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ECOLOGICAL FOOTPRINT AND BIOCAPACITY – METHODOLOGY AND REGIONAL AND NATIONAL DIMENSIONS

ABSTRACT

The scientific approach to the two novatory concepts – the Ecological Footprint and the Biocapacity – as a premiere in the Romanian agrarian economy research, starts from the identification of the main reasons why the above-mentioned concepts gained in methodological consistency and applicability area; it continues with the presentation of the main methodological elements for the calculation of the quantifying indicators of the two concepts, on the basis of which a diagnosis-analysis is made of the evolution of the global spatial distribution of the demand of resources (ecological footprint) and of the supply of resources (biocapacity) in time, with the specification of Romania's position in this respect.

Keywords: ecological footprint; biocapacity, bioproductivity; global hectare (gha); renewable resource.

JEL Classification: O57; Q51; Q56; R14.

1. INTRODUCTORY BENCHMARKS

The approach to the ecological dimension (together with the economic and social dimension) of sustainable development also implies, in recent times, tackling the ecological footprint and biocapacity issue, on the basis of which a complex study can be made on the agro-economic problems from a given territory. Two main motivations plead in this direction:

- The considerable scientific progress made in the field of economy and environmental statistics, both from the perspective of conceptual tools modernization, for the identification of the interferences between the sustainable development facets, and from the point of view of the statistical-methodological and operational tools for the quantification of the biunivocal flows between the human activity and nature, between production and resources;
- The need to connect the agrarian economy and rural development research to inter-disciplinary research breakthrough areas, which seem to be increasingly implied in solving up certain complicated problems related to aggravating disagreements between the explicit targets of the economic policies of the world

production players and the discouraging perspectives of the stock of main resources of the planet.

The reasons why the development and consolidation of the ecological footprint and biocapacity concepts became increasingly present in the scientific and decisional areas, at national and international level, start from the *reconsideration of wealth in a limited world of resources*[1], as it is known that, for thousands of years, everything people needed has come from nature[2] (food, wool for clothing, wood for constructions and heating, etc.), and only less than 200 years ago people began to think that natural resources might be depleted. Even nowadays, everything needs an area. Be it cotton or sheep wool, mining or gravel pits, carrots or beef loin, everywhere in the world, in order to obtain them, we need square meters of terrestrial area. And finally, in order to get them, we also need a place for turning waste and gas emissions into inoffensive substances.

In the year 1994, the scientists W. Rees and M. Wackernagel proposed *the ecological footprint* as a measure of the demand human activity puts on the biosphere. More precisely, this measures the amount of biologically productive land and water required to produce all resources necessary for human consumption, which is expressed in global hectares (gha). While the consumption of area per 1 kg of potatoes is relatively easy to calculate, the calculation of electric power and oil consumption is more difficult, yet possible. If we do not to pollute the air with carbon dioxide any more, we have to fuel the electric power stations and vehicles either with renewable energy, or to remove the carbon dioxide from the air, which results from the combustion of oil and coal, by the cultivation of land areas and establishment of forests. This also need land areas, the same as the rapeseed for biodiesel, and these areas can be also calculated in hectares.

It is not about prescribing to others how to diminish the ecological footprint, but rather about how to live better, so that the core question that is raised is the following: *how can we defend our ecological wealth, as this is decisive for the future quality of our lives.*

From the correct scientific point of view, not the (conventional) hectare is the measure unit of the ecological footprint, but the *"global hectare" (gha)*; this can be assimilated to a unitary "currency" by which the different fertility of land areas is equalized. As a given area, from a certain cultivation zone, can naturally produce more than the same area in a desert. Thus the *"global hectare" corresponds to a hectare of biological productivity at global level;* this makes it possible to compare ecosystems with differing bioproductivity in different areas of the world with the same unit, a global hectare.

[1] See: Mathis Wackernagel: Foreword to "Ecological Footprint Atlas 2009", 24.11.2009, GFN;

[2] According to the physicist H.P. Duerr, "when a system cannot be extrapolated any more, this is the end".

If all people were to live in the same conditions as we, European, do, almost 3 planets like Terra would be needed[3], and if all people were to live like the people in the United States, 5 planets would be needed. As we know for sure that we have only one planet available, Terra, and this planet will not grow, it results *the greatest injustice in the history of mankind, i.e. we, the Europeans, deprive the people from the poorer countries of their area.* A future lifestyle could be envisaged, in the sense that people can live happily and pleased within the ecological footprint that is available to them on a fair play basis. This could mean that we, here in Europe, live beyond our conditions.

The ecological footprint is a scientific concept and, at the same time, a highly educative (instructive) image. The representation of resource consumption and of the need to diminish it, in terms of biologically productive area, has a great advantage: it reveals, in a simple manner, the limitation of our living space, of our planet the Earth. And this because one thing is indubitable: *the terrestrial area size is absolutely limited.* This terrestrial area size cannot be changed. That is why questions on *who uses the limited areas and what is the object of their use,* are, in fact, accuracy questions. For example, in India, one hectare could be used for feeding an entire family of to produce fuels for a single tourist to fly to India on vacation.

What is remarkable is the fact that *humanity, in its entirety, has already a Footprint that is larger than our planet.* Translated into economic language, this means that *we do not live on "interests" (renewable land resources) but rather on "capital" (nature's substance)*. In other words, this issue could be put under other form: how much larger should our biosphere (the inhabited part of the Earth) be so as to support a given Footprint, on long term?

For few years we have begun to understand that the stealthily poisoning of the environment, the biotechnology and the biological weapons, the hole in the ozone layer and the global warming are threatening our planet in its entirety. This adds to overbidding and destructing valuable eco-systems, resulting in the loss of biodiversity.

The environmental problems are also multiplied results of each individual's behaviour. That is why they are difficult to remove. And yet some hope exists, as the people's behaviour is prone to adjustment. In simple words, *the global ethics means that our "freedom" to choose a desired lifestyle ends where our living way does not alter the life of other people, in the same human aspiration (the categorical ecological imperative).*

The competition for ecological services will play an essential role in the 21st century. If we continue business as usual, peak energy and climate change will

[3] Mahatma Ghandi, answering to a British journalist's question how much time India would need, as a recently independent country (1947), to catch up with the former mother country England, from the economic point of view, said: "The small island England had to conquer and exploit half the planet to accumulate its wealth. How many planets would India need for this?".

combine with food shortages, biodiversity loss, depleted fisheries and freshwater stress, to create a global supply-demand crunch of essential resources.

Humanity is already in "overshoot", using more resources than Earth can renew. In a "peak everything" world, if consumption trends in today's wealthy nations and in the emerging economies continue at current rates, overshoot will increase dramatically. This will mean further degradation of the Earth's capacity to generate resources, continuing accumulation of greenhouse gases and other wastes, and the possible collapse of critical ecosystems.

But these problems are not unsolvable. The good news is that solutions need not wait for a global consensus. While the current debates assume that those who act first may be at a competitive disadvantage, the opposite is often true. Acting aggressively now to implement sustainable solutions will reward the "pioneers" with lower resource costs, greater flexibility in the face of supply chain perturbations and better positioning to take advantage of opportunities provided by a fast changing economy.

Many opinion leaders are trapped in the misconception that advancing the sustainability idea is detrimental to the economy, an expense that will be only affordable at some later date. Unfortunately, later means now, *and the consequences of putting off change until later is that humanity will be unprepared for the challenge of living within the limits of our natural resources.*

Resource accounting is therefore as vital to the interests of any country, or city as is financial accounting. *Those who are prepared for living in a resource-constrained world will fare far better than those who are not.*

In an age of growing resource scarcity, the wealth of nations will be increasingly defined in terms of *who has ecological assets and who does not.* Preparing for this new economic "truth" will take time, making it urgent to begin as quickly as possible. Strategies will need to be simultaneously implemented so as to protect the ecological reserves, while minimizing or reducing a nation's demand on ecosystem services – its "Ecological Footprint" (EF).

