FOOTPRINT FORUM 2010

The State of the Art in Ecological Footprint Theory and Applications

Editor Simone Bastianoni

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The World is moving towards a severe limitation of resources and, in particular, some of those resources most important for human well-being are approaching their peak point (the point beyond which their withdrawal is no longer convenient). Understanding if a Nation is using its natural stocks and flows of natural resources in a sustainable way is becoming crucial information for policy makers in order to have a complete picture when developing future strategies. Sustainability poses the challenge of determining whether we can hope to see the current level of well-being at least maintained for future generations, and how this can be possible. Since the 1980’s, policy makers and academics as well as the general public have been debating over what sustainable development is, what the best metrics are to measure the level of sustainability a country (or a region), and how to understand and manage the available natural capital.

The Ecological Footprint was introduced at the beginning of the 90’s by Mathis Wackernagel and William Rees. The Ecological Footprint is, in fact, 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 would take in any given year to support human demand of resources in that given year. Starting from its introduction into the academic debate, the concept has achieved increasing interest in society, from the scientific world to the common people. The results of the Ecological Footprint for 150 Nations worldwide are well-known and rather striking: since the mid-1980’s, humanity's footprint has been larger than the planet's carrying capacity, and in 2008 humanity's total Footprint exceeded the Earth’s Biocapacity by approximately 44 per cent.

This second Footprint Forum, hosted by the Ecodynamics Group of the University of Siena and co-organized with the Global Footprint Network, represents a double occasion and is a unique event, aiming to connect the academic community with national and international stakeholders and Footprint practitioners, in order to learn and share knowledge and experiences regarding the use of the Ecological Footprint.


The papers presented in this book deal with three main topics - Theory; Applications and Communication/Policy relevance, and proposals for new developments on subjects as: the integration of the Ecological Footprint with other methodologies; sustainability accounting; visualization and communication; the use of the Ecological Footprint as an educational tool for environmental awareness.

The Forum has brought together a considerable group of distinguished participants from more than 30 countries of five continents. On the objective basis of the numerous and excellent contributions received, it promises to become a step forward in the
advancement of the methodology and the cross-fertilization between different “worlds” of Footprint practitioners.

We gather here in Colle Val d’Elsa (Italy) this week to learn about and discuss the Ecological Footprint and the biosphere’s ecological limits, as well as to strengthen a network of people and organizations working towards the common good.

Over the last year and half all of us from the Ecodynamics Group of the University of Siena and the Global Footprint Network have been involved in the organization of the Footprint Forum 2010, and we are now grateful to all of you for joining us. May Colle Val d’Elsa now be a hospitable and inspirational environment for all of us.

Colle Val d’Elsa, 9 June 2010

[Signature]
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All life on Earth today derived from common ancestors. The first to evolve - yet the last to be studied in detail - are bacteria. Scientists have now discovered that bacteria not only are the building blocks of life, but also occupy and are indispensable to every other living being on Earth. Without them, life's essential processes would quickly grind to a halt, and Earth would be as barren as Venus and Mars.

Far from leaving microorganisms behind on an evolutionary ladder, we more complex creatures are both surrounded by them and composed of them. New knowledge of biology alters our view of evolution as a chronic, bloody competition among individuals and species. Life did not take over the globe by combat, but by networking. Life forms multiplied and grew more complex by co-opting others, not just by killing them.

*Lynn Margulis and Dorion Sagan*
Globalization, Eco-Footprints and the Increasingly Unsustainable Entanglement of Nations

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Keywords: Globalization, trade, global change, eco-footprints, entropy, sustainable, carrying capacity, overshoot, self-reliance, far-from-equilibrium dissipative structure.

Introduction
The unchallenged objective of national economic policy virtually everywhere is to maximize gross domestic product and, therefore, per capita incomes (i.e., consumption). The implicit belief is that welfare is invariably associated with income growth, even in rich countries. Governments and international development agencies certainly see economic growth as the only practical means to alleviate poverty.

Economists argue that so-called ‘globalization’ can contribute significantly to accelerating economic growth by assisting nations to exploit their ‘comparative advantage’ in producing certain goods. Ricardian trade theory suggests that if all countries specialize in, and export those goods that they can produce at a lower relative price than other countries, and import those goods for which their relative costs are higher, both total global output (GWP) and national incomes will increase. From this perspective, trade is a positive-sum game with all parties benefiting from free exchange.

Regrettably, conventional economic logic is based on false assumptions and monetary measures of efficiency that are wholly divorced from biophysical reality. For example, mainstream theory treats the economy as if it were floating free from the ecosphere unfettered by ecological constraints. By re-examining the assumptions of trade theory and reconnecting the economy to nature, this presentation argues that globalization and trade actually contribute to unsustainability.

Methods
The analysis is based on a reframing of trade theory using modern interpretations of the second law of thermodynamics and on specific case studies of trade flows using ‘disaggregated eco-footprint analysis’ [3, 2, also 1]. This framework recognizes that: 1) the economy is a growing wholly dependent sub-system of the non-growing ecosphere and that; 2) the economy is a far-from-equilibrium ‘dissipative structure’. These realities imply that, beyond a certain point, the human enterprise can produce itself and grow only by consuming the ecosystems that sustain it.

Results and Discussion
As presently structured, the global trade system violates the assumption of capital immobility essential to its efficient function and is otherwise failing on its own terms. The economic benefits of trade-induced growth go primarily to the already wealthy who don’t
need them while the collateral social costs weigh most heavily on the poor. Meanwhile, trade effectively extends the ecological footprints of importing nations halfway around the globe. Analysis shows that major import-dependent countries (e.g., the US) can thus overshoot their domestic carrying capacities. They continue to grow, in part, by (over)exploiting ecosystems in exporting countries that still have biophysical surpluses. Half or more of the resource depletion (entropic decay) of exporting countries such as Canada can be attributed to economic production to satisfy foreign consumers. Ironically, this trade-induced ecological degradation threatens future export capacity and thus the long-term security of the now import-dependent populations. Indeed, all trading partners put themselves at economic or ecological risk from global ecological change and any resultant geopolitical instability. In short, the continuous expansion of inter-regional trade creates a pattern of potentially fatal interdependence, an inherently unstable ‘entanglement of nations’ that accelerates the entropic dissipation of the ecosphere and ensures that we all hit global limits simultaneously.

**Conclusion**

The present form of growth-inducing globalization contributes significantly to the unsustainability of techno-industrial society. This raises several questions that have yet seriously to be addressed in discussions of unfettered trade [4]:

- What are the economic, ecological and moral implications of purposefully creating irreversibly dependent material relationships among nations if those relationships are unlikely to sustainable in the face of accelerating global change and resource scarcity?
- Is it wise for any nation to develop such that its future well-being and security depend significantly on vulnerable imports of extra-territorial biocapacity located half a planet away?
- What risks does a nation assume by committing substantial portions of its limited biocapacity to foreign consumers?
- At what point do the benefits of economic diversity, greater self-reliance and the enhanced security gained thereby, balance the gains from globalization and trade?

No individual nation can address these questions on its own. The world community must work cooperatively to create a new ‘steady-state’ model of exchange that will actually contribute to global sustainability for the common good.

**References**

“Ecological bootprinting” as a method for illustrating the inadequacy of eco-efficiency for moving towards a sustainable development: the Norwegian case

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Keywords: Ecological footprint, eco-efficiency, sustainable development

Introduction
This article challenges the idea that subjecting production processes to eco-efficiency measures is sufficient for reducing the overall environmental impact and achieve a sustainable development. An alternative assumption is presented: In high-consuming industrialised countries such as Norway, the overall environmental impact of production has been reduced substantially for the last decade or so, whereas the overall environmental impacts of consumption have increased. The research questions we will address are as follows: (1) How has the environmental impact of production and consumption in Norway changed in the period 1987-2007? (2) In reshaping national environmental policy, how can the Norwegian Government achieve an increased focus on consumption? In order to answer the first research question a comparison between the environmental impact of Norwegian consumption and production has been carried out by the use of ecological footprinting. Due to data limitations, we had to simplify the calculation method. We have coined this simplification “ecological bootprinting”. Hence, we have added a third methodology-oriented research question: (3) What are the strengths of ecological footprinting as a methodological element in sustainable development research?

Methods
Our point of departure is the distinction between consumption and production. Consumption is defined as the end consumption of goods and services by private households and the public sector, and production is understood as all other types of economic activity. Furthermore, we have introduced a more detailed distinction between consumption and production developed by Aall and Hille [1] which distinguishes between ownership of the production facilities/nationality of the consumer (domestic or foreign); location of production facilities/consumption (domestic or foreign); and nationality of products and services to be consumed (domestic or foreign). The environmental pressure from production and consumption has been assessed in two different ways. For the case of production, we have made use of the official set of environmental indicators, although adjusted when it comes to the range of economic activities included (cf. our definition of production above). The environmental impacts of Consumption is not included in the official Norwegian system of environmental indicators. We therefore had to make our own selection of data in order to assess the environmental pressure of consumption. In order to make the task
manageable, we decided to produce only one indicator: the ecological footprint (EF). However, in order to attain figures that allow for comparison with the production indicators described above, we had to simplify the methods for calculating EF. These simplifications will be elaborated in the full version of the paper.

**Results and discussion**

We have assessed the environmental pressure from Norwegian production and consumption for the period 1987-2007. The results indicate that the environmental impact of Norwegian consumption has increased somewhat stronger than the environmental impact of Norwegian production in the period, but with one clear exception: over-fertilisation (eutrophication) as a result of the massive increase in the volume of Norwegian fish farm production. In the full version of the paper, we will discuss in detail the development of the different production indicators and determine what has caused the increase in the consumption index.

**Conclusion**

The results indicate that consumption contributes significantly to the environmental impact in Norway, and thus should be included in an effective environmental policy. So far political measures to influence consumption has generally been regarded as too controversial by the Norwegian authorities [3]. Our results has been used as an argument in the political debate, trying to influence the authorities to focus on consumption in addition to production.

For this purpose, a simplified Ecological footprint method have been sufficient to show the overall picture; the size of the consumption related impacts compared to the production related impacts, and the relative growth of consumption related impacts compared to those of production.

We will present a few possible changes in the focus of environmental policy in order to integrate consumption, including a discussion of the following arenas of consumption: Inland private consumption, imports of commodities, public procurement, and tourism.

The paper finally discusses the use of ecological footprinting as a method in research, and discuss what types of research issues ecological footprinting is appropriate and less appropriate for exploring. This will be seen in light of the ongoing discussion on method refinement within the ecological footprinting community.

**References**


Policy role of the Ecological Footprint as an indicator: UAE case study

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Keywords: Ecological Footprint, United Arab Emirates, policy relevance, EEIO-EF, scenario model.

Introduction
In October 2007, the Al Basama Al Beeiya (Ecological Footprint) Initiative was launched as a national effort by the UAE to ensure a sustainable future by measuring and understanding the impact of our ways of living on planet Earth. The Ecological Footprint Initiative is a three year federal partnership under the patronage of the UAE Ministry of Environment and Water (chaired by the Minister) and other partners include, Abu Dhabi Global Environment Data Initiative (AGEDI with the Environment Agency – Abu Dhabi), Emirates Wildlife Society in association with WWF (EWS-WWF) and Global Footprint Network. The Initiative aimed at understanding what the UAE’s Footprint is, the sectors that are contributing to it, and how the government can use this environmental accounting tool to manage the country’s demand for natural resources and ecological services [1].

Methods
Since its launch, the Al Basama Al Beeiya (Ecological Footprint) Initiative has been focusing on data collection and verification, science and research, awareness and outreach, and policy analysis. Particularly, during the second year, an “Environmentally extended Input-Output” approach to Ecological Footprinting [2] was performed to further break down the 2005 UAE Footprint value by industrial sectors, final demand, and household consumption categories.

Results and Discussion
The initiative has achieved a number of accomplishments with respect to research, science, capacity building amongst different institutions in the UAE, and communications within the last three years.

In Year I, the initiative was able to verify the data used to calculate the UAE Footprint, and determined that it was representative of the UAE [1]. The initiative has also worked on methodology and data review and in Year II it focused on the fishing ground Footprint. As explained by Hartman et al [3], it was found that the published figure for the 2005 UAE’s fishing ground Footprint is likely a significant overestimation of the actual values.

On the awareness component, the Initiative has combined a top down and bottom up approach for communications on the Footprint in the UAE. A number of activities have been accomplished with the aim of raising awareness on the issue and motivating behavioral change within the country. At the start of the initiative in 2007,
communications were focused on training of the Footprint as there was confusion of the tool and its applicability in the UAE. Following on from year I, media coverage on the Footprint of the UAE continued but was represented in a positive light.

On the scientific accomplishments, in year II the Initiative’s research team was able to identify and account for the main causes determining the high per capita Ecological Footprint through the use of an EEIO-EF analysis [4]. It was determined that household’s consumption is the main driver of the nation’s Footprint, representing 57% of the UAE’s consumption followed by capital formation (30%) and government consumption (12%).

The outcomes of this analysis have led to the development of a campaign on saving energy and water known as “Heroes of the UAE”. Along with this, the Initiative was also able to determine the role of each sector of the UAE economy and the contribution of different daily activities to the UAE Ecological Footprint. In year III, the Initiative has been able to develop a preliminary research agenda for future scenario modelling of the electricity and water sectors’ Footprint.

**Conclusion**

The research team’s findings and activities in year II and III are of fundamental value in guiding scientists, investors, educators and policy makers, on what areas of the UAE society have great need and potential for improvements. The research conducted for the Initiative is not only very relevant for guiding sustainability campaigns but also for policy prioritization, as it helps us prioritize those sectors of society that contribute to our Footprint the most. This in turn helps facilitate the UAE’s development towards sustainability - a development designed to guarantee human well-being while ensuring the economic competitiveness of the nation. Furthermore, the development of quantifiable evidence-based scenarios that map how the UAE’s Footprint might evolve in the future is crucial from a policy making perspective. This can not only help assess the implications of current policies and plans on the Footprint but, by developing alternative ‘lower Footprint’ scenarios, it help facilitate the development of science based policy portfolios to reduce the UAE’s Footprint.

**References**


Creating an Ecological Footprint Assessment: Using Component and Compound Economic Input Output Methods together with The Natural Step to Develop a Sustainability Management System

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Keywords: Ecological Footprinting, Eco-planning, Ecologically Oriented Economics

Introduction
Ecological footprint studies, or environmental assessment studies, demonstrate the need for integrating sustainability management systems into academic institutions to effectively and efficiently monitor demands for biocapacity as an important aspect of total impacts on the environment [1]. British Columbia Institute of Technology’s (BCIT’s) first Ecological Footprint Assessment was completed for the year 2006/2007 and demonstrated the need for centralizing environmental information and making this data accessible to many different users. One intent is to use the data to also inform greenhouse gas emission reporting now required in the Province of British Columbia by all public institutions. The assessment considered energy and material flows through the campus from water, food, food packaging, staff travel, student travel, consumables, built form and related space-conditioning and lighting, green space, and solid waste. The total ecological footprint for the Burnaby Campus for the study year was 16,590 global hectares (gha).

Methods
This assessment demonstrates how to create a framework and a set of indicators to measure an organization’s ecological (un)sustainability. Two major concepts are explored: i) the hybrid approach to completing an Ecological Footprint and ii) the Natural Step’s sustainability principles (TN) [2]. The hybrid Ecological Footprint [3], [4] is derived by a combination of the component and compound economic input output methods to calculate the footprint. The component method uses Life Cycle Assessment (LCA) data to derive the footprint. The compound economic input-output method is a top down approach which takes aggregated data and divvies it up into smaller pieces to calculate the footprint of each component. The TN principles are over-arching indicators to include aspects that may not be accounted for in the ecological footprint, such as products that are not easily assimilated by the biosphere.

Results and Discussion
The largest component in the assessment is food and drink, accounting for 28% of BCIT’s ecological footprint. This is followed closely by student travel (all modes) at 26%. The second most significant categories are energy and consumables, each at approximately 18%. Together, these four components account for 90% of BCIT’s footprint. Staff travel, at 7%, is comprised half by commuting to work and the other half by air travel for work. The remaining components: water, waste to landfill, and food packaging account for the remaining 3% of the ecological footprint assessment. However, future studies could inform how to revise the methodology so that food and food packaging are more...
accurately accounted for. Similarly the waste to landfill component excludes the decomposition of waste at the landfill (assuming this would fall within a different jurisdictional authority) but could be included in future assessments.

The information gained from the ecological footprint assessment both surprised the BCIT community and helped to re-direct the focus of campus sustainability efforts towards the most significant components. Interest in centralizing and tracking the information required to complete an annual ecological footprint assessment also increased and an effort is currently under-way to automate this process. Effort is also underway to harmonize the reporting of the ecological footprint assessment with requirements to report greenhouse gas emissions. The aim is to develop a robust sustainability management system, built on the data collection platform for the ecological footprint assessment, combined with the Natural Step framework.

The methodology makes appropriate use of combining the component and the compound ecological footprint assessment method, including material flow analysis, lifecycle assessment, and input-output analysis. A suggestion for future research is to compare the ecological footprint assessment methodology used in this study to the greenhouse gas emissions reporting protocols introduced by the Province of British Columbia (BC).

