malta and Luxembourg the EF data are available only for the year 2008. Whereas the EF of Malta was 4.3 gha, Luxembourg showed the highest EF among the monitored countries, even higher than that of US, concretely 10.7 gha. However, it must be pointed out that these results can be ambiguous because of low population and the high standard of living whereas the product is predominantly produced by foreign workers. Using the indicators composed of the EF and biocapacity by means of Eq. 2 and Eq. 3 the more detailed results of the EU and the other three developed countries are summarized in Table 4. The first indicator – Number of Countries required – measures if a country's resource exhaustion is in compliance with its own resource stock. This indicator is mainly dependent on the biocapacity wealth of the individual countries. On the one hand, the Northern countries, including the developed countries and the Baltic countries, dispose of the largest biocapacity and reach low level of the Number of Countries required (up to one). Finland has the largest available biocapacity per capita and thus achieved the best results. This indicator results reach up to one also in Bulgaria and Romania because of the lowest levels of the EF indicator. On the other hand, the countries with the low biocapacity stock often represent the debtors, i.e. they need more area than the country provides to meet the needs of people. The worst results are typical of Cyprus, followed by Belgium, Netherlands, Italy and Switzerland.

The second indicator, the Number of Earths required, compares the countries' requirements with the average Earth's biocapacity. Only five countries reached the lower number than the value of 2. These are mostly the least developed EU countries such as Romania, Bulgaria, Hungary and Croatia together with one Southern economy – Portugal, which also showed the low EF level. However, they still need more than 1 Earth to meet the needs of their inhabitants. Six countries need three and more than three Earths, concretely Austria, Estonia, Latvia, Belgium, Sweden and the US with 3.9 Earths required and thus with the highest biocapacity required compared to the world's average. Since this indicator is based on the same biocapacity for comparisons with countries' EFs, the impact of the countries on resources is more visible regardless of the resource stocks available in the individual countries.

Table 4 Number of Earths required, Number of Countries required by the EU countries, Norway, Switzerland and the US, 2011

C	NE	NC	C	NE	NC	C	NE	NC
FI	2.8	0.4	HU	1.6	1.2	PT	1.9	2.2
EE	3.2	0.5	IE	2.7	1.2	ES	2.0	2.3
NO	2.8	0.6	SK	2.2	1.3	GR	2.3	2.6
SE	3.8	0.6	FR	2.4	1.4	UK	2.4	3.0
LT	3.2	0.6	AT	3.0	1.6	CH	2.8	3.5
BG	1.5	0.9	CZ	2.6	1.7	IT	2.4	3.8
DK	2.5	1.0	US	3.9	1.9	NL	2.6	4.0
RO	1.5	1.0	PL	2.2	1.9	BE	3.4	5.1
LV	2.5	1.0	SL	2.6	1.9	CY	2.1	10.3
HR	1.9	1.2	DE	2.5	2.1			

Source: Global Footprint Network (2015a)
Note 1: NE = Number of Earths required; NC = Number of Countries required;
Note 2: Countries are ordered according to the Number of Countries required from the lowest to the highest number.
Note 3: Malta and Luxembourg are not included because of lack of data.

The last part of the analysis is focused on the relations between the indicators, particularly, the standard of living / human development stage and the EF per capita. The less developed countries often show the lower level of the EF and conversely. Countries with the abundance of the natural resources can also show high levels of the EF levels in case of more intensive usage of them to meet the needs. These are often the developed countries; however, it is not always a rule. Countries with the abundance of natural resources are at the various levels of material and human development.

Whereas the correlation coefficient (*r*) between the EF and biocapacity in the EU plus other three developed countries (except Luxembourg and Malta) reached 0.48, in the overall sample of 182 countries for which data of Global Footprint Network (2015a) are available, its level is minor (0.083). It can be at least claimed that the biocapacity abundance can determine wealth of the economy and its EF, whereas the EF is certainly affected by other factors as well (see section 2.2). The efficiency of the resource usage is especially of particular importance. The causality between the standard of living / level of development, the EF and biocapacity needs to be investigated more in detail using longer time series data. Using cross-section data in this Paper the basic dependences can only be detected.

