# "Socio-economic Design and Nature": a possible representation through ecological footprint

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## Abstract

No society would be able to function without the support of healthy forests, clean waters, fertile soils, and other types of ecological capital that provide resources for our use and absorb the wastes we generate. These ecosystem services can be measured through an environmental indicator named biocapacity. On the other side, an environmental tool named Ecological Footprint can be used to measure human consumption related to life style. The main aim of this paper is to verify if a correlation exists between these two parameters and the well being perceived by humans. Data on Life Satisfaction was used as a subjective measure of the satisfaction level perceived by humans. The analysis performed in this study helped one to understand whether our pattern of development is able to make us happy, and whether it is possible to be happy without cost to our planet. The analysis was based on a database of about 130 countries of the world. A geographically based analysis was also performed to compare regional to global trends. Finally, some case studies were presented in time series to analyze the temporal evolution of these three parameters.

*Keywords: ecological footprint, life satisfaction, biocapacity, sustainability.*

## 1 Introduction

The world is moving into severe resource constraints as most of the strategic resources are approaching their point of "peak". Peak represents the point where the withdrawal of a resource is no longer convenient because half of its stock has

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already been used. Globally, resource consumption rates are increasing and since mid 1980s Earth is in overshoot: human demand on natural resources exceeds the capacity of the planet to regenerate them as measured with the Ecological Footprint Analysis [1].

The latest projections from Global Footprint Network indicate that overshoot has been increasing during the last fifty years and this was caused by a mounting demand for the photosynthetic land needed to uptake human induced carbon dioxide emissions [1]. This is mainly due to the habits of a low percentage of the world population (about 20%), which is located in high income countries and is generally characterized by: i) an intensive use of resources; ii) the predominant use of energy based resources; iii) high level of technology [1].

In the long run, this pattern of consumption is likely to lead humanity towards a progressive and irreversible depletion of natural capital and a contemporary high level of stress for the environment. A change in human consumption habits is thus desirable to make possible for future generations to experience the same level of life satisfaction we currently have.

In 2006, the New Economics Foundation (NEF) developed a new index, called the Happy Planet Index (HPI), as a measure of the environmental efficiency of supporting well-being in a given country. HPI is a function of three very different indicators: ecological efficiency, life satisfaction and life expectancy. The results of their survey are quite optimistic to support the theory that is possible to live with the means of nature [2].

In 1974, the economist Richard Easterlin proposed a happiness-income paradox (also known as the Easterlin Paradox), according to which the subjective wellbeing of a population is positively correlated with income until a certain point in time (short term) after which it increases more slowly than income (long term) [3, 4].

The aim of this paper is to test whether it could be possible for humans to reduce their levels of resource consumption without compromising wellbeing and life satisfaction and, at the same time, protecting the environment.
The trends of three different indicators were analyzed to test the hypothesis:

1. Ecological Footprint as a measure of human consumption in terms of appropriation of lands needed to produce the resources and ecological services consumed;
2. Biocapacity as measure of natural capital within a country;
3. Life Satisfaction as a subjective measure of well being.

Data for about 130 world countries for these three indices were collected and correlated to each other. As the question is really complex, and a lot of factors determined the value of these indices, their dynamics over the time (long term) were deeply evaluated for few nations.

Referring to the Easterlin paradox, we used Life Satisfaction instead of the Happiness and the Ecological Footprint instead of Income. The use of the Ecological Footprint is aimed to include also environmental aspects that are becoming more and more limiting for the development of human societies. This could help us to verify the existence of a threshold, after which the increasing of

resource consumption does not produce the same increase of the satisfaction of life.

## 2 Methods

Three indicators were used to perform this study. The first two belong to the family of environmental based indicators (Ecological Footprint and Biocapacity) while the second one derives from the social sciences (Life Satisfaction). A database of these indexes was collected for about 130 world nations representing more than 95% of the world population. Data generally referred to the year 2005 or the year closer to it. Data from Gross Domestic Product (GDP), was taken from the World Bank [5], and used to support our consideration. The main features of each indicator are briefly described below.