**Conclusion**

This report demonstrates an important contribution to the body of literature that documents ecological footprint assessments of educational institutions. In using the component method supplemented by the compound method for ecological footprint assessment, it provides a reasonably comparable analysis to other institutions that have used a similar approach. This study is, we believe, the first of its kind to be completed with such a high level of rigour and integration by a North American post-secondary institution.

This report documents the methodology of the study that is being used both as an aid to teaching the ecological footprint assessment methods as well as to further communicate with the BCIT community and those interested from outside the community.

**References**


Support area as an indicator of environmental load: comparison between ecological footprint, embodied energy and emergy accounting

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Keywords: Ecological Footprint, Emergy, Embodied Energy, Biofuels, Support Area

Introduction
Energy demanded by society increases in proportion to population number and lifestyle and vice-versa, life-style and population increases if potential energy is available. Scientific research shows that fossil fuel use influences the climate change. Due to these facts, there is a market for the so-called “green” biofuels. The following questions appear: Can biofuels replace fossil fuels? Are biofuels a solution for global warming? Although these questions haven’t been answered yet, a large number of biofuel plants are being built around the world without a proper environmental assessment. There are many scientific tools used to obtain system's sustainability indices and some researches indicate that several methodologies with its own rules and meanings should be used for that purpose. Embodied Energy Analysis is a well known methodology used in several studies. Ecological Footprint is being accepted by scientific community and its use is increasing in the last decade; it can be used for different scales and its results presented in hectares are easy to understand by the general public and decision makers as well. Emergy Evaluation has been proved to be a valuable methodology, because it accounts for all the energy embodied in the system inflows, including those from nature. Considering that the largest amount of ethanol produced in the world comes from sugarcane and corn, the objective of this work is to assess the support area of the agricultural production system of sugarcane in Brazil and corn in United States using three different approaches: ecological footprint, embodied energy analysis and emergy accounting.

Methods
Three methodologies were used to obtain indices for the environmental load of agricultural energy production systems (sugarcane in Brazil and corn in United States): Ecological Footprint [1], Energy Analysis [2] and Emergy Accounting [3]. The support area related to ecological footprint (SA_{EF}) was estimated considering two different categories: CO₂ sequestering area (area needed to absorb the equivalent CO₂ emitted indirectly) and soil loss recovery area (area needed to replace the soil loss). The support area provided by the energy analysis (SA_{EE}) was calculated considering the total embodied energy used direct and indirectly by the systems. That amount of energy was converted into the equivalent tropical forest area necessary to absorb the CO₂ released to atmosphere. In the case of emergy accounting, the support area was obtained considering two approaches: net primary productivity (SA_{NPP}) and renewable empower density (SA_{R}). The first one show how many hectares of tropical rain forest would be needed to balance the non-renewable emergy used by the system. The second shows the support area of the surrounding region that would be required if the economic activity were solely supported by renewable emergy inputs.
Results and Discussion

The table below shows the support area needed for one hectare of biofuel crop area. The lower support area was obtained by the SAEE approach, meaning that for each hectare of sugarcane it must be preserved 0.04 hectares of tropical rain forest; in the case of corn, the forest area demanded was 0.05 hectares. These low values were expected because SAEE approach accounts only for the CO$_2$-equiv. released indirectly by the materials used in the sugarcane and/or corn production. SA$_{EF}$ also includes the area demanded to absorb the CO$_2$-equiv. released indirectly, but the sequestration rate used was three times lower than that used in the SAEE approach; moreover, SA$_{EF}$ considers the soil loss, resulting in a bigger support area than SAEE's. Larger support area was obtained by the SARI approach, reaching 5.15 hectares of tropical rain forest for sugarcane and 5.32 for corn. SARI is strongly affected by the Emergy Renewable Density (ERD) of the region: a high value of ERD means that the area supplies great amount of renewable resources. The region considered in this work was a tropical rain forest with high ERD, thus SARI shows the best performance if compared to any other kind of natural or human dominated systems. SA$_{APP}$ showed a medium value, reaching 1.97 ha for sugarcane and 2.03 ha for corn. Considering the support area as an indicator of environment load, it can be said that sugarcane production is more sustainable than corn. For a complete study, all the chain should be assessed from production to consumption, but in this paper the aim was to evaluate the agricultural phase.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Sugarcane (Brazil)</th>
<th>Corn (USA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA$_{EF}$</td>
<td>0.22</td>
<td>0.27</td>
</tr>
<tr>
<td>SAEE</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>SARI</td>
<td>1.97</td>
<td>2.03</td>
</tr>
<tr>
<td>SAPP</td>
<td>5.15</td>
<td>5.32</td>
</tr>
</tbody>
</table>

Conclusion

Sugarcane and corn give almost the same values of support area in each approach used. The support area values vary with the method used but not with the crop. Methods show different results due to the different assumptions used. The great range of support areas obtained by different methods, suggest that would be interesting a critical and deeper analysis on their technical procedures in order to make possible a correlation of considerations with results obtained. Before say that one result is more realistic or precise than another, it is necessary to understand the scope, scale and objectives envisioned in each method.

References

A Benchmark to Assess Local Ecological Footprint Account

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Keywords: local ecological footprint, public policy

Introduction
Ecological footprint is good at telling us how much we weight relative to global ecological resources. However it tells us nothing on the precise location of the ecological resources we use and if we overuse it or not. It makes no distinction between ecological resources we use from distant or local land. Moreover it does not measure the intensity of exploitation of soils or other sustainability considerations like biodiversity loss. Therefore the results provided by the footprint calculation are barely suitable for planning and policy design, as information on real use of local land is lost in the process of calculation. This issues are well known and are part of the research agenda set by the footprint research community [1]. Recommendation has been made to deal with them (see [3], [5] and [2]). What seems missing to us is clarity in an integrated mathematical framework that shows in a compact manner what modifications these recommendations entail in the calculation of the ecological footprint. We propose to delineate this mathematical framework. Furthermore we propose to compute a benchmarks taking in account: our global weight on nature, our degree of dependence on non-locals ecological resources and the real pressure on the local hectares used. This synthetic benchmark could serve side by side with monetary evaluation to estimate the value of goods and services and thus guide a local public policy geared toward sustainability.

Methods
The method builds on the formalism introduced by Wiedmann [5] and Turner [4] and more generally on the technique of multipliers and multi-region input-ouput (MRIO) model. It introduces through the use of input-ouput table derived at the local level a way to calculate the actual local land use induced directly or indirectly by our consumption. From this we infer a measure of our local independence on natural resource. Then we compute a land use intensity measure. This allows to weight the actual local hectare used with their intensity of exploitation. This method thus gives a coherent three dimensional view of sustainability with global weight, intensity of exploitation of local hectares, and degree of dependence on non-local ecological resources. From this three dimensional view, we build our benchmark which can be computed for each consumed goods and services.

Results and Discussion
It is our claim that ecological footprint needs flexibility in his calculation. Indeed depending on the questions we are asking we do not want to calculate the same thing. However it is important to distinguish easily at first glance what is common and what is different between the calculation variants and to go easily from one to the other. For
example it should be straightforward to go from global hectare to real hectare or pressured hectare. The use of simple matrix algebra in the input-output analysis framework allows to do that as we have shown. The main result of this paper is first a three dimension analysis (footprint, pressure, independence) and second mathematical clarity in the calculation of ecological footprint which we claim has been missing before and led to a lot of confusion. This mathematical clarity allow the calculation to be modified in a transparent way and allow comparison with variants. From this framework it was possible to use it to extract information on our reliance on local ecological resources, and on the intensity with which we are using this local resources. These different informations were used to compute a synthetic benchmark of sustainability. Although we claim that providing such a benchmark is a prerequisite to use ecological footprint as a useful tool for local policy we recognize it still falls short of uncovering the socio-economic drivers of our ecological footprint necessary to implement efficient policies.

Conclusion

Ecological footprint has been a very efficient communicating tool to raise awareness about environmental degradation caused by excessive consumption. This simple "footprint" indicator, however, fails to fully describe the complexity of the relationships that a city establishes with its rural hinterland[1]. Hence it falls short of being a policy tool for sustainable management of our ecological resources. Indeed, because of the way the calculation is done, most of the relevant information required at the local level is lost. We introduce a clear mathematical formalism which, without breaking from the fundamental structure of calculation of the footprint, allows some transparent modifications to it in order that the information needed at a local level is isolated and not lost in global averaging process. These local informations allow to go a step further and to compute an ecological benchmark which can be used to drive local public policy.

References


A complete ecological footprint analysis of a building:

the case of Concorezzo (Italy)

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Keywords: building, embodied energy, ecological footprint

Introduction
Worldwide consumption related to housing represents a remarkable part of the total use of primary energy and gives a high contribution to CO₂ emissions as well as soil occupation. In Italy the great majority of the existing building is characterized by low energetic and environmental performances and most of the new constructions are still produced with low or null attention to the principles of green building.

In order to improve and diffuse sustainable building production it is important to develop methodologies and tools to evaluate and compare the environmental performances of green and normal building. On this subject a waste literature has been developed during this last decade: among other methods, the EFA (Ecological Footprint Analysis) [6; 4] has been used in several studies (among the others: BioRegional Development Group, [1]; Cras, [3]; Murray, [5]; Contu et al., [2]).

The main aim of the study presented in this paper is to apply the EFA to the complete quantification of the ecosystems appropriation caused by both, the phase of construction and that of utilization of a building. The analysis has been performed using real measured data and not just values derived from scenarios of energy emission and resources consumptions estimated from building design characteristics.

Furthermore, to verify the effectiveness of EFA as accounting system applicable to the building sector, the study has focused its attention on a particular building, characterized by two wings: a former part that has been restructured following the principles of sustainable building while for the second one normal practices has been adopted.

Methods
For its peculiar characteristics, already mentioned in the introduction, we have chosen, as case study, the building “Corte Nuova” localized in Concorezzo (MI, Italy).

The analysis of the construction and restructuration of the building has been made in two phases. A former stage was focused on the quantification of all the material and energy used for the building activities. All these data were converted, in a latter phase, into bioproducive area using the specific conversion factors calculated by GFN [4]. When conversion factors were not available, embodied energy coefficients were used to estimate at least the corresponding energy land.

The evaluation of the ecological footprint related to housing activities, ranging from heating to lighting system, from air conditioning to water consumption, has been made using data collected directly on the building during a long interval of time and still in
course. This monitoring system allowed an accurate quantification and distinction of the resources (material

**Results and Discussion**
The study has allowed a direct comparison of the ecological footprint values of the phase of construction and that of utilization of the Concorezzo building.

An interesting analysis has regarded the level of ecosystem appropriation related to different living style and behaviours of the families and different family compositions. Furthermore, an in depth examination and comparison of the environmental costs related to the different heating systems of pellet and natural gas, gives as results a better environmental performance of the former, that however critically depends on the origin of the material and on the production techniques adopted.

Final results have been compared with others EF evaluations of green building (like the BedZED of London) and with the averaged Italian ecological footprint for housing.

**Conclusion**
Differently with respect to several other EF evaluation of building, the analysis described in this paper focuses on the complete quantification of the ecological footprint related to both, the phase of construction and that of utilization of a building. Furthermore the study has been performed using real measured data and not just figures estimated from building design characteristics.

The results of our analysis suggest some considerations on the environmental utility of the solutions adopted for the green building compared to the traditional one. Indications can be drown to minimize the overall ecological footprint: in some case can be preferable to adopt design and building technical solution more EF intensive than for traditional building, if these impacts are overcompensated by the EF saving of the utilization phase; while in other cases a suitable mix between the two aspects can be more easily adopted.

**References**


A joint implementation of Ecological Footprint Analysis and Cost Accounting techniques for measuring environmental pressures at the company level

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Keywords: Firm metabolism, Ecological footprint Analysis, Cost Accounting

Introduction
The aim of this paper is to provide a conceptual framework for evaluating firms’ draw on nature. The model is based on the joint implementation of EFA (Ecological Footprint Analysis) and CA (Cost Accounting) techniques for measuring environmental pressures at the company level. The methodology of CA is applied by companies to determine the monetary cost of their products [3; 7]. These techniques are adopted by business administration in case of complex production chains, characterised by joint production, presence of processes with loops and feedbacks, different outputs [8]. This paper adapts such monetary techniques to the purpose of measuring not the economic but the environmental costs, that are coherently accounted thanks to the harmonization of EFA methodology with CA.

Methods
In our approach, the production chain is divided in several activity centres, that best reflect both the generation of impacts on ecosystems and the process of economic value production. The environmental pressures of the different activity centres are represented in term of their appropriation of ecologica productive land following the well established EFA accounting system [9; 4]. This methodology further improves the Ecological Footprint procedures, as already applied to evaluate a production activity (among the others: Chambers and Lewis [2]; Lenzen [5]; Niccolucci et al., [6]; Wiedmann et al., [10]; Cerutti et al.,[1]).

The calculation is structured on two main levels. A former stage quantifies the environmental costs (in term of global hectares) generated by the different activities related to production (land needed to host buildings and infrastructures, to provide renewable resources, to absorb waste and emissions, etc.). A latter step is introduced to reallocate the quantified hectares from the initial activity centres to the final ones, that better reflect the outputs of the whole production chain. This operation is performed by using specific drivers for environmental costs in parallel to those utilized by the CA techniques to determine the monetary cost of final products.

Results and Discussion
The methodology proposed in this paper is particularly useful in two cases: to evaluate network utilities, i.e. industrial sectors using large nets, that can be quantified with great
difficulty, and to calculate, with high level of accuracy, small changes in EF due to little
differences or small improvements in the production processes.
To test our model we have chosen two different cases study representative of the
situations above mentioned: the EF of the Italian railways, a great network utilities, and
the evaluation of the EF related to the production of veal meat, a typical product of the
Piedmont Region (Italy), following two different breeding techniques.

Conclusion
For the Italian railways case study, the application of our methodology has allowed the
evaluation of the EF caused by a single unit of transport service, thanks to its ability to
analyse the complex production chains characterizing this business and to assign the
environmental costs between several different outputs (people transport, goods
transport).
The second case study has showed the high level of accuracy obtained in EF calculation
by adopting this joint method, that is able to capture also small differences in ecological
footprint due to little variations of the productive process (depending on the slightly
different utilization of mechanised breeding techniques)

References
Ecological Footprint Analysis on nectarine production: methodological issues and
results from a case study in Italy, Journal of Cleaner Production, 18(8), 771-776.
Sustainability Indicator for Business. London, Certified Accountants Educational
Trust.
France, “Que sais-je” n.1556.
Footprint Network 2009. Available at www.footprintstandards.org. Last access
April 1st, 2009.
Ecological Footprint and an example application. ISA Research Paper 02-02,
University of Sidney
Ecological footprint analysis applied to the production of two Italian wines,
Agriculture, Ecosystems and Environment, 128, 162-166.
Holland, Amsterdam.
Edward Elgar, Aldershot.
And Benchmarking the Sustainability Performance of Businesses, Journal of
**Indicator and Indicandum: “Sustainable way” vs “using prevailing technology” in Ecological Footprint definition**

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**Keywords**: indicator, indicandum, ecological footprint, sustainability

**Introduction**

The Ecological Footprint (EF) was initially defined as the total amount of ecologically productive land required to support the consumption of a given population in a sustainable way [1]. The aim was to show the difference between a sustainable way of life and “business as usual”. The indicandum (what is to be indicated) is therefore a measure of sustainability: resources used and wastes produced with respect to the capacity of the Earth to provide resources and dispose of wastes. Thus the EF is a quantification of Daly’s principles of sustainability [2], that consumptions and emissions should occur at rates compatible with Nature’s tempos. Because it is difficult to determine what is “a sustainable way”, the most widely used Footprint definition is now the amount of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates using prevailing technology and resource management practices. This and other approximations used in the calculations, may imply a dichotomy between indicator and indicandum.

**Materials and Methods**

The EF of a product is defined as the sum of the footprints of all of the activities required to create, use and/or dispose of that product during its life cycle [3].

\[
\text{EF}_{\text{product}} = \sum_{i=1}^{n} \sum_{j=1}^{m} \text{EQF}_i \times \text{EF}_{i,j}
\]

where \( i \) = the land type (cropland, grazing land, fishing grounds, forest, built-up land and energy land), \( j \) = production inputs, and \( \text{EQF}_i \) is the equivalence factor of the \( i \)-th land.

Biocapacity (BC) is assessed by multiplying the land area available annually for production \( (A) \) of each type of land \( i \), by the appropriate yield \( (YF) \) and equivalence factors (EQF):

\[
\text{BC} = \sum_{i=1}^{n} A_i \times YF_i \times \text{EQF}_i
\]

We analyzed an intensive production of sugar cane in the Everglades area in South Florida [4]. Inputs include sunlight, wind, rain, surface water, fertilizers, fuels, etc. An important source is the storage of soils that are being depleted.