4.2 Cross-section Analysis of the Relations between Ecological Footprint and Standard of Living / State of the Human Development

The cross-section model is applied to detect the dependence between the Ecological Footprint as the explained and the HDI and GDP per capita as the explanatory variables. Firstly, the effort was to create the model for the overall sample of 168 countries for which data of Global Footprint Network (2015a) are available. Although the positive relationships result from the regression analyses for both variables, the assumptions of the models are violated and are thus not further presented. The positive relationships between the HDI / GDP per capita and the EF are evident, among others on the basis of the relatively high positive *r* values (for GDP per capita: 0.793; for HDI: 0.769; in the sample of 168 countries of the world with available data), but the significant outliers can be present in the sample and thus the relationships should be explored in the smaller samples including countries with more similar characteristics. This is beyond the scope of this Paper. Secondly the EU-28 countries plus three other developed economies, i.e. Norway, Switzerland and the US, were separately investigated. The results are as follows:

$$ln\, EF = -3.936 + 0.52 \times ln\ GDP\ \ p.c. + \mu_i, \quad (5)$$

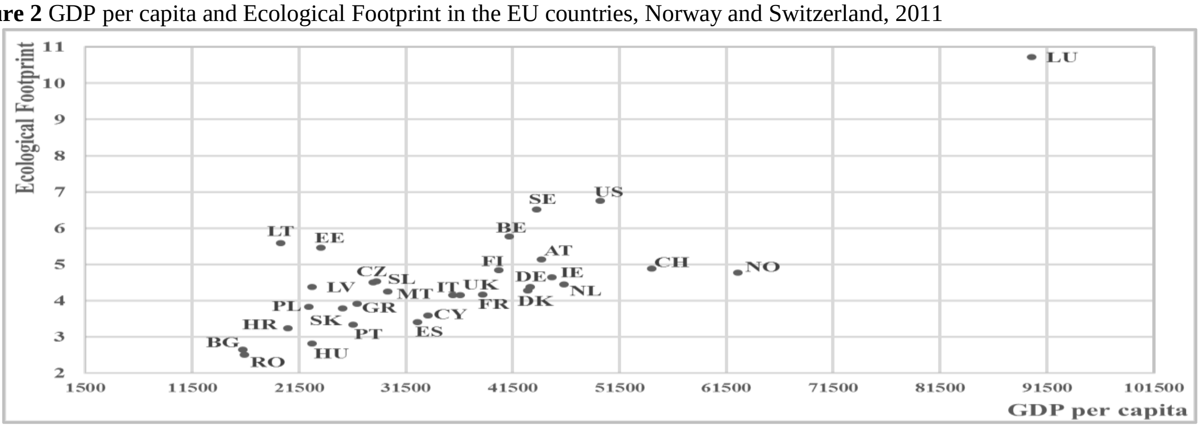
$$Obs.: 31;\ R^2 = 0.513;\ adjR^2 = 0.496;\ Prob. = 0;\ 0;\ Prob(F - stat.) = 0$$

$$ln\, EF = 1.905 + 3.06 \times ln\, HDI + \mu_i, \quad (6)$$

$$Obs.: 30;\ R^2 = 0.401;\ adjR^2 = 0.379;\ Prob. = 0;\ 0;\ Prob(F - stat.) = 0$$

In the first model (Eq. 5) all the assumptions of linear regression were met. In the second model (Eq. 6) Luxembourg was omitted from the analysis because its values of the variables are outliers (see Figures 2 and 3) and the normality of the error distribution assumption was violated. After its omission all the assumptions of the linear regression are met. The results indicate positive dependence of the EF on the HDI and the GDP per capita. The elasticity (*b* coefficient) is higher in Eq. 6 for HDI as an explanatory variable; however, the R^2 and *r* are lower in the model with the HDI as an explanatory variable. Thus the proportion of the EF variance explained by the regression model is higher in Eq. 5 when GDP per capita as an explanatory variable is used. Concretely, ***r*** = 0.575 between HDI and EF and ***r*** = 0.77 between GDP per capita and EF (31 countries) and moreover in the first case it would drop to 0.398 if Luxembourg was included in the sample. Indeed, there are many other factors which determine the EF level in the countries. Although the EF level can be better explained by the GDP per capita, the HDI is significantly correlated with this indicator, i.e. it is one of its partial indicators. The EF is determined by the consumption which depends on production, however, also the productivity is important and this significantly affects sustainability and SD. It is more difficult to detect the relations between the other components of the human development included in HDI related to education and long and healthy life. However, it is obvious that countries achieving high human development stage also use more resources and thus larger areas included in the EF to meet their needs.

