



An overview on ecological footprint and sustainable development: a chat with Mathis Wackernagel

M. Wackernagel¹ and A. Galli²

¹Global Footprint Network, Oakland, CA, USA.

²Department of Chemical and Biosystems Sciences, University of Siena, Siena, Italy.

INTRODUCTION

Building on human carrying capacity debate [1–5] in the early 1990s, Mathis Wackernagel and William Rees introduced a new environmental accounting method, the Ecological Footprint [6, 7], to measure human demand on the biosphere.

After the 1992 Earth Summit in Rio [8] the need to reduce human impact on the Earth became undeniable and widely recognized. What Wackernagel and Rees proposed was a method capable of making global ecological limits accessible by comparing human demand on the biosphere to its regenerative capacity. The method does this by expressing both resource demand and supply in terms of area necessary to support these flows [9].

The use of an area as a measure of life-supporting natural capital was chosen to underline that many basic ecosystem services and ecological resources are driven by areas where photosynthesis takes place [10], showing in this way how humanity is constrained by nature's negentropic capacity to transform low quality solar energy into high quality chemical energy and living matter.

In the following interview with Mathis Wackernagel, we explore how Ecological Footprint puts in practice the principles of sustainability identified by Herman Daly [11], namely that: 'For the management of renewable resources there are two obvious principles of sustainable development. First that harvest rates should equal regeneration rates (sustained yields). Second that waste emission rates should equal the natural assimilative capacities of the ecosystems into which the wastes are emitted. Regenerative and assimilative capacities must be treated as natural capital, and failure to maintain these capacities must be treated as capital consumption, and therefore not sustainable.'

INTERVIEW

Alessandro Galli (AG): What got you interested in sustainability and ecological overshoot?

Mathis Wackernagel (MW): When I was 10 years old, *'Limits to Growth'* woke humanity up to the possibility of global overshoot and collapse. While the book was certainly beyond my level of comprehension, my father recognized its importance and explained its graphs to me. This was the seed in my mind: What are the long-term consequences of an ever-expanding human enterprise on a finite, living planet?

Enthused by appropriate technology, 'small is beautiful', and the emergence of renewable energy, I became an energy-systems engineer. Soon I recognized that the origin of environmental problems, mainly humanity overshooting the regenerative capacity of the planet, was not technical, but largely one of mindset. Without corrective feedback, any system self-destructs and indeed, humanity was not getting adequate feedback about ecological overshoot. Developing a tool for dealing with overshoot became a reality for me when I got a scholarship for regional planning at the University of British Columbia in 1989. This is where I met Bill Rees.

AG: Since its introduction the Ecological Footprint has been used by a growing number of scientists, government authorities, local administrations, agencies, organizations and communities. What's new about the Footprint? There has been a long debate on carrying capacity before stretching back through the entire history of economics ...

MW: The Footprint is one of the first comprehensive attempts to measure human carrying capacity not as a speculative assessment of what the planet might be able to support, but as a description of how many planets it actually takes in any given year to support human demand on resources in that given year. Comparing ecological supply to human demand is really a simple idea but had not been done – and when we put out our first concept papers, they were passed on from one NGO to the next. Particularly in the aftermath of the 1992 Rio Conference, NGOs started to promote the Ecological Footprint with enthusiasm and it nearly grew on its own.

AG: How did you move forward once you established the concept with William Rees?

MW: After finishing my PhD in 1994, this interest in the Footprint opened opportunities for me. My first stint was in Costa Rica with Earth Council and then I moved on to found a small Center for Sustainability Studies in Mexico, at a local university. Four years in Latin America gave me an appreciation of the world from a southern perspective.

Over the last 15 years of Footprint work, finding suitable funding has at times been a struggle – the resistance to the simple idea of 'there is only one planet Earth' has always been puzzling to me. But this also makes this quest exciting – it's the most fascinating and relevant puzzle to solve. I am so smitten by it that I have not swayed from addressing the question, only adjusted the strategies.

On the path, I have learned to take a more compassionate approach, towards others as well as toward myself. I recognized the importance of being inviting rather than preachy, lighter rather than stubborn. The challenge needs to be presented as factual and non-judgmental as possible in order not to alienate people or to put them on the defensive.

In the course of the years, I have lectured for community groups, governments and their agencies, NGOs, and academic audiences at more than 100 universities around the world. As a result, the interest is growing steadily.

AG: Despite this general increase in environmental awareness, 14 years after the Rio Conference and four years after the United Nation Summit in Johannesburg human unsustainability is still an open

subject of debate and many environmental problems are still unsolved. What does the Ecological Footprint tell us?

