



Reply to the first systematic response by the Global Footprint Network to criticism: A real debate finally?



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ABSTRACT

We respond to a reaction of the Global Footprint Network/GFN on our 8-point criticism of the ecological footprint. We also refer to, and comment on, an associated debate in this journal between [Giampietro and Saltelli \(2014a, 2014b\)](#), on the one hand, and [Goldfinger et al. \(2014\)](#), on the other. We conclude that criticism on the footprint is accumulating and coherent across the various studies and disciplines and among the different authors. This was the first time that Wackernagel/GFN systematically responded to our criticisms. Hence, our response contains several original elements and the resulting exchange can be seen to add value to the existing literature. It ultimately allows readers to better make up their mind about the different viewpoints on the ecological footprint.

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1. Introduction

The ecological footprint is perhaps the best known and most used environmental indicator worldwide. A superficial observer might therefore interpret it as a reliable measure of environmental pressure or unsustainability. However, the criticism on it is gradually accumulating ([Gordon and Richardson, 1998](#); [van den Bergh and Verbruggen, 1999](#); [VROMraad, 1999](#); [Ayres, 2000](#); [Moffatt, 2000](#); [Opschoor, 2000](#); [van Kooten and Bulte, 2000](#); [EAI, 2002](#); [Grazi et al., 2007](#); [Lenzen et al., 2007](#); [Fiala, 2008](#); [van den Bergh and Grazi, 2010](#); [Blomqvist et al., 2013a, 2013b](#)).¹ These various studies seem to agree on the main shortcomings, summarized recently in [van den Bergh and Grazi \(2014a\)](#) in the form of 8 main points:

1. False concreteness
2. Global hectares: Adding to the hypothetical character of the ecological footprint
3. A case of “land value theory”: Land use as a proxy of environmental pressure
4. Incompleteness in terms of capturing relevant environmental pressures
5. Aggregation through unfounded, implicit weights
6. Carbon sink land resulting from an arbitrary “sustainable energy scenario”
7. Countries versus “bioregions”
8. Ecological deficit and antitrade sentiments

[Wackernagel \(2014\)](#) commented on [van den Bergh and Grazi's \(2014a\)](#) article, but avoided to systematically respond to these eight concerns and instead raised four different questions. In our counter-response ([van den Bergh and Grazi, 2014b](#)) we addressed his four questions, but concluded that Wackernagel finally did not respond to seven of the eight criticisms and did not seriously engage with our arguments in a separate section on the policy irrelevance of the footprint. To our surprise, immediately after the publication of the journal issue in which our article and his first response appeared, Wackernagel published a second – more systematic and more clarifying – response to our eight criticisms on the website of his Global Footprint Network (GFN) ([Wackernagel et al.,](#)

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¹ We could add here a large number of studies applying the ecological footprint that include (minor or major) changes in its methodological assumptions. In effect, such studies implicitly levy criticism on certain aspects of the footprint method. Major studies in this respect are mentioned in [van den Bergh and Grazi \(2014a\)](#). Note further that over time Wackernagel and his Global Footprint Network have frequently altered the assumptions of the method. All this means that much care is needed in comparing footprint estimates between studies or over time.

2014). We wrote a reaction to this and asked him to post it on this website too, but got a negative reaction. To contribute to better construction and use of environmental indicators, and learn from the mistakes of the footprint, we offer below this detailed reaction to GFN/Wackernagel. We further comment on related interactions on the ecological footprint in this journal between representatives of the GFN (Goldfinger et al., 2014) and Giampietro and Saltelli (2014a, 2014b). The latter authors present a very fundamental criticism of the footprint, adding several points to the above 8-point list. Below, text in *Italics* is the GFN's response to van den Bergh and Grazi (2014b), which was posted on its website (see Wackernagel et al., 2014), while our detailed reaction to their response is in normal letter type.

One might be inclined to think that this debate just involves a repetition of arguments. But in fact, as this was the first time that Wackernagel/GFN systematically responded to our criticisms, our response contains several original elements. The resulting exchange can therefore be seen to add value to the existing literature, and to allow readers to better make up their mind about the distinct viewpoints.