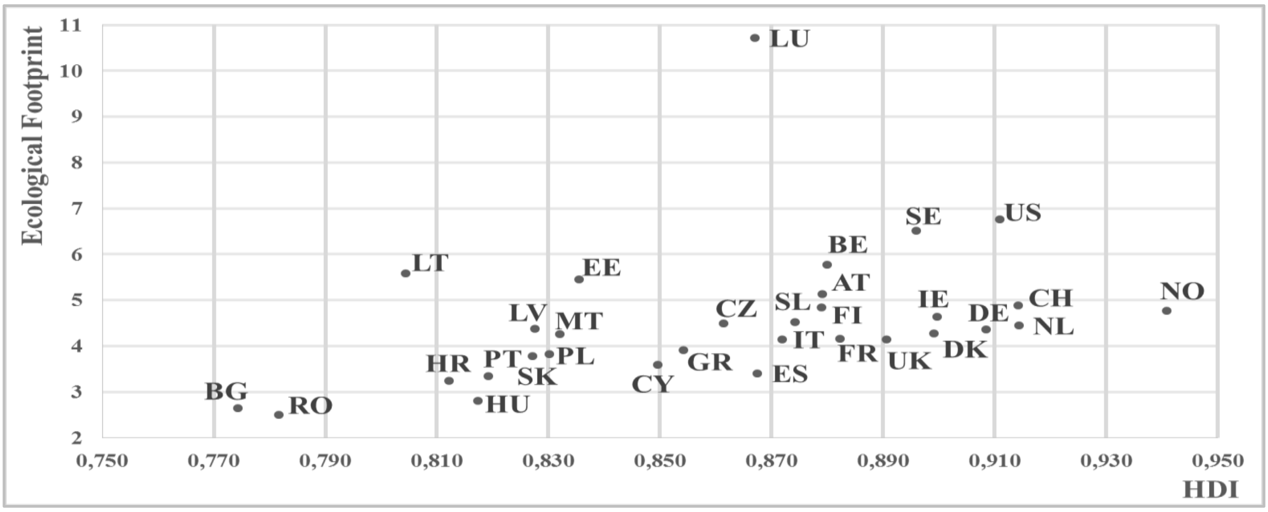
Figure 2 GDP per capita and Ecological Footprint in the EU countries, Norway and Switzerland, 2011



Source: Global Footprint Network (2015a)

Figure 2 and Figure 3 display the relations investigated by Eq. 5 and Eq. 6. The positive relationships can be seen in both cases, i.e. between GDP per capita / HDI on the one hand and the EF on the other hand. Luxembourg is the outlier in both cases with the highest EF and GDP per capita; however, its HDI is lower than 0.9 and thus not one of the highest levels in the sample that significantly affects the cross-section analysis (Eq. 6). On the other hand, if it was left out from the model with GDP per capita (Eq. 5) the elasticity would further decrease to 0.414 as well as R^2 to 0.382.

Figure 3 HDI and Ecological Footprint in the EU countries, Norway and Switzerland, 2011



Source: Global Footprint Network (2015a)

To sum up in both Figures 2 and 3 there are few countries in the left bottom side. These are the countries with the lowest standard of living and level of human development together with the lowest EF levels, particularly, Romania, Bulgaria, Croatia and Hungary. Latvia which also showed the lowest levels of HDI and GDP per capita stands out of this group because its EF is one of the highest in the EU. In the right bottom part the countries with the highest HDI and GDP per capita levels as well as high level of resource usage can be particularly found. In addition to already mentioned Luxembourg, these countries are especially Norway, Switzerland, the US, Austria, Sweden, Netherlands and Belgium in both Figures 2 and 3 again (additional countries can also be included).

5 Conclusions

The aim of the Paper was to evaluate sustainability in the EU and its countries by means of the Ecological Footprint and the available biocapacity and to detect the relations between the countries' EF and their standard of living and human development level. Accordingly, the main focus of the Paper was on the EU region and the EU-28 countries together with other three developed countries – Norway, Switzerland and the US, which were included in the sample, especially due to the better comparison possibilities.

Comparing the seven regions of the world it can be concluded that the results related to the Ecological Footprint and its components comply with the standards of living, the stages of development, as well as the structures of their economies and the production and consumption patterns in these regions. In the EU the Built up Land as the footprint component reached the highest level among the examined regions. This reduces its usage for the other purposes and thus this can be evaluated as a negative trend (aspect) in relation to sustainability and sustainable development. The Cropland, Grazing, Carbon and Fish Footprints of the EU are the third highest among the monitored regions. The Total Ecological Footprint of the EU is the second highest following North America reaching the highest overall Footprint per capita. The biocapacity stocks of the regions are in compliance with the natural conditions including climate in these regions as well, with the Latin America being the wealthiest region and the largest creditor as regards the bioacapacity area.

