# Ecological footprint (EF)

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# Ecological footprint (EF)

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## 1 Introduction to ecological footprint

How to account for humanity's energy and resource throughput? How to make the ecological condition of sustainability measurable? These are not the least questions Wackernagel and Rees (1996) and Wackernagel et al. (1999) ask themselves in a seminal research project on sustainability. Rees (1996) discussed the concept earlier by stating that 'Conventional wisdom suggests that because of technology and trade, human carrying capacity is infinitely expandable and therefore virtually irrelevant to demography and development planning. By contrast, ecological carrying capacity remains the fundamental basis for demographic accounting. A fundamental question for ecological economics is whether remaining stocks of natural capital are adequate to sustain the anticipated load of the human economy into the next century. Since mainstream (neoclassical) models are blind to ecological structure and function, they cannot even properly address this question.' Rees then presents a framework that assesses the capital stocks, physical flows, and corresponding ecosystems areas required to support the economy using "ecological footprint" analysis. Larsson, Folke and Kautsky (1994) also used the notion of ecological footprint in their sustainability analysis of shrimp farming.

Here we are at the heart of the problem: finding an indicator for carrying capacity, and in general, finding indicators for sustainability; otherwise stated (Wackernagel et al., 1999) 'How much nature people use to sustain themselves'.

## 2 Methodology of ecological footprint

There is an overwhelming amount of literature on finding the one and only indicator of sustainability. Green accounting (see the discussion elsewhere in this project) is perhaps the best example of this type of confusing discussions: basically we have physical aggregate indicators and monetary aggregates to revise existing macroeconomic indicators. At one extreme we find (Hueting and Bosch, 1990; Hueting and Reijnders, 1998) corrections of national income for environmental losses and at the other extreme we detect material flow accounts. Wackernagel et al. (1999) follow this type of division of labour and suggest (p. 377) that the famous article by Costanza et al. (1997) on the monetary value of the ecosystems in the world is an excellent approach for awareness building, but is not suitable for action. They thus propose an indicator that is based on biophysical units. Ecological footprint (EF) represents the critical natural capital requirements of a defined economy or population in terms of the corresponding biologically productive areas. In their view productive land is a good proxy for natural capital and many of the resource flows and essential life supporting services that this capital provides. Land area communicates the finite character of the world in readily understandable terms.

Why land? The argument by Wackernagel et al. (1999) is that the area in each ecosystem category is roughly proportional to its photosynthetic potential for low entropy biomass production. Land thus is an indicator of the functional integrity of related ecosystems. Moreover, and most important, most of the resources we use and the waste we generate can be converted to biologically productive area necessary to produce these functions.

Several land categories are distinguished: consumed/degraded land, gardens, crop land, pasture land and grass lands, productive forests, and energy land. Energy takes a special place in footprint analyses: More than 50% of EF estimates relate to land needed to catch $CO_2$ emissions from burning fossil fuels.

EF does not compute actual land use; the footprint is a hypothetical figure. But, it enables to compare regions and countries. Wackernagel et al. (1999) calculate that per global citizen 2 ha is available. This figure thus becomes the ecological benchmark for comparing people's ecological footprints.

# 3 Process of ecological footprint

Not described yet.

# 4 Review of ecological footprint

## 4.1 Evaluation results of ecological footprint

In the literature serious criticism has been raised against EF. In the following we will discuss the major objections.

The most fundamental issues in the critique on EF is on measurement: van Kooten and Bulte (2000) object strongly against EF because it is not clear what is being measured, and how resources and waste are being converted. The first problem is rather devastating: it is not well defined what is ‘nature’ in the definition of ‘How much nature people use to sustain themselves’. Moreover, they state that it is not clear what is meant with the finding that EF > carrying capacity. Is this necessarily bad? van Kooten and Bulte (2000) conclude that EF is only a convenient means of organizing globally available data on population, income, resource use and resource availability into a single metric.

Secondly, EF claims that resources and waste flows are converted into productive land. However, little is known about what happens to wastes when they enter ecosystems, and even less is known about how to convert resource and waste flows into a productive land area.

Van den Bergh and Verbruggen (1999) formulate additional critique on the underpinning of the footprint. First of all they criticize the hypothetical nature of the metric. That is a great danger in that it will be interpreted as actual land or at least realistic land use. They call it false concreteness. Moreover, there is no distinction between sustainable and unsustainable land use. That implies that it is not possible to allow for a trade−off between environmental sustainability and intensive/extensive land use, notably in agriculture. Neglecting multiple land use will bias EF.

Secondly, for most developed countries 50% of EF estimates relate to land area needed to catch $CO_2$ emissions. According to van den Bergh and Verbruggen (1999) this is questionable: $CO_2$ assimilation by forests is one of many options.

Thirdly, EF calculations per country are rather arbitrarily from an environmental perspective. It would be more consistent to use environmental boundaries in stead of state boundaries. But apart from this accounting point of view a fundamental issue is that it is not clear whether it is a bad thing if a region or a country faces a high EF. Van den Bergh and Verbruggen (1999) note that in comparing the per capita EF among regions its value appears to be a reflection of the global distribution of wealth. But the spatial concentration of people has a positive impact on sustainability (sic!).

This third point of criticism relates to a fourth objection regarding an underlying implicit assumption in EF analysis: some form of self−sufficiency or autarky is a desirable situation. This leads to the following conclusion: trade between countries is allowed but arbitrarily only up to the point where the sum of (hypothetical) land use domestically and abroad equals the available productive land in the region. Needless to say that this objection is of high importance.

Opschoor (2000) concludes that the concept of ecological footprint is not the measuring rod we are searching for. EF is more a metaphor. Which is an interesting conclusion because Wackernagel et al. (1999) themselves claimed that their research differed so much with ‘awareness’ literature in that they applied biophysical units instead of money.

## 4.2 Experiences with ecological footprint

There is a fair amount of literature on ecological footprint. Almost in every country there is attention to the concept. There is a footprint quiz on www.myfootprint.org, and WWF pays continuously attention to footprints (http://www.panda.org/downloads/general/lpr2004.pdf).

## 4.3 Combinations of ecological footprint with other tools

Despite all critical remarks, there is something appealing in the concept of EF. That is the idea of indirect effects: how much are we directly and indirectly dependent on nature in our consumption and production? (Herendeen, 2000). The notion of dependence is of course taken from input−output analysis where we try to compute the multipliers related to an increase in final demand (consumption, investment and export). We may distinguish between production and employment multipliers, but also energy and, of course, space. Lenzen and Murray (2001) revised the EF principle to accommodate for input−output analysis. We consider this change as a major step towards an indicator based on actual land use instead of a hypothetical indicator. However, it still is not an indicator for (un)sustainability.

## 4.4 Strengths and limitation of ecological footprint

| **Strengths** | **Weaknesses/limitations** |
|---|---|
| Didactic strength | Not suitable to support policy making |
| Easy to communicate | Based on arbitrary assumptions and data, not including all environmental impacts |
| | Choice of $CO_2$ emissions is subjective |

## 4.5 Further work

Not described yet.

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