Stimulating and supporting the technological innovations and services that promote well-being without draining resources will play a key role in this effort. *The cities, regions or countries that are not able to promote a high quality of life on a low Ecological Footprint will have a less favourable position in a resource-constrained future.*

In the absence of significant change, *the countries that extensively depend upon ecological resources from abroad will become particularly vulnerable to* supply chain disruptions, as well as to rising costs for greenhouse gas and waste disposal. At the same time, *the countries with sufficient ecological reserves to balance their own consumption and even export resources will be at a competitive advantage.*

2. MATERIAL AND METHOD

2.1. Ontogenesis of Ecological Footprint and Biocapacity metrics

Without a way to compare the demand on ecological services to the available supply, it is easy for policy makers to ignore the threat of overshoot, and remain entangled in ideological debates over the "*affordability of sustainability*". Clear metrics are needed to change these ideological debates into discussions based on empirical facts. This will lead to an understanding of what the real risks are, and facilitate building consensus over the actions needed to address them.

As a reaction to this need for metrics, the Ecological Footprint (EF) was developed over 15 years ago. Since that time, *this has become an increasingly mature and robust way of capturing human demand on nature.* But its evolution is not yet complete. With growing recognition of the value of this measurement and its adoption by more governments and economic activities, it has become clear that the development of the Ecological Footprint needs to be significantly accelerated.

In the year 2003, *Global Footprint Network (GFN)* was created to respond to this need. Besides improving the scientific rigour and transparency of the *Ecological Footprint methodology*, this international NGO works to *promote a sustainable economy, by making ecological limits central to decision-making.* The goal is *to ensure population's well-being by ending overshoot, decreasing pressure on critical ecosystems*, so that they remain robust, while continuing to provide humanity with essential ecological services.

The *Global Footprint Network (GFN)* does this on the basis of the Ecological Footprint, in collaboration with more than 100 partner organizations, which are included in the network. It coordinates the research activity, develops methodological standards, and supplies the decision-makers with extensive resource accounts, so as to help the human economy operate within the Earth's ecological limits. At the core of this effort are the *National Footprint Accounts (NFA)*, which provide *a detailed accounting of ecological resource demand and supply for all nations with populations over 1 million inhabitants*.

The *Global Footprint Network (GFN)* and its partners alone cannot achieve the shift to sustainable economy. All the key stakeholders – mainly nations, international agencies, regions and companies – should get involved, as it is they who are subject to risk if they cannot monitor their ecological performance.

One thing is clear*: as the natural capital becomes scarcer than financial capital, a good governance will depend on the resource accounts,* such as the *Ecological Footprint (EF)*, as much as it depends on *Gross Domestic Product (GDP)* and other financial accounts.

In an increasingly resource-constrained world, it is *government's fiduciary responsibility to know well its ecological capacity and how much it is using of the* *capacity it has. The Global Footprint Network (GFN),* therefore, makes the *governments institutionalize the Ecological Footprint metric and use it as an indicator for planning and policy decisions, in parallel with financial indicators such as GDP.* As this effort focuses on nations, the goal will not be reached in the absence of active participation from the part of the economic sector, of civil society and academic institutions. Therefore, the Network is working with these entities as well.

2.2. Methodology used for calculating the Ecological Footprint and Biocapacity

2.2.1. Preliminary methodological hypotheses

The Ecological Footprint (EF) is a measure of the demand addressed to the biosphere by the human activity. More precisely, it *measures the amount of biologically productive land and water area needed to produce all the resources that an individual, population or activity consumes and to absorb the waste that these generate*, given the current technology and management practices of the existing resources. This area can then be compared with the *biological capacity (biocapacity),* respectively the *amount of productive area that is available to generate these resources and to absorb the waste.*

If a land or water area provides more than one of these services it is only counted once, so as not to exaggerate the amount of productive area actually available. *Land or water area is scaled according to its biological productivity. This scaling makes it possible to compare ecosystems with different bioproductivity from different areas of the world in the same unit, the global hectare (gha). A global hectare represents a hectare with world average productivity.*

The Ecological Footprint (EF) and Biocapacity (BC) accounting is based on six fundamental assumptions (hypotheses) (Wackernagel 2002):

1. The majority of the resources people or activities consume and the wastes they generate can be tracked;

2. Most of these resources and waste flows can be measured in terms of the biologically productive area necessary to maintain them. Resource and waste flows that cannot be measured in terms of biologically productive area are excluded from the assessment, leading to a systematic underestimation of the total demand these flows place on ecosystems;

3. By scaling each area in proportion to its bioproductivity, different types of areas can be converted into the common unit of average bioproductivity, the global hectare (gha). This unit is used to express both the Ecological Footprint (EF) and the Biocapacity (BC);

4. Because a global hectare of demand represents a particular use that excludes any other use tracked by the Footprint, and all global hectares in any single year represent the same amount of bioproductivity, they can be summed. Together, they

represent an aggregate demand or Ecological Footprint. In the same way, each hectare of productive area can be scaled according to its bioproductivity and then added up to calculate biocapacity;

5. As both concepts are expressed in global hectares (gha), human demand (as measured by Ecological Footprint accounts) can be directly compared to global, regional, national or local biocapacity;

6. Area demanded can exceed the area available. If demand on a particular ecosystem exceeds the ecosystem's renewal capacity, the ecological assets are being diminished. For example, people can temporarily demand resources from forests or fisheries faster than they can be renewed, and the consequences are smaller stocks in that ecosystem. When the human demand exceeds available biocapacity, this is referred to as overshoot, i.e. "exceeding the limits".

Ecological Footprint analysis tracks the regenerative capacity of an ecosystem in terms of historical flows of natural resources. A "flow" corresponds to an amount per time unit, (for instance the number of tons of roundwood grown in a given area over a one-year period). A "stock" is the standing balance of resources at any specific time, (for instance, the tons of roundwood available for harvest in a hectare of forest at the end of a given year). The National Footprint Accounts (NFA) capture flows rather than stocks, and thus do not specify when overshoot will result in the total depletion of accumulated resources in an ecosystem.

Humanity is using the regenerative capacity of the Earth each year – the flow of resources – while at the same time eating into the standing stock of resources that has been built over time and accumulating waste in the environment. This process reduces our ability to harvest resources at the same rate in the future and leads to ecological overshoot and possible ecosystem collapse.

2.2.2. Calculation methodology of the national ecological footprint

The National Footprint Accounts[4] *(NFA)* track the countries' use of ecological services and resources, as well as the available biocapacity of each country. As in the case of other resource accounts, these represent static, quantitative descriptions of outcomes, for any given year in the past for which data exist.

The National Footprint Accounts (NFA) objectives are the following:

- To provide a scientifically robust and transparent calculation of the demands placed by different nations on the regenerative capacity of the biosphere;
- To build up a reliable and consistent method that enables the comparison of nations' demand on global renewal capacity;
- To produce information in a format that is useful for the development of policies and strategies on living within biophysical limits;

[4] The detailed calculation methodology of the most updated accounts is described in *Calculation Methodology for National Footprint Accounts, 2009 Edition* (Ewing et al. 2009). The implementation of the National Footprint Accounts, through templates based on databases, is described in *Guidebook to the National Footprint Accounts 2009* (Kitzes et al. 2009).

• To generate a core dataset that can be used at the basis of sub-national Ecological Footprint analysis, such as those for provinces, states, economic activities or products.

The National Footprint Accounts, 2009 Edition, calculates the Footprint and Biocapacity for 240 countries, territories and regions, since 1961 up to 2006. Out of the 240 countries, territories and regions, 126 were consistently covered by the UN statistical system and by other datasets.

The evaluation of the Ecological Footprint starts from the fact that all the renewable resources come from the Earth. This is calculated for the flows of energy and matter to and from any defined economy and converts them in corresponding land and water areas needed, revendicated by nature to support these flows.

The Ecological Footprint is defined as the "productive land area and water ecosystem necessary to produce the resources consumed by the population and to assimilate wastes produced by the population, in any place located on land and water".[5] The actual extraction of renewable resources is then compared with what is renewed each year. The non-renewable resources are not evaluated, as by definition their utilization is not sustainable.

The total "Footprint" for a given population's activities is measured in terms of *"global hectares." A global hectare is one hectare (2.47 acres) of productive biological area, with an annual productivity equal to the world average. At present, the biosphere totals about 11.2 billion hectares of biologically production area, which corresponds to about one quarter of the Earth's area.* These biologically productive hectares include 2.3 billion hectares of ocean and inland waters and 8.8 billion hectares of land. The terrestrial land area consists of 1.5 billion hectares of cropland, 3.5 billion hectares of grazing land, 3.6 billion hectares of forestland, as well as 0.2 billion hectares of built-up land.