**Results and Discussion**

The manner in which EF is calculated leads to the result that EF may exceed BC for energy land, but not for any other land types, because BC is calculated based on prevailing conditions and not on the sustainable management of cropland, grazing land, etc. Thus BC seems to increase if a more efficient manner of production is found, regardless of its sustainability. Overexploitation of fertile soil, for example, is as much a
problem for sustainability as the use of fossil fuels. While the EF correctly reflects the problem of fossil fuels, i.e. their use is sustainable if there is enough land to absorb the CO₂ emitted, overexploitation of the other types of resources (e.g. topsoil) is not accounted for. Thus part of the indicandum fails to be reflected by the indicator, making the EF appear to be an indicator that supports business as usual practices. In fact there may be a discrepancy between the results obtained by “sustainable way” and “prevailing conditions” approaches. In this case, the “sustainable way” BC would be lower than the “prevailing conditions” BC, since lower productivity must be assumed. It follows that EF would be higher by the “sustainable way” approach, since more land would be required to produce the same amount of output.

To clarify this idea let us consider the case of cultivation of sugar cane in southern Florida [4]. Sugar cane is cultivated intensively without any rotation, leading to topsoil loss. Reduced availability of fertile land implies a decline in BC, or the regenerative capacity of the area, in time. The real BC should be evaluated taking into account the intensity of land use with respect to recovery time, as proposed in the following formula:

\[ BC_S = BC_{PC} \times \frac{T_{use}}{T_{recovery}} \]

where \( BC_S \) is “sustainable” BC, \( BC_{PC} \) is “prevailing conditions” BC, \( T_{use} \) the time of effective use of the land in years and \( T_{recovery} \) the time for topsoil to reform, in years.

Conversely, “sustainable” EF is bigger than “prevailing conditions” EF:

\[ EF_S = EF_{PC} \times \frac{T_{recovery}}{T_{use}} \]

In the case analyzed [4], estimated net loss of topsoil is 0.025 m/year, with a recovery time of ten years. Thus real (or “sustainable”) BC is 1/10 of the BC estimated by the “prevailing conditions” approach, since it takes 10 years (\( T_{recovery} \)) to restore the quantity of topsoil consumed in one year (\( T_{use} \)). Vice versa, \( EF_S \) is 10 times bigger than \( EF_{PC} \), for the same reason. In other words, for a stock of topsoil of 0.3 m, after about twelve years of intensive cultivation, no more topsoil is available for sugar cane production.

**Conclusion**

The example shows that by the “prevailing conditions” approach, it is only possible to have a Footprint higher than Biocapacity for energy land; for cropland and grazing land it becomes intrinsically impossible. This implies a dichotomy between the indicandum of the Footprint method and its indicators, that can be substantial in cases such as the above. Though it makes collection of reliable data more difficult, the method would benefit from a return to the original aim and definition.

**References**


The contribution of sub-regional areas to local sustainability

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Keywords: biocapacity, ecological balance, ecological footprint, local employment systems

Introduction
The aim of this work is to evaluate in which way different sub-regional areas contribute to the environmental sustainability of a whole region. This kind of analysis could represent a useful tool to support the policy makers in the governance of the sub-regional territories. Indeed, as the study carried out shows, this instrument can facilitate policy makers in promoting measures finalized to the overall regional sustainability managing the dynamics of exchange of ecological services among the different local systems.

Methods
The first part of the study focuses on the evaluation of environmental sustainability in the province of Viterbo through the comparison of EF and BC. These two indicators are calculated through the GFN sheet, where we have adapted the bioproductivity coefficients to the local conditions. After verifying that this region presents an overall positive ecological balance (see “Results and Discussion”), the scale has been reduced and the contribution of the single local systems to this condition of sustainability has been determined calculating the EF and the BC.

To this purpose, the study refers to the Local Employment Systems (LESs), which are the result of a functional zoning that identifies territorial units according to their geographical and socio-economic characteristics. The focal criteria adopted for the definition of LES is the self-sufficiency of labour demand and supply. The term labour self-sufficiency expresses the ability of a territory to keep within its boundaries the majority of human relationships due to working and residential activities. A territory with this feature is defined as a local system, thus a socio-economic entity that embraces residence, employment and social relations.

Italy is not the only country adopting such functional zoning; indeed, according to an Oecd survey, besides the British experiences for the identification of the travel-to-work-areas (Ttwa), many other European countries have adopted functional zonings based on commuting flows (Denmark, France, Germany, Portugal, Sweden, Finland, Austria).

Results and Discussion
Starting from the data related to the environmental sustainability of the whole region, the level of environmental sustainability of each LES (in the province of Viterbo there are 8) has been evaluated in order to verify which ones are net importers or exporters of biocapacity. For this purpose, and supported by the available statistical data, it has been assumed that the lifestyle of the residents within the province is similar and then the EF can be considered identical in all the LESs (3.31 gha). For the estimation of the biocapacity, the CORINE-Land Cover chart of the province of Viterbo has been elaborated, and thus, using the ArcGIS software, the different land uses and the related biocapacity (corrected with local conversion factors) have been identified (see table).
<table>
<thead>
<tr>
<th>Land categories</th>
<th>Province</th>
<th>BC of Local Employment Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EF</td>
<td>BC</td>
</tr>
<tr>
<td>Cropland</td>
<td>1.06</td>
<td>3.00</td>
</tr>
<tr>
<td>Grazing land</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Fishing ground</td>
<td>0.25</td>
<td>0.06</td>
</tr>
<tr>
<td>Forest</td>
<td>0.33</td>
<td>0.65</td>
</tr>
<tr>
<td>Built-up land</td>
<td>0.18</td>
<td>0.17</td>
</tr>
<tr>
<td>Energy land</td>
<td>1.47</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>3.31</td>
<td>3.89</td>
</tr>
<tr>
<td>Ecological balance</td>
<td>0.58</td>
<td>---</td>
</tr>
</tbody>
</table>

**Conclusion**

The paper presents and discusses the results of the comparison between natural resource demand (EF) and the related availability (BC) at a sub-regional scale. The aim was to verify the ways in which different local systems contribute to the environmental sustainability of the whole region.

A first analysis, carried out within an Italian province, has shown how a situation of environmental sustainability is the result of a high diversity of the local systems in which the territory is divided. These systems, identified in the Local Employment Systems, have shown very different situations regarding the balance between EF and BC. More specifically, out of the 8 LESs of the province, 5 generate an ecological surplus that is able to cover the ecological deficit observed in the other 3 LESs.

**References**


Ecological Footprint vs Biocapacity of world regions: a geopolitical interpretation

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Keywords: biocapacity, dynamics, ecological footprint, geopolitics

Introduction
The realization that resources are limited has led to the development of tools designed to measure how much “nature” is needed to maintain a certain human lifestyle. The Ecological Footprint was conceived as a tool for revealing the relationship between the lifestyles and consumption patterns of a population and the natural capital consumed. The indicator shows when and by how much humans are living over – or in some cases below – the planet’s carrying capacity, expressed by biocapacity, which is the potential ability of an area to provide ecological goods and services (biodiversity, climate stability etc.). Biocapacity can be regarded as the expression of a new type of wealth, and it will have a geopolitical value for territories. It will play a fundamental role in competitiveness and relationship patterns between nations, as well as in communities’ quality of life.
This paper aims to observe the temporal dynamics of the Ecological Footprint (hereafter EF) and Biocapacity (BC) for most of world countries, between 1961 and 2005, in order to appraise different development paths adopted jointly with other indicators.

Methods
First, the per capita EF vs BC temporal dynamics of about 150 nations were analyzed and grouped per trend similarity. Remarks on the origin and the consequences of these profiles and a geopolitical interpretation were then offered through a combined analysis of other indicators. The aim is to monitor several different aspects of sustainability, from social to economic and environmental. For this reason changes in population demography, Gross Domestic Production (GDP), Index of Sustainable Economic Welfare (ISEW), Human Development Index (HDI) and Environmental Performance Index (EPI) were observed, when available.

Results and Discussion
Four main profiles were identified and considered as relevant (see Figure 1).
1) The first type, named RAILS (case a), shows BC and EF trends which proceed in parallel without any significant change over time. Generally BC is greater than EF; this implies the presence of an ecological surplus for the country. Countries belonging to this profile (such as Finland, Sweden, Australia, ...) are privileged: they enjoy a consistent endowment of BC; they can be considered as an ecological niche. Generally small changes in demography were also observed. Moreover, HDI and EPI generally report high values.
2) The second type, named SCISSORS (case b), shows an increasing trend of EF while BC is stable over time. This kind of trend reveals a gap (or an ecological deficit) which is also increasing and which leads to a progressive ecological dependence on external sources (or from “ghost” lands). This type applies to industrialized countries with high consumption (i.e. most European countries) or to countries whose economies are in transition (i.e Turkey, Algeria,...).
3) The third type is called WEDGE (case c): EF is generally constant and with low values while BC is rapidly decreasing over time. This particular trend is quite significant because it reveals a serious risk: this case highlights a progressive loss of reproductive capacity. EF values are generally low or anyway lower than world average EF: consumption is constant over the time. BC is initially very high but, due to considerable demographic expansion, falling rapidly. Most of the countries showing this profile are classified as developing according to other indicators, such as the HDI.

4) The fourth type, called DECREASING TRACKS (case d), where both EF and BC are decreasing with a trend that may be similar or not similar. Countries belonging to this typology are generally environmentally and socio-economically vulnerable. Finally, particular attention is devoted to countries whose dynamics reveal a “transition point”, where there is a change from ecological surplus to ecological deficit.

![Figure 1: Examples of the four main types of EF vs BC temporal dynamics per nation: a) rail, b) scissor, c) wedge, d) decreasing tracks. Data are expressed in gha per person.](image)

**Conclusion**

The paper highlights very different territorial contexts, identifying situations of high value (ecological excellence and ecological niches), at risk (in transition) or vulnerable (irreversible changes are already underway). The paper also includes some reflections on the geopolitical value of natural capital. Countries that show an ecological surplus (BC>EF), for example, use less natural capital than they produce every year; whereas countries with an ecological deficit (BC<EF) use more natural capital than they have available. In order to overcome the deficit, these countries need to import biocapacity from abroad, or overexploit local resources whereas they should be preserved. In conclusion, some policy suggestions are made. The comparison between the changes in BC and EF leads us back to the theory of export dependence and the imbalances between “resource consumer” countries and those that own them.

**References**


Comparing Ecological Footprint and Life Cycle Assessment in the sustainability evaluation of tourism activities

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Keywords: Ecological Footprint of tourism, Life Cycle Assessment, accommodation.

Introduction
Within the recent debate about the needs for improving Ecological Footprint (EF) method [1] has been highlighted the necessity of standardized and detailed Life Cycle Assessment (LCA) studies to support the calculation of specific impacts accounted in EF. Moreover, when the evaluation is performed at sub-national level, the availability of site-specific or sector-specific studies becomes crucial for obtaining reliable input data and thence significant results. Ecological Footprint has been identified as a useful method for the evaluation of sustainability of tourism activities [2], even if only few studies are specifically devoted to the evaluation of sustainability of hospitality structures. Within this field of research, the present work represents an attempt to investigate the possibility to improve the EF analysis through the comparison of EF accounts with LCA of accommodation buildings.

Methods
The study relies on the methodology developed by Castellani and Sala [3] for the EF account of tourism, which is specifically focused on the EF of accommodation: the methods allows for the comparison of the EF of one night spent by tourists in seven different kind of hospitality structures. LCA [4] has been focused on the life cycle of the hotel building from cradle to grave. The following phases have been included in the system boundaries: extraction of raw materials; production of building products; building construction; use and management of structures, including activities of hotel maintenance; end of life of building materials.

Results and Discussion
The following table illustrates the results of the EF category “Housing” (referred to the construction of the building and the maintenance and use phase) for different types of hospitality solutions. Land needed to compensate fossil energy emission (related to energy consumption for the extraction of raw materials, building operations and use phase) and built-up land are the two categories of EF relevant for this kind of activity.

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>1-2* hotel</td>
<td>15.75</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>9.04</td>
<td>0.00</td>
<td>24.78</td>
</tr>
<tr>
<td>3* hotel</td>
<td>32.10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>27.12</td>
<td>0.00</td>
<td>59.21</td>
</tr>
<tr>
<td>4* hotel</td>
<td>66.34</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>53.08</td>
<td>0.00</td>
<td>597.22</td>
</tr>
<tr>
<td>Second house</td>
<td>186.72</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>10.28</td>
<td>0.00</td>
<td>197.00</td>
</tr>
<tr>
<td>Agritourism</td>
<td>13.53</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>23.30</td>
<td>0.00</td>
<td>36.83</td>
</tr>
<tr>
<td>B&amp;B</td>
<td>12.07</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>3.60</td>
<td>0.00</td>
<td>15.67</td>
</tr>
<tr>
<td>Camping site</td>
<td>14.92</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1233.98</td>
<td>0.00</td>
<td>1248.89</td>
</tr>
</tbody>
</table>
The results of LCA confirm the importance of energy consumption in the use phase ("electricity consumption") and highlight the great share of impact related to the building ("hotel assembly"), coming from the extraction and use of raw materials and the energy consumption during the entire phase (Table 2). The damage category "resources" is the most impacted by this kind of activity.

Table 2: evaluation of damage categories (Eco-indicator 99 meth.) in LCA of a 2* hotel (values in %).

<table>
<thead>
<tr>
<th>Damage category</th>
<th>Total</th>
<th>Hotel assembly</th>
<th>Water consumption</th>
<th>Gas consumption</th>
<th>Electricity consumption</th>
<th>Waste</th>
<th>Food transport</th>
<th>Maintenance</th>
<th>Dismantling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human health</td>
<td>49.1</td>
<td>10.20</td>
<td>4.76</td>
<td>0.53</td>
<td>30.15</td>
<td>-1.37</td>
<td>3.69</td>
<td>1.08</td>
<td>0.12</td>
</tr>
<tr>
<td>Ecosystem quality</td>
<td>20.1</td>
<td>10.50</td>
<td>1.24</td>
<td>0.09</td>
<td>6.90</td>
<td>-0.35</td>
<td>0.75</td>
<td>0.89</td>
<td>0.02</td>
</tr>
<tr>
<td>Resources</td>
<td>30.8</td>
<td>29.70</td>
<td>-121.00</td>
<td>31.00</td>
<td>80.38</td>
<td>-14.30</td>
<td>20.20</td>
<td>4.50</td>
<td>0.22</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>50.40</td>
<td>-115.00</td>
<td>31.60</td>
<td>117.40</td>
<td>-16.00</td>
<td>24.60</td>
<td>6.47</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Conclusion
This first attempt to compare the results of EF and LCA of tourist accommodation buildings proved to be useful for improving the analysis. There is a certain correspondence between the two methods (e.g. the phases of the process that generate the most important impacts) but also some aspects that could be further investigated through LCA. For instance, due to the fact that EF measures all impacts in term of land use, the camping site results to be the most impacting structure because all the area occupied is considered as built up land; nevertheless, the area occupied by a camping site still maintain some ecological functions (e.g. it is not totally rainproof), so it could be more easily reconverted to a natural state than an area occupied by an hotel and its infrastructures. This aspect could be evaluated considering the dismantling phase in LCA.

References
Building a network for the Ecological Footprint Community

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Keywords: Communication, Partners, Networks

Introduction
Networks are an important means of mobilising opinion, communicating knowledge and disseminating information. To retain their relevance, networks must have sets of shared values and provide added value for their members. For Global Footprint Network (GFN) and its partners these challenges could be acute as the Network brings together a diverse range of partner organisations. Partners will have an interest or ‘stake’ in the Ecological Footprint but these are likely to be expressed in very different ways.

GFN is now in its seventh year and it is particularly timely to analyse the relationship between the ‘core’ of the Network and its partners. Why do its partners value GFN? What messages does GFN provide to its partners? How might we characterise the nature of the relationship between GFN headquarters and its partner organisations? In this paper, we provide preliminary answers to these questions and analyse the challenges that the global Ecological Footprint community faces in further developing a network-based model of communication and engagement.

Methods
An online survey was developed for partners of GFN and made available between June and August 2008. All current partners of GFN were contacted explaining the purpose of the study, who was conducting the research and how the results would be used. Given the size of GFN, partners were also assured complete anonymity in their responses. The survey contained forty-two questions, which were developed in conjunction with GFN, and which were grouped into the following seven themes: partnership with GFN; ecological and carbon footprint activities, partners thoughts on GFN, Network committees, suggestions on strengthening the Network, responses to partners’ issues and concerns, communications and partner involvement in other network activities. For each responding organisation, the online survey was completed by one person.

Results and Discussion
The survey achieved a response rate of 57% and was representative of the types of organisations that were partners of GFN at that time. Responding organisations were located in Europe (52%), North America (25%) and Australasia (18%), South America (4%) and Africa (2%). Twenty-nine percent of organisations had been partners of GFN for 4 years or more, 46% for 2-3 years and 25% for 1 year or less. For organisations who had partnership for 4 years or more, the largest proportion were social benefit/NGO/non profit organisations (38%). For organisations with 2-3 years partnership, the largest
A key objective of the survey was to understand the role of professional networks and their perceived value by network members. Partners’ main priorities in terms of what a profession network should offer its members included opportunities for ‘learning and knowledge exchange’ (52%), ‘information dissemination’ (23%), ‘capacity building’ (18%) and ‘collaboration between sectors’ (13%). This was also reflected in how partners perceived and valued Global Footprint Network. Partners perceived that the three most important services and functions provided by GFN were ‘advancement of national accounts research’, ‘coordination of standards committee and publication of standards’ and, ‘acting as an official source of information on the EF’. Interestingly, only 21% of partners had an active role in the Network through the Ecological Footprint Committees whereas 75% played a more passive role. A leading suggestion on how partners perceived the Networks’ current services and function could be improved related to better engagement with its partners.

