Ecological footprint

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The **ecological footprint** is a measure of human demand on the Earth's ecosystems, the amount of natural capital used each year. The footprint of a region can be contrasted with the natural resources it generates.[1]

A common type of footprint estimates the amount of biologically productive land and sea area necessary to supply the resources a human population consumes, and to assimilate the waste that population produces. At a global scale, this has been used by some ecological analysts to estimate how rapidly we are depleting limited resources, vs. using renewable resources. The Global Footprint Network, for instance, is an ecological organization that calculates a global ecological footprint from UN and other data, and publishes the result. They estimate that as of 2007, the planet uses up major ecological resources 1.5 times as fast as they are being renewed.

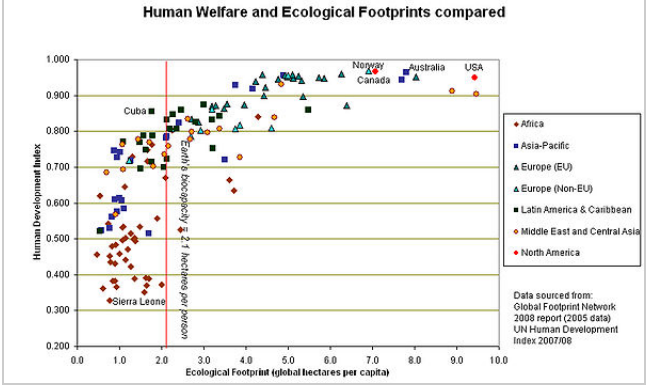
Contents

Footprint measurements

In 2007, the Global Footprint Network estimated the global ecological footprint as 1.6 planet Earths; that is, they judged that ecological services were being used 1.6 times as quickly as they were being renewed.[2]

Ecological footprints can be calculated at any scale: for an activity, a person, a community, a city, a region, a nation or humanity as a whole. Cities, due to population concentration, have large ecological footprints and have become ground zero for footprint reduction.[3]

There is no fixed way to measuring such footprints, and any attempts to describe the capacity of an ecosystem in a single number is a massive simplification of thousands of key renewable resources, which are not used or replenished at the same rate. However, there has been some convergence of metrics and standards since 2006.[4]



Ecological footprint for different nations compared to their Human Development Index.

Overview

The first academic publication about ecological footprints was by William Rees in 1992.[5] The ecological footprint concept and calculation method was developed as the PhD dissertation of Mathis Wackernagel, under Rees' supervision at the University of British Columbia in Vancouver, Canada, from 1990–1994.[6] Originally, Wackernagel and Rees called the concept "appropriated carrying capacity".[7] To make the idea more accessible, Rees came up with the term "ecological footprint", inspired by a computer technician who praised his new computer's "small footprint on the desk".[8] In early 1996, Wackernagel and Rees published the book *Our Ecological Footprint: Reducing Human Impact on the Earth* with illustrations by Phil Testemale.[9]

Footprint values at the end of a survey are categorized for Carbon, Food, Housing, and Goods and Services as well as the total footprint number of Earths needed to sustain the world's population at that level of consumption. This approach can also be applied to an activity such as the manufacturing of a product or driving of a car. This resource accounting is similar to life cycle analysis wherein the consumption of energy, biomass (food, fiber), building material, water and other resources are converted into a normalized measure of land area called global hectares (gha).

Per capita ecological footprint (EF), or ecological footprint analysis (EFA), is a means of comparing consumption and lifestyles, and checking this against nature's ability to provide for this consumption. The tool can inform policy by examining to what extent a nation uses more (or less) than is available within its territory, or to what extent the nation's lifestyle would be replicable worldwide. The footprint can also be a useful tool to educate people about carrying capacity and over-consumption, with the aim of altering personal behavior. Ecological footprints may be used to argue that many current lifestyles are not sustainable. Such a global comparison also clearly shows the inequalities of resource use on this planet at the beginning of the twenty-first century.

In 2007, the average biologically productive area per person worldwide was approximately 1.8 global hectares (gha) per capita. The U.S. footprint per capita was 9.0 gha, and that of Switzerland was 5.6 gha, while China's was 1.8 gha.[10][11] The WWF claims that the human footprint has exceeded the biocapacity (the available supply of natural resources) of the planet by 20%.[12] Wackernagel and Rees originally estimated that the available biological capacity for the 6 billion people on Earth at that time was about 1.3 hectares per person, which is smaller than the 1.8 global hectares published for 2006, because the initial studies neither used global hectares nor included bioproductive marine areas.[9]

A number of NGOs offer ecological footprint calculators (*see* Footprint Calculator, below).

Ecological footprint analysis is now widely used around the Earth as an indicator of environmental sustainability.[13] It can be used to measure and manage the use of resources throughout the economy. It can be used to explore the sustainability of individual lifestyles, goods and services, organizations, industry sectors, neighborhoods, cities, regions and nations.[14] Since 2006, a first set of ecological footprint standards exist that detail both communication and calculation procedures.