### 2.1 Ecological footprint and biocapacity

The Ecological Footprint (hereafter EF) was introduced by Wackernagel and Rees in the early 1990s [6]. EF was defined as the surface of ecologically productive lands (i.e. cropland, grazing land, forest, built up land, carbon uptake land and fishing ground area) needed to sustain an individual, a population or an activity [6]. In other words EF provides a conservative estimation of natural capital requirements – in terms of both resources (food, energy and materials) and ecological services (to absorb the waste) – of a population. This area is expressed in terms of global hectares (*g*ha) or hectares with world average productivity [7].

The EF of a population is generally a function of three main factors: a) population; b) affluence (i.e. resources consumption), c) technology (i.e. energy intensity of products).

While the EF measures human consumption, a second term called Biocapacity (hereafter BC), gives insight on the ecological budget available for human use. BC is a function of the total region surface, land coverage and the prevailing management techniques. BC is also measured in global hectares (*g*ha) to be directly comparable with EF [7].

When EF is compared to BC an ecological (or resource) balance is defined, which can be used to identify the extent to which societies' consumption is far from sustainability. If EF is greater than its domestic bioproductive land, the country runs an ecological deficit that is a synonymous of over-use of resources. The greater is the ecological deficit the higher the distance from sustainability. Conversely, when the local supply of resources is higher than the human demand, a surplus of resources locally unused originates.

EF and Biocapacity data used in this paper are taken from the Global Footprint Network [1, 8].

### 2.2 Life satisfaction

The meaning of happiness has been debated since the time of Aristotle. In recent years, the debate has moved from philosophy towards science, and scientists are

now discussing both its meaning and the ways to measure it. Happiness, in fact, depends on many factors, such as family relationships, financial situation, work, community and friends, health, personal freedom and personal values [9].

In this paper Life satisfaction (hereafter LS) is used as a subjective measure of well being as estimated by surveys. Individuals' responses are generally related to the size of their social network, relationship status as well as to their material conditions, such as employment and income [10]. LS values typically range from 0 (dissatisfied) to 10 (satisfied). LS data are gathered from the New Economics Foundation (NEF) [2].

## 3 Results and discussion

The first step of our analysis was to check the statistical correlation among the selected indicators in order to highlight the relationships among the variables and detect when one values of one variable correspond to those of another with certain regularity.

The correlation analysis was carried out by means of the Bravais-Pearson model. In this case, the correlation coefficient ranges from –1 (close indirect correlation) to +1 (close direct correlation between variables). No correlation exists when the coefficient is equal to 0 [11].

The correlation analysis was conducted for each parameter (LS, GDP, BC and EF) for 130 world nations. Results are reported in Table 1.

Table 1: Bravais-Pearson correlation among social (Life Satisfaction, LS), economic (Gross Domestic Product, GDP) and environmental (Ecological Footprint, EF and Biocapacity, BC) indicators.

| | LS | BC (gha) | EF (gha person$^{-1}$) | GDP ($ person$^{-1}$) |
|---|---|---|---|---|
| LS | **1** | | | |
| BC (gha) | 0.182776 | **1** | | |
| EF (gha person$^{-1}$) | 0.629009 | 0.163013 | **1** | |
| GDP ($ person$^{-1}$) | 0.676218 | 0.128843 | 0.883504 | **1** |

Results show:

1) The presence of a large correlation between an economic indicator, such as the wealth of a nation expressed by Gross Domestic Product (GDP) per person, and the individual consumption accounted by EF. This suggests that the richer a population the higher the human consumption. A similar result was also found by Jorgenson and Burns [12].
2) A very small correlation between Biocapacity and LS. This reveals that satisfaction is not correlated to the presence of ecologically bioproductive areas within the country. This can be explained because Biocapacity is a measure of the potential bioproductivity of an area and its value represents the potential resource availability of these areas. However, from Figure 1 we

can say that countries with greater Biocapacity (as Brazil, Canada and USA) show the highest satisfaction levels.