**Conclusion**

As GFN moves into a more mature phase, the Network has to cope with a more complex context. First, the growing institutionalisation of the EF is confirming the importance of methodological rigour and standardisation. However, this is also leading to different partners joining the Network with their own expectations as to its purpose. Second, a more diverse membership raises challenges for communication and maintaining core values. Third, members have highly variable levels of engagement with the Network, from the active to the passive, and this will raise issues of legitimacy.
Carbon Footprinting and UK Nuclear Energy Policy

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Keywords: carbon footprint, nuclear energy, energy policy, United Kingdom

Introduction
The UK has one of the most rigorous carbon reduction targets in the world. The Climate Change Act (2008) enshrined in law an obligation to reduce the country's greenhouse gas emissions by 80% of 1990 baseline levels by 2050. The 2008 white paper on nuclear power outlined the UK Government's reviewed stance on atomic energy and concluded that the development of new power stations would help it to meet its objectives on CO₂ emissions reduction and energy security and that it would be in the public interest to allow energy companies to invest in nuclear power. The carbon footprint of nuclear energy development is, however, the subject of much controversy and the role of the carbon reduction agenda in nuclear policy formulation is poorly understood. The relatively low carbon footprint, as an essential element of ecological footprint analysis [3], is widely considered as one of the main drivers for future nuclear development both in the UK and internationally [2,8].

Methods
Policy analysis indicates the wide variety of nuclear carbon footprint figures used by the various arms of the UK Government. Re-assessment of existing international studies on nuclear footprint analysis, with a focus on removing bias and taking into account regional variation, results in data more applicable in policy development. This is not to say that there is no such thing as an unbiased, accurate life cycle analysis of the nuclear fuel cycle but it seems clear that the ranges used by policy makers in their decision making and by carbon accountants in their calculations have significant potential for error [6].

Results and Discussion
Initial analysis of the values attributed to CO₂ emissions resulting from nuclear energy development indicates that there is a spread over a significant range. Parliamentary figures released in 2006 set the carbon footprint of nuclear generation at 5 - 6.8 gCO₂/kWh [4]. In the same year, the Sustainable Development Commission highlighted a wider range of 2 - 20 gCO₂/kWh and concluded that the carbon reduction potential was insufficient to justify increasing generation [5]. The 2008 nuclear energy white paper, on the other hand, uses a range of 7 - 22 gCO₂/kWh and proposed further nuclear development [1]. Each of these ranges was derived from a small number of international sources and included emissions from the entire nuclear lifecycle. The most recently published peer-reviewed paper on the CO₂ emissions associated with nuclear energy production, however, analyses over 100 international studies and derives a very large range of 1.4 - 288 g/kWh, with a mean figure of 66 g/kWh [7].
Conclusion
This paper seeks to develop a new model for carbon footprint analysis in the nuclear energy sector which takes into account both regional variations and sources of bias. Such re-assessment allows for more accurate evaluation of the role of nuclear energy in UK carbon budgets. The effects of the carbon reduction agenda in nuclear policy development will also be explored.

References
Losing Weight or Treading Lightly: Understanding the Carbon Footprint

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2) Institute for Sustainable Energy & the Environment (I-SEE)

Keywords: Footprint, carbon emissions, carbon weight

Introduction
Carbon footprints have recently received a lot of attention, not only from the media, but also from academics, policy makers and the general public alike. The carbon footprint is the largest contributor to humanity’s total environmental footprint¹, approximately 50% [2]. The use and application of the carbon footprint has become popular, however, the term ‘carbon footprint’ is often misused. A footprint is fundamentally measured in spatial units of global hectares, but the carbon footprint so often referred to is actually a ‘carbon weight’, of kilograms per person or activity [3]. With the growing popularity of the carbon footprint and the recent focus upon the disparity between nation states, it was possible to establish the dominance of factors such as varying economic wealth upon the carbon footprint. By generating a correlating equation and highlighting the G-20 nations, the need for careful environmental policy and carbon reduction strategies was identified.

Methods
The analysis was based upon the methodology of Cranston et al. [1] and their development of the correlating power-law equation for national environmental footprints. Four determinants were considered, all others having been eliminated [1]. The carbon footprint was postulated to be a function of economic wealth (GNI) [per capita $], population density (PD) [population per hectare], energy intensity (EI) [MJ/$] and carbon ratio (CR) [μgC/J]. This can be written as a correlating power-law equation, as per engineering and physical sciences:

\[ cf = (GNI)^a (PD)^b (EI)^c (CR)^d \]

To determine the significance of each of the factors, a power-law correlation was applied. The correlation established the dominance of each factor upon the per capita national carbon footprint, cf. Each variable was raised to a power which represents its relationship with the carbon footprint. The variables were all shown to be independent of one another such that there was no double counting or cross-correlation. A total of 107 countries were analysed for the year 2005. This does not include all the nation states of the world due to the limited availability of data, particularly for some less developed nations. However, it still offers a good range and indication of the differences within the international community of nations.

The misuse of the term ‘carbon footprint’ was also considered. The carbon weight or ‘carbon consumption’ for 107 nations was calculated and compared with their respective carbon footprint.

¹ when looking at developing countries other contributions may dominate
Results and Discussion

It was shown that economic wealth offered the strongest direct correlation with the carbon footprint. This was to be expected as the footprint is a purely consumptively driven indicator; those nations with larger incomes and successful economies inevitably emit a larger magnitude of emissions. The final result showed that energy intensity and carbon ratio were also important factors related to the carbon footprint, such that $c = 1$ and $d = \frac{3}{4}$. The dominance of the industrialised world is evident in Figure 1, with many of the highlighted countries clustered about the correlating line. Those above the correlating line are considered to be wasteful in terms of their resource use, whilst those below it are more frugal.

It was shown that the carbon footprint and carbon weight values are very similar, since the conversion factor is almost 1. This is convenient as it could aid those who fully understand the footprinting concept to readily convert the 'carbon weight' to a carbon footprint. The G-20 nations were highlighted once again to show whether countries are frugal or profligate in terms of their carbon emissions and consumption. The 'developed' countries were clustered at the top end of the plot; the 'developing' nations were further down the plot and relatively more spread out.

Conclusion

Carbon footprints have caught the attention of the world and have stirred many into a frenzy of carbon reducing action. Unfortunately the common portrayal of the carbon footprint is not a footprint at all, but a mass or weight. This study considers the significance of this difference and the importance of the carbon indicator. Alongside this, the influence of economic wealth, population density and pollutant emission intensity upon the carbon footprint are considered and developed into a correlating 'power-law' equation. The way in which countries are wasteful or frugal with their resource use is illustrated by highlighting the G-20 nations. The necessity to aid the developing world as they move towards industrialisation is also discussed in view of the results. As the transitional countries grow in geopolitical power and become key economic players, it becomes important to consider how best to implement action against climate change. There must be a commitment from both the industrialised and developing world which can be implemented through post-Kyoto negotiations.

References

The potential of voluntary environmentalism vs. policy driven environmentalism in reducing ecological footprint -

the case of Hungary

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Keywords: Introduction
Better sustainability policy is supposed to lead to better sustainability performance. Nonetheless, recent research predicts further growth of the ecological footprint and stable ecological deficit in Europe and North America despite their impressive policy efforts [5]. Similarly, individual strategies result in somewhat reduced load for committed consumers, but this reduction cannot offset the total impact of the socio-economic configuration: consumers in higher income countries tend to pollute more. Committed consumers “offset” a part of their environmental load by carrying out green purchases. A radical change assumes a change in lifestyles [1]. The study aims at revealing sustainable and unsustainable lifestyles in Hungary, and also testing the potentials for change by voluntary environmentalism or by policy measures.

Methods
At the first stage of our research we have calculated the ecological footprint of consumption by income deciles using the environmentally extended Leontief model as proposed by Wiedmann et al. [6] and others. It relies on industrial input-output tables and published ecological footprint data. This model is able to capture the direct as well as indirect ecological footprint impacts in consumption of various product groups. The impacts were compared to the biocapacity per capita data in order to reveal the sustainability of lifestyles in different income groups.

The second phase of the research is based on a random representative sample of 1000 people. The survey will build up a bottom-up approach of footprint calculation and will be used to refine and test the results of the first research phase. Combining ecological footprint questions with life satisfaction questions provides an interesting insight towards the acceptability of sustainable and unsustainable lifestyles.

Results and Discussion
The study aims at measuring the significance of attitude elements as compared to the significance of the socio-economic system on the ecological footprint in various income groups. Our hypothesis suggests that conscious consumption behaviour is able to keep the ecological footprint within the limits of bio-capacity mainly in the mid-income social groups in the mid-income countries. Environmental attitude in itself is insufficient to control ecological impacts in high income groups: the impact of the socio-economic system offsets the gains of environmentally conscientious behaviour. Thus education and awareness raising have limitations when they are not accompanied by changes in the infrastructure, economic policy, etc.

The results showed high theoretical potential for reducing ecological footprint by conscientious purchasing in mid-income groups and less potential in high income groups.
The survey phase, based on a 1000 elements representative sample, studies how much this potential is actually exploited by different clusters of the society. It aims at measuring the impact of the socio-economic system as compared to the individual attitude in defining the ecological impact of consumption. It also searches for social clusters with sustainable lifestyles and a high level of life satisfaction. The survey will be completed by the end of April, with first results available by the time of the symposium.

**Conclusion**

The first phase of the research, based on combining ecological footprint with industrial input-output tables, revealed that about the lowest three income deciles of the population live within the biocapacity limits of the country. Mid-income groups, about 30-40 percent of population, live at the margin of sustainability, where environmentally aware consumption behaviour has a potential to reduce ecological footprint to the sustainable level. The highest 30 percent is far beyond sustainability, where attitude changes are insufficient to offset high footprint: major changes in the socio-economic system are required. The survey phase has the purpose of refining these statements and also to test the social acceptance towards sustainable lifestyles. For this reason, life satisfaction questions will be combined with ecological footprint questions.

**References**


Developing Indicators for the Urban Institutional and Ecological Footprint

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Keywords: Ecological footprint, urban metabolism, urban ecosystem, urban institutional footprint

Introduction
The ecological footprint has been developed as a tool to estimate nations and cities’ metabolism consumption of natural resources from an environmental economy point of view. The urban planning and management, that is environmentally oriented, which has to “control” cities metabolism needs an assessment tool that can be integrated easily in the urban planning process. The Urban Institutional and Ecological Footprint tool is a strategic planning tool at city level composed of the Ecological Footprint associated to the Urban Institutional Footprint. The strategic tool can measure the urban metabolism for an easy control and management toward a sustainable city. The urban Institutional Footprint is developed from a set of indicators and the result is a footprint displayed graphically in a radar chart.

Methods
The paper uses the systemic approach to build a model of an urban ecosystem in order to understand its metabolism flows and regulation functions. The regulation system is outlined into a series of institutional valves for each flow. Indicators are drawn from the valves control level status. The indicators are aggregated into a final footprint index to be outlined in a radar chart.

Results and Discussion
The paper presents the Urban Institutional and Ecological Footprint method. It explains the construction method of this strategic tool and its application. First, it defines the general frame of the association of the two tools: the Ecological Footprint and the Urban Institutional Footprint. Then, the method outlines the UIF construction by the development of a set of indicators from the institutional valves of control of the urban metabolism system. The indicators are aggregated at different levels to finally result in an AMOEBA graphic and an index value of the UIF. The graphic AMOEBA of the Institutional Urban Footprint is compared to the Ecological Footprint to define overshoot problems and pinpoint institutional actions to be taken in order to reduce flows and control the metabolism. The result helps decision making for planning issues in order to control and manage urban metabolism related to Ecological Footprint results. It also helps comparing different cities’ metabolism and their Institutional Footprint.
Conclusion

The paper introduces the new strategic tool of Urban Institutional and Ecological Footprint, its method and application. The tool composed of the Ecological Footprint and the Urban Institutional Footprint helps in the decision making of urban metabolism control for a sustainable city. The Urban Institutional footprint is developed around a set of indicators drawn from the flows valves status of the urban ecosystem’s metabolism regulation centre. Its results are outlined in an AMOEBA chart in the form of a footprint to be compared to the EF of the same urban metabolism. The aim is to transform the EF assessment results into urban actions to be integrated in the urban ecosystem planning process. The different footprints can be compared to other cities footprints for urban practices comparison.

References

Matripolis: A Community Centered Ecocity System

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Keywords: Matripolis, Matripolitan, Matripole, Re-localization, Self-regulation, Local Self-sufficiency.

Introduction
Scientists have warned that, if we continue on a path of ‘business as usual’ catastrophic climate change will ensue. But the global economic system is now in an ‘unusual’ state of recession. This presents a unique opportunity to re-localize it so that in the future no component of it can grow ‘too big to fail’.
The human species, has naturally pursued its own interests like any other species, but with vastly greater success. In the last 200 years is has developed tools so powerful in reshaping the environment to its own ends that it has not only greatly damaged the habitat of other species but has set in train an all-but-irreversible cycle of climate change that threatens the survival of all life on earth, including our own.
The good news is that we all now know that this is truly a mistake we have made and that we must set about changing our life patterns to remedy it.
There are three kinds of remedy needed:
One is to move as fast as possible to a post-carbon era where coal, oil and gas are left in the rock beneath our feet and never again burned in the open air.
Two is to step back from our encroachment on the habitat of other species and give back to them some of the space we have stolen from them.
Three is to provide much more space for other species, particularly plant life, in our cities, to become once more part of our daily life. Cities have become too artificial and too isolated from the rest of the biosphere. Interaction between species appears to be an essential ingredient of the health of any one. Artificially ‘sealed’ areas brought about by human activity must be reduced in area and they can be – by consolidating cities and converting them to eco-cities.

Methods
Designing a new society to replace a sick civilization can be interpreted as a design problem with a design solution. The city is the site for our industrial civilization and only the Ecocity can save it.

Results and Discussion
Result: My book (see references below).
Discussion:
1. Is Matripolis practical?
2. How relevant is Matripolis to solution of immediate problems such as ending use of fossil fuels?
3. Is strong articulation of community identity consistent with anonymity and privacy for those who desire it?
4. What about daylight access for those in the workplace who desire it?
5. Does not Matripolis produce excess floor plate capacity?

Conclusion

The word Matripolis is a take-off from Metropolis (which has become in the meanwhile nothing but Auto-City) and suggests that we should move away from cities of phallic skyscrapers, symbolic of patriarchy, towards a softer greener city that by contrast would be based on places and spaces for people, plants and other animals. It would be a city of nested communities providing a nurturing environment as hospitable to old and infirm as to the growing child with all demographics in between.

So I will be using the word and its derivatives, Matropolis and Matripole as shorthand for the urban design theory that I have evolved and am briefly presenting to you today.

Matropolis is a system for consolidating the growth of cities by layering functions one on top of another so that at once they grow vertically and fill out horizontally to form a continuum of built form replacing the traffic isolated blocks of the contemporary metropolis.

Three dimensional zoning laws replace conventional zoning plans permitting greatly expanded opportunities. Cities are rescued from the destructive effects of motorized traffic. People of all ages and other animals may once more wander freely and safely in all the outdoor spaces of the city as they once did. Instead of the meager sidewalks and occasional parks and plazas of today these spaces are themselves expanded to cover the entire footprint of the city - by means of ramps and terracing. Most of this expanded public domain is also planted with trees and other vegetation including edible landscaping. The orientation of properties is turned inside out. Instead of buildings lining a stream of traffic Matropolitan home leasers look out on an artificial green valley encircled with the homes of those with whom they share it. Each Matripole is a social incubator in which sharing in the cultivation of community gardens will encourage the emergence of strong community identity, without loss of privacy.

Artificial Landscape.

By making all roofs of the city earth-bearing and then connecting them together at each level there is provided plenty of space for playgrounds, playing fields, parks, private gardens, community gardens etc. But also there is space for urban farming, permaculture, hydronic horticulture, allotments, orchards, vineyards, market gardening, greenhouses, etc. And because all this greenery is juxtaposed directly with the housing it provides perfectly safe space for children to play and also to gain hands on experience of the organic world so often denied to today’s city dwellers.

References

[2] see also bibliography for the above.
Corporate water footprint accounting and impact assessment: the example of a sugar-containing carbonated beverage

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Keywords: water footprint, business water accounting, carbonated beverage

Introduction
All water use in the world is ultimately linked to final consumption by consumers. It is therefore interesting to know the specific water requirements of various consumer goods, particularly for goods that are water-intensive, like food items, beverages and clothes. This information is relevant not only for consumers, but also for retailers, traders and other businesses that play a central role in supplying those goods to the consumers. This article aims to estimate the water footprint of a hypothetical sugar-containing carbonated beverage in a 0.5 litre PET-bottle produced in a hypothetical factory that sources its sugar alternatively from sugar beet, sugar cane and high-fructose maize-syrup (HFMS) from different countries. The composition of the beverage and the characteristics of the factory are hypothetical but realistic; the data assumed have been inspired by a real case. The objective is primarily to learn from the practical use of existing water footprint accounting and impact assessment methods and to refine these methods and develop practical guidelines, for instance with respect to the necessary scope and degree of detail of analysis in such a study.