Methodology

The ecological footprint accounting method at the national level is described in the l Footprint Atlas 2010[15] or in greater detail in the Calculation Methodology for the National Footprint Accounts.[16] The National Accounts Review Committee has also published a research agenda on how the method will be improved.[17]

In 2003, Jason Venetoulis, Carl Mas, Christopher Gaudet, Dahlia Chazan, and John Talberth developed Footprint 2., which offers a series of theoretical and methodological improvements to the standard footprint approach. The four primary improvements were that they included the entire surface of the Earth in biocapacity estimates, allocated space for other (i.e., non-human) species, updated the basis of equivalence factors from agricultural land to net primary productivity (NPP), and refined the carbon component of the footprint based on the latest global carbon models.[18][19]

Studies in the United Kingdom

The UK's average ecological footprint is 5.45 global hectares per capita (gha) with variations between regions ranging from 4.80 gha (Wales) to 5.56 gha (East England).[11]

Two recent studies have examined relatively low-impact small communities. BedZED, a 96-home mixed-income housing development in South London, was designed by Bill Dunster Architects and sustainability consultants BioRegional for the Peabody Trust. Despite being populated by relatively "mainstream" home-buyers, BedZED was found to have a footprint of 3.20 gha due to on-site renewable energy production, energy-efficient architecture, and an extensive green lifestyles program that included on-site London's first carsharing club. The report did not measure the added footprint of the 15,000 visitors who have toured BedZED since its completion in 2002. Findhorn Ecovillage, a rural intentional community in Moray, Scotland, had a total

footprint of 2.56 gha, including both the many guests and visitors who travel to the community to undertake residential courses there and the nearby campus of Cluny Hill College. However, the residents alone have a footprint of 2.71 gha, a little over half the UK national average and one of the lowest ecological footprints of any community measured so far in the industrialized world.[20][21] Keveral Farm, an organic farming community in Cornwall, was found to have a footprint of 2.4 gha, though with substantial differences in footprints among community members.[22]

Critiques

Early criticism was published by van den Bergh and Verbruggen in 1999,[23] which was updated in 2014.[24] Another criticism was published in 2008.[25] A more complete review commissioned by the Directorate-General for the Environment (European Commission) was published in June 2008.[26] A number of countries have engaged in research collaborations to test the validity of the method. This includes Switzerland, Germany, United Arab Emirates, and Belgium.[27]

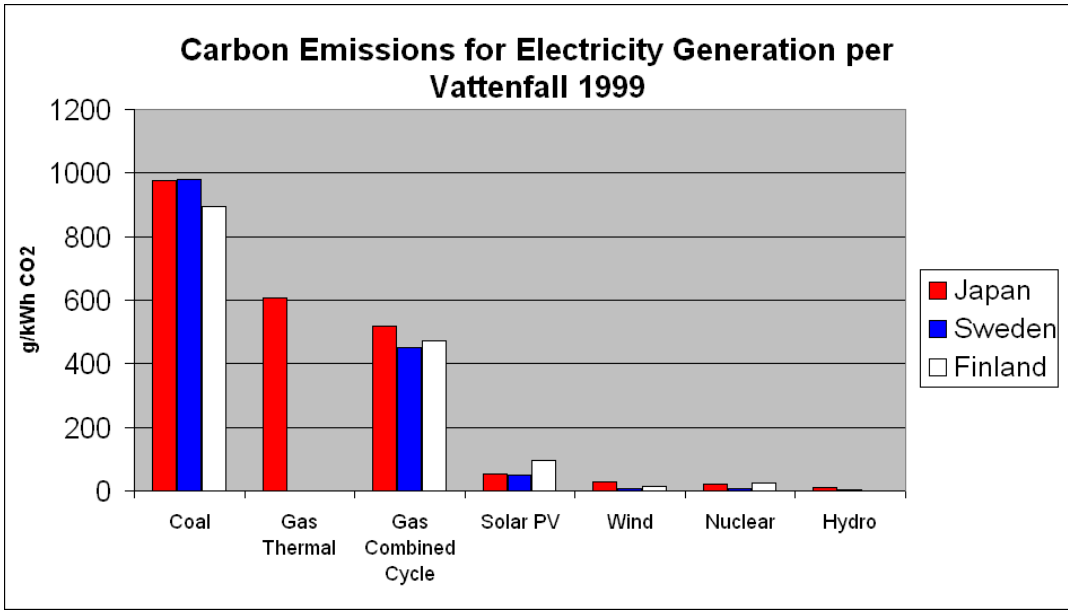
Grazi et al. (2007) have performed a systematic comparison of the ecological footprint method with spatial welfare analysis that includes environmental externalities, agglomeration effects and trade advantages.[28] They find that the two methods can lead to very distinct, and even opposite, rankings of different spatial patterns of economic activity. However this should not be surprising, since the two methods address different research questions.

