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MES Analytical Essay

An Analysis of the Adequacy of Ecological Footprints and Carbon Footprints

Research Question: As currently defined, is the ecological footprint, of which the carbon footprint is a component, adequately comprehensive and reliable enough to guide humanity toward sustainable environmental policy?

Introduction: Simple answers to complex questions can be appealing. However, the way we ask questions, and the tools we use to answer them, frame the solutions we find. Decision-making bodies are increasingly using the mathematical constructs of carbon footprints and ecological footprints (eco-footprints or EFs) to simplify and clarify sustainable choices. EFs are also used to calculate the draw on planetary resources and to inform climate change legislation. EFs offer one aggregate number to describe multifaceted circumstances. Increased usage of EFs can leave government representatives and scientists vulnerable to over-simplification, omissions, errors, and the resultant public skepticism. This weakness applies to EFs created in good faith. While use of EFs, created by various groups with agendas to deceive, leaves EF users vulnerable to manipulation from questionable sources with profit motivation. Bad faith EFs won't be addressed in the scope of this paper.

Eco-footprint's definition and inception: The eco-footprint is a measured in global hectares (ghas). One gha is about two and a half (2.471) acres. The EF is a measure of regenerative bio-capacity, which is expressed as a resource draw, for any industry, business, person, or country. Currently, each person would be allotted less than two (1.85) hectares, for equitable sustainability. This value is shrinking, due to population growth. Humanity's consumption of natural resources is outpacing the Earth's ability to replenish even its renewable resources. Ecologists, William Rees and Mathis Wackernagel created and developed the EF (Hayden 2022). In their 1996 paper, "Our Ecological Footprint," eco-footprints include carbon dioxide (CO_2), water use, and land use. An individual's EFs includes land use for edible crops, animal food production, grazing of sheep, cotton fields, industry, residences, transportation, fishing, and forests which process CO_2 (York U 2018). Today, either CO_2 (carbon dioxide) or CO_2e (carbon dioxide equivalency), which includes other greenhouse gases (GHG), is calculated into the eco-footprint.

Carbon footprint's definition and inception: A carbon footprint, a component of the EF, as defined by The Carbon Trust in 2009 as "the total set of greenhouse gas emissions caused directly and indirectly by an [individual, event, organization, or product] expressed as CO_2e." CO_2 and CO_2e differ in that CO_2e combines greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PCFs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Interestingly, the first 'carbon footprint' calculator appeared online in 2005, as part of British Petroleum's marketing campaign. BP's strategy was to shift culpability for 'global warming' from the fuel industry to individuals. This narrative redirection, ironically, empowered individuals to grasp their participation in climate change. The fact remains, a few global conglomerates are the world's largest polluters. However, consumers buy the products, which keep them in business.

Acceptance and use of the eco-footprint: Today, around the world, ecological footprint analysis is used to support sustainability assessments. It measures the use of natural resources for individuals, manufacturers, industries, cities, and countries. According to Encyclopedia Britannica, social scientists have used the EF as a comprehensive indicator of human ecological impacts. The United Kingdom, The European Union, The United Arab Emirates, and Japan have increased their usage and acceptance of eco-footprints. EFs have "found increasing mainstream acceptance among businesses and governments" (Hayden 2022). Calculating one's eco-footprint online is fast and easy. Answer a few questions, state the country, then a calculator estimates the number of Earths required, to sustain the global population living in that manner. An individual can compare the eco-footprint to national averages from around the world and discover tips on lowering EFs in general.

CO_2e and EF criticisms: Critics argue CO_2e figures obscure, or omit, vital data and exclude context. Detractors cite an absence of clarity and incomplete assessments, which leads to a dearth of eco-footprint credibility. Some scientists claim eco-footprints include misleading assumptions and are deficient in consistency and transparency.

Obscured or lacking information and context of CO_2e: Decriers of carbon footprints, an integral part of eco-footprints, claim combining all GHG data together obscures which gases are responsible for most of the potential warming of the system being studied. Each of the GHGs has a unique warming potential and breaks down at a different rate. The Global Warming Potential (GWP) measures the warming contribution of a ton of a given gas, compared to that of a ton of CO_2, over a year. CO_2 is standardized at 1.0 GWP. Carbon dioxide is the dominant atmospheric greenhouse gas at 77%; it dwarfs methane at 16%. However, according to the EPA, methane warms Earth more efficiently, in fact over 83 times more efficiently than carbon dioxide in the short term (20 years), as published in *Newsweek* (Browne 2021). Other gases, while considerably more potent than methane, are much less prevalent. Knowing the amount and GWP of each gas emitted from the studied system is crucial in determining effective regulations. Context, such as the milage one can drive emitting the same amount of CO2e, is vital to understanding the meaning of the CO_2e number. Also pertinent, but frequently omitted from analysis, are facts on emission reducing technologies, alternate available energies, and likely results of proposed regulations.

History of EF criticisms: Debate has plagued the EF, since shortly after its inception. Criticism began as early as 1999 (Jeroen Et al 1999). Questions persisted almost a decade later, despite extensive use. In 2008, a comprehensive review, commissioned by the Directorate-General for the Environment (European Commission), both accepted the EF and echoed criticisms. The abstract states, “The Ecological Footprint is a useful indicator for assessing progress on the EU’s Resource Strategy and is unique among the 13 indicators reviewed in this study in its ability to relate resource use to the concept of carrying capacity. … Further improvements in data quality, methodologies and assumptions are required” (Best Et al 2008). Today, we continue to use and disparage EFs.

Lack of clarity: Ecological and carbon footprint calculators often obscure, or omit, the calculations used to obtain the results. This creates confusion as to how a measure of land adequately accounts for water use, total carbon emissions, and resources for housing, food, plastics, pets, clothes.