Method
First, the production-chain diagram for the 0.5 litre PET-bottle sugar-containing carbonated beverage is identified, indicating the relevant process steps from source to final product and identifying the steps with a substantial water footprint. Following identification of the relevant process steps, the water footprint of the beverage is calculated, distinguishing between the green, blue and grey components. The water footprints are calculated using the methodology developed by Hoekstra and Chapagain [2]. The study includes an analysis of both the operational and the supply-chain water footprint of the beverage, following the definition by Gerbens-Leenes and Hoekstra [1]. New in this study, we distinguish between the water footprint of the inputs (ingredients) that can immediately be related to the production of the product and a so-called overhead water footprint, which refers to freshwater use that can only indirectly and partially be associated with the production of the specific product considered. It includes for example the freshwater use in the toilets and kitchen of a factory and the freshwater use behind the concrete and steel used in the factory and machineries. Finally, an impact assessment of the water footprints is made, by differentiating between the type of impact, its location and timing in the year.

Results and Discussion
The total water footprint of the predefined 0.5 litre PET-bottle sugar-containing carbonated beverage is calculated as minimum 168.4 litres (sugar beet from the
Netherlands) and maximum 309.4 litres (sugar cane form Cuba). The operational water footprint of the product is 0.5 litres, which forms 0.2 – 0.3 % of the total water footprint. The supply-chain water footprint of the product thus constitutes 99.7-99.8 % of the total water footprint.

It is also important to identify and analyse the colours of the water footprint of the product in order to assess the impacts of the water footprints. The highest blue water footprint of the product is 124.5 litres with sugar cane from Pakistan and the lowest is 8 litres with sugar beet from the Netherlands. The green water footprint is the highest if the beverage is made from sugar cane from Cuba (229.7 litres) and lowest if the source is sugar cane from Peru (134.5 litres). The grey water footprint of our product is the lowest when the sugar is made from sugar cane from Brazil (9.2 litres), and highest with HFMS from China (18.8 litres).

The main impacts of the product are stemming from the grey and blue water footprints of the product. Ingredients like sugar, vanilla, caffeine (coffee) cause contamination of natural freshwater sources (grey water component) because of the use of fertilizers and pesticides.

**Conclusion**

The results of this study show the importance of a detailed supply-chain assessment in water footprint accounting. Common practice in business water accounting is mostly restricted to the analysis of the operational blue water consumption. However, this study shows that compared to the supply-chain water footprint, the operational side is almost negligible. Given this inclusion of water use in the supply chain plus the fact that the water footprint includes green and grey water on top of blue water, the concept of the water footprint provides a more comprehensive tool for water accounting.

The study indicates that the water footprint of a product can be very sensitive to the precise source of the inputs, in this case the origin of the sugar (beet, cane or maize) and the production location and circumstances. Additionally, the ratios between the green, blue and grey water footprint components strongly differ from one to another location. These results reveal the importance of the spatial dimension in water footprint accounting.

The study shows that even seemingly minor ingredients can significantly affect the total water footprint of a product. On the other hand, the study also shows that many components studied hardly contribute to the overall water footprint. This is the first study quantifying the overhead water footprint of a product. Strictly spoken, this component is part of the overall water footprint of a product, but it was unclear how relevant it was. This study reveals that the overhead component is not important for this kind of studies and is negligible.

**References**

Comparison of Carbon and Water Footprint

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Keywords: carbon footprint, water footprint, response formulation, footprint offsetting, footprint reduction

Introduction
Carbon footprint has become very popular over the last few years and is currently widely used across the media and public. Several calculation methods and approaches for carbon footprint have been proposed to provide estimates (basic to sophisticated analysis). Despite the lack of scientifically accepted and universally adopted guidelines, the carbon footprint has become a widely accepted concept, which describes anything from the narrowest to the wildest interpretation of greenhouse gases measurement and reduction [3]. The water footprint has also become a popular term like carbon footprint. Although definitions and methodology of the water footprint are well defined, there is a high potential of a less rigorous usage of the term similar to carbon footprint. The ambiguity problem around the concept of the carbon footprint can also become a problem for the water footprint concept in the near future. By understanding the development and mechanisms of carbon footprinting (both accounting and response formulation), and extracting lessons from the history and development of carbon footprint, we draw lessons that may help to reduce the risk that the water footprint will lose its strict definition and interpretation.

Methods
This study focuses on comparison of carbon and water footprints. The history, development of both footprints is analysed in order to understand the similarities and differences between the two footprints. An extensive literature survey is done for gathering necessary information and to elaborate the advances in both concepts. This study not only assesses methodologies, related problems but also the measures and institutional mechanisms adopted for response formulation.

Results and Discussion
In response to the increasing concern about climate change and global warming, decision makers (governments), businesses and consumers are considering ways to reduce greenhouse gas emissions. The two main response strategies are: reduction and offsetting. Reduction is to do the things in a less “carbon” intensive way; offsetting refers to taking external actions to offset carbon footprint by means of some form of carbon capture or reduction elsewhere by others. These mechanisms are applied and supported widely through businesses and governments. However, the effective reduction of humanity’s carbon footprint is seriously challenged because of two reasons. The first is the absence of a unique definition of the carbon footprint, so that reduction targets and statements about carbon neutrality are difficult to interpret, which leaves room for making developments show better than they really are. The second problem is that existing mechanisms for offsetting leave room for creating externalities and rebound effects. In the case of the water footprint, the identification of how to respond is still under question. Also here it has been recognised that one can distinguish between ‘reduction’ and ‘offsetting’ strategies. The terms “water neutral” and “offsetting” are considered as possible alternatives similar to carbon footprint [4]. The strategy of offsetting may face
the same sort of problem as in the case of carbon offsetting, but there is an additional problem: water footprints impact at specific locations and in specific periods of time and offsetting can only be effective if offsetting efforts relate to those locations and periods of time.

Carbon footprint accounting has been promoted by NGOs, companies and private initiatives rather than driven by research. This has led to many definitions and solutions on how a carbon footprint should be calculated and what kind of response should be formulated. As seen in the example of companies which are responding rapidly to formulate schemes to tout their carbon neutrality, the interest is mainly characterized by high level of interest in brand imaging. Businesses see marketing benefits in using carbon footprint as an advertising tool rather than reducing their impacts. Similarly carbon accounting and labelling is seen as a main solution rather than to be used as a supportive instrument in the toolbox of measures available to mitigate climate change. Carbon offsets distract attention from the wider, systemic changes and collective political action that needs to be taken to tackle climate change. For water protection, these insights can be helpful in the search for effective instruments that can contribute to a more efficient, sustainable and equitable use of the globe's water resources.

**Conclusion**

Global warming and reductions of carbon emissions are at the top of the environmental policy agenda today. However, at the moment the carbon footprint presents serious challenges to effectively tackling environmental problems. This study argues that the weakness of offsetting in the case of carbon footprint shows that applying both offsetting and neutrality in water footprint cannot be effective solutions and ideas. A more effective tool are probably direct water footprint reduction targets to be adopted by both governments and companies.

**References**


Harmonizing the National Footprint Accounts with the System of Integrated Environmental and Economic Accounting

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Keywords: National Footprint Accounts, System of Integrated Environmental and Economic Accounting, System of National Accounts

Introduction
An international standard accounting framework is needed to analyze the reliance of economies on the environment and the environmental repercussions of economic activities. The System of Integrated Environmental and Economic Accounts (SEEA) - a satellite system to the economic System of National Accounts (SNA) - provides this interdisciplinary functionality and compatibility between various environmental accounts. Harmonizing the National Footprint Accounts (NFA) with the SEEA represents an opportunity to link bioproductivity-weighted material flows with the principles, concepts, and classifications currently utilized by government statisticians and economists. More specifically, it will provide consistency between the Ecological Footprint and biocapacity indicators and the physical flow accounts, the hybrid flow accounts, and the natural resource asset accounts of the SEEA.

Methods
Aligning the accounting methodology of the NFA with the SEEA requires consistent boundaries and common definitions. For instance, there are four types of flows distinguished within the SEEA: products, natural resources, ecosystem inputs, and residuals. In this context, the Ecological Footprint is a physical flow indicator that measures the amount of bioproductive area required to produce the biological natural resources consumed, and uptake the carbon dioxide residuals generated, by a given population or activity.

Classification codes vary by accounting frameworks. The NFA product classifications are based mostly on UN Food and Agricultural Organization (FAO), Harmonized Commodity Description and Coding System (HS), and Standard International Trade Classification (SITC). Land cover classifications within the NFA are based on the FAO Land Cover Classification System (LCCS) [1]. The SEEA classifications for physical and hybrid product and industry flows are based on the Central Production Classification (CPC) and the International Standard Industrial Classification (ISIC). Classifications in physical and monetary supply and use tables for government and household consumption are based on the Classification of the Functions of Government (COFOG) and the Classification of Individual Consumption According to Purpose (COICOP) [2]. The environmental assets (EA) of the SEEA are based on the non-financial assets (AN) of the SNA [3]. Land cover classifications have been proposed for the SEEA 2013 based on the FAO LCCS system.
The use of different coding systems thus necessitates the creation of comprehensive bridge tables to harmonize the various products, resources, assets, and activities between accounting systems. The United Nations Statistical Division has published bridge tables between most of these classifications.

Furthermore, integrating input-output analysis within the NFA would expand the current emphasis on land use classifications to include the supply and use of resource throughput by each country’s economy; thus forming a hybrid - physical and monetary - flow account [4, 5]. The use of biological natural resources and emissions of carbon dioxide could thereby be separated into intermediate inputs by industry, investment, final consumption by households and government, and imports and exports. This integration with input-output analysis precludes a comprehensive harmonization of the NFA with the SEEA hybrid flow accounts.

Results and Discussion
Policy applications of a harmonized NFA-SEEA framework would include analyzing the land use and economic drivers of environmental degradation, analyzing the de-coupling of economic growth from resource throughput, decomposing the drivers of change in consumption over time [6], and aligning the NFA with complementary indicators and descriptive statistics. Limitations of the SEEA include poor compatibility at the sub-national level or on an intra-annual basis and aggregation of products or commodities within the supply and use framework that is greater than currently available from NFA source datasets.

Conclusion
Harmonizing the NFA with the SEEA facilitates integrated environmental-economic analysis and links data from government statistical offices directly to the NFA. Research collaborations with governments will consequently provide real-time data that can improve the information available for policymakers.

References
A Systematic Approach to the Creation of Sub-National Biological Capacity Accounts

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Keywords: National Footprint Accounts, Geographic Information Systems

Introduction
The current National Footprint Accounts provide biological capacity (biocapacity) results for more than 150 nations \cite{1}. However, calculations and results at the national level conceal the sub-national variability in land cover and bioproductivity. This paper provides a framework and sample results for the systematic production of sub-national biocapacity accounts for all nations. To the author’s knowledge, this is the first publication utilizing geographic information systems (GIS) to measure biocapacity for multiple nations at a sub-national resolution.

Methods
Biocapacity is defined as “the capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans, using current management schemes and extraction technologies” \cite{2}. Biocapacity, $BC$, is measured for any land use or fishing grounds area as

$$ BC = A \cdot \frac{Y_L}{Y_W} \cdot EQF $$

where $A$ is area, $Y_L$ is local yield, $Y_W$ is world average yield, and $EQF$ is the equivalence factor; for each land use type or fishing grounds area.

The proposed creation of sub-national biocapacity accounts relies on GIS datasets to measure land cover areas and yields for each of the land use type classifications used in the National Footprint Accounts. Maps are obtained at the highest available quality for each respective region of the world. Multiplying the land cover areas by yields within the same geographic coordinates enables a direct measure of local biocapacity; rather than utilizing national average yields. Local results are then divided by world average yields and multiplied by equivalence factors. The resulting biocapacity maps can be aggregated to a preferred administrative level.

Source data for land cover, yields, and administrative areas are available from publicly-accessible GIS data portals. The quality of source datasets will improve through additional research and collaborations with governments. The European Space Agency’s GlobCover map is currently the highest resolution global land cover map at 300 meters spatial resolution \cite{3}. Yield maps are currently available for net primary productivity at 1000
meters spatial resolution [4]. Sub-national administrative boundaries are typically available to the county or district level.

**Results and Discussions**

Below is a representative example of the improved resolution.

Applications with the sub-national biocapacity accounts include linking the National Footprint Accounts data with additional GIS datasets; such as protected areas, species habitats, ecosystems, or land use change. As might be expected, the use of satellite imagery to infer land cover or yield for small administrative areas may deviate land class accuracy. It is therefore important that continuous improvements are made to acquire the highest resolution geographic information.

**Conclusion**

Ideally, sub-national biocapacity accounts will be analyzed in parallel with sub-national Ecological Footprint accounts and other related datasets. This project was initiated to provide a foundation for future developments of the National Footprint Accounts database into an accessible geospatial information portal.

**References**


Global Citizenship and Sustainable Change: Better Information, Smaller Footprint

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Keywords: Global Citizenship, Individual Actions, Sustainability

Introduction
For real and meaningful environmental progress to be achieved around the world, individuals will have to alter their behavior and expand their view of the world. There are many possible avenues to achieving this change. The individual can be approached as a consumer in a commercial model of exchange; the home owner can pay for an energy audit and then use the information to improve the home's energy efficiency to save money and carbon emissions. Additionally, information can be diffused to the individual via social activist or volunteer models. The government can take the lead on educating and do so out of public interest with taxes. An interesting newer model is the Care2.com model of a website that generates revenue through advertisements and does the desired action for the web-browsing citizen. But is there another way? Instead, we could imagine people identifying themselves as global citizens. Not as voters, not as consumers, not as civil society members, not as state citizens. A global citizen should be able to think globally and act globally.

For global citizen governance we need to draw upon the connectivity of communal actions. We must expand the “imagined community” (Anderson) to include all concerned people of the world. This citizen based governance will empower people to overcome the obstacles which have previously prevented them from efficaciously shrinking their carbon footprint.

The primary vehicle for achieving this is through the development of an underappreciated and underdeveloped governance structure: Global Citizen Action

The focus of Global Citizen Action will be on responsibility. If an individual causes a greenhouse gas emission, he or she should have the power to reduce, eliminate, or offset that emission. The foundation of the global citizen governance structure rests on information and knowledge. In order to transform an ordinary individual into a global citizen, we need to create the identity and community of global citizens.

When scaled across social networks and communities, the aggregated impacts of individuals can be recognized within policy frameworks to allow for better governance and decision-making. As old models like Kyoto stay in play and new initiatives like the Smart Grid take hold, the impact of global citizen governance will complement them all as it grows. Both homegrown community based projects, Congressional legislature and public-private partnerships can work in tandem with global citizen governance to combat carbon emissions.

There remains one substantial barrier to implementing a citizen based governance such as Global Citizen Action: lack of reliable information. Current resources for individuals
interested in taking steps to reduce their footprint often contain information that is incomplete, difficult to quantify, not optimally effective, and lacking in scientific rigor.

**Methods**

Organizations promoting what individuals can do to reduce their carbon footprint are increasingly popular, offering numerous resources and suggested actions for individuals interested in reducing GHG emissions ¹.

Our research began with an attempt to find the most common actions suggested to individuals seeking to reduce their carbon footprint, in order to analyze the quality of the information presented to the average citizen. The basic approach behind our research was to find the most public and accessible information available. Mainly through internet searches - as the internet remains the main source of information on sustainable actions for most individuals - we compiled an extensive list of educational websites with a high amount of prestige and public trust. The most frequently suggested action items turned into our “Dirty Dozen” list of recommendations. From this list, we then examined how much analysis went behind each recommendation. Many of the recommended actions provided no supporting data. In order to fairly compare each of the action items’ claimed reductions, the items were converted to impact in tons of carbon dioxide.

A review and analysis of the advice provided on these sites on the connection between individual action and actual GHG reductions show them to be largely unsubstantiated, imprecise, often conflicting, and highly aggregate.

The virtual public sphere is clouded with carbon footprint calculators intended to help individuals grasp their impact on climate change. Unfortunately when identical data is entered into different calculators, the results are drastically different². For example, the difference between the Climate Crisis and the Nature Conservancy calculators is a factor of ten. The calculators available are unreliable, use generalized data and overly simplify the information necessary to individuals looking to take responsibility for their GHG emissions.

**Results and Discussion**

Our research thus far has confirmed that these two goals - promoting Global Citizen Action and improving the reliability of information available to individuals around the world - must be pursued simultaneously in order to affect real and sustainable environmental change. The tenets of Global Citizen Action will motivate individuals around the world to take personal responsibility for their carbon footprint; reliable and quantifiable information will empower and enable them to actually act on that responsibility.