These areas represent the total amount of the biologically productive hectares on which we rely for our survival. These represent the natural land capital, and their yearly yield represents the yearly yield of our natural capital.

This measurement can be also presented in terms of types of products or services provided by a global hectare. For example, in terms of goods from the crop land, products of animal origin, fish, forestry products, built-up land, as well as use of energy and water, such analyses identify what zones put the highest pressures on ecosystems and can help to the establishment of policy priorities. The increase in products of animal origin and in the consumption of fossil fuels are two areas under fast growth.

The *National Footprint Accounts (NFA)* track the human demand of ecological services in terms of *six main types of land use* (cropland, grazing land, forests, carbon footprint, fishing grounds and built-up land).

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[5] Wackernagel Mathias and W. Rees, Our Ecological Footprint, Gabriola Island, BC: New Society Publishers, 1996.

Except for the built-up land and forest, for carbon dioxide uptake, *the ecological footprint, by each type of land use, is calculated by summing up the contributions of a variety of specific products.*

The Ecological Footprint calculates the combined demand of ecological resources, wherever these are located, and present them as average global area necessary to support a specific human activity. This quantity is expressed in units of global hectares (gha), defined as hectares of bioproductive areas with world average bioproductivity.

By expressing all results in a common measurement unit, *biocapacity and Ecological Footprint can be directly compared across land use types and countries.*

The demand for resource production and waste assimilations are translated into global hectares, *by dividing the total amount of a resource consumed by the average yield per hectare,* or by dividing the waste emitted by the absorption capacity per hectare.

The average yields per hectare are calculated on the basis of various international statistics, from FAO in the first place (FAO ResourcesSTAT Statistical Databases).

Yields are mutually exclusive: if two crops are grown on the same hectare at the same time, one portion of the hectare is assigned to one crop, and the remaining portion to the other crop. This avoids double registration. This follows the same logic as measuring the farm size: each hectare is counted only once, even though it might provide multiple services.

The Ecological Footprint (EF), under its simplest form, is calculated by the following equation:

$\mathbf{EF = (C_A / R_A)}$ **(1)**, where:

– $\mathbf{C_A}$ is the annual demand of a product and

– $\mathbf{R_A}$ is the annual yield of the same product, expressed in global hectares.

The way global hectares are calculated is explained in more detail below, after the various area types are introduced. But, in essence, the global hectares are estimated by means of two hectares: *the yield factors* (that compare the national average yield per hectare and the world average yield for the same land category) and *the equivalence factors* (that capture the relative productivity of different land and sea area types).

Therefore, the *Ecological Footprint (EF)* formula becomes:

$\mathbf{EF = [(Q / q_N)*f_q*f_e]}$ **(2)**, where:

– $\mathbf{Q}$ is the quantity of a product harvested or waste emitted (equal to $\mathbf{C_A}$ from the formula above);

– $\mathbf{q_N}$ is the national average yield for **Q;**

– $\mathbf{f_q}$ si $\mathbf{f_e}$ are the yield factor and equivalence factor, respectively, for the respective country and land use type.

The yield factor ($\mathbf{f_q}$) is the ratio of national to world average yields. It is calculated as the annual availability of usable products and varies by country and year. *The equivalence factors* ($\mathbf{f_e}$) translate the area supplied or demanded of a specific land use type (e.g. world average cropland, grazing land, etc.) into units of world average biologically productive areas (global hectares) and varies by land use type and year.

The annual demand for manufactured or derivative products (e.g. flour or wood pulp) is converted into primary product equivalent (e.g. wheat or wood), by using the *extraction rates.* These quantities of primary product equivalent are then translated into Ecological Footprint. The Ecological Footprint also includes the necessary energy required by the manufacturing process.

The Ecological Footprint Accounts (EFA) calculate the Ecological Footprint (EF) of a population from several perspectives. Most commonly reported is the *Ecological Footprint of consumption* (EF_C) of a population, just typically called Ecological Footprint.

The Ecological Footprint of consumption (EF_C) for a given country measures the biocapacity demanded by the final consumption of all the residents of the country. This (consumption) includes their household consumption, as well as their collective consumption (such as schools, roads, fire brigades, etc.) that serves the household, but may not be directly paid for by the households.

By contrast, the *Ecological Footprint of primary production* (EF_P) of a country is the sum of Footprints for all the harvested resources and waste generated within the country's geographical borders. The following are included here: the total area of the country necessary for supporting the harvest of primary products (cropland, grazing land, forest land, fishing grounds), the country's infrastructure and hydropower (built-up land), as well as the area needed to absorb fossil carbon dioxide emissions generated within the country (carbon Footprint).

The difference between the production and consumption Footprint is represented by trade, which is shown in the next equation:

$\mathbf{EF_C = [EF_P + EF_M - EF_X]}$ **(3)**, where:

- – $\mathbf{EF_C}$ is the Ecological Footprint of consumption;
- – $\mathbf{EF_P}$ is the Ecological Footprint of production;
- – $\mathbf{EF_M}$ **and** $\mathbf{EF_X}$ are the footprints of the imported and exported commodity flows.

In order to measure the footprint of imports ($\mathbf{EF_M}$) and of exports ($\mathbf{EF_X}$), one needs to know both the quantities traded and the embodied resources (the carbon dioxide emissions inclusively) in all categories.

The embodied Footprint is measured as the number of global hectares necessary to obtain a ton of a given product per year. The Footprint intensity of any primary product is by definition the same anywhere in the world as it is expressed in global hectares. However, the embodied Footprint of secondary products will depend on transformation efficiencies (extraction rates), and these vary across countries.

The National Footprint Accounts, 2009 edition, track the embodied Ecological Footprint of over 700 categories of traded crop, forestry, livestock and fish products. The embodied carbon dioxide emissions in 625 categories of products is used with trade flows from the United Nations' COMTRADE database (UN Commodity

Trade Statistics Database 2007) to calculate the embodied carbon Footprint in traded goods.

In the National Footprint Accounts, the embodied Footprint of trade is calculated assuming world average Footprint intensity for all products. Using world average efficiencies for all traded goods is an overestimate of the Footprint of exports for countries with higher-than-average production efficiency. At the same time, it underestimates the Footprint of consumption in the respective country. For the countries with below-average transformation efficiencies for secondary products, the opposite is true: an underestimate of the embodied Footprint of exports determine an exaggerated Footprint of consumption.

The Ecological Footprint refers to the total number of hectares worldwide, which are necessary to support a specific population, regardless if these hectares are inside the national frontiers where this population lives. It takes into consideration the net consumption of the population (or of the activity) of interest, deducting the global hectares used for export from those used for imports and production. The Footprint of individual nations varies considerably, from high levels of about 10 hectares per capita for countries such as United Arab Emirates, United States and Kuwait, to less than 1 hectare per capita, in Haiti, Somalia and Afghanistan.

By comparing the Ecological Footprint size with the actual bioproductive capacity of a given country, it is possible to determine whether the country is facing an *ecological deficit* (using more than it has) or it has *ecological reserve.* The United States, Japan, Great Britain as well as the United Arab Emirates are all under ecological deficit, using a much higher number of global hectares than it is provided by their own land area. The countries with ecological reserve are Australia, Mongolia and Gabon. Certain countries can have ecological deficits by taking bioproductive hectares from other countries. However, the world deficit, represented by an overshoot of 20%, cannot be compensated, as there is only one planet available. These data highlight the intimate link between the ecological sustainability and even distribution, as well as the international trade contribution to the inequalities in national Footprints.

The Ecological Footprint methodology is detailed, but not excessively complex. The input data are accessible to the public from national, international and private organizations. A variety of calculation hypotheses are made, but these are explicit and always imply a conservative interference. The weaknesses in this pioneering effort have been recognized, many of them have been corrected, while others are approached by the continuation of research.

One of the numerous strengths of the Ecological Footprint is its immediate intuitive recurrence. Together with the reasonable and continuous improvement of methodology, this recurrence led to its use on a large scale, in a variety of settings, approaching the national, regional, municipal and even individual Footprints. The measure *per se* describes the Footprint size for a given population or activity.