MW: Humanity is now consuming more than the Earth can produce. Our economies operate as if ecological resources are limitless, without recognizing that this ever-increasing consumption is undermining the Earth's ability to provide for us all. Today, humanity's demand on nature, its Ecological Footprint, is 25% greater than the planet's ability to meet this demand. It now takes the Earth one year and three months to regenerate what we use in a year. This global 'ecological deficit' or 'overshoot' is depleting the natural capital on which both human life and biodiversity depend.

The consequences of this environmental pressure are already evident. Collapsing fisheries, loss of forest cover, depletion of fresh water systems, accumulation of CO₂ in the atmosphere and the build-up of wastes and pollutants are just a few noticeable examples. If continued, overshoot will permanently reduce the Earth's ecological capacity and lead to ecological collapse and social misery.

While these trends affect us all, they have a disproportionate impact on the poor, who cannot buy themselves out of the problem by getting resources from elsewhere. To reverse this trend, it is imperative that individuals and institutions all around the world recognize the reality of ecological limits and start making decisions consistent with these limits. By scientifically measuring the supply of and demand for ecological assets, expressed in hectares of land area, the Ecological Footprint provides a resource accounting tool which reveals ecological limits, helps communicate the risk of overshoot, and facilitates sustainable management and preservation of the Earth's critical ecological assets.

AG: From a thermodynamic perspective, why don't you just use energy rather than hectares as the measurement unit?

MW: Surface is a good indicator for life because it is where life happens (and we can map everything happening above and below it to a surface, much like a classical map does). In other words, we could say that the Earth is the biggest solar collector available: its surface captures solar energy that, through photosynthesis, can produce biomass. There need to be other conditions as well (enough water, etc.,) to sustain life but surface is a limitation and it is probably a good first approximation for measuring biocapacity. We go a step further since we are not measuring in hectares, but global hectares. In other words, we adjust each surface according to its productivity. One hectare of Sahara, even though it receives a lot of sun, does not represent the same productivity as one hectare of Amazon forest. Amazon forest has a much higher ability to regenerate biomass, so we count it as more global (i.e. standardized) hectares according to our mechanics system. But then again, why surface, why not energy?

Energy can be very confusing because through the energy cascade from the initial solar flux to the final carrot we eat we have enormous differences in energy. The sun powers the Earth with about 1.75E+05 TW constantly but some of this has been reflected in the stratosphere from clouds, etc. and therefore not everything reaches the ground. But that is the power we get from the sun. Now these 1.75E+05 TW are translated through photosynthesis into a Net Primary Productivity (NPP) of the planet of perhaps 100 or 200 TW, about 1000 times less. And, not all of NPP is usable; we have to ask: 'how much of that become food for us?' Human food production uses about 40% of the biological capacity of the planet, and that corresponds, in a first approximation, to a food intake of 2,500 Kcal/day per person. Considering a world population of 6.5 billion people, this leads to an amount of less than 1 TW – again about a factor of 100 less than the NPP. At what stage in the energy cascade do we measure? How do we make sure people do not confuse solar Watts with NPP Watts, or food Watts?

Also, if we provide results in TW people do not understand what a TW means but if the results are provided in hectares, or acres, people can easily understand how big they are, since 1 acre is the

extent of a soccer field. So the cascade effect, the quality effect, the exergy effect or the entropy effect is directly captured by considering the quality of the area to capture the energy and make some useful biomass out of it. For some scientists, our approach may be a bit confusing since we are measuring a flow in terms of the stock necessary to provide this flow. Just think of it like this: consuming 10 kg of tomatoes a year means continuously occupying a few square meters of garden space that can grow these tomatoes.

So that is why I think, from an accounting perspective, it is easier to use hectares, and it doesn't lead to that easy confusion that we have when looking at energy flows or energy cascades, where the energy quality leads to a very rapid reduction in the available energy from $1.75E+05$ TW down to 1 TW, and where confusion can arise easily when one Watt is compared to another Watt.

AG: In the last months the Living Planet Report 2006 [12] and the Stern Review [13] have been released providing a clear and undeniable understanding of the environmental and economic consequences of human activities. At the same time, despite the fact that some important questions regarding the Kyoto Protocol have still to be solved, climate change problems are becoming more and more significant. Has the time come to really do something about sustainability?