Integrating Ecological, Carbon and Water Footprint into a “Footprint Family” of indicators

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Keywords: footprint family, human impact assessment, integrated approach

Introduction
In recent years, attempts have been made to develop an integrated footprint approach for the assessment of the environmental impact of production and consumption [1-3]. In this paper, we provide for the first time a definition of the “Footprint Family” as a suite of indicators to track human pressure on the biosphere with a wide range of applications. This builds on the premise that no single indicator per se is able to comprehensively monitor human impact on the environment, but indicators rather need to be used and interpreted jointly [4]. A description of the research question, rationale and methodology of the Ecological, Carbon and Water Footprint is first provided. Similarities and differences among the three indicators are then highlighted to show how these indicators overlap, interact, and complement each other. The paper concludes by defining the “Footprint Family” of indicator and suggesting its appropriate use and interpretation at national level, taking the example of the EU’s One Planet Economy Network (OPEN:EU) project [5].

Methods
Three indicators have been selected to be included in the Footprint Family: Ecological, Carbon and Water Footprint. The Ecological Footprint [6] tracks human pressures on the planet in terms of the aggregate demand that resource-consumption and CO2 emissions places on ecological assets. The Carbon Footprint [7] tracks human pressures on the planet in terms of total GHG emissions and human contribution to climate change. The Water Footprint [8] tracks human appropriation of natural capital in terms of the water volumes required for human consumption. The three indicators have been tested against a number of criteria such as scientific robustness, presence of a clear research question, policy usefulness, temporal and spatial coverage, etc. A methodology for integrating the three footprint indicators in a streamlined ecological-economic modelling framework has also been suggested and explored for use in the OPEN:EU project [9].

Results and Discussion
All three indicators were found able to represent the environmental consequences of human activities, though they are built upon different research questions and tell different stories. By looking at the amount of bioproductive area people demand because of resource consumption and waste emission, the Ecological Footprint can be used to inform on the impact placed on the biosphere. By quantifying the effect of resource use on climate, the Carbon Footprint informs on the impact humanity places on the atmosphere. Lastly, by tracking real and hidden water flows, Water Footprint can be used to inform on the impact humans place on the hydrosphere. The Footprint Family is thus defined as a set of indicators - characterized by a consumption-based perspective - able to track
human pressure on the planet in terms of appropriation of ecological assets, GHGs emissions and freshwater consumption and pollution. It gives an answer to clearly identifiable research questions and helps to more comprehensively monitor the environmental pillar of sustainability. The Footprint Family has a wide range of research and policy applications as it can be employed at scales ranging from a single product, a process, a sector, up to individual, cities, nations and the whole world.

**Conclusion**

The Footprint Family as defined in this paper presents a quantifiable and rational basis on which to begin discussions and develop answers on the limits to natural resource and freshwater consumption, as well as on how to address the sustainability of natural capital use across the globe. The different and yet complementary points of view of the three indicators included in the Footprint Family allow for a more comprehensive assessment of the demand humans place on the planet. The three indicators can be regarded as complementary in the sustainability debate and the Footprint Family as a tool able to track human pressures on various life-supporting compartments of the Earth (biosphere, atmosphere, and hydrosphere) and from various angles.

**References**


Ecological footprint of an organization: can it really be measured?

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Keywords: Environmental Management, Ecological footprint, National park

Introduction
Ecological footprint aims to compare the demand on ecological services to the available supply. Such a metric is needed to make policy makers understand the threat of overshoot of natural resources and to facilitate the emergence of a consensus over the actions that are needed to address the ecological risks. During the 2000’s, the Global Footprint Network has endeavored to develop and mature the methodology of the National Footprint Accounts [1]. This metric attends to assess current ecological supply and demand, at a macro-economic scale.

The aim of this paper is to question whether applying such a metric at a micro-economic scale is possible and relevant. Which method can be used to estimate the ecological footprint of an organization? Does this estimation make it possible to set goals of improvement, to identify options for action, and to track progress toward these goals? Which are the limits of such an exercise?

The method, that will be presented, has been developed and validated for the Vanoise National Park, in the Alps, France. This public organization is in charge of preserving the territory of the Vanoise, getting knowledge about its natural and cultural patrimony and making the public aware about the necessity to protect it.

Methods
Ecological Footprint aims to evaluate the human appropriation of ecosystem products and services in terms of the amount of bioproductive land and sea area needed to supply these services. Its unity is the “global hectare” (gha) defined as a hectare that has the world average productivity of biologically productive land and water in a given year. The area of land or sea that is biologically productive is called biocapacity. It represents the biosphere’s ability to meet human demand for biological resources’ consumption and CO2 sequestration. The Ecological Footprint and biocapacity accounts cover six land use types: cropland, grazing land, fishing ground, forest land, built-up land and carbon uptake land. For each component, the ecological footprint is obtained through the consumption of a harvested product (or amount of emission of CO2) divided by the yield for this ecological services. This value is then converted into “global hectares” thanks to yield and equivalence factors [2]. The same principles were considered to estimate the ecological footprint of an organization. The following approach was followed:

- The first step was to define the scope of the activity under study [3].
- The second step requires collecting the consumption data of the organization. Five categories of components were considered: infrastructure, mobility, food, manufactured goods that are used for the activities and communication of the public institution (consumables and depreciation), services.
- The third step consists in organizing the information and calculating the conversion factors into global hectares. When possible, information sources
must be consistent with the information sources of the Global Footprint Network (for example, FAO for harvested products). Concerning the carbon emission factors, the “Bilan Carbone®”, which has been developed by the French national energy agency, ADEME [4], was used in order to make the Carbon footprint be consistent with the results of the more official “Bilan Carbone®”. However, it takes into account 6 greenhouse gases contrary to the GFN method that only considers CO₂ emissions.

- The fourth step is to calculate the ecological footprint of the organization and to verify the results by cross-checking.
- The fifth step is the synthesis and interpretation of the results in order to identify the components that have the most important contribution to the ecological footprint.

Results and Discussion
The main results obtained by this estimation will be described. For instance, the ecological footprint of the administration of the Vanoise National park was estimated to 189 gha (or 2.52 gha / employee) in 2007 and 148 gha (or 1.70 gha / employee) in 2008. But are such figures easily understandable and interpretable? To what extent can they be compared to national biocapacity results? Which are the conceptual and methodological limits of this exercise?

For example, the Vanoise National Park has committed to reduce its ecological footprint by 3 percent each year. In order to track progress toward this goal, it wants to measure yearly its ecological footprint. This poses methodological difficulty. Indeed, rigorously, when calculating the ecological footprint of a new year, conversion factors should be updated to take into account the annual yields. In this case, the variations of ecological footprint could be explained by changes in the consumptions of the organization and / or changes into conversion factors. The latter are linked to variations of national or even world-wide productivity. With an environmental management point of view, this is not satisfying. Indeed, the aim of the organization is to track only changes that it is responsible for and that are linked with its own consumptions. Then, the choice was made keep the same conversion factors every year.

Conclusion
Although the exercise of calculating ecological footprint for an organization raises several methodological and conceptual questions, it also has some interests as an indicator for an environmental management system. For example, it obliges to implement an information system based on physical data and not only monetary data and it make it possible to identify goals of improvement and to track progress toward these goals.

References
Research of parameters of a personal ecological footprint as an effective tool of education for sustainable development

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Keywords: personal ecological footprint, education for sustainable development

Introduction
It is known how detrimental the philosophy of “consumerism” is to the future sustainable development of our civilization. One of the most visual indicators of the measure of consumption is the ecological footprint. Ecologically friendly consumption and a lifestyle are insufficiently promoted in the society and in particular among young people. Therefore the ecological footprint can become an effective tool in education for sustainable development, in changing the stereotypical views about the unlimited nature of resources, and in the process of decision making related to the promotion of ecologically friendly consumption. Modern civilization continues all more strongly “exert pressure” on nature, and the degree of this pressure is reflected in an “ecological footprint”. Since 1998, the World Wildlife Fund (WWF) publishes the «The Living planet» report which provides a quantitative estimation of the condition of our environment and human impact on it. [1]. In Russia the opportunity to learn more in detail the methods of calculating ecological footprint and its practical application came through the work of the graduate of Environmental Leadership Program at the University of California in Berkeley (USA) Svetlana A. Chernikova (a senior lecturer at the Department of Ecological Safety and Regional Sustainable Development of the Saint-Petersburg State University). The Russian office of the “Global Footprint Network” was opened and the first book in Russian «The Ecological footprint of Russia and Russian people» was published in 2005[2]. In October of 2004 an international theoretical and practical seminar called «The ECOLOGICAL FOOTPRINT in Russia» took place within the framework of the program of cooperation in the field of sustainable development and environmental management of the St.-Petersburg State University and the University of California, Berkeley, USA.

Methods
The possibility of calculating a personal ecological footprint is a rather attractive instrument which can be successfully used in education for the sustainable development. It allows us to determine the measure of resource consumption and forces us to think about the limited nature of the resources on our planet and to strive to change our lifestyle into an ecologically friendly direction. Therefore after the seminar on ecological footprint conducted by Mathis Wakernagel in Peterhoff, St.Petersburg State University in 2004 there emerged the idea to conduct a comparative analysis of ecological footprints by the students of various universities and colleges in Saint-Petersburg. There are several methods of calculating an ecological footprint (calculators from the USA, Britain, and New Zealand). We have used a test recommended by Mathis Wakernagel and presented on the official website of the Global Ecological Footprint Network www.myfootprint.org [3] which includes multilanguage questions concerning the main four aspects of a person's life – food, shelter, transportation, and goods and services. By completing the test one can find out by how much our needs exceed the planet resources.

Results and Discussion
The study of the comparative analysis of personal ecological footprints by Saint Petersburg university students was conducted from 2004 to 2009. The research group selected target groups among the students and conducted pilot studies of personal ecological footprints. Participating colleges included two public (state) and two private (non-state) universities and institutes: 1. Saint Petersburg State University; 2. Russian State Hydrometeorological University; 3. Nevsky Institute of Language and Culture; 4. Saint Petersburg Hospitality Institute. The goals of the research are as follows: -to popularize the ideas of sustainable development through making young people familiar with the ecological footprint as a visual indicator of resource consumption; -to study personal
ecological footprints -to promote ecology-oriented self-perception and behavior in young people. During the initial stage of the research the notion of ecological footprint was introduced to the students as part of the courses on sustainable development and environmental management. Modern information technologies were used. After a detailed instruction, the students were given a computer test to calculate their personal ecological footprint. The results showed that on average the majority of the students consume fewer natural resources than other people in the country (4.5 ha). This can be easily explained by the fact that most students don’t own cars, housing, and consume meat products less often than adult population. Only 1% of the students have an ecological footprint of 1.8 ha, which means that the resources of one planet would be enough for them. The highest ecological footprint indicator was shown by students of the Nevsky Institute of Language and Culture (12.2 ha) and it is primarily related to the frequency and length of using air transportation. The following pattern was observed: the goods and services category has the biggest impact on the ecological footprint of the students from Saint Petersburg State University, Russian State Hydrometeorological University, and Saint Petersburg Hospitality Institute. Transportation had the most significant impact only among several groups of students from Nevsky Institute of Language and Culture, while the category of food was prominent in one group of students from Saint Petersburg Hospitality Institute. Students’ financial wellbeing also has an impact, that is when a person has more means he consumes more goods and services consequently leaving a greater ecological footprint. Most students don’t use transportation, but walk or use a bicycle, while some of them own a car and use considerable amount of gasoline.

Conclusion

Thus, students attending state universities are leaving lighter steps on the planet than the students from non-state institutes. Students of Saint-Petersburg state university showed the lowest footprint indicators with more than 80% of them not exceeding the country average. As a result we can conclude that using the ecological footprint indicator in the framework of ecological education is an effective tool of evaluating personal impact on the environment and planning one’s behavior. We can also recommend further dissemination and introduction of the method into various programs of ecological education. Research implications

- Popularization of the ecological footprint method as a visual indicator of one’s consuming capacity which forces people to consider their use of resources and limited nature of resources.
- Development of a PR-project to promote the ideas of ecologically friendly consumption and lifestyle among young population based on the ecological footprint concept.
- Need to promote ecological footprint as an effective tool for measuring consuming capacity which contributes to the wider idea of sustainable development.
- Prospect of studying and comparing ecological footprints not only among students of Saint-Petersburg but of other cities and countries.
- Creation of a youth coordinating council to promote the ecological footprint.
- Development of recommendations for promoting the ideas of ecologically friendly consumption and lifestyle among young people through the means of ecologically footprint.

Each of us can make an impact on the size of our own ecological footprint thereby preserving nature’s resources, but no all are able to commensurate one’s needs and the resources of our planet. Unfortunately, not all people are aware of their impact on environment and many people do not even begin think about the fact that the protection and support of our life and life of other creatures depend on our wisdom in using the planet resources. What will be our step into the future like? It’s up to us! Each minute, each day of our life we make choices: the more ecologically oriented our choice is, the lighter are our footprints, and the better is the life on our one-of-the-kind planet which needs time to replenish resources. Or we can leave deeper footprints because of our immoderate consumption of food, goods and other resources we take away from nature.

References

Reflections on the fishing ground Footprint Methodology: the UAE as a case study

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Keywords: Ecological Footprint, United Arab Emirates, fishing ground footprint, landing statistics, methodology and data review.

Introduction
In September 2007 the UAE Al Basama Al Beeiya (Ecological Footprint) Initiative embarked on an ambitious and innovative three-year journey to evaluate data, advance research, and subsequently inform sustainable development policies to reduce the environmental impact of the UAE society. In Year I, the focus was the verification of UAE population and carbon Footprint data. In Year II the Initiative advanced its objectives of methodology and data review on another important land-type in the UAE’s Ecological Footprint estimate: the fishing ground Footprint.

Methods
The fishing ground Footprint was calculated according to the classical methodology developed by Global Footprint Network (GFN) [1]. In calculating a nation’s fishing ground Footprint, GFN usually draws fish landings data for that country from the FAO FishSTAT database [2]. Review of the fishing ground Footprint therefore included both a review of the 2005 raw data used for the calculation of the UAE value (locally generated data were compared against those from international databases), as well as an assessment of the fishing ground Footprint methodology itself.

Results and Discussion
In reviewing raw data, values from the FAO FishSTAT Fisheries Statistical Database [3] were compared with emirate-level and extrapolated data. The comparison showed statistical inaccuracies between national and international data sets. The FishSTAT database showed an enormous over-estimation of fish landings in the UAE for the period 2003-2007 (Table 1). By using emirate-level and extrapolated data it was found that the UAE’s 2005 fishing ground Footprint may be on the order of 46% lower than the original published figure of 2005. In reviewing the fishing ground Footprint methodology a significant drawback was that the Footprint and Biocapacity estimates were not congruent to each other. Measuring up the consumption of fisheries products (Footprint) against the carrying capacity of the marine environment (biocapacity), one should be able to determine if the status of fisheries is over-exploited (overshoot), sustainable (balance) or under-exploited (undershoot). In UAE marine ecosystems, the biocapacity for fishing grounds is nearly seven times higher than its Footprint, which suggests that UAE’s natural marine resources are healthy and under-exploited. In reality, a Fisheries Resource Assessment Survey conducted in the UAE [6] and additional stock assessment studies on commercial species [7], indicated moderate to high fisheries exploitation rates for UAE marine waters. There may be several underlying reasons why the fishing ground Footprint inaccurately reflect the exploitation of fish stocks.
Table 1. Fisheries statistics for Abu Dhabi Emirate and the UAE, reported by EAD and MEW respectively. *indicates a total estimated by FAO.

Conclusion
The omission in the application of the fishing ground Footprint methodology is recognized by GFN and initiatives are underway to review this methodology in the coming third phase. In light of these review comments on the Fisheries methodology it is fair to conclude that while the Ecological Footprint of a country does provide important insights and messages vis-a-vis resource use, the inability of the fishing ground Footprint component to indicate over-exploitation renders it ineffective in communicating the known problem of fish stock decline to decision makers and is an area for future improvement.

References
Is Endocrine Disruption a Man Made Ecological Indicator of Marine Environment?

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Keywords: Ecological indicator, Endocrine Disruption, Marine.

Introduction

Environmental contamination by endocrine disruptors is presently a major issue of concern. Such synthetic chemicals can mimic or block hormones interfering with the endocrine system and eventually compromising crucial biological processes [2]. Various categories of contaminants may cause adverse effects on endocrine systems of aquatic organisms. Endocrine disrupting chemicals (EDCs) are man-made and naturally occurring chemicals which can affect the balance of hormone function of organisms, e.g. pharmaceuticals, pesticides, industrial chemicals (PCBs, PAHs, phthalates, styrenes), Hg, and other heavy metals [3].

Methods

Experimental design for in vivo test: At start with mercury analysis of water and sediment (method details in below) of 26 creeks in Mahshahr region (Northwest of Persian Gulf) we choose four more pollutant (Ghazaleh, Zangi, Majidieh and Petroshimi) and one less pollutant creeks (Jafari).

Experimental design for in vitro test: One hundred and thirty five Fish all immature male in same size (120 g final body weight average) were obtained from Mahshahr creeks with hooks in a Upon capture.