2. The Ecological Footprint method represents “false concreteness”

GFN say: van den Bergh and Grazi claim that Footprint accounting compares “real” land area with “hypothetical” land area, and this represents a “false concreteness” of the method. The core of their claim is based on a common misconception about the Footprint methodology, in their words “that the [Ecological Footprint] method calculates the land area used by a human activity or economy as if they were sustainable, meaning that certain types of environmental, negative externality (e.g., pollution) have to be neutralized. This neutralization then translates into land area (used). Shifting from an unsustainable situation to a sustainable one requires a set of assumptions, which render the result, in terms of land use, hypothetical in nature.”

In fact, Footprint methodology makes no assumptions about the sustainability of human demands on a land area, nor does it “neutralize” negative externalities in the calculations. If it did, it would indeed be a hypothetical, predictive measure. Instead, it is simply descriptive, with both Footprint and biocapacity results based on actual measured values of current ecosystem productivity, including both resource production and carbon sequestration, without assessing whether other factors may make this level of productivity unsustainable in the future.

Our reply: The footprint approach makes many assumptions as we discuss in our original article (van den Bergh and Grazi, 2014a). To illustrate one that has an immense impact on the outcome: Carbon sequestration is assumed to occur only through forestation in the footprint calculations. But it can be realized in many ways, even without forests that use a lot of land. Carbon sequestration is not even needed if one reduces CO₂ emissions by replacing fossil fuels by renewable energy, which implies other values of land use per ton of CO₂ than the footprint assumptions. The result would be a different size footprint for many countries, notably as the carbon sequestration is responsible for about half of the footprint of many rich countries.

GFN say: In addition, they argue that because “Obviously, real land use could never exceed available land area,” the fact that the Footprint can overshoot biocapacity reveals the “unrealness” of this measurement. This is a perplexing comment. Ranchers, for example, who must ensure that there is sufficient feed for their herds, calculate the ability of available land to support cattle in “cow-calf acres” or “animal units,” taking into account both the number of hectares on their ranch and the average productivity per hectare. This rangeland management methodology parallels that of the Ecological Footprint,

with the latter taking into account human demand on cropland, forest and fishing grounds in addition to that on grazing land, and expressing this in a measure reflecting the average productivity per hectare of all these areas combined. Just as a ranch may not produce a sufficient flow of grass to keep up with the demands of a herd, so too a biologically productive area (a nation or the whole planet, for example), may not produce a sufficient flow of resources to keep up with human demand. This does not make overshoot hypothetical, however, it just means that demand will be met by dipping into prior years' accumulated flows (stocks of timber or fish, for example), or by allowing carbon emissions to go unsequestered and thus accumulate in the atmosphere.

Our reply: The problem here is that land use is confused with stocks. The confusion is introduced by the sentence “This does not make overshoot hypothetical, however, it just means that demand will be met by dipping into prior years' accumulated flows”. The second part of the sentence clarifies that overshoot is hypothetical, or is just an analogy for reducing stocks (accumulated flows). Note that in the rangeland example actual land use can never exceed actual land availability. So the analogy is not convincing. Note that Giampietro and Saltelli (2014a, p. 8) make various comments about the inconsistency of stocks and flows in the footprint approach.

GFN say: There is nothing hypothetical about these stocks or carbon accumulation, even if expressed in global hectares, a proxy representing the area of land required to produce these stocks or sequester the accumulated carbon. One would hardly make the argument that because distance is converted into abstract units called “meters” that this measurement is hypothetical rather than real. For any measurement, “the map is not the territory;” if van den Bergh and Grazi feel the Footprint accounting has an issue with false concreteness simply because it attributes a biocapacity value to surface areas, then they must have a gripe with any metric.

Our reply: A meter is always a meter, but a “global hectare” is not always a hectare. We criticize comparing hypothetical land use with hypothetical land availability. Overshooting of land use could not happen if real land use would be compared with real land supply. The first would always be limited by the latter. Laypersons like the footprint because it suggests something concrete, but it turns out to be misleading as it is all about virtual and hypothetical measures, both on the “demand and supply sides” of the footprint analysis. This is why we refer to “false concreteness”. Giampietro and Saltelli (2014a) affirm this problem, referring to “virtual hectares” of land. As a reviewer suggested, an additional complication arises from multi-functionality and multiple uses. These can mean that the footprint is further biased (for a discussion, see van den Bergh and Verbruggen, 1999, Section 3.2).