3) A medium correlation between EF per person and LS was found. In general, this could confirm that people with high consumption and income levels are more satisfied with life than people with lower consumption and income levels (see for example USA, Australia, Canada, and New Zealand). But data are quite dispersed to define a trend and extrapolate more robust information (see also Figure 1).

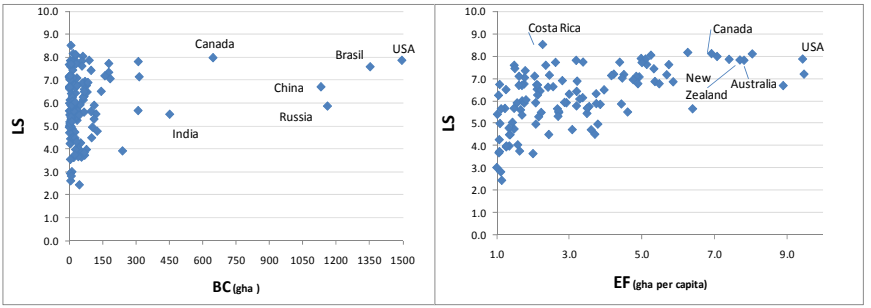


Figure 1: Scatter plot of life satisfaction *vs* ecological footprint (left) and biocapacity (right) for 130 world countries.

To more deeply analyze this last correlation (EF *vs* LS), data from all nations were grouped in 19 categories by geographical location and plotted again as reported in Figure 2. From this representation it is possible to show that few exceptions from previous considerations exist. This is the case, for example, of the countries located in Southern and Central America. Their satisfaction is comparable to that of Western Europe and Northern America, even if the EF is twice or three times lower. It is quite interesting to note that about the 16% of the world biocapacity is concentrated in this area. As underlined by Easterlin [13], this could indicate that in some cases satisfaction and happiness are driven not only by material consumption but also by other social and societal factors such as relationships, employment, life cycle and aspirations.

A further look at each world region provides interesting information. Divided into 4 subcategories Africa, for example, shows a *vertical distribution* as the same unit of consumption (in this case the EF values are quite similar) produces different perceptions of satisfaction. On the contrary, Asia reports a *horizontal distribution* indicating that to reach the same level of satisfaction, different levels and patterns of consumption (i.e. the EF values are very different) are necessary. This could be due to the differences in wellness within a big continent as Asia.

In general, we can define a new index given by the ratio between the level of satisfaction of a country and its Ecological Footprint (LS / EF). It measures the level of satisfaction produced by a unit of (material) consumption. Its value should be as high as possible to maximize satisfaction and minimize the

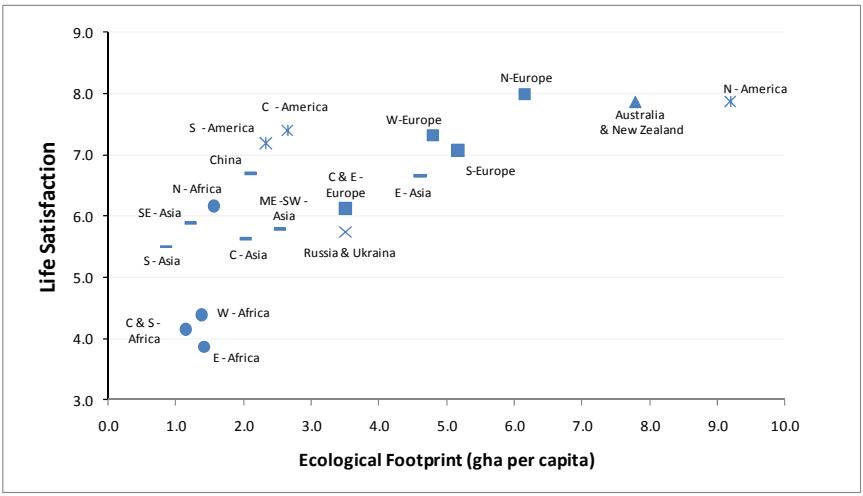


Figure 2: Ecological footprint per capita *vs* life satisfaction for sub-regions. legend: N is for north, W is for west, S is for south, E is for east and C is for central.

consumption of goods and services as well as the impacts on the environment. However, when read in isolation, this information could be in some cases misleading. For example no information is known about the countries' social as well economic condition: their EF could be low because they do not have the possibility or the availability of resources to consume more. The ratio presented in here thus gives information only from a single perspective but it is not comprehensive enough to represent and discuss about the country sustainability. To have a more comprehensive picture of this complex issue, other kind of information need to be collected because numbers seemingly similar each other could tell very different story. Furthermore it seems quite interesting to study the LS trends in the short and long run compared to the time series of EF and Biocapacity.