Fish maintenance: After LC50 test, the remaining fish (forty five) were randomly divided into five equal groups (12 per group) and each tank was randomly assigned to one of 5 experimental treatments and allocated to a 15 static cylindrical polyethylene tank filled with the appropriate concentration of an aqueous solution of Hg (standard solution for atomic absorbance spectrophotometer) in dechlorinated tap water. The Yellow fin sea bream were exposed to nominal mercury concentrations of 0 µg l (tank 1), 10 µg l (tank 2), 20 µg l (tank 3), 40 µg l (tank 4), 80 µg l (tank 5) respectively, and maintained for 3 weeks with aeration. These sub-lethal doses were chosen on the basis of preliminary toxicity tests and determinations of LC50 96h for this species, suggestive of inducing toxic effects but not lethally.

Testosterone steroid analysis: Serum testosterone were assay using pre-coated ELISA kits purchased from IBL Testosterone Enzyme Immunoassay Kit (RE52151), Hamburg, Germany according to supplier’s instructions. Absorbance was measured using a Testosterone Eliza (RE52151) instruments at 420 nm for detection. The limit of detection
(LOD) of the procedure was 100 pg/ml mL. Intra-assay and Inter-assay coefficients of variation were of 9.5% and 11.6% (T) respectively.

**Results and Discussion**
With respect to in vitro raw data, the Kolmogorov-Smirnov normality test was significant at a P<0.05, for all our measured parameters. Results of hormone activity analysis are presented in table 1. No significant changes occurred in the activities of the Testosterone (P<0.05), however it was decrease too. During in vitro results, the correlation between mercury with hormone parameter was statistically tested by analyzing the data obtained during the mercury exposed. The testosterone levels had not statistically significant correlation (P<0.05) with mercury exposed and this correlation was negative. During in vivo results, the correlation between mercury with hormone parameter was statistically tested by analyzing the data obtained during the five sampling creeks. Curve estimation regressions data were used to determine the relationship between mercury concentration and Testosterone activity. Testosterone had not statistically significant (P<0.05) with mercury.

**Conclusion**
Decreased serum levels of testosterone and correlations between biomarkers and pollutant concentrations indicated that factors in the aquatic environment have affected important physiological functions of yellowfin sea bream [1]. As mentioned, exposure of chemicals with different modes of action is also one of the reasons for unclear causal relationships between measured contaminants and biomarkers. Nevertheless, the data support the use of wild chub as a sentinel species in monitoring of aquatic ecosystems contamination.

**References**
Application of Fish Blood as Ecological Indicator of Undesirable Materials

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Keywords: Fish, Blood, Ecological Indicator

Introduction
The measurement of biochemical and physiological parameters is a diagnostic tool commonly used in aquatic toxicology and biomonitoring. Hematological parameters are more often used when clinical diagnoses of fish physiology are used to determine subchronic concentrations of pollutants [1]. Fish blood is sensitive to pollution-induced stress and changes in the hematological and metabolic parameters can be used as toxicity indicators of the toxicant [2]. The objectives of current study were to determine the both in vivo and in vitro effects of mercuric chloride (HgCl₂) on hematological and immunological features yellowfin sea bream to aim bioindicator of mercury pollution.

Methods
Determinations of the number of CBC tests were performed immediately on fresh blood. Numbers of Blood leukocytes (Lk count 10⁴ cells ml⁻¹) was performed by diluting heparinized blood with Giemsa stain at 1:30 dilution and cells were counted using a hemocytometer Neubauer under the light microscope (Stevens, 1997).

The leukocyte differential count was made in peripheral blood smears stained by Merck Giemsa (Beutler et al., 2001). Lymphocyte numbers were determined by direct counting under the microscope using a Neubauer chamber.

Hematocrit readings were performed with the aid of a microhematocrit reader.

Hemoglobin levels (Hb mg/100) were determined colorimetrically by measuring the formation of cyanomethemoglobin according to Van Kampen and Zijlstra (1961) and (Lee et al., 1998).

Mean corpuscular hemoglobin concentration (MCHC) were calculated from RBC, Ht, and Hb according to Lee et al. (1998) as MCHC(mg l⁻¹) = Hb(mgdl-1) / Ht(ratio).

Serum total protein levels were determined by the method of Lowry et al. (1951) at 546 nm and 37C. The quantitative determination of serum glucose was carried out by the glucose oxidase method according to Trinder (1969).

Result and Discussion
All in vitro activities exhibited significant analysis of variance (P<0.05), but the statistical analysis did not reveal any significant difference (p>0.05) between control groups and MCHC and differential monocyte.
In vitro result declared significance increase of Hb, Ht and differential monocyte within higher considerable values than those of the control group, beside significance decrease of leukocyte count, differential lymphocyte and eosinophyle (P>0.05) with lower considerable values than those of the control group. Values recorded for activity of total protein show high significance depletion (P<0.001) with mercury exposed. Although glucose was increase in different treatment, but there was not find significant variation (P<0.05). Curve estimation regressions data were used to determine the relationship between mercury concentration and Hb, Ht, MCHC, Leucosyte, Lymphocyte, Monocyte, Neutrophil, Eosinophils, Protein and Glucose activity. Only the Ht and monocyte and MCHC levels had not statistically significant and other parameter show significant linear regression (P<0.05) with mercury. Results of the present investigation indicated that the sub- acute mercury concentrations tested, which are closed to those used in agriculture purposes, may cause several changes in the metabolic and hematological parameters of the studied fish.

**Conclusion**

The major findings of this study are that the sub- acute and chronic mercury concentrations tested may cause several changes in the hematological and immunological parameters of the studied fish and we can use these changes as biomarkers of mercury detection. In conclusion, estimation of hematological biomarkers in fish, as in the present study, could provide a useful indicator of pollution of water bodies.

**References**


Ecological Unequal Exchange: A comparative analysis

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Keywords: Ecological Unequal Exchange, Ecological footprints, Carbon dioxide embedded in trade, Material flow analysis, Water footprints, Ecological Justice

Introduction
Unequal Exchange has been studied in terms of unequal flows of labour time (Emmanuel), or purchasing power (Prebisch, Singer) between one part of the world (the North, the Centre) at the expense of another part (the South, the Periphery). However, such studies, although relevant in their own right, do not take ecological exchange into consideration. This paper discusses various metrics to capture the ecological content of international trade flows in order to be able to judge if and to what extent Ecological Unequal Exchange (EUE) does exist.

EUE is of particular political relevance in the climate change (CC) negotiations of the UN where only domestically produced greenhouse gases (GHG) are accounted for, while GHG related to consumption are not figured in; hence, net GHG exporters can be held to be overtaxed, and net GHG importers undertaxed, when it comes to allocating responsibility for CC.

Methods
This study applies existing data to measure EUE. Material flow analysis (MFA), water footprint analysis (WF), embedded CO2 (EmCO2) and Ecological footprints of traded goods (EF) are used to quantify EUE. The time period covered varies, but is mostly restricted to the decades at the turn of the century in order to enable comparisons of metrics.

Results and Discussion
On a very general level – comparing North-South trade flows – it is found that EUE takes place and can be measured irrespective of which of the four metrics we apply: in general the North is benefitting from EUE by receiving more embedded ecological resources than it exports. Such EUE is quite substantial: as much as 40 percent of the environmental loads registered in countries of the South may be allocated as the responsibility of the importing countries of the North [1], but figures vary. Thus, considering EUE is essential when discussing justice in CC policies.

Also, a case of deteriorating terms of trade has been established, with the South exporting ever larger volumes of ecological resources to generate one unit of export income in the 1990's as compared to the 1970's [4]. This supports the Prebisch-Singer thesis of deteriorating terms of trade for raw material dependent countries.

Over time, however, the EUE may change signs, going from negative to positive for individual countries [5]; such changes also occur from one year to another for countries which have a more balanced exchange.

Although there is a great deal of common understanding on a general level – studying the North vis-à-vis the South – interesting differences do appear when analysing specific cases; also, different indicators give contradictory evidence of EUE [6]. This is especially so when using the WF as countries which depend on agricultural exports of the North (USA, Australia) turn out to be exporting more WF than they import. Thus, the WF may
give opposite conclusions as compared to the other measures of individual countries' EUE. But so may other indicators as well (see Table below).

**Conclusion**
While measuring EUE in general terms, North-South, breach similar conclusions irrespective of indicator, the situation gets more complex once we analyze individual countries, and their changing interaction with the world economy. This paper argues that two measures of embedded environmental loads of trade, the EF and EmCO2, have the potential of convincingly being used to measure EUE, whereas WF and MFA give less useful measures of environmental load displacement on account of the uneven distribution of local water resources, and hence of the meaning of EUE as such (in the case of WF); and, secondly, an unclear environmental significance of traded volumes (MFA).

**References**

<table>
<thead>
<tr>
<th>Table: Ecological Unequal Exchange as measured by different indicators, app. 2000.</th>
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<tbody>
<tr>
<td><strong>Indicator [Source]</strong></td>
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<tr>
<td>----------------------</td>
</tr>
<tr>
<td>MFA [12, 13]</td>
</tr>
<tr>
<td>WF [2]</td>
</tr>
<tr>
<td>EmCO2 [3]</td>
</tr>
<tr>
<td>EF 2000-2006*</td>
</tr>
</tbody>
</table>

* Calculated from Export and import EF calculated from data supplied by the Global Footprint Network. ** Only trade in primary commodities.
Negative = when a country exports more ecological resources than it imports;
Positive = when a country imports more ecological resources than it exports.
Introduction

The Ecological Footprint (EF) has reached worldwide popularity in the last decade and its applications have been extended to different fields. However, shortcomings of the methodology behind the EF calculations have been reported, as well as the need for further improvement [1]. Thus, the EF has been the subject of criticism and controversy [2] and alternative EF methodologies continue to be studied by various authors [3-5].

The definition of EF has traditionally referred to the biologically productive land and water area required to provide the resources and absorb the wastes of a population. Nonetheless, the wastes appraisal is not that clear, especially when considering pollutants or toxic flows that can not be absorbed or broken down by biological processes [2]. To this respect, Herva et al. have developed a method for the EF accounting of wastes based on thermal plasma technology [6].

Another important issue in EF accounting is the quality and reliability of the factors employed. EF studies generally apply global factors, so that comparability is ensured. However, some aspects handled in EF assessments are highly site specific, and using global factors can significantly alter the final results. Thus, this work also deals with the estimate of a carbon sequestration ratio for Galicia (NW Spain) based on the specific species found in the forests of this region.

Methods

EF of wastes

It is assumed that, in a simplified approach, a thermal plasma process closes the waste cycle in the biosphere due to the fact that the combusted syngas returns to the biosphere via CO$_2$ absorption in forests and oceans, and the vitrified material returns to the production cycle as new input material. Three terms were considered for the EF estimate: electricity balance, CO$_2$ emissions in the combined cycle and counter-footprint associated to materials recycling. Correlations based on data from the literature were obtained to build the global model.

Local CO$_2$ sequestration factors

The distribution of species was extracted from a Galician forest inventory. Three methods were employed to appraise the increase of forest biomass: a) Biomass Expansion Factor (BEF); b) Temperate and Boreal Forest Resources Assessment (TBFRA); c) Alometric equations.
Results and Discussion

EF of wastes
A model implemented in MS Excel where the 3 main terms, i.e. net electricity balance, carbon emissions and slag were converted into units of area, was obtained. Thus, to estimate the EF of a given waste, it is necessary to account for the carbon content and the amount of waste generated. The model was tested through its application for assessing the EF of the wastes generated in a textile process. A value of 56.5 gha was obtained for non hazardous wastes, which has the same order of magnitude compared to that obtained applying the traditional EF methodology [7].

Local CO₂ sequestration factors
The absorption factors yielded by the three methods employed were: a) 3.92; b) 3.81; c) 4.58 t CO₂/ha/yr, respectively. The former methods give absorption factors slightly higher than the global one used in Living Planet Reports (3.67 t CO₂/ha/yr). Meanwhile, the alometric equations, which can be considered as a more rigorous methodology, provided a significantly different value in relation to the other methods (a 25% higher). This means that employing global instead of regional factors could lead to an overestimation of the EF of activities developed in Galicia.

Conclusion
The availability of composite indicators like the EF is very interesting, especially for enterprises involved in Corporate Social Responsibility and thus interested in reporting their environmental performance in an easily understandable way. The refining and enhancement of the EF methodology (wastes, local factors, etc.) makes it more attractive for the evaluation of production processes. Besides, standardization is desirable, but the use of local factors should be discussed to approximate as much as possible to reality.

References
Ecological Footprint of biofuels. A comparison between biodiesel and bioethanol production processes

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Keywords: ecological footprint, biodiesel, bioethanol, sustainability, energy

Introduction
The progressive depletion of non-renewable fuels, as well as the increasing concern over climate change, is raising awareness on the need to search for alternative sources of clean energy. One renewable solution is the use of solar energy in form of biomass (bioenergy). To this regard, the EU biofuels directive promotes the use of biofuels in order to help Europe meet its greenhouse gas (GHG) emission reduction commitments, improve energy supply security and promote rural development [1]. Policies and targets for biofuels have been set in several countries; however, there is ongoing and intense debate over whether biofuels are really capable of meeting these expectations. The sustainability profile of biofuels has recently been questioned [2]. Different authors have addressed this matter using diverse environmental evaluation tools and indicators, namely Life Cycle Assessment –LCA- studies [3], Ecological Footprint –EF- [4], Carbon Footprint –CF- [5] or Water Footprint –WF- [6]. In the present work, two biofuel production processes implemented in Spain (biodiesel and bioethanol), were analyzed from an EF perspective.

Methods
The EF component method was applied [7] and gate to gate system boundaries were defined for the inventory collection. The studied biodiesel process is a pilot plant (5000 t/year) using sunflower oil as raw material and other input materials as methanol, KOH and sulphuric acid. Apart from the biodiesel, glycerine, potassium sulphate and fatty acids were obtained as outputs to the system. The possible reuse of glycerine was considered and computed as a counter-footprint. Meanwhile, an industrially implemented bioethanol production from corn fermentation process (58,512 t/year) was evaluated. The embodied EF of the other chemicals employed and of the wastes generated (mainly biomass and fermentation CO2 emissions) was included. In both cases, the electricity consumption was estimated based on the equipment power and the working hours. Other sources of energy consumed (e.g. natural gas) were extracted directly from the inventory of the processes.

Results and Discussion
The main results from the study were collected in Table 1. It can be observed that, according to the particular production processes evaluated, the relative EF was higher for the bioethanol than for the biodiesel. For the former, the major contributor was the wastes category (mainly influenced by the CO2 released during the fermentation of corn). Meanwhile, in the case of biodiesel, the total EF was mostly composed by the area
required for crop production. When other scenarios were simulated (recycling of wastes or other sources of raw materials), the results changed significantly in some cases.

<table>
<thead>
<tr>
<th>Biofuel</th>
<th>Total EF (gha/year)</th>
<th>Relative EF (gha/t biofuel/year)</th>
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<tbody>
<tr>
<td>Biodiesel</td>
<td>23,113</td>
<td>4.62</td>
</tr>
<tr>
<td>Bioethanol</td>
<td>383,792</td>
<td>6.55</td>
</tr>
</tbody>
</table>

### Conclusion

Given the strong relation between area requirements and biofuel production sustainability, the EF resulted as a very appealing indicator in this context. The yield of crops used as raw materials is a key factor, as it was observed for the case of biodiesel. Sunflower oil has quite a high yield; however, the EF of biodiesel production could be significantly reduced if palm or rape seed were employed. To complete the comparison between both biofuels, the geographical origin of raw materials employed should be defined, given that distance from production processes could highly influence the final results.

### References


An agenda for establishing the Ecological Footprint as communication instrument and indicator for sustainable development in small countries: Case study Luxembourg

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Keywords: Ecological Footprint, indicator for sustainable development, Luxembourg

Introduction
The Ecological Footprint methodology proposed by the Global Footprint Network (GFN) seems to be not entirely appropriate for small countries with less than one million inhabitants [3]. This may be a reason why e.g. results for Luxembourg, a country with 470,000 inhabitants, have never been included into official country Footprint comparisons. Therefore, the methodology needs to be adapted to be used for communication purpose in Luxembourg. This contribution presents Luxembourg's approach for illustrating the national consumption impacts to finally discuss the integration of the Ecological Footprint as an indicator for sustainable development in the national indicator system.

Methods, Results and Discussion
The Ecological Footprint is one possible approach to assess the environmental impacts of national consumption patterns. The statistics taken into account represent all trade flows within a country, covering the resident's consumption as well as the activities of non-residents (e.g. tourists and commuters). In the case of small, highly industrialized countries with a strong economy, the influence of non-residents may be high, but the 2008 National Footprint Accounts do not allow identifying the responsible parties of the consumption impacts. For Luxembourg, based on statistics from 2005, the per capita Footprint was 12 gha - one of the highest worldwide. However, this result neither reflects the impact of 121,000 cross-border commuters (equal to one quarter of the population) which worked and consumed in Luxembourg nor quantifies the impacts of road fuel exports. Based on nationally available expenditure statistics, emission models and expert knowledge, 62% of Luxembourg's total Consumption Footprint can be allocated to the residents, 16% to the commuters and 22% to fuel tourism.