Once the Ecological Footprint implications for the policy and planning purposes have been recognized, it begins to be applied by many countries and municipalities, in the application and monitoring of their sustainable development agenda. This proved to be a useful research tool in order to explore the Ecological Footprint of specific activities, such as the different transport modes or agriculture methods. There is also an annual world report on the Ecological Footprint, which provides an overall picture, useful in many specific domains[6].

The Ecological Footprint is not an absolutely accurate measure of the ecological sustainability. As this is likely to be the best estimation that has been made so far, it is very important to know *its limits:*

a) in general, the Footprint underestimates the impacts of human activity upon biosphere;

b) as it focuses upon the renewable resources, the Footprint provides limited information on most non-renewable resources and on their impact upon eco-systems (except for the impact of fossil fuels, which are approached only on a partial basis);

c) the concept of “global hectare”, of average world bioproductivity is useful to address the problems of Ecological Footprint at global level (the individual applications refer to certain locations): in the case when an impact exists, the local areas that can have different productivity rates compared to the world average and in the case when local available data can be used;

d) the approach makes it possible to identify only general types of bioproductive areas (for example agricultural land, forests, etc.), the specific ecosystems from these areas are not approached.

The Ecological Footprint (EF) is considered the most appropriate empirical measure that is available to estimate the scale of maximum sustainability at present. It captures the bioproductive capacity necessary to support a certain level of material extraction, with the current practices and organization systems. The maximum sustainability scale refers to the sum of physical extraction of materials in the economic activities, in relation to the biophysical limits of the ecosystems that are implied as sources. The Ecological Footprint is different in the sense that it involves extractions implied in all the human activities. Most activities, yet not all, are economic activities.

The Ecological Footprint is connected to *many other thinking approaches* to the sustainability scale and its measurement:

- The Ecological Footprint and the biocapacity, respectively, are a modality to measure the historical human support capacity. Most studies on the support capacity are trying to address a hypothetical issue: how many people could live on the planet?. The Footprint reveals how much of the planet has been occupied by people. It is a historical question, which can be determined on an empirical basis, rather than making presuppositions with regard to future possibilities;

[6] Living Planet Report 2004, World Wildlife Foundation, http://www.panda.org/downloads/general/lpr2004.pdf.

- The Ecological Footprint analysis provides a modality to evaluate the impact of the population, wealth (consumption) and technology. The Ecological Footprint was extensively used in the latest updating of the limits of growth, so as to provide a synthetic report on the human demand on nature;
- The Footprint translates the material flows to necessary areas to support these Flows;
- The current efforts focus on the standardization and improvement of the methodology at the basis of the Footprint, and on integrating the areas or problems that have not been captured so far.[7] This continuous concern for the methodological and conceptual rigour is a positive aspect that will contribute to increase the utility of this sustainability indicator.

2.2.3. Biocapacity calculation methodology

The national biocapacity calculation starts from the total amount of available bioproductive land. "Bioproductive" refers to the land and water areas that support the important photosynthesis activities and biomass accumulation, while ignoring the non-productive areas or areas with low, dispersed productivity. This means that areas such as the Sahara desert, Antarctica or the mountain peaks of the Alps do not represent a support for life, and their production is too dispersed to be harvested by humans.

Biocapacity is an aggregated measure of the available land area weighted by the respective area productivity. It represents the biosphere capacity to produce crops, animals (grazing land), timber products (forest), as well as to uptake the carbon dioxide in forests. It also includes how much this regenerative capacity is occupied by infrastructure (built-up land). In short, it measures the capacity of the areas of land and water to produce ecological services.

The biocapacity (**BC**) of a given country, for any type of land use, is calculated by the following formula:

BC = **[S * f_q*f_e] (4)**, where:

– **BC** is the biocapacity;

– **S** is the available surface for any utilization type of a given area;

– f_q and f_e are the yield and equivalence factor for the land use type in the respective country.

The yield factor (**f_q**) is the ratio of the national yield to the world yield. It is calculated as annual availability of utilizable products and it varies by country and year.

The equivalence factors (**f_e**) translate the supply or demand of area from a certain land use type (e.g. the world average of arable land, of grazing land, etc.) into units of world average biologically productive area (global hectares) and it varies by the land use type and year.

[7] Global Footprint Network Homepage, www.footprintnetwork.org

By dividing (by total population) the 11.2 billion hectares available for the world population, it results, on the average, 1.8 bioproductive hectares by inhabitant of the planet. The report "The Living Planet 2004" reveals that the actual utilization was 13.5 billion global hectares or 2.2 hectares per capita – more than 20% overshoot.[8] The resulting overshoot reveals that the annual decrease of natural capital results in the diminution of natural capital revenue and in the diminution of the capital itself. Such an overshoot is ecologically unsustainable.

The world time series on the Ecological Footprint (EF) reveal that the human activities have been in overshoot for about three decades, and in time, the overshoot is increasing. In other words, the current *ecological overshoot* (EO) means that the sustainable ecological scale has been exceeded.

The implications of these results are even more urgent when we realize that the Ecological Footprint is likely to be an underestimation of the actual demand on the terrestrial ecosystems[9].

3. RESULTS AND DISCUSSIONS

3.1. Land area types of the National Footprint Accounts (NFA)

The National Footprint Accounts (NFA) include six main land use types: cropland, grazing land, fishing ground, forests for timber and fuel wood. Forests for carbon dioxide uptake and built-up land. For all these land use types there is a demand on the area as well as a supply of such an area.

In the year 2006, the area of biologically productive land and water of the Earth was about 11.9 billion hectares. Thus, the world biocapacity is also 11.9 billion global hectares (gha), as the total number of average hectares is equal to the total number of actual hectares. But the relative area of each land type expressed in global hectares differs from its distribution expressed in actual (normal) hectares.

In 2006, the world had 3.7 million global hectares of cropland biocapacity as compared to 1.6 billion hectares of cropland area. This difference is due to the relatively high productivity of cropland compared to other land use types. This is not surprising as long as the cropland typically uses the most suitable and productive land areas, unless they have been urbanized. Thus, cropland provides more biologically productive services to humans than the same physical area of other land use types.

The cropland is the most bioproductive of all the land use types and consists of areas used to produce food and fiber for human consumption, feed for livestock, oil crops and rubber. Worldwide in 2006, there were 1.6 billion hectares designated as cropland (according to FAO ResourcesSTAT Statistical Database 2007); the

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[8] Monfreda C., Wackernagel M. and Deumling D., *Establishing national natural capital accounts based on detailed ecological footprint and biological capacity assessments*, Land Use Policy 21, 2004, 231-246

[9] Global Footprint Network Homepage, www.footprintnetwork.org

National Footprint Accounts calculate the cropland Footprint according to the production quantities of 164 different crop categories. The cropland Footprint calculations do not take into account the extent to which the farming techniques or risky agricultural practices cause long-term soil degradation.

The grazing land totalled 3.4 billion hectares in 2006, being used to raise livestock for meat, dairy cows, hide and wool products. The grazing land Footprint is calculated by comparing the amount of livestock feed available in a country with the amount of feed required for the livestock production obtained in that year, with the remainder of feed demand assumed to come from grazing land. Since the yield of grazing land represents the amount of above-mentioned primary production available in a year, overshoot is not physically possible over extended periods of time for this land use type. Out of this reason, a country's grazing land Footprint of production is capped at its biocapacity level.

The forest Footprint is calculated on the basis of the amount of timber, pulp, timber products and fuelwood consumed by a country on a yearly basis. The FAO statistics places the total area of world forests at 3.9 billion hectares. Estimates of forest timber productivity[10] give a world average yield of 1.81 m^3 of harvestable round wood per hectare per year. These data sources also provide information on plantation type, coverage, timber harvest and areas of protected and economically inaccessible forests.

The fishing grounds Footprint is calculated using estimates of the maximum sustainable catch for a variety of fish species (Gulland 1971). These estimates are converted into an equivalent mass of primary production based on the trophic levels of various species. This estimation of maximum harvestable primary production is then divided among the different continental shelf areas of the world. Globally, there were about 2.4 billion hectares of continental shelf and 433 million hectares of inland water areas in the world in 2006 (according to. World Resources Institute and FAO ResourcesSTAT Statistical Database 2007).