MW: Again it is interesting if we look back at *Limit to Growth*, at the curves that were generated in 1972. People say they were discredited, though now they are becoming recognized as actual curves. When you look at, for example the Stern Report curves of how soon we have to reduce our CO₂ emissions in order to not exceed the 450 ppm threshold, the curves have their inflection points pretty much at the same place as in the 1972-study. Or if you look at the peak oil curves, for example the Shell curves, again they are extremely congruent with the *Limits to Growth* curves. The same curves are in the Living Planet Report 2006 showing how fast we need to get out of overshoot in order not to liquidate our planet. For some time we can be in overshoot but not for too long because the capital stock on which we can liquidate for some time is limited.

I believe I have seen a switch in public opinion over the last few years from debating limits to now feeling so overwhelmed by the limits that many think that we can't do anything about it. We are now faced with more cynicism, or defeatism, that we can't do anything about the situation. 'Cynicism' does not want to take the situation seriously and 'defeatism' recognizes the challenge but is overwhelmed by what is needed.

If we had recognized these challenges earlier it would have been easier. Achieving sustainability is not a binary event, but one of degree: how much suffering can we avoid and of course, the earlier we do turn around the easier it will be. There is no indication why it should be easier in the future than today, so the earlier we do it the better.

AG: In their text book *Ecological Economics: Principles and Application* [14] Herman Daly and Joshua Farley report: 'This is not a textbook in the above sense, because ecological economics is not a discipline, nor does it aspire to become one. For lack of a better term, we call it a *transdiscipline*. We think that the disciplinary structure of knowledge is a problem of fragmentation, a difficulty to be overcome rather than a criterion to be met. Real problems do not respect academic boundaries. We certainly believe that thinking should be "disciplined" in the sense of respecting logic and facts, but not "disciplinary" in the sense of limiting itself to traditional methodologies and tools that have become enshrined in the academic departments of neoclassical economics'. What is your position regarding the Daly and Farley *transdiscipline* and the integration of knowledge?

MW: What we are doing is building bridges between cultural perspectives. That is why we are in the United States and operate in Europe, Africa, Australia and Asia. The overshoot story has to be explained and told in ways that resonate with people from different cultures. We are also building

bridges between different disciplines – we are not even implanted in a particular discipline. Perhaps in John Stuart Mill's time, he would have put us in economics, but current economists wouldn't see us in that way. We are not chemists either even though we work in thermodynamics. We are not earth scientists because we don't study how the Earth works; we are just doing the accounting that brings together human demand and ecological supply. So we are a bridge between the various disciplines, an accounting mechanism to document outcomes so that modeling and more sophisticated approaches become possible.

Just as economics uses GDP as a baseline for then testing their models about how they think the economy works, there needs to be some accounting method to test the sustainability models against. Then we can play with scenarios and models to find out what kind of intervention would help to make human enterprise compatible with ecological realities.

Generally, I think disciplines separate us and we need to find ways to be much more problem focused than method driven, and that is why probably rigid academic disciplines are not that useful for the twenty-first century.

AG: Is the Footprint a full sustainability measure?

MW: No, the Footprint only addresses one key aspect of sustainability, namely how much of the biosphere's regenerative capacity is occupied by human activities. It needs to be complemented by other measures for a full sustainability assessment. The Footprint has possibly become the world's most cited sustainability indicator. Indeed, without addressing the question of how much nature there is and how much nature we use, the quest for sustainability becomes futile. It is this very question that distinguishes development from sustainable development.

AG: How does the Ecological Footprint fit within the Ecological Economics theory?

MW: At the core of Ecological Economics there is the idea of scale. We have to look at how big the economy is compared to the biosphere. Now that is exactly what the Footprint looks at. I mean, the Footprint is just a name, the name for a research question which is: how much of the regenerative capacity of the planet is occupied by the human activities? That is all we are looking at.

As the science matures, all the different answers to the research questions will converge. We are much ahead now from where we were 15 years ago in developing the method so our answers are getting more consistent. Our science is maturing.

So in essence, scale is certainly a key concern of Ecological Economics. The Footprint helps frame the questions. As a result we can make sustainable development much more specific than we ever could before. Because even though sustainable development as a term is probably misused 99 times out of 100, if it is used we can say 'come to my office, let's see to what extent we are achieving what you are saying you want to achieve'.

What we want to achieve is development, meaning probably for most people who want to have development, to have great lives. There are different methods to measure that: United Nations uses the Human Development Index (HDI) which is probably limited, but still I don't know anybody who wants to live on less than 0.8 HDI because that means shorter lives, little access to education and very minimal incomes. The HDI doesn't cover everything but it's a good first approximation of a minimal condition: an HDI 0.8 is a threshold for high human development according to the United Nations Development Programme (UNDP). And in addition, we need to ask: 'how can we achieve this within the capacity of the planet, i.e. an ecological budget of 1.8 global hectares per person?' That's what we have available today, including the space for wild species. And it will be less per person as the human population grows.