3. The use of global hectares contributes to the hypothetical character of the Ecological Footprint

GFN say: In addition to their qualms discussed above, van den Bergh and Grazi argue that the fact that a global hectare may represent a varying amount of productivity each year contributes to its hypothetical nature. This is a bit like saying that because a dollar may vary in purchasing power each year, it is a hypothetical rather than a real measure of financial wealth.

Our reply: Wackernagel/GFN proposes another incorrect analogy here. We are discussing land, which has a very clear interpretation: square meter, kilometer or hectare. It is not variable, unless land is taken by the water (flooded). Or a specific area of land can be turned into another use, so that the area for the first function is reduced in amount. But mixing productivity and

area size is confusing and just makes the entire footprint unclear, difficult to understand and easy to misinterpret. This stretches the common meaning of the words “land” and “hectare”. It would better be given another name to avoid any confusion with normal, concrete, fixed land area. Giampietro and Saltelli (2014a, p. 8) state the same criticism as follows: “What is measured in the NFA protocol are densities of virtual flows produced by generic virtual global hectares”.

GFN say: A global hectare is a hectare of productive land with the average resource flow of all productive area on the planet. Because this average flow varies somewhat from year to year, so too does the value of a global hectare in terms of the actual resource productivity it represents. But because both demand (Ecological Footprint) and the capacity to meet this demand (biocapacity) are measured in this same unit, when calculating the degree of overshoot the effects of any annual variation will cancel. To allow direct comparison of actual productivity or demand across years, more recent Footprint accounts have been expressed in “constant global hectares” based on a given reference year, much in the same way that “constant US dollars” are used to hold purchasing power constant in comparisons across years.

Our reply: Wackernagel/GFN's comparison with money is misplaced. Then it is better not to refer to land at all, but rather to biomass (or something similar). A given area of land can produce different amounts of biomass in different years. So biomass is variable, while land is fixed. (Note that this is not meant to suggest that some biomass overshoot indicator would be a good proxy of a variety of environmental problems).

4. Footprint accounting implies that land use is the all-important sustainability variable

GFN say: Any indicator in widespread popular use is invariably subject to distortion or misinterpretation—this is hardly unique to the Footprint. While it is not clear (since they provide no references) where van den Bergh and Grazi are seeing an “[Ecological Footprint] assumption that all (important) environmental impacts of humans can be captured or approximated by land use” it is surely possible that this erroneous claim exists somewhere in the universe of print and online media. This does not mean, however, that it represents the position of Global Footprint Network, which has repeatedly emphasized that Footprint accounting measures only a single dimension of human pressure on the biosphere—human demand on the regenerative capacity of the Earth's productive areas—while stressing the importance of including other variables, such as those impacting the fragility of biocapacity and those such as the HDI that track important human development variables, in an attempt to provide a more complete and nuanced assessment of the sustainability of human activities.

Our reply: This point by Wackernagel/GFN is a misinterpretation or misunderstanding of our critique, which was: The ecological footprint is a case of “land value theory”. The defense of Wackernagel/GFN under point 2 makes very clear that this is the case. Wackernagel/GFN moreover is inconsistent here in first claiming that the footprint is not a sustainability indicator (“sustainability variable”) but ending with the statement that it complements indicators like the HDI (which is not an environmental indicator but aimed at capturing important dimensions of social welfare) so as to arrive at a complete perspective on sustainability.

More importantly, if Wackernagel/GFN really think that the footprint is a very incomplete indicator of environmental impacts, than it would be good to state this clearly in all footprint publications and advertising material, because most innocent users really interpret “footprint overshooting” as a good proxy of overall unsustainability.

5. The Footprint does not capture all relevant environmental pressures

GFN say: Aside from the question of how completely Footprint accounting captures demand on biocapacity, van den Bergh and Grazi complain that “the common interpretation of the [Ecological Footprint], in most of the broader academic and popular literature (and media), is as an aggregate environmental indicator.” Without citing any references to support the validity of this claim, they go on to offer an incomplete but accurate list of environmental pressures and impacts not included in Footprint accounting: water pollution, toxic emissions, noise pollution, depletion of the ozone layer, acid rain, ecosystem fragmentation and biodiversity loss. From all this they somehow conclude that the Footprint is problematic.