The fishing ground Footprint is calculated on the basis of the estimated primary production required to support the fish caught. This primary production requirement (PPR) is calculated from the average trophic level of the species in question (1439 different marine species and more than 268 freshwater species are taken into consideration).

The built-up land Footprint is calculated based on the area of land covered by human infrastructure – transportation, housing, industrial structures, and reservoirs for hydropower stations. The built-up area occupied 0.167 billion hectares of land worldwide in 2006, according to satellite images and research data sets.[11]

The carbon dioxide emissions, resulting from burning fossil fuels in the first place, are the only waste product included in the National Footprint Accounts.

[10] Reference works: "Temperate and Boreal Forest resource assessment", UNEC and FAO; "Global Fiber Supply Model", FAO; "Intergovernmental Panel on Climate Change ", UNEC 2000, FAO 2000, FAO 1998, IPCC 2006;

[11] According to: FAO 2005 and IIASA Global Agro-Ecological Zones 2000;

From the demand perspective, the carbon Footprint is calculated as the amount of forestland necessary to absorb given carbon emissions. It is the largest portion of humanity's current Footprint – although in some countries it is a minor contribution to their overall Footprint.

The first step in calculating the carbon Footprint is to sum up the atmospheric emissions of carbon dioxide from burning fossil fuels, land use change (deforestation, for instance), and emissions from the international transport of passengers and freight. This total is the amount of anthropogenic emissions of carbon dioxide into the global atmosphere in a given year.

The second step, after deducting the amount of carbon dioxide absorbed by the world's oceans each year from the anthropogenic total, the remaining carbon dioxide is translated into the amount of bioproductive forest that would be necessary to store it that year.

3.2. Normalizing (converting) bioproductive areas – from (normal) hectares to global hectares (gha)

The Ecological Footprint results are expressed into a single measurement unit, the global hectare. To achieve this, the Ecological Footprint scales different types of areas to account for productivity differences by land and water type areas.

Equivalence factors and yield factors are used to convert actual areas of different land use types (in hectares) into global hectare equivalents. The equivalence factors and yield factors are applied to both Footprint and biocapacity calculation.

The yield factors account for the productivity differences of a given land type between a country and the global average of this area type. A hectare of grazing land in New Zealand, for example, produces more grass on the average than a world average grazing land hectare. Conversely, one hectare of grazing land in Jordan produces less. Hence it results that the hectare in New Zealand is potentially capable of supporting more meat production than the global average hectare of grazing land. These differences are the result of natural factors, such as rainfall or soil quality, as well as of the management practices. To account for these differences, the yield factor compares the production of a specific land use type to the world average hectare of the same land use type. Each country and each year has its own set of yield factors (Table 1).

It has to be noticed that the grazing land in New Zealand is on the average 2.5 times as productive as the world average grazing land. The yield factor for built-up land is assumed to be equal to that for the cropland, since urban areas are typically built on or near the most productive cropland areas.

The equivalence factors translate a specific land use type (i.e. world average cropland, grazing land, forest, fishing ground) into a universal unit of biologically productive area, the global hectare. In 2006, for instance, the cropland had an equivalence factor of 2.39 (Table 2), indicating that world average cropland productivity was more than double the average productivity for all land combined.

In the same year, grazing land had an equivalence factor of 0.51, showing that grazing land was, on the average, half as productive as the world average bioproductive hectare. The equivalence factor for built-up land is set as equal to that of cropland. The equivalence factors are calculated for each year, and are identical for every country in a given year.

Table 1

Sample yield factors for selected countries, 2006

	Cropland	**Forest**	**Grazing land**	**Fishing grounds**
World average	1.0	1.0	1.0	1.0
Algeria	0.6	0.4	0.7	0.9
Germany	2.1	4.1	2.2	3.0
Hungary	1.4	2.6	1.9	0.0
Japan	1.5	1.4	2.2	0.8
Jordan	1.0	1.5	0.4	0.7
New Zealand	1.9	2.0	2.5	1.0
Zambia	0.5	0.2	1.5	0.0

Source: Ecological Footprint Atlas 2009, GFN.

Table 2

Equivalence factors, 2006

Area type	**Equivalence factors (global hectares per normal hectare)**
Cropland	2.39
Forest	1.24
Grazing land	0.51
Marine	0.41
Inland water	0.41
Built-up land	2.39

Source: Ecological Footprint Atlas 2009, GFN.

3.3. Factors determining Biocapacity (BC) and Ecological Footprint (EF)

Biocapacity is determined by two factors: *area* of biologically productive land or water and the *productivity* of that area, measured by how much it yields per hectare.

A careful land management can ensure that bioproductive areas do not decrease due to anthropogenic influence on factors including urbanization, deforestation, erosion, pollution and desertification. Yields can be often increased through technology, yet innovation needs to be cautiously managed so as to avoid the negative effects upon human or ecological health.

Mechanized agriculture equipment, genetically engineered seeds, irrigations, chemical fertilizers and pesticides can increase the yield of biologically productive land. However, many of these technological inputs are the outcome of a larger Ecological Footprint due to additional energy and resource input use. These technologies may also decrease biocapacity in the next years by increasing topsoil runoff, reducing water availability, decreasing biological diversity or increasing the degradation of surrounding areas.[12]

Although all the three factors are likely to be limiting on the long term, modern societies usually try to increase affluence and many of them attempt to maintain a continuous population growth. Therefore, in the attempt to avoid catastrophic resource depletion, continually improving technology is assumed.

The driving forces behind changes in the Ecological Footprint can be derived from the IPAT model, with a total of five factors influencing the degree of global overshoot or a country's ecological deficit. The Ecological Footprint is determined by *three factors*: *population, consumption per person* and *resource and waste intensity* (Table 3).

Table 3

Footprint and biocapacity factors and global overshoot, 2006

Area x Bioproductivity = Biocapacity (CAPACITY) **1.8 global hectares per person (Global biocapacity in 2006)**	**Gap between supply and demand: OVERSHOOT**
Population x Consumption per person x Resource and waste intensity = Ecological Footprint (DEMAND) **2.6 global hectares per person (Global Footprint in 2006)**	

3.4. Ecological Footprint (EA) and Biocapacity (BC) – level and dynamics

At global level, under the background of a demographic growth rate of 1.71% per year, in the period 1961–2006 (45 years), the total Ecological Footprint (EF) of the planet reached a faster growth rate (1.98%), compared to Biocapacity (BC) (0.09%).

The almost 2% global Ecological Footprint rate has been influenced by the rates of its six main components, ranging from a minimum value of 0.25% per year (EF – grazing land) to 5.20% (EF – carbon) (Table 4).

Yet, at the same time, the growth rate of the global supply of renewable resource capacity is much lower than the consumption growth rate. These different intensities of the two ecological balance "pans" of the planet (the Ecological Footprint and Biocapacity) resulted in a "moment" when humanity began to consume more resources than the resources that can be sustainably renewed. This "moment" was the year 1980; up to that moment, for about two decades, the EF/BC ratio had evolved from 0.62 (1961) to 1.00 (1980), to become unbalance afterwards, and reached 1.44 in the year 2006.

[12] In the year 1971, Paul R. Ehrlich and John P. Holdren published an extremely interesting work in which they decomposed the anthropogenic driving forces of natural capital appropriation into three variables: Population, Affluence and Technology (Ehrlich & Holdren, 1971). This model came to be known as the IPAT model (Environmental Impact = Population x Affluence x Technology), and remains a useful framework for examining the environmental impact.

Table 4

Global Ecological Footprint (EF) and Biocapacity (BC), 1961–2006 (billion global hectares)

	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2006
Global Population (billion)	3,1	3,3	3,7	4,1	4,4	4,8	5,3	5,7	6,1	6,5	6,6
Total Ecological Footprint	**7,1**	**8,1**	**9,6**	**10,6**	**11,7**	**11,9**	**13,3**	**13,8**	**15,1**	**16,8**	**17,1**
Cropland Footprint	3,3	3,4	3,5	3,5	3,6	3,6	3,7	3,7	3,7	3,7	3,7
Grazing Land Footprint	1,3	1,3	1,4	1,4	1,4	1,1	1,3	1,4	1,4	1,5	1,4
Forest Footprint	1,1	1,2	1,2	1,2	1,3	1,4	1,5	1,4	1,8	1,9	1,8
Fishing Ground Footprint	0,3	0,3	0,4	0,4	0,4	0,4	0,5	0,6	0,6	0,6	0,6
Carbon Footprint	0,9	1,7	2,9	3,8	4,7	4,9	5,9	6,4	7,3	8,7	9,1
Built-up Land	0,2	0,2	0,2	0,3	0,3	0,3	0,3	0,3	0,4	0,4	0,4
Total Biocapacity	**11,4**	**11,5**	**11,6**	**11,6**	**11,7**	**11,7**	**11,9**	**12,0**	**12,0**	**11,9**	**11,9**
Ecological Footprint to Biocapacity ratio	**0,62**	**0,70**	**0,83**	**0,92**	**1,00**	**1,01**	**1,12**	**1,15**	**1,27**	**1,41**	**1,44**

Notes*:* 2009 Edition. Totals may not add up due to rouding.
Source: National Footprint Accounts 2009, GFN.