In figure 3, the trends of two European countries (Italy and Germany), one Central American (Mexico) and one North American (United States) country are shown.

The first observation to emerge is that during the 1961–1980 period, small changes in EF values in Mexico have produced greater changes in the country's LS if compared to the two European countries. EF changes in Italy and Germany have been almost double than in Mexico but the increase in LS has been smaller. It could be interesting to test if these trends are typical of poorer and richer countries respectively. Unfortunately, LS trends were not available for other middle and low income countries.

It can also be observed that Italy, Germany and Mexico seem to respect the happiness-income paradox proposed by Easterlin [3, 4] according to which "… at a point in time happiness varies directly with income, but over time happiness does not increase when a country's income increases". In fact, the three countries

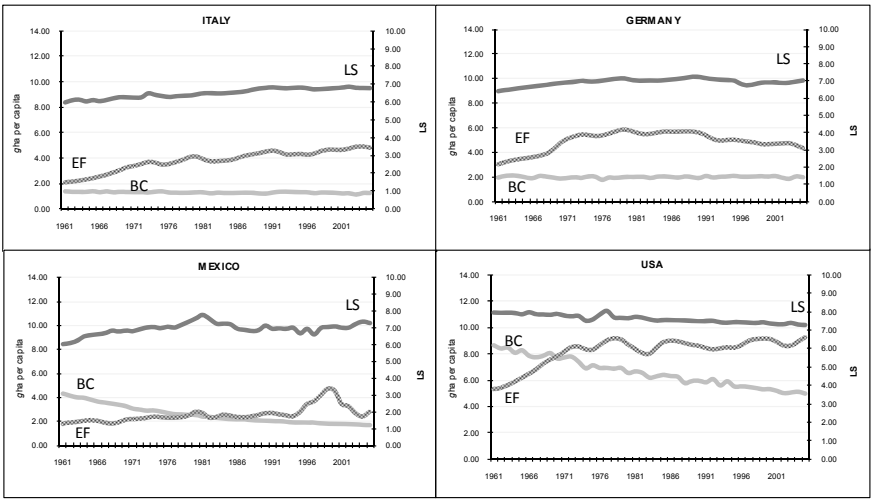


Figure 3: Time series of ecological footprint, biocapacity and life Satisfaction for Italy, Germany, USA and Mexico.

show changes in LS coupled with changes in EF but only up until a certain time when LS trends become insensible to changes in EF.

The case of United States appears singular and atypical. The LS trend is lightly decreasing since 1961 without any inversion despite its EF doubled in the same period.

Finally, results for the countries presented in here show that the growth of life satisfaction tends to be smaller with the increase of the gap between EF and Biocapacity (ecological deficit). Further investigation is needed to answer questions such as: are environmental issues becoming important for our satisfaction or is this just a coincidence?

## 4 Conclusion

Usually, the overall wellbeing of a population or a nation is described by economic indices as GDP or social indices as the HDI (Human Development Index). However other aspects can influence the overall happiness of an individual or a community. This paper represents a preliminary study carried out to test the eventual existence of a relation between the pattern of development of a country and the overall life satisfaction perceived by its inhabitants. The main result of this paper is to confirm that a satisfied life is possible also by consuming less, and reducing stress on the Earth and natural resources' depletion. This paper can represent a starting point for future research on this socio-environmental topic and probably more detailed statistical analyses are needed. Furthermore, environmental aspects should be considered during the investigation to establish the happiness or satisfaction of a person.

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