Their logic seems to be as follows: That regardless of what an indicator is designed to measure, if its purpose is misinterpreted by some hypothetical public, and the indicator then does not effectively support this misinterpreted purpose, it is a bad indicator. We suggest instead that this is bad logic, and that a far more useful way of evaluating an indicator would be to assess how well it measures what it is intended to measure—which for Footprint accounting is not a somewhat random litany of environmental ills, but instead, competing demands on biocapacity, and the availability of biocapacity.

Our reply: We could accept this defense if it were not for the fact that from an environmental science perspective the demand on regenerative biocapacity, which the footprint intends to represent, ideally involves not only extraction of various resources but all kinds of pollution (including toxics affecting ecosystem functioning, and even noise disturbing animals) that negatively affect the biocapacity. GFN seems to accept this general point given that global warming, a pollution and not resource extraction issue, is completely integrated in the footprint method through the scenario of the carbon sequestration by forestation. However, other pollution problems are absent, not because they are irrelevant, but as there is not obvious way to translate them into hectares.

Given that certain relevant environmental pressure categories, which affect biocapacity, are omitted, the footprint is an incomplete and biased indicator of not just environmental pressure but also of regenerative biocapacity.

Giampietro and Saltelli (2014a, pp. 8–9) also draw attention to this problem of gross incompleteness of the footprint coverage of environmental issues, noting a number of examples of omitted “ecological and biophysical constraints to the sustainability of economic development”, additional to the ones mentioned in van den Bergh and Verbruggen (1999) and van den Bergh and Grazi (2014a).

6. The Footprint aggregates distinct environmental problems using arbitrary weights

GFN say: Van den Bergh and Grazi conflate two different issues in this criticism. The first is the question of whether Footprint accounting is aggregating fundamentally different types of environmental problems, and the second is whether the weightings used in this aggregation are arbitrary and unfounded.

The answer to the first question is simple: Footprint accounting focuses solely on one environmental problem, competition for available biocapacity. Aggregation of these demands on biocapacity is based on the percentage of global biocapacity each type of demand—for food, fiber, timber or carbon sequestration—occupies. At its most basic, each of these demands requires surface area on the planet where plants can grow to provide resources that are useful to society; these resources can then either be harvested, or left standing in order to absorb carbon emissions. Since there is limited area available on the planet to grow these resources, footprint accounting simply asks if this area is sufficient to keep up with all the competition on it, and if not, how much

additional area of the same kind is needed to provide for this excess demand. Only by aggregating all of the demands on biocapacity can Footprint accounting effectively shed light on the status of this critical environmental problem.

Our reply: This continues our point under 4, where we argued that in effect the footprint aggregates distinct environmental issues and thus cannot avoid using implicit weights. Again the defense is “biocapacity” and now Wackernagel/GFN even say that this is “solely . . . one environmental problem”. As indicated already in our previous comment, this is incorrect. Biocapacity is related to various environmental problems and associated environmental pressures. You cannot simply decouple biocapacity from acid rain, toxic metal emissions, a range of biodiversity pressures (other than land use), ozone depletion, noise pollution, etc. Moreover, the current footprint already integrates multiple environmental pressures (notably land use and global warming) so aggregation through implicit or explicit weighting is impossible to avoid. Possibly Wackernagel feels he is not doing this because it is implicit, hidden in the assumptions of the calculation method. If he really would be capable to avoid this weighting then he would have accomplished something comparable to finding a perpetual mobile.

GFN say: *The second question is more complex, in that it is asking just how the productivity of different types of ecosystems, and of the demands on them, is aggregated. While this is explained in detail in publications made freely available by Global Footprint Network, the short answer is that the aggregation is based on clearly defined principles and on measurements of actual productivity, and not on arbitrary weights. In particular, all Footprint and biocapacity components are expressed in a common unit, the global hectare. In current National Footprint Accounts, global hectares are calculated using yield factors that adjust for the differences between local and global average productivity of each type of ecosystem, and using equivalence factors that adjust for inherent differences among forest, cropland, grazing land and fishing ground ecosystems in their capacities to generate resources.*

Our reply: Unfortunately, Wackernagel/GFN addresses another point, namely aggregation of productivity and demands, which is not the same as what we criticized. We were talking about implicit weights for different environmental issues or pressures implied by the calculation method. These remarks by Wackernagel/GFN do not address and therefore do not undercut our argument. The use of motivated weights for productivity or demands does not guarantee correct (implicit) weights for distinct environmental problems.