It is worth mentioning that in the period 1990–2006 (when radical economic and social structural changes were produced in many Central and East-European countries), the annual growth rates of resource consumption (demand) and the sustainable renewal of resources respectively significantly decreased, to reach 1.59% (total Ecological Footprint) and 0.02% (Biocapacity). The most significant diminution was noticed in the carbon Footprint, for which the annual rate was down by almost half (2.70%).

The regional and national distribution of the global Ecological Footprint (EF) and Biocapacity (BC) has two main presentation forms, based on *two classification criteria of countries* (development level criterion – income per capita, and the geographical-regional criterion) (Table 5).

From the first criterion perspective, in the year 2006 (for which the latest measurements are available), the Ecological Footprint of total consumption of resources in the countries with a high income per capita was 6.1 global hectares (gha) per capita, 2.35 times as high than the world average and 6 times as high compared to the average of the countries with low income per capita.

The dispersion of the Ecological Footprint of total consumption, at global level, by continents (geographical regions) ranges from minimum 1.4 gha/capita (in Africa) to maximum 8.7 gha/capita (in Canada and USA).

In this context, the European continent is at the middle of this scale, with 4.5 gha/ person, while in the panel of the 23 EU member countries for which calculations have been made, the average Ecological Footprint of total consumption is about 5.5 gha/person, ranging from maximum 8.2 gha/person (in Ireland) to minimum 2.7 gha/person(in Romania).

It is worth mentioning that in 15 of the 23 EU member countries under investigation, the Ecological Footprint of total consumption is higher than the European average.

In the hierarchy of the six investigated geographical areas, Europe is on the 4th place in 4 of the 6 components of the Footprint (total consumption), from the point of view of the relative contribution to its level configuration. Thus, Europe is on the 4th place in the decreasing hierarchies of the share of Footprint components for the cropland (with 23.41%), forests (with 10.99%), grazing land (with 2.74%) and built-up land (with 1.63%).

Table 5

Ecological Footprint at regional and national level, 2006, (gha/capita)

		ECOLOGICAL FOOTPRINT (EFP) (global hectares per capita)						
	Population (million)	CONSUMPTION	Cropland	Grazing	Forest	Fishing Ground	Carbon	Built-up Land
World	**6.592,9**	**2,6**	**0,57**	**0,22**	**0,28**	**0,10**	**1,37**	**0,06**
High Income Countries	**1.022,1**	**6,1**	**0,93**	**0,19**	**0,70**	**0,28**	**3,85**	**0,11**
Middle Income Countries	**4.281,1**	**1,8**	**0,46**	**0,17**	**0,19**	**0,08**	**0,82**	**0,06**
Low Income Countries	**1.277,0**	**1,0**	**0,36**	**0,10**	**0,23**	**0,02**	**0,26**	**0,05**
Africa	**942,5**	**1,4**	**0,48**	**0,20**	**0,29**	**0,04**	**0,35**	**0,05**
Asia	**3.983,9**	**1,5**	**0,38**	**0,06**	**0,14**	**0,08**	**0,80**	**0,06**
Europe	**731,3**	**4,5**	**1,06**	**0,12**	**0,50**	**0,22**	**2,49**	**0,12**
Austria	8,3	4,9	0,72	0,16	0,73	0,11	2,98	0,19
Belgium	10,4	5,7	1,84	0,38	0,56	0,17	2,44	0,31
Bulgaria	7,7	3,3	0,77	0,22	0,36	0,04	1,69	0,17
Czech Republic	10,2	5,3	1,03	0,12	0,99	0,07	2,95	0,16
Denmark	5,4	7,2	1,10	0,21	1,24	0,60	3,77	0,28
Estonia	1,3	6,4	0,44	0,15	2,40	0,14	3,15	0,13
Finland	5,3	5,5	1,27	0,03	1,02	0,38	2,67	0,14
France	61,3	4,6	0,81	0,16	0,63	0,30	2,49	0,21
Germany	82,6	4,0	0,93	0,07	0,51	0,14	2,21	0,18
Greece	11,1	5,8	0,93	0,25	0,43	0,12	3,94	0,08
Hungary	10,1	3,2	1,16	0,06	0,41	0,03	1,39	0,17
Ireland	4,2	8,2	1,06	0,72	0,64	0,33	5,19	0,25
Italy	58,8	4,9	1,02	0,20	0,50	0,24	2,88	0,08
Latvia	2,3	4,6	0,97	0,15	2,39	0,16	0,86	0,07
Lithuania	3,4	3,3	0,35	0,09	0,93	0,33	1,54	0,10
Netherlands	16,4	4,6	1,22	0,21	0,41	0,18	2,44	0,14
Poland	38,1	3,9	0,65	0,01	0,66	0,11	2,38	0,07
Portugal	10,6	4,4	0,85	0,19	0,14	0,74	2,41	0,04
Romania	**21,5**	**2,7**	**0,84**	**0,09**	**0,33**	**0,05**	**1,21**	**0,14**
Slovakia	5,4	4,9	0,59	0,06	0,59	0,07	3,48	0,15
Slovenia	2,0	3,9	0,79	0,06	0,78	0,10	2,07	0,09
Spain	43,9	5,6	1,16	0,17	0,46	0,53	3,25	0,05
United Kingdom	60,7	6,1	0,93	0,20	0,58	0,23	4,00	0,18
Latin America and the	**564,7**	**2,4**	**0,58**	**0,71**	**0,36**	**0,11**	**0,60**	**0,08**
Canada and USA	**335,5**	**8,7**	**1,07**	**0,08**	**1,16**	**0,17**	**6,13**	**0,09**
Oceania	**33,8**	**5,8**	**0,26**	**2,33**	**0,88**	**0,52**	**1,75**	**0,06**

Source: National Footprint Accounts 2009, GFN.

In the share of fishing grounds, Europe is on the 3rd place (with 4.90%), while in the carbon Footprint it is on the 2nd place (with 55.32%), next to Canada and USA (with 70.46%). Thus, it is confirmed that the most industrialized zones had the highest Ecological Footprints, generated by the carbon emissions.

In the European Union, the minimum average shares of the 6 components are found in Estonia (for the cropland), Hungary (fishing grounds), Latvia (carbon), Poland (grazing land), Portugal (forests and built-up land). Maximum shares are found in Hungary (cropland), Ireland (grazing land), Latvia (forests), Portugal (fishing grounds), Romania (built-up land) and Slovakia (carbon).

From the perspective of sustainable renewal of resources capacity (Table 6), Europe is on the 5th place in the 6 geographical zones of the Earth, in decreasing order of the shares of the 5 components (for grazing land – with 6.16%), on the 4th place in the other two components (cropland with 33.49% and fishing grounds with 9.11%) and on the 2nd place (forests with 47.31% and built-up land with 3.93%).