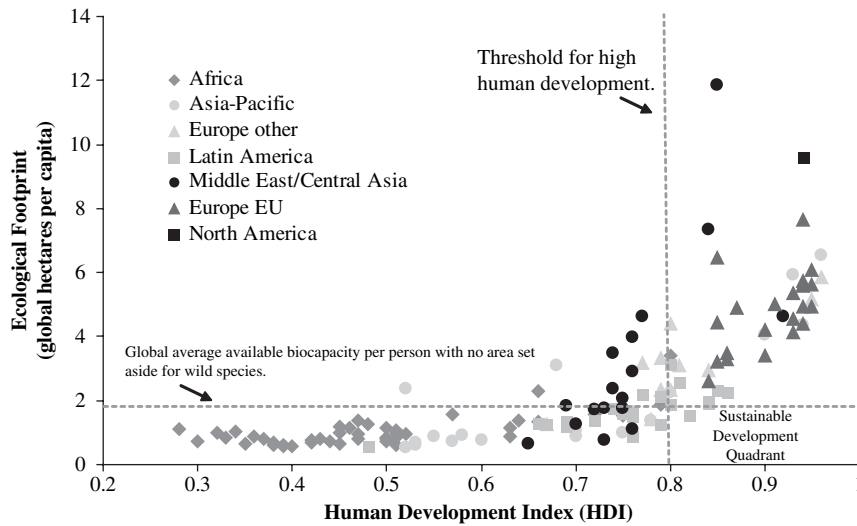


Figure 1: Sustainable development can be assessed using the Human Development Index (HDI) as an indicator of socio-economic development and Ecological Footprint as a measure of human demand on the biosphere. The United Nations considers an HDI of over 0.8 to be 'high human development'. An Ecological Footprint less than 1.8 global hectares per person makes a country's resource demands globally replicable. Despite growing adoption of sustainable development as an explicit policy goal, most countries do not meet both minimum requirements.

It doesn't take a rocket scientist to find out how much capacity there is on the planet. You can do that on your kitchen table. You find out how big the planet is, 51 billion hectares of surface, and consider that about a quarter of it is highly productive. You can see what I mean on any high school map of the world. Divided by the 6.5 billion people on the planet, it makes about 1.8 hectares per person. That's the budget we have available per person in the world.

Essentially sustainable development means this cross section between how we can provide a high development, meaning higher than 0.8 HDI, using at the same less than 1.8 global hectares. This puts us in a 'box' and we have to learn how to 'think inside the box'; that is the new challenge. Here in the graph (Fig. 1) most countries haven't met that challenge. Globally, in order not to liquidate this planet, we need to move into the box – but this doesn't mean it is individually desirable to be in the box. It is merely a necessary condition for humanity if we don't want to liquidate the biosphere. This is the question that Ecological Economics tries to resolve: how we can build a system that moves us in this direction.

AG: Despite the Ecological Footprint's wide use it is not yet officially recognized as a national planning and resource managing indicator. What does the Global Footprint Network propose?

MW: In 2003 we launched (in collaboration with my wife Susan Burns) Global Footprint Network with the mission of ending global overshoot by bringing ecological limits to the center of decision-making everywhere. Over the last three years it has grown rapidly, now including over 70 partner organizations from around the world. Global Footprint Network, of which I am the executive director,

began out of the spare bedroom in our house and bloomed into a \$1 million organization within three years with 15 staff and presence in both Oakland (California) and Zurich (Switzerland).

In 2005 we set a specific, ambitious goal: 'Ten-in-Ten' institutionalizing the Ecological Footprint in at least ten key nations by 2015. Our aim is to have ecological accounting given as much weight as economic accounting, with the Ecological Footprint as prominent a metric as the gross domestic product (GDP). This will allow nations to systematically account for and manage their ecological assets, and to measure their progress towards sustainability in tangible ways.