The indicators based on the Ecological Footprint and biocapacity reflect the position of the region / country in a resource management. The overall EU is a debtor with the Biocapacity Deficit of -1.795 gha, requiring 2.375 of the average Earth's biocapacity and 1.783 of its own biocapacy. The EU has still sufficient amount of the Cropland and Fishing ground where the biocapacity exceeds the Footprint. However, the damages to environment are not adequately included in the Ecological Footprint concept, which is especially related to the Cropland Footprint. Thus, the impacts on this kind of the biocapacity area can be underestimated and the results would not be so optimistic after inclusion of these damages. On the other hand, the Grazing Footprint surpasses biocapacity and this is also the case of the forest component when Carbon Footprint is also included, i.e. added to the Forest Product Footprint. These results highlight the importance of combating climate change. The Northern countries including the developed EU countries plus Norway, and the Baltic countries, have the largest available biocapacity and show the low values of the Number of Countries required, i.e. the figures reaching up to one. Accordingly, Finland which has the largest biocapacity also achieved the best results. The countries with the small biocapacity stock are often in the debtor position, i.e. they need more area than the country provides to meet the needs of their people. The worst results are typical of Cyprus, followed by Belgium, Netherlands, Italy and Switzerland. Only five countries in the examined sample showed the Number of Earths required lower than 2. These are mostly the least developed EU countries such as Romania, Bulgaria, Hungary and Croatia together with one Southern economy – Portugal. However, they still need more than 1 Earth to meet the needs of their inhabitants. Six countries need three and more than three Earths, concretely Austria, Estonia, Latvia, Belgium, Sweden and the US. The main resource debtors are Belgium, Switzerland, Netherlands, Cyprus, the US and Italy; whereas all these countries except for the US have very low available biocapacity. However, the Footprint of the US is the second highest in the sample following Luxembourg. The main creditors are the above mentioned Northern countries which also dispose of the largest areas of biocapacity.

The positive relationship between GDP per capita / HDI and the Ecological Footprint can be confirmed at least in the group of the developed countries including the EU countries, Norway, Switzerland and the US. The proportion of the Ecological Footprint variance explained by the regression model is higher when GDP per capita as an explanatory variable is used compared to HDI, although in the latter model the elasticity is higher. Luxembourg is a country with the extraordinary position reaching the highest Ecological Footprint and GDP per capita, however its HDI is lower than 0.9. In the examined sample the countries with the lowest standard of living and level of human development together with the lowest levels of the Ecological Footprint are especially the following ones: Romania, Bulgaria, Croatia and Hungary. Countries with the highest levels of HDI and GDP per capita as well as high level of resource use are especially: Luxembourg, Norway, Switzerland, the US, Austria, Sweden, Netherlands and also Belgium.

Using the footprint and biocapacity methodology together with the relevant macroeconomic indicators the basic economic – environmental (resource management) trends, reflecting also sustainable development aspects, were detected. It is evident that the EU region cannot be regarded as the sustainable region and the large number of its countries cannot be considered to be sustainable as well, or at least the more detailed analysis would be required. Moreover, sustainability aspects need to be investigated from the more complex point of view. According to the analysis applied in this Paper, there is no country achieving the sufficiently low level of Ecological Footprint together with sufficiently high levels of GDP per capita and HDI. According to all aspects investigated, Finland can be regarded as the most sustainable economy in the sample.

The challenge for the further research is to advance the methodology of the Footprint Indicators that better reflects the damages to environment or to combine these indicators with the additional indicators or sets of indicators which monitor the relevant aspects of sustainable development, such as decoupling.

References

Daly, H. E. (1996). *Beyond Growth.* Boston: Beacon Press, 1996. ISBN 978-0-8070-4709-5.

Drastichová, M. (2014). Measuring Sustainable Development in the European Union Using the Adjusted Net Saving. In: I. Honová, M. Hon, L. Melecký, L., M. Staníčková (Ed.), *Proceedings of the 2nd International Conference on European Integration 2014* (pp. 87 – 101): Ostrava: VŠB – Technical University of Ostrava. ISBN 978-80-248-3388-0.

European Commission (2016). *Environment. Beyond GDP* [Online]. Last updated: 25. 11. 2016 [cit. 29. 11. 2016]. Available on: http://ec.europa.eu/environment/beyond_gdp/index_en.html

European Commission (2015). *Environment. Sustainable Development* [Online]. Last updated: 08. 06. 2015 [cit. 25. 9. 2015]. Available on: http://ec.europa.eu/environment/eussd/.