Giampietro and Saltelli (2014a, p. 8) and 2014b, Table 1) make a related point, namely that the footprint indicator is overly aggregated, arguing that no single number by itself can capture in detail a complex phenomenon like sustainability. Indeed, the latter relates to multiple environmental impact dimensions, some of which are aggregated through unsubstantiated implicit weights (this point), while others are neglected (our point 4) or treated in an arbitrary, debatable way (see the next point 6). Giampietro and Saltelli (2014b, Table 1) suggest that an aggregate indicator is even more problematic if it is presented without providing any indications, or sensitivity analysis, of the underlying uncertainties.

7. Calculation of the carbon Footprint component is based on an arbitrary “sustainable energy scenario”

GFN say: *Using a logic similar to that adopted by the UN Reducing Emissions from Deforestation and forest Degradation (REDD) Programme, calculation the carbon component of the Ecological Footprint is based on the average rate per hectare at which global forests can sequester carbon. But contrary to claims by van den Bergh and Grazi, the choice of this approach is not arbitrary, and the calculation of the carbon Footprint is based on empirical measurements of average forest productivities, not on hypothetical values.*

Our reply: The REDD case is not a good comparison as it specifically and only deals with forests, and the associated loss in CO₂ sequestration capacity. CO₂ emissions here are only due to loss of forest quality or quantity. Of course the carbon content of forests then is a good starting point for the calculation approach. The footprint approach, on the other hand, wants to use only forests for compensating CO₂ emissions regardless of the source of these emissions (deforestation, transport, heating, electricity production, etc.). This clearly is not the same as the problem addressed by REDD and therefore the comparison of REDD and footprint approaches falls short.

As said already, carbon sequestration can be done in many ways, even without forests that use a lot of land. Carbon sequestration is not even needed if one reduces CO₂ emissions through technical solutions like renewable energy or energy efficiency improvements. Each of these alternatives will result in different, unique footprint values. How to choose between them? This is not obvious, and that is why we maintain that the fixed choice in the footprint method is arbitrary and thus open to debate.

Giampietro and Saltelli (2014a), and most of the other critics of the ecological footprint mentioned at the beginning of this note, equally argue that this part of the footprint estimate is not warranted in view of the particular assumptions and simplifications it involves.

The main problem with this arbitrary way of translating energy use (or carbon dioxide emissions) into footprint is that the increase of the footprint over time for most countries and the world as a whole are largely due to increasing energy use. This suggests that a more careful approach focusing on energy alone, which avoids extreme aggregation problems, is warranted. Such an approach is in fact already available, widely used, and completely accepted in the area of climate change studies, namely the CO₂-equivalent approach. In other words, the footprint approach does not add anything in this respect, but merely generates confusing and debatable information.

GFN say: *At the risk of sounding repetitive, Ecological Footprint accounting tracks competing demands on biocapacity, and compares that with available biocapacity. Anthropogenic carbon dioxide emissions not captured by the oceans and that are not otherwise sequestered (for example, through carbon capture and storage) compete for available biocapacity in that if they are not absorbed into terrestrial ecosystems, they will accumulate in the atmosphere. While the biocapacity demanded could be calculated in a number of ways, the Ecological Footprint methodology adopts the strategy commonly used in carbon trading and similar protocols of basing this calculation on forest sequestration capacity. The latter is a directly measured property of forests, and global average values can be obtained from the UN Food and Agriculture Organization (FAO). Thus neither the overall approach nor the specific sequestration values used in calculating the carbon Footprint component are arbitrary, but are instead based on what is currently established best practice.*

Our reply: Wackernagel/GFN’s argument here does not add any new substantial motivations that counter our critique. Referring to common approaches does not undo the arbitrary character of the assumptions. This issue can only be resolved by looking well at the assumptions. Based on these we have arrived at our critical assessment. We of course understand that the use of easily available global average values (like from FAO) simplifies the footprint calculation method, but this cannot compensate for the subjectivity and arbitrariness of the approach.