Table 6

Biocapacity (BC) and Ecological Reserve (Deficit), at global, regional and national level, 2006 (gha/ oc)

	BIOCAPACITY (BC), (global hectares per capita)						Ecological (Deficit)
	TOTAL	Cropland	Grazing	Forest	Fishin	Built-up Land	or Reserve
World	**1,8**	**0,56**	**0,26**	**0,74**	**0,18**	**0,06**	**(0,8)**
High Income Countries	**3,3**	**1,16**	**0,32**	**1,18**	**0,57**	**0,11**	**(2,7)**
Middle Income Countries	**1,7**	**0,47**	**0,24**	**0,76**	**0,14**	**0,06**	**(0,1)**
Low Income Countries	**1,0**	**0,35**	**0,22**	**0,29**	**0,08**	**0,05**	**(0,0)**
Africa	**1,5**	**0,42**	**0,45**	**0,46**	**0,12**	**0,05**	**0,1**
Asia	**0,7**	**0,33**	**0,08**	**0,15**	**0,10**	**0,06**	**(0,8)**
Europe	**3,0**	**1,01**	**0,19**	**1,43**	**0,28**	**0,12**	**(1,5)**
Austria	3,0	0,60	0,17	2,02	0,00	0,19	(1,9)
Belgium	1,1	0,32	0,12	0,28	0,05	0,31	(4,6)
Bulgaria	2,7	1,20	0,19	0,99	0,10	0,17	(0,6)
Czech Republic	2,6	1,11	0,14	1,22	0,00	0,16	(2,7)
Denmark	5,2	2,50	0,04	0,29	2,09	0,28	(2,0)
Estonia	9,0	0,67	0,39	3,21	4,59	0,13	2,6
Finland	13,0	1,38	0,00	8,66	2,81	0,14	7,5
France	2,8	1,28	0,28	0,89	0,18	0,21	(1,8)
Germany	1,9	0,87	0,10	0,64	0,08	0,18	(2,2)
Greece	1,4	0,79	0,10	0,14	0,25	0,08	(4,4)
Hungary	2,6	1,72	0,11	0,57	0,01	0,17	(0,6)
Ireland	4,3	0,98	0,91	0,25	1,88	0,25	(3,9)
Italy	1,0	0,53	0,08	0,27	0,07	0,08	(3,9)
Latvia	7,2	1,03	0,72	3,34	2,08	0,07	2,6
Lithuania	3,7	0,70	0,92	1,64	0,29	0,10	0,3
Netherlands	1,0	0,27	0,06	0,08	0,50	0,14	(3,6)
Poland	1,8	0,82	0,13	0,71	0,12	0,07	(2,0)
Portugal	1,2	0,24	0,26	0,57	0,08	0,04	(3,2)
Romania	**2,3**	**0,84**	**0,18**	**1,00**	**0,10**	**0,14**	**(0,4)**
Slovakia	2,7	0,83	0,09	1,60	0,00	0,15	(2,3)
Slovenia	2,4	0,22	0,25	1,80	0,00	0,09	(1,5)
Spain	1,3	0,84	0,13	0,24	0,06	0,05	(4,3)
United Kingdom	1,6	0,62	0,11	0,11	0,56	0,18	(4,5)
Latin America and the	**5,4**	**0,72**	**0,90**	**3,40**	**0,33**	**0,08**	**3,0**
Canada and USA	**5,7**	**2,17**	**0,29**	**2,22**	**0,89**	**0,09**	**(3,0)**
Oceania	**12,8**	**1,90**	**4,95**	**2,82**	**3,09**	**0,06**	**7,0**

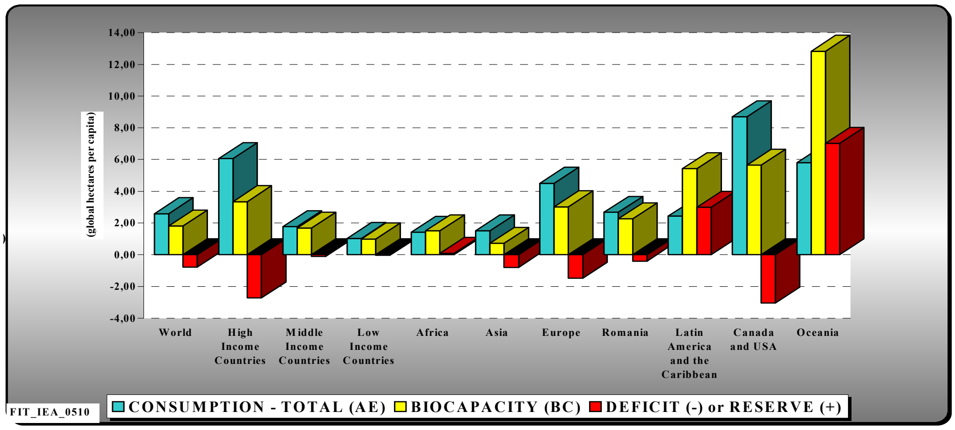
Source: National Footprint Accounts 2009, GFN.

Among the 23 investigated EU member countries of EU-27, the lower limits of the shares of the 5 biocapacity determinants are present in Estonia (with 7.40% for cropland), Finland (with 0.03% in grazing land), Denmark (with 5.56% for forests), Slovenia (with 0.11% for fishing grounds) and Latvia (1.02% for built-up land).

At the same time, higher limits of the shares of the 5 national bioproductivity determinants in the 23 EU countries are found in Hungary (66.69% for cropland), Lithuania (with 25.19% for grazing land), Slovenia (76.12% for forests), Netherlands (47.45% for fishing grounds) and Belgium (with 28.3% for built-up land). Graph 1 gives a synthetic picture of the world distribution of biocapacity deficit or reserve, by geographical regions and development levels.

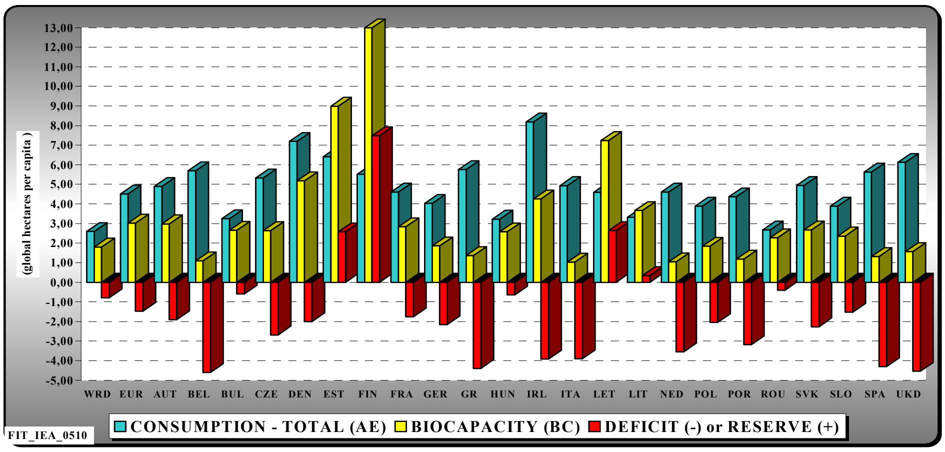
It results that the world biocapacity deficit of about 0.8 gha/person comes from the asymmetrical distribution of the Ecological Footprint (EF) / Biocapacity (BC) balance by geographical regions (from the maximum deficit of 3.05 gha/person in Canada and USA, to the reserve of 7.02 gha/person in Oceania). According to the development level criterion, the maximum deficit is found in the high-income countries, while the minimum deficit in the low-income countries.

The same analytical approach, applied to the 23 Member States from EU – 27 enables Romania's positioning from the perspective of sustainable renewal of resources capacity (Graph 2).



Source: Own calculations, on the data base from "National Footprint Accounts 2009". GFN.

Graph 1. Consumption (EFP), Biocapacity (BC) and Ecological Reseve (Deficit), at global, regional and national level, 2006 (gha/capita)



Source: Own calculations, on the data base from "National Footprint Accounts 2009". GFN.