Lack of comprehensiveness: Now defined by the EF, ecological sustainability “is achieved when the ecological footprint equals carrying capacity” (Lyndhurst 2003). However, if the EF calculation isn’t robust enough to describe all ecological influences, then conclusions, based on such calculations, risk inaccuracy. As an example, it appears that EFs would be helpful in evaluating how to feed 8 billion people most efficiently. Because bio-productivity varies globally each year and between regions, an annual adjustment factor is included for each region so crop EFs, can be compared globally. However, this doesn’t make similar crops, grown in different regions, equally viable. UC Santa Barbara marine ecologist, Ben Halpern, and Halley Froehlich, assistant professor in environmental studies at UCSB, studied the eco-footprints of aquatic and land-based foods. Froehlich sums up findings in *The Current Science & Technology,* "The environmental efficiency of producing a particular food type varies spatially, such that rankings of foods by efficiency differ sharply among countries, and this matters for guiding which foods we eat and from where," (Froehlich 2022). Food production efficiency varies by region. Local economics and growing conditions over-ride low EFs in determining optimum crops. So, answers to feeding the planet most efficiently don’t distill down to the eco-footprint of ½ a cup of lentils vs. that of an Impossible© burger.

EFs account only for regenerative capacity, so if none exists for a resource or if that resource can't be expressed as a unit of land, then it's not included in the EF. Biodiversity, which increases resiliency for stressed systems is not considered. All species need water, and some need land. Detractors hold that decision makers must consider interactions between all ecosystem factors, to avoid errors. Misunderstanding of the interconnectivity of ecosystem contributors can have devastating consequences. Zimbabwe's government killed 40,000 elephants to prevent desertification and reverse local effects of climate change; but after the 'cull,' desertification increased (Savory 2013). In addition, other detriments such as toxic chemicals and substances aren't represented in an EF at all.

Credibility issue: Omission of crucial factors from eco-assessments such as CO_2 sinks, melting ice currents, the release of methane from melting permafrost or from the deep ocean, and the erroneous climate change predictions resulting from such omissions, undermine public credibility. In 1988, NASA Scientist, James Hansen, made dire predictions about temperature rises due to GHGs in testimony to a Senate Committee on Energy and Natural Resources. The United Nations' models he used predicted twice the observed warming for today. Models failed to account for aerosols countering warming and overlooked other factors (Michaels and Maue 2018). These and other incomplete analyses and subsequent inaccurate predictions fuel current skepticism for climate change deniers.

Misleading assumptions: EFs assume the same technology is available for all regions of the earth and through time (Hayden 2022). A farmer must be able to afford machinery or labor to plant and/or harvest certain crops. Economics eclipse a crop's low EF. The assumption that all farming methods are equal is also invalid. Intensive crop production methods, decrease EFs and increase yield, but are less sustainable. Organic farming lowers yield and raises EFs, despite benefits. So, EFs don't consistently indicate the best long-term solutions.

Inconsistency of EF calculations and lack of transparency: Assembling information, originating from different websites, exposes measurement inconsistencies. Some sites inaccurately report units of measurement or don't report units at all. Incongruities are unaccounted for by conversion between measurement systems. Calculations are often not shown, so reproduction and verification are difficult. Oversight of self-reported results, in some proprietary cases, doesn't exist.

My perspective: We have been using a non-living measurement to describe a living system. A measure of inert land does not include its bionetwork. Inclusion of the living ecosystem and additional relevant data in the analysis is essential to realizing sustainability. As social scientists, we must be open to increasing the comprehensiveness and reliability of our EF calculations. As an example, in 2014, Wright, Laurence, Kemp, and Williams proposed an improvement to the carbon footprint definition to include carbon dioxide and methane, from all relevant sources, sinks, and storage using the 100-yr global warming potential, GWP100 (Write Et al 2014). The Greenhouse Gas Protocol now includes all GHGs, a modest improvement.

It also seems prudent to prioritize, or weight, certain components of EFs. Decision makers ought to evaluate individual environmental measurements, relevant to the issue under consideration. Consistent measurement units, transparency, verifiability, and repeatability are fundamental to science. Also, the carbon footprint's origin doesn't make it less useful, as some critics hold, nor does it absolve major polluters from responsibility, as BP had hoped. We can use our imperfect tools carefully, and we can improve them.

Conclusions: Presently, eco-footprints and carbon emissions aren't adequate for the tasks we ask them to perform. We need to address environmental questions with systems thinking and improve our tools. The increase in comprehensiveness and resulting complexity of measurement should reward us with a broader understanding of the operations of systems and human effects upon them. Hopefully, the expected rise in accuracy of our climate change predictions will enhance public trust. We may also be less likely to suffer an environmental mistake.

Carbon footprints and eco-footprints can continue to aid our comprehension and inform our choices toward sustainability, if we use them with an understanding of their omissions, possible ambiguity, and certain subjectivity. In eco-footprint calculation and presentation there is estimation, assumption, and bias. Let's improve our tools and consciously use them, until we can agree on enhancements. Suggestions for use include:

- Meaning/Context/Clarity: Understand what the numbers represent; include context to illuminate meaning
- Comprehensiveness: Consider biologic and economic facts not included in analysis, look for omissions
    - Biodiversity: Study the ecosystem, needs of all animals and plants, impacted by this decision
    - Detriments: Consider chemical toxins or detrimental effects, unaccounted for in the calculations
- Assumptions: Be aware of inherent assumptions; gather additional information when necessary
- Consistency/Transparency: Use various sources to confirm consistent units, define measurements, show work
- Prioritize Data: Prioritize or weight factors appropriately for the decision at hand

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