8. Footprint applications focus on countries rather than on “bioregions”

GFN say: *Global Footprint Network’s National Footprint Accounts measure the Ecological Footprint at the scale of nations, but the*

metric can be applied at any scale desired—to a single activity, an individual's lifestyle, a city, a bioregion, a nation, or humanity as a whole.

The Accounts focus on the national level because the best quality and most complete data on production, consumption and emissions exist at this level, plus many other complementary indicators that one might want to look at in conjunction with the Footprint track aspects of national performance (e.g., human development, economic, population). In addition, many of the key policy decisions are set and enforced at the national level, because typically countries enter into international agreements on environmental concerns (e.g., ozone depletion, biodiversity, carbon emissions). It hardly seems a weakness of an indicator that it can provide results for the same geographic areas that are of primary concern to policymakers.

Nothing, in principle, limits researchers who prefer to analyze Footprint or biocapacity for bioregions. The challenge, however, may be in finding sufficient data to carry out the analysis.

Our reply: We of course agree that it is a plus if an indicator can provide results for policy-relevant geographic areas. But this comment avoids addressing our central point, which is that biocapacity calculations make much more sense for bioregions, which unfortunately do not generally coincide with politically relevant borders.

9. Measurement of national ecological deficits supports antitrade sentiments

GFN say: If a country's total Ecological Footprint exceeds its total biocapacity, it is described as running an ecological deficit. This means it is harvesting resources from its domestic ecosystems faster than these resources are being regenerated, and/or emitting more carbon dioxide than its ecosystems are sequestering, and/or that the embedded biocapacity in its imports is higher than in its exports.

Our reply: This argument by Wackernagel/GFN lacks generality. Putting declining stocks and trade (not giving rise to declining stocks in the region of origin) in the same category and calling this “ecological deficit” is not subtle and unnecessarily creates a negative tone, which illustrates (but does not reflect the entire) anti-trade sentiment.

Our general point was that the trade-versus-environment issue has so many more dimensions that one should be careful to use terms that stimulate anti-trade sentiments on the basis of a very partial analysis. “Ecological deficit” creates a negative tone, which illustrates (but does not reflect the entire) anti-trade sentiment. To illustrate, the statement “emitting more carbon dioxide than its ecosystems are sequestering” is not a physical, inevitable constraint but merely a normative constraint which makes the procedure not objective, and calling it a deficit is therefore debatable too. Why might a densely populated city or country not benefit from much carbon sequestration potential outside its boundaries, for instance, in regions or countries with a low population density? Why should citizens be constrained in their CO₂ emissions by the arbitrary nature present within their national boundaries. This suggests that people in countries with a low population density and/or much nature can emit much more per capita than those in countries with a high population density and/or little nature. Such strange implications undercut the reasonableness of the assumptions of the method. Giampietro and Saltelli (2014a, p. 8) affirm this criticism, referring to the famous Stiglitz-Sen-Fitoussi “Commission on the Measurement of Economic Performance and Social Progress” (Stiglitz et al., 2009), that footprint analysis does not shed light on the environmental advantages and disadvantages of trade for the countries involved, and that its authors do not respect the fact that trade is a logical response to inhomogeneous spatial distributions of people, resources, capital and environmental capacity.

GFN say: Van den Bergh and Grazi seem to assume that an ecological deficit only reflects the latter factor of trade balances in embedded biocapacity, which is incorrect.

Our reply: First or all, the term “factor of trade balances” employed by Wackernagel is unusual and cryptic. Second, we do not assume any outcomes, we only stress that “ecological deficit” sounds negative and creates a clear antitrade sentiment. It insufficiently recognizes that trade can be driven by ecological differences and comparative advantages. For example, why should a large, sparsely populated country (e.g., Canada) not trade with a small densely populated country (e.g., Belgium) to balance national surpluses and shortages of certain natural resources? This in itself does not (generally) go against sustainability. Judging it negatively or using indicators that foster such judgments is not good sustainability science but merely reflects a debatable normative approach. This does not deny that certain changes in trade patterns would be good for sustainability. In fact, already since several decades environmental economics provides many insights into how trade patterns will change under the influence of stringent environmental regulation (e.g., Copeland and Taylor, 2004; Rauscher, 1997).