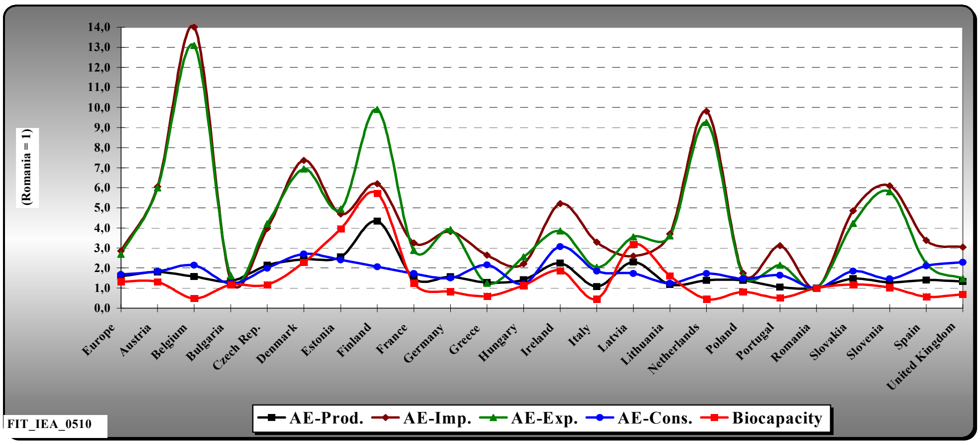
Graph 2. Ecological Footprint (EF), Biocapacity (BC) and deficit (-) or reserve (+), in certain EU Member States, 2006 (gha/person)

A few remarks can be made on the national distribution of the biocapacity deficit or reserve in the 23 EU Member States:

• The biocapacity reserves are found in only for 4 countries (Estonia, Finland, Latvia and Lithuania), ranging from 0.34 gha/capita (Lithuania) to 7.48 gha/capita (Finland);

• The remaining 19 countries have biocapacity deficit, ranging from minimum 0.40 gha/capita (Romania) to maximum 4.61 gha/capita (Belgium).

On a comparative basis, practically for all the 4 components of consumption Footprint, at macro-economic level, the 22 EU member countries taken into consideration have higher levels compared to Romania (Graph 3). This reveals that in the reference year 2006, the Ecological Footprint related to the national production was significantly influenced by the unfavourable foreign trade balance (prevalence of imports in the face of exports).



Source: Own calculations, on the data base from "National Footprint Accounts 2009", GFN;

Graph 3. Ecological Footprint (EF) and Biocapacity (BC) in Europe, 2006 (Romania = 1)

On the other hand, with regard to Biocapacity, 9 of the 22 compared countries have lower levels of biocapacity per capita (Belgium, Germany, Greece, Italy, Netherlands, Poland, Portugal, Spain and United Kingdom). In numerical terms, the ecological deficit of 0.4 gha/capita in Romania (resulting from difference between the Ecological Footprint – 2.7 gha/capita and biocapacity – 2.3 gha/capita) is the lowest in the 19 investigated countries, while the maximum deficit is present in Belgium (- 4.6 gha/capita).

Romania's place among the EU Member States with regard to the Ecological Footprint and Biocapacity levels can be completed with the changes that were produced in the reference period 1961–2006 (Table 7).

Under the background of 16,2% demographic growth in the period 1961–2006, Romania had relative modifications in the quasi-totality of investigated indicators, which are rather close to minimum levels.

Thus, with a 69.1% increase of its total Ecological Footprint, in the year 2006 compared to 1961, Romania is placed between the minimum trend (+10.7% in Hungary) and the maximum trend (+408.8% in Greece). Per capita, the trends are maintained as regards the direction, but they differ as regards the intensity, due to the correction induced by the population dynamics.

Table 7

Relative changes in the Ecological Footprint and Biocapacity in the period 1961–2006, in correlation with the human development indices (HDI), in the EU Member States

Regions/Countries	Population	EFP per cap.	EFP-Total	BC per cap.	BC-Total	HDI - 1980	HDI - 2006
World	**114**	**13**	**141,9**	**-51,4**	**4**	**-**	**-**
Europe	**21,6**	**33,4**	**52,7**	**-20,8**	**-9,3**	**-**	**-**
Austria	17,5	95,7	129,9	-14,6	0,3	0,87	0,95
Belgium	14,1	32	50,5	-25,4	-14,9	0,87	0,95
Bulgaria	-3,1	35,5	31,3	-1,9	-4,9	-	0,84
Denemark	17,7	12,1	31,9	-23,5	-10	0,88	0,95
France	32,5	38,2	83,1	-9,2	20,3	0,88	0,96
Germany	12,6	37,1	54,3	0,1	12,7	0,87	0,95
Grece	32,6	283,6	408,8	0,6	33,5	0,84	0,94
Hungary	0,4	10,2	10,7	7,5	8	0,8	0,88
Irlande	49	126,2	237	-22,3	15,7	0,84	0,96
Italy	16,2	116	151,1	-2,07	-7,8	0,86	0,95
Netherlands	40,6	40	96,9	-26,6	3,3	0,89	0,96
Poland	26,9	24,8	58,3	-38,3	-21,7	-	0,88
Portugal	18,8	73,6	106,2	6,3	26,2	0,77	0,91
Romania	**16,2**	**45,5**	**69,1**	**-5,5**	**9,8**	**-**	**0,83**
Spain	42,7	120	214	-27	4,2	0,86	0,95
United Kingdom	14,8	59	82,5	1,4	16,5	0,86	0,95

Source: National Footprint Accounts 2009, GFN.

While in total Ecological Footprint, in the investigated period, a general increasing trend was noticed (justified by the increasing demand of resources in the economic development process), in total Biocapacity, as expression of the supply of renewable resources, the trends are both positive in 11 countries (from 0.3% – Austria to 33.5% – Greece, and Romania 9.8%) and negative in 5 countries (from –4.9% in Bulgaria to –21.7% in Poland). Per capita, the demographic growth incidence corrected the total biocapacity trend, in the sense that in 5 of the 16 investigated countries the trend was progressive, while in 11 countries the trend was regressive.

4. CONCLUSIONS AND OPENINGS

1. The correct unit of measurement of the Ecological Footprint is the "global hectare" (gha) and not the (normal) hectare; this can be considered a unitary "currency" by which the different fertility of areas can be equalized. The "global hectare" thus corresponds to a biological productivity hectare at global level, making it possible to compare different countries or zones, at global level.

2. The Earth, in its entirety, has already a Footprint that is larger than our planet. Translated into economic language, this means that we are living not on "interests" (perennial renewable resources), but on "capital" (the substance of nature). At this can last only for some time.

3. The humanity is already in "overshoot", using more resources than the planet can regenerate; if the consumption trends in the rich countries and in the emergent economies continue at current rates, this overshoot will dramatically increase, resulting in increased degradation of the Earth's capacity to generate resources, continuation of greenhouse gas and other wastes accumulation, and the possible collapse of the critical ecosystems.

4. The Ecological Footprint (EF), more than 15 years ago, became an increasingly robust modality to capture the human demand on nature. Yet its evolution is not completed. With the recognition of the value of this metrics and its adoption by more governments and businesses, it has become clear that the Ecological Footprint (EF) development must be significantly accelerated.

5. The total Footprint for the activities of a given population is measured in term of "global hectares". A global hectare is one hectare (2.47 acres) of biological productive area, with annual productivity equal to the world average. At present, the biosphere has approximately 11.2 billion hectares of biological production area, which corresponds to about one quarter of the Earth's area.

6. By comparing the Ecological Footprint measure with the actual bioproductive capacity of a certain nation, it is possible to determine whether the country has ecological deficit (using more resources than it has) or it has ecological reserve.

7. The regional and national distribution of global Ecological Footprint (EF) and Biocapacity has two main presentation forms, based upon two classification criteria of countries (the development level criterion – income per capita and the geographical-regional criterion).

8. In this context, the European continent is placed, with its 4.5 gha/person at the middle of the scale, while in the panel of the 23 EU member countries for which calculations have been made, the average Ecological Footprint of total consumption is about 5.5 gha/person, ranging from maximum 8.2 gha/person (in Ireland) to minimum 2.7 gha/person(in Romania).

9. From the perspective of the capacity of sustainable renewal of resources (biocapacity), Europe is on the 5th place among the 6 geographical areas of the Earth, as decreasing order of the shares of the 5 biocapacity components (grazing land – with 6.16%), on the 4th position in other two components (cropland – with 33.49% and fishing grounds – with 9.11%) and on the 2nd position (forests – with 47.31% and built-up land – with 3.93%).

10. While in total Ecological Footprint, in the investigated period, a general increasing trend was noticed (justified by the increasing demand of resources in the economic development process), in total Biocapacity, as expression of the supply of renewable resources, the trends are both positive in 11 countries (from 0.3% in Austria to 33.5% in Greece, and Romania 9.8%) and negative in 5 countries (from –4.9 % in Bulgaria to –21.7% in Poland). Per capita, the demographic growth incidence corrected the total biocapacity trend, in the sense that in 5 of the 16 investigated countries the trend was progressive, while in 11 countries the trend was regressive.

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