Calculating the ecological footprint for densely populated areas, such as a city or small country with a comparatively large population — e.g. New York and Singapore respectively — may lead to the perception of these populations as "parasitic". This is because these communities have little intrinsic biocapacity, and instead must rely upon large *hinterlands*. Critics argue that this is a dubious characterization since mechanized rural farmers in developed nations may easily consume more resources than urban inhabitants, due to transportation requirements and the unavailability of economies of scale. Furthermore, such moral conclusions seem to be an argument for autarky. Some even take this train of thought a step further, claiming that the Footprint denies the benefits of trade. Therefore, the critics argue that the Footprint can only be applied globally.[29]

The method seems to reward the replacement of original ecosystems with high-productivity agricultural monocultures by assigning a higher biocapacity to such regions. For example, replacing ancient woodlands or tropical forests with monoculture forests or plantations may improve the ecological footprint. Similarly, if organic farming yields were lower than those of conventional methods, this could result in the former being "penalized" with a larger ecological footprint.[30] Of course, this insight, while valid, stems from the idea of using the footprint as one's only metric. If the use of ecological footprints are complemented with other indicators, such as one for biodiversity, the problem could maybe be solved. Indeed, WWF's Living Planet Report complements the biennial Footprint calculations with the Living Planet Index of biodiversity.[31] Manfred Lenzen and Shauna Murray have created a modified Ecological Footprint that takes biodiversity into account for use in Australia.[32]

Although the ecological footprint model prior to 2008 treated nuclear power in the same manner as coal power,[33] the actual real world effects of the two are radically different. A life cycle analysis centered on the Swedish Forsmark Nuclear Power Plant estimated carbon dioxide emissions at 3.10 g/kWh[34] and 5.05 g/kWh in 2002 for the Torness Nuclear Power Station.[35] This compares to 11 g/kWh for hydroelectric power, 950 g/kWh for installed coal, 900 g/kWh for oil and 600 g/kWh for natural gas generation in the United States in 1999.[36] Figures released by Mark Hertsgaard, however, show that because of the delays in building nuclear plants and the costs involved, investments in energy efficiency and renewable energies have seven times the return on investment of investments in nuclear energy.[37]

The Swedish utility Vattenfall did a study of full life cycle emissions of Nuclear, Hydro, Coal, Gas, Solar Cell, Peat and Wind which the utility uses to produce electricity. The net result of the study was that nuclear power produced 3.3 grams of carbon dioxide per KW-Hr of produced power. This compares to 400 for natural gas and 700 for coal (according to this study). The study also concluded that nuclear power produced the smallest amount of CO_2 of any of their electricity sources.[38]



Claims exist that the problems of nuclear waste do not come anywhere close to approaching the problems of fossil fuel waste.[39][40] A 2004 article from the BBC states: "The World Health Organization (WHO) says 3 million people are killed worldwide by outdoor air pollution annually from vehicles and industrial emissions, and 1.6 million indoors through using solid fuel."[41] In the U.S. alone, fossil fuel waste kills 20,000 people each year.[42] A coal power plant releases 100 times as much radiation as a nuclear power plant of the same wattage.[43] It is estimated that during 1982, US coal burning released 155 times as much radioactivity into the atmosphere as the Three Mile Island incident.[44] In addition, fossil fuel waste causes global warming, which leads to increased deaths from hurricanes, flooding, and other weather events. The World Nuclear Association provides a comparison of deaths due to accidents among different forms of energy production. In their comparison, deaths per TW-yr of electricity produced (in UK and USA) from 1970 to 1992 are quoted as 885 for hydropower, 342 for coal, 85 for natural gas, and 8 for nuclear.[45]

Footprint by country

The world-average ecological footprint in 2012 was 1.8 global hectares per person. The average per country ranges from over 10 to under 1 hectares per person. There is also a high variation within countries, based on individual lifestyle and economic situation.[46]

The GHG footprint differs from the ecological footprint in that the former is expressed in units of GHG warming potential (GGWP) and is generated by products or services, whereas the latter is expressed in units of land area and is generated by whole societies.[47]

Implications

> . . . the average world citizen has an eco-footprint of about 2.7 global average hectares while there are only 2.1 global hectare of bioproductive land and water per capita on earth. This means that humanity has already overshot global biocapacity by 30% and now lives unsustainabily by depleting stocks of "natural capital"[48]

See also

- Carbon footprint
- Dependency theory
- Ecological Debt Day
- Ecological economics
- Ecosystem valuation
- Environmental impact assessment
- Greenhouse debt
- Greenhouse gas emissions accounting
- Happy Planet Index
- Life cycle assessment
- *Limits to Growth*
- List of environmental issues
- Netherlands fallacy
- Physical balance of trade
- *The Population Bomb*
- Simon–Ehrlich wager
- Water footprint

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Since the 1950s, a new geological epoch called the Anthropocene has been proposed to distinguish the period of major human impact.[1]

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External links

- Global Footprint Network *Ecological Footprint : Overview* (http://www.footprintnetwork.org/gfn_sub.php?content=footprint_overview)
- WWF "Living Planet Report" (http://www.panda.org/livingplanet/), a biannual calculation of national and

global footprints
- Life Cycle Assessment, introduction (http://lca.jrc.ec.europa.eu/lcainfohub/introduction.vm)
- *US Environmental Footprint Factsheet* (http://css.snre.umich.edu/css_doc/CSS08-08.pdf)
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