GFN say: Based on this assumption, they argue that in calculating ecological deficits, “the [Ecological Footprint] approach suggests that trade should be restricted to remain within the national ecological capacity. That is, trade is limited by the [sic] own land area, not by the population size.” Continuing this line of reasoning, they then go further afield, even to the point of suggesting that the Footprint makes “a strong plea against cities.”

But there are no “shoulds” in Ecological Footprint accounting; it is simply a descriptive measure, and does not offer any policy prescriptions. In short, the Footprint documents, but it does not judge. Blaming Footprint accounting for the fact that the results are sometimes misinterpreted and used to promote policies that one finds undesirable is a bit like blaming your bank statement for the fact that your expenses exceed your income. In both cases, the accounts provide information that you may want to consider in planning future strategy, but on their own do not tell you the best way to proceed.

Our reply: Of course the footprint studies generally avoid judging cities and trade very explicitly, probably because the authors realize that this would make them sensitive to easy criticism or because they understand that cities and trade are unavoidable and generate many advantages. That is why we phrased our criticism carefully as “supports anti-trade sentiments”. It is undeniable that that tone of many footprint studies is negative about trade.

GFN say: Regarding trade specifically, it would seem helpful to know how much biocapacity is embodied in international trade flows, and how much of a country's consumption can be met by local production capacity as opposed to having to rely on imported goods. For example, if imported goods were to become unavailable, and a country that needed these goods was forced to rely on its own ecosystem productivity to replace them, how much biocapacity would be required?

Our reply: These remarks just illustrate the anti-trade sentiments so very clearly. In our article we expressed a very different (and in our view a more balanced) view on the relationship between trade and environment, but unfortunately Wackernagel/GFN did not respond to this at all (in neither of his reactions). By the way, we do not think you need to calculate all of this to change trade patterns in an environmentally beneficial direction. Good policies will do the job here, and their formulation does not require information about how much “biocapacity is embodied in international trade flows”.

GFN say: Footprint accounting on its own does not tell what to do, but it can help drive policies designed to build resilience in a world that will have to adapt to the consequences of climate change and other ecological disturbances. This is true whether these policies are designed to address trade, investment in societal infrastructure, or many of the

other factors that contribute to the development of a sustainable society.

Our reply: We are not sure what concrete policy insights can be drawn from footprint studies. We devoted an entire final section to this in our article (pages 15–17). Here we assessed the policy content of many footprint studies and concluded that they generally offer trivial insights and do not provide any concrete, new or surprising policy lessons. Wackernagel/GFN did not respond to this part of our critique. Footprint studies do not offer concrete policy suggestions, not in terms of density of land use, optimal trade flows, trading-off negative versus positive effects of land use, or trading of density of land use versus total land use. As an approach to address such policy-relevant questions coherently and systematically we proposed some time ago a modeling approach based on an environmental extension of the famous Krugman agglomeration-location model (Grazi et al., 2007). Rather than making simple judgments it includes the full spectrum of environmental, economic and welfare effects of land use in a two-region system with trade. This allows for various policy-relevant trade-offs under global sustainability constraints. This model includes a module with various ecological footprint calculations to study the shortcomings of these. Its results show that one can easily make wrong decisions from a social welfare angle if one sails on a footprint indicator.

10. Concluding comments

Wackernagel and associates have adopted the strategy to defend against any criticism, that is, not to give in on any criticism. This does not make them very credible—for how can it be that so many critics (see references in the opening section) are wrong on so many accounts? Our impression is that the footprint work has sacrificed good science and indicator development for simplicity and popular support. Perhaps it is of consolation to footprint devotees to know that other efforts to arrive at an aggregate environmental indicator have failed as well (see the wide range of indicators assessed by Pillarisetti and van den Bergh, 2010, 2013). We suggest that statistical offices and NGOs take utmost care in adopting a footprint approach. It is advisable to understand well its shortcomings as documented in the literature mentioned at the opening of this article, and rely on the advice of scientists not married to any single indicator. One of the most interesting responses by Wackernagel/GFN was under critique 3. Here Wackernagel/GFN admits that the footprint is an incomplete indicator of environmental impacts. It would be good to state this clearly in all footprint publications, because most innocent users, understandably, interpret the ecological footprint as an overall environmental or (un)sustainability indicator.

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