European Environment Agency (2015). *Ecological footprint of European countries* [Online]. Last updated: 04. 09. 2015 [cit. 28. 11. 2016]. Available: http://www.eea.europa.eu/data-and-maps/indicators/ecological-footprint-of-european-countries/ecological-footprint-of-european-countries-2

Eurostat (2015). Sustainable development in the European Union. *2015 monitoring report of the EU Sustainable Development Strategy*. Luxembourg: Publications Office of the European Union: ISBN 978-92-79-49391-1. doi: 10.2785/999711

Ewing B., Moore, D., Goldfinger, S. Oursler, A., Reed A., & Wackernagel. M. (2010). *The Ecological Footprint Atlas 2010*. Oakland: Global Footprint Network.

FEEM (2011). Sustainability Index. *Methodological Report* [Online]. [cit. 2015-07-07]. Available: http://www.feemsi.org/documents/methodological_report2011.pdf.

Giljum, S., Burger, E., Hinterberger, F., Lutter, S., & Bruckner, M. (2011). A comprehensive set of resource use indicators from the micro to the macro level. *Resources, Conservation and Recycling* 55 (3), 300-308.

Global Footprint Network (2015a). Results from the National Footprint Accounts: NFA 2015 Public Data Package. 2015 Edition, www.footprintnetwork.org. © 2015. National Footprint Accounts.

Global Footprint Network (2015b). *World Footprint. Do we fit on the planet?* [Online]. Last updated: 12. 03. 2015 [cit. 28. 9. 2015]. Available: http://www.footprintnetwork.org/en/index.php/GFN/page/world_footprint/.

Goodwin, N., Nelson, J. A., Ackerman, F., & Weisskopf, T. (2008). *Consumption and the Consumer Society.* Medford: Tufts University Global Development and Environment Institute.

Hediger, W. (2006). Weak and Strong Sustainability, Environmental Conservation and Economic Growth. *Natural Resource Modeling,* 19(3), 359 – 394. doi: 10.1111/j.1939-7445.2006.tb00185.x

Hoekstra, A., & Wiedmann, T. (2014). Humanity's unsustainable environmental footprint. *Science*, 344 (6188), 1114-1117.

Holmberg, J., Lundqvist, U., Robèrt, K. H., & Wackernagel, M. (1999). The ecological footprint from a systems perspective of sustainability. *International Journal of Sustainable Development and World Ecology,* 6, 17 – 33.

International Monetary Fund (2015). World Economic Outlook Database, published in April 2015 [Online]. Last Updated: 14. 04. 2015 [cit. 24. 09. 2015]. Available: https://www.imf.org/external/pubs/ft/weo/data/changes.htm.

Pearce, F. (2013). Putting our foot in it. *New Scientist*, 220 (2944), 28-29.

Rees, W. E., & Wackernagel, M. (1994). Ecological Footprints and Appropriated Carrying Capacity: Measuring the Natural Capital Requirements of the Human Economy. In Jansson, A. M., Hammer, M., Folke, C. & Costanza, R. (eds.), *Investing in Natural Capital: The Ecological Economics Approach to Sustainability*: Washington DC: Island Press.

Segnestam, L. (2002). Indicators of Environment and Sustainable Development. Theories and Practical Experience. *Environmental Economics Series,* 89.

Singh, R. K., Murty, H. R., Gupta S. K., & Dikshit A. K. (2009). An overview of sustainability assessment methodologies. *Ecological Indicators,* 9 (2009), 189 – 212. doi:10.1016/j.ecolind.2008.05.011

Tukker, A., Bulavskaya, T., Giljum, S., de Koning, A., Lutter, S., Simas, M., Stadler, K., & Wood, R. (2014). *The Global Resource Footprint of Nations. Carbon, water, land and materials embodied in trade and final consumption calculated with EXIOBASE 2.1*. Leiden/Delft/Vienna/Trondheim. ISBN: 978-3-200-03637-6.

United Nations Development Programme (UNDP) (2014). *Human Development Report 2014.* Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience. New York, USA: UNDP, 2012. ISBN 978-92-1-126368-8.

World Bank (2012). Contribution to Beyond GDP, "Virtual Indicator Expo". Summary prepared by: Environment Department, The World Bank [Online]. Last updated: 29. 06. 2012 [cit. 28. 10. 2016]. Available: http://ec.europa.eu/environment/beyond_gdp/download/factsheets/bgdp-ve-ans.pdf.

World Commission on Environment and Development (WCED) (1987). *Our common future.* Oxford: Oxford University Press, 1987. ISBN 978-0-19-282080-8.

WWF, Zoological Society of London & Global Footprint Network (2012). *Living Planet Report 2012*. Biodiversity, biocapacity and better choices. Gland, Switzerland: WWF International, 2012. ISBN 978-2-940443-37-6.