Institutionalizing the Ecological Footprint at the national level requires acceptance by statistical offices, policy advisors, academia and businesses of the methodology and data underlying the Footprint. To influence these decision makers and accomplish our overarching mission, we are working with 73 partner organizations around the world to carry out four key programs:

- **National Footprint Accounts Research:** We maintain and update the National Footprint Accounts from 1961 to the present for 152 nations. These accounts provide the underlying data sets for all Footprint analyses worldwide. We coordinate the research necessary to refine these accounts.
- **Standards:** The adoption of the Ecological Footprint is dependent on Footprint analyses being conducted consistently and rigorously, and the results being reported in an unbiased manner. Therefore, we have created a consensus-based process for establishing standards governing all Ecological Footprint calculations worldwide. The first Ecological Footprint standards were launched in June 2006.
- **Network Building and Outreach:** We are building a network of the world's leading practitioners and institutions, which are working to advocate the Ecological Footprint. The network now includes 73 partner organizations on six continents. Through our newsletter, website, training and media work we are sparking a global dialogue about ecological limits and overshoot.
- **Applications:** Working with our partner organizations we are applying the Ecological Footprint in innovative ways in education, business and government. These applications create recognition of overshoot, demand for action and tools to drive institutional change.

We carry out all of our programs in active collaboration with our partners. Our diverse partner network includes the key players worldwide that are using the Ecological Footprint in education, government, business and academia, such as WWF with 5 million supporters, ICLEI with 475+ member cities worldwide, and government agencies such as the Ministry of Environment in Finland and EPA Victoria in Australia. Our partners make the Ecological Footprint relevant and practical in the countries in which they operate, create innovative applications, and through their collaboration with us and each other, increase penetration of the Footprint across the globe. Partners participate in our standards committees, and pool resources in innovative projects that accomplish much more than any one of us could on our own.

AG: Are you an advocacy or a scientific research organization?

MW: I use advocacy only for promoting my research question, and science for answering the question. This makes the venture stable and harder to undermine.

Also, I have kept a sharp purpose based on a simple premise which has intrigued me since early adulthood: we cannot secure human well-being if we systematically liquidate our ecological assets on which all life depends. There is only one life-supporting planet available to humanity and ultimately, undermining this support system results in unacceptable levels of human suffering.

While this premise is indisputable, current economics, politics, and lifestyles typically ignore it. We continue to resolve all problems through 'providing more'. This dilemma has driven me to seek answers to what I believe to be the most decisive questions of our time: Why have we failed in the

past to address these obvious issues? How can we build momentum now? Who are our friends? Who needs to be avoided? How can we build buy-in while maintaining a sharp focus?

For my entire professional life, I have dedicated myself to helping build a just and sustainable world. I feel deeply rewarded by the wave we have been able to build, and from seeing the growing potential of catalyzing a global shift in perception about ecological limits.

AG: How can citizens and national authorities interact to create a sustainable future? What is your theory of social change?

MW: To gain the greatest leverage, we target decision makers within large institutions that have significant influence over the allocation of financial resources and the direction of human endeavor. We therefore focus on multi-national agencies, national and local governments, and businesses. Our Ten-in-Ten Campaign represents the practical expression of our theory of change: building national commitment in ten key countries to take responsibility for ending ecological overshoot.

With the Ecological Footprint, large institutions can measure their overall demand on the biosphere, assess their sustainability performance, set realistic targets, monitor projects and programs, communicate successes and, by comparing scenarios, identify implications of their choices. The Footprint also allows them to establish policy and budget priorities that encourage large Footprint reductions. By providing these actors with a common framework and metric that works at all geographic scales, the Ecological Footprint enables comparisons, communication and concerted action – all in service of sustainability.

Large-scale, systemic social shifts will come from local, national and international institutions assuming responsibility for ending overshoot. This makes our initiative a good ‘return on investment’: institutionalizing the Footprint, first in 10 countries and then as a globally accepted metric, might cost \$50–100 million over 15 years. If we are successful at instilling this sense of responsibility for ending overshoot in large institutions, the results will also be large. This could stimulate the \$1–5 trillion of annual investments it may take to bring humanity out of overshoot. Not investing this money will be far more expensive. In other words, every dollar invested in institutionalizing the Footprint now is intended to catalyze over \$100,000 worth of future investments in sustainability. This means that, if our efforts are successful, we will generate a 100,000-fold return on our initial investments.

We also believe that institutionalizing robust, relevant information about ecological limits, combined with a positive vision for the future, will inspire innovation and action. Further, by providing Footprint results in as neutral and trustworthy a fashion as possible, without imposing our own interpretation of the data, more individuals and institutions will take it on, creating ripple effects throughout society. For example this has happened within the European Commission, where the support of one department has led to other departments adopting the Footprint. Now we are in close contact with the European Environment Agency, Eurostat, and various groups within the European Commission, and the Footprint has been integrated into the EU’s sustainable development strategy. In essence, our work advances the Ecological Footprint and communicates a positive vision that humanity can live well, within the means of one planet Earth.

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