The Ecological Footprint communicates for developed countries and their citizens how much land is consumed worldwide due to their way of life. It raises the awareness of global resource depletion and the individual responsibility for global problems. Therefore, it is essential to correctly communicate Luxembourg's total consumption Footprint including the allocation to the residents and non-residents without ignoring Luxembourg's responsibility for the impacts of non-residents. National workshops will be organized to satisfy both needs - to transfer technical knowledge on the Ecological Footprint methodology and to provide guidance on how the concept can be used for awareness raising, education and public relations.
Conclusion
As stakeholders and researchers recognize the need for further development of indicators to trace sustainability [5], the policy application of the Ecological Footprint as an indicator for sustainable development is discussed at national and European levels [6, 4, 1]. In this context, the Ecological Footprint is discussed to be used as part of a basket of sustainability indicators in Luxembourg. In cooperation with the Government Statistics Service, an agenda will be elaborated to fit the Ecological Footprint to the indicator panel proposed by the Competitiveness Observatory of Luxembourg.

References
Structural Decomposition Analysis of the Ecological Footprint in Okinawa, Japan

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Keywords: Structural Decomposition Analysis, Input-Output Analysis, National Footprint Accounts, Okinawa

Introduction
This abstract documents the use of Structural Decomposition Analysis (SDA) to the Ecological Footprint of production (EFp) for Okinawa, Japan. SDA is an application of input-output analysis that identifies the key explanatory determinants responsible for change in specified variables over time [1]. This research decomposed the EFp from 1985 to 2000 for the Okinawa prefecture into the change of four explanatory variables: physical intensities, level of final demand, input coefficients, and import coefficients. To our knowledge, this is the first SDA analysis utilizing the National Footprint Accounts.

Methods

The National Footprint Accounts are a bioproductivity-weighted material flow and residual emissions accounting framework. Data are available for more than 150 nations with source data utilized primarily from international statistical databases. For each nation, results are presented in Footprint of production, imports, exports, and apparent consumption.

Okinawan regional input-output tables—available in five-year intervals from 1985 to 2000—were aggregated into 32 industrial sectors. Values for each table were converted to currency equivalents for the year 2000 by referring to data from Okinawa Prefecture Account [2,3].

Equation 1 was applied to decompose the change of EFp from year t to t+1 in terms of fours factors. Each product—contained in brackets in the equation below—measure changes in physical intensities (Δd), level of final demand (ΔF), input coefficients (ΔA), and import coefficients (ΔP) over time, respectively.

\[ \Delta Y = Y^{t+1} - Y^{t} = [(\Delta d) B^{t} F^{t-1}] + [d^{t+1} B^{t+1} (\Delta F)] + [d^{t+1} B^{t+1} \hat{F}^{t+1} (\Delta A)X^{t}] + [d^{t+1} B^{t+1} (\Delta \hat{P}) A^{t} X^{t}] \]  

(Eq.1)
where $d$ physical intensity vector of EF$_P$, $B$ is the Leontief Inverse, $\left[I -(I - M)A\right]^{-1}$ and $F$ is final demand vector, $X$ is vector of total output, and $P$ is vector of self-sufficient rate. $\Delta$ represents the change of values from year $t$ to year $t+1$.

**Results and Discussions**

![Graph showing change in EF in Okinawa from 1985 to 2000](image1)

Figure 1 shows Okinawa’s EF$_P$ steadily increased from 2.2 million global hectares (gha) to 3.4 million gha from 1985 to 2000. Figure 2 shows the change in physical intensity ($\Delta d$) and final demand ($\Delta F$) are the key economic drivers for the increase in EF$_P$ over time. Additionally, households and exports currently represent approximately 60% and 30%, of the final demand, respectively; tourists visiting Okinawa represent an increasingly large percentage of the exports category of final demand. The change in input coefficients ($\Delta A$) and import coefficients ($\Delta P$) slightly moderated this increase of the EF$_P$.

**Conclusion**

In conclusion, SDA provides valuable insight on the underlying economic drivers for human appropriation of biocapacity. SDA provides additional information to analyze policies related to industrial metabolism, dematerialization, and de-coupling environmental repercussions from economic activities. These benefits of SDA require additional assumptions that can limit the accuracy of the results. However, the insight gained from this analysis provides information previously unavailable to decision makers and Ecological Footprint practitioners. This novel approach to Ecological Footprint analysis provides a foundation for future research and applications of input-output-based Ecological Footprint analysis.

**References**


“And the winner is......South Australia”: Ecological footprint reduction by government, community and university actions

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Keywords: South Australia, water, recycling, transport, energy, biodiversity, integration

Introduction
South Australia (SA) is a national and international leader in addressing ecological footprint reduction challenges. The State has developed a Strategic Plan [1] and a Climate Change Policy for Adelaide [2], where more than 90% of the state's people live. The government has thus set a range of targets for its own practice, for industry and for the community to strive to achieve reductions in its ecological footprint in areas of waste recycling, water security, energy efficiency and biodiversity preservation.

Methods
Objective three of the SA State Strategic plan for “Attaining Sustainability” relates to the targeted reduction of the ecological footprint of the community. South Australia's ecological footprint is currently 7.0 global hectares per person; which is much higher than the OECD’s average of 5.2. To attain sustainability it is important to reduce this ecological footprint, which will involve more responsible consumption, innovation and new technology. The principal targets are to reduce South Australia’s ecological footprint by 30% by 2050 and in particular to reduce waste to landfill by 25% by 2014. Other targets include limiting the state's greenhouse gas emissions to 108% of 1990 levels during 2008-2012 and to increase the use of public transport to 10% of metropolitan weekday passenger vehicle kilometres travelled by 2018. SA's biodiversity has also been adversely affected through land clearing, inappropriate development and release of contaminants, which has degraded the natural environment. The results have been loss of species, the loss of natural habitats for both animals and plants, erosion of valuable agricultural land and pollution of the marine environment. Three targets to counter these issues are; to lose no further native species, to establish five biodiversity corridors and to create 19 marine parks aimed at maximising ecological outcomes by 2010. About 50% of greenhouse gas emissions in Australia come from the electricity generation sector. However, SA is a leader in the use of wind and solar power and its energy targets are for 20% of the state's electricity production to be derived from renewables by 2014. Likewise the State aims to improve the energy efficiency of government buildings by 25% from 2000-01 levels and increase the energy efficiency of dwellings by 10% by 2014.

Results and Discussion
It is important that such a broad state-wide search for sustainability and reduction of its ecological footprint should involve stakeholders, including government, industries, universities and the community. The University of South Australia's own research groups are carrying out coordinated studies of these attempts to reduce the ecological footprint. “Winning” exemplars designed to reduce the State's footprint are now appearing. Ways to reduce emissions of greenhouse gases by individual households have been investigated by detailed surveys of SA councils and local government [3]. These include changing travel behaviour, increased recycling, enhanced building insulation and alternative energy usage. Other built environment initiatives include incorporation of environmental
sustainability analysis during project management, while Aman et al [4] studied the challenges of responding to sustainability with implications for affordable housing. Energy studies monitor usage and model how baseload and peak demands can be managed on the local grid [5]. Modelling transport systems, public transport usage, congestion and network vulnerability, have demonstrated an ability to make changes to travel behaviour [6]. Urban ecology studies have added value to greening of the environment [7]. Management of water supplies have led to a greater understanding of how Water Sustainable Urban Design is critical to waterproofing Adelaide [8]. Permeable pavements, siphonic roof drainage, aquifer storage and recharge (ASR) and biofiltration channelways are all being incorporated into the city’s fabric. Research into the previously listed areas and communication and policy development in these are actively being carried out by research academic staff and doctoral students at UniSA. Educational programs in environmental science, management and planning, and the research associated with them are helping to communicate the importance of sustainable development and footprint reduction targets to a wide range of future professionals and the general public.

Conclusion
Adelaide is an ideal model for a sustainable and liveable city state. It’s population on the edge of Australia’s deserts central has lead to an understanding of the necessity to plan for reducing its ecological footprint. The population is planned to grow significantly over the next decade like many other cities in the region and it is implementing hard targets for footprint reduction which will be outlined in this paper.

References
Delivering equitability to sustainability: Examination of current models in delivering sustainable economic and environmental outcomes

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Keywords: Ecological Footprint; equitability; sustainability; corporate taxation base; net neutral outcome

Introduction

The Ecological Footprint has been developed as a measure of humanity’s demand on nature. In an effort to deliver equitability to sustainability, an adaptation of the Ecological Footprint is being utilised to develop a corporate taxation base.

Currently, the approach of emissions trading schemes ("ETS") is essentially an administrative approach to control pollution by providing economic incentives. Conversely, the command-control regulatory approach has spawned a plethora of environmental taxes. Both of these approaches have proven to be difficult to implement, almost impossible to manage effectively and have produced negligible outcomes. This has occurred due to their narrow focus, industry bias and ability of lobby groups to dilute their intention. The resultant inequitability has highlighted the need for a new approach.

This paper aims to present a new approach through the comparative analysis of a proposed Ecological Footprint-based corporate taxation model and current approaches, with a focus on equity.

Methods

This research is newly initiated and integral to my PhD thesis. Currently the integration of an Ecological Footprint model to taxation policy is theoretical and this paper is exploring one aspect of that application, namely equitability.

Although the data will be both qualitative and quantitative, the analysis will primarily be qualitative.

A literature review will be conducted on environmental revenue systems (ETS and common fees and taxes) to determine the general consensus as to the impact they have both economically and environmentally. This will provide the assumptions against which a model based on the Ecological Footprint will be assessed.
An analysis of the Ecological Footprint will be undertaken to devise a model capable of delivering economic and environmental outcomes. A comparison will assess sustainability and usability.

**Results and Discussion**

There is a fundamental inequity in the imposition and operation of the current environmental tax schemes. No singular approach delivers either equitability or sustainability. The direct and indirect costs associated with these models perpetuate a disproportionate societal impost. As an example, for an ETS it is highlighted by the impact on resource and manufacturing sectors and the virtual exclusion of services. Taxing at source, as with an ETS, increases the price paid by consumers. Environmental taxes, such as user-pays fees and charges, are consumption taxes which are inequitable in nature. These also give rise to free-rider issues.

The utilisation of the Ecological Footprint is asserted because it is presented as neither pro- nor anti-trade. Therefore, as an accounting tool, its application can be applied equally across all industry sectors as well as between different scales of company operations. This, in turn, should not raise any competitive or anti-competitive issues and should result in a net neutral outcome for business.

**Conclusion**

There is the potential from the proliferation of ETS-style revenue systems for the emergence of a new industry. This is likely to present as trade facilitators, or ‘middle-men’, and will not be dissimilar to the role of Lehman Brothers within the financial services industry. This, in turn, has the potential to create a hyper-capitalist environment and could result in another ‘global crisis’.

The issues associated with an ETS or command-control measures cannot arise with the use of an impartial, unbiased measure such as the Ecological Footprint.

If this research confirms the viability of an Ecological Footprint-based corporate tax model, it is envisaged that the outcomes will deliver only economic and environmental positives. This will be ultimately achieved through the incentivisation of the corporate taxation model.

**References**

Referencing for this paper will be limited as this is new research being undertaken with no other comparable studies underway.
Pre-Service Science Teachers’ Views of Ecological Footprint

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Keywords: ecological footprint, preservice science teachers, sustainable living

Introduction
To make sustainability a reality, Mathis Wackernagel and William Rees developed an Ecological Footprint Analysis as a measurement tool to determine whether humanity’s demands remain within the capabilities of the globe’s natural capital stocks [1]. The ecological footprint is an indicator of sustainability that converts consumption and waste production into units of equivalent land area [2]. EF is a model and teaching tool for measuring the ecological impact of nations and individuals [3]. Ecological footprinting is a stimulating way to introduce students to some of the less obvious but crucial dimensions of human ecology and to familiarize them with some of the ecological implications of the consumer society. Several individuals and organizations are developing teaching tools and handbooks to assist students and teachers in undertaking their own simple footprint analyses. Ecological Footprint is also a rich resource for teachers, students and policy makers at all levels. It will help communities around the world make their lifestyles more sustainable and ensure a consistent quality of life for present and future generations [3]. In this study, the goal is to produce well-informed science education pre-service teachers who can critically think about sustainable living, ecological footprint and can therefore contribute to development of sustainability principles in their school and society. Therefore, in the present study, ecological footprints of pre-service science teachers, who will educate future generations, are calculated in order that they can see their effects on the world. Then views of pre-service teachers about ecological footprint were researched.

Methods
Total 49 pre-service teachers (31 male, 18 female), who attend third class of science education department from Gazi University, participated in this study. The activities of the study were preformed in a five-week period. In the study, pre-service science teachers were asked individually to define the concept of ecological footprint with their own expressions. Before and after the sustainable life education, pre-service science teachers were asked questions such as “What is the Ecological Footprint? Define it with your own expressions” in order to learn their views about sustainable life. Pre-service teachers were asked to express their views about this concept writing in 15 minutes. In the analysis of the qualitative data, content analysis based on coding was used.

Results and Discussion
Pre-service teachers stated that they had never heard of ecological footprint and had no idea about ecological footprint before they were trained on sustainable life subjects. The fact that though, in most countries, the ecological footprint analysis that is considered to be the indicator of the sustainable life was known approximately 12 years ago, it was not
known by the pre-service teachers who participated in the research in Turkey, demonstrates there are significant backwardness's in our country in this area. After the education, views of pre-service science teachers are collected in 6 categories: Production of the consumed resources, biological area for the absorption of the wastes created, intuitional measurement of the effect of individual/society on nature, indicator of sustainability, the total effect of human on the world, environment policy and the calculation instrument used for environment management and other.

Since pre-service teachers who participated in the research gave answers, which were included in more than one category, they made totally 67 preferences. In 36% of these 67 preferences, the pre-service teachers’ responses included "the total effect of human on the world" category, 24% of them included "production of the consumed resources", "biological area for the absorption of the wastes created" category, 19% included "intuional measurement of the effect of individual/society on nature" category, 3% included "environment policy and the calculation instrument used for environment management" category, 3% included "sustainability indicator category", and 15% included other category. This study is important to reveal this shortcoming even if it is for a small sample. It was observed that vocabularies of the pre-service science and technology teachers developed and their vision got richer after the research.

Conclusion
In the present study, the pre-service teachers’ opinions about the concept of ecological footprint were investigated before and after activities concerning sustainable life were performed by calculating their ecological footprints. The study aimed to determine whether any development occurred in the pre-service science teachers’ opinions about the concept of the ecological footprint after they participated in the activities. Total 49 pre-service teachers (31 male, 18 female), who attend third class of science education department from Gazi University, participated in this study. Respondents’ footprints were measured using the 'Ecological Footprint Quiz'. Pre-service teachers’ conceptions of ecological footprint were elicited using a questionnaire. In the research, qualitative research method was used. Pre-service teachers stated that they had never heard of ecological footprint and had no idea about ecological footprint before they were trained on sustainable life subjects. After the sustainable life education, it was observed that the pre-service teachers’ awareness of ecological footprint raised and their visions developed.

References
Managing trade with the Ecological Footprint Analysis -

The case of Israel's grain supply

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Keywords: Grains; Israel; International Trade; Consumption; Ecological Footprint

Introduction
In today's world, any nation's ecological footprint (EF) is spread all over the globe. Still, most footprint studies are not yet sensitive to the specific locations on which the footprint falls and to the unique production characteristics of each supporting region. Most studies count hectares of globally standardized bio-productivity, or 'global hectares' and do not tell whether impacts occur within the consuming country or abroad [5, 2]. In recent years some studies have acknowledged the need to quantify the 'real land' footprints (e.g., Wackernagel et al. [8; Erb [1]) and particularly land embodied in international trade (e.g., Van Vuuren and Smeets [7]; Widemann [9]; Moran et al. [6]; Kissinger and Rees [3]). The presentation aims to add to this increasing and dynamic approach, to discuss the potential contributions to the development of the EF, and to highlight some of the challenges and limitations of that approach. It will present the results of a research focused on analysing Israel's grain footprint on specific locations around the world within the last two decades [4]. It will then discuss some potential implications for future research and policy.

Methods
The research involved the following steps: 1) Documentation of the grain consumed - covering the three major grains consumed in Israel - wheat, corn and barley; 2) Identification of the sources of supply and the amount imported from each source - all together the research documented the import from 25 countries plus consumption from local sources in Israel; 3) Quantification of land and major energy inputs involved in production in each source - the research documented the arable land and the energy inputs (fertilizers and machinery) required for growing the imported quantity from each source; 4) Quantification of energy inputs and Carbon Dioxide emissions embodied in transportation from each growing area to Israel; 5) Estimation of the area of terrestrial ecosystem devoted to the production of exported commodities in each source.

Results and Discussion
On average during the research period Israel's annual grain supply footprint was 853,400 Ha. This is an area equal to more than three times the entire agriculture land of the state of Israel. Our research revealed that most of Israel's grain footprint falls on the U.S followed by Ukraine and Turkey. Our study also revealed that despite the continuous increase of overall grain consumption during the research period the size of the footprint has been declining in recent years as a consequence of changing sources of supply and grain composition. For example in 1991 Israel consumed 1,779,500 tonnes of grain and the footprint was 597,000 ha, in 1998 grain consumption had increased to 2,973,000 tonnes and the footprint reached a record high of 1,121,000 Ha. Since the end of the 1990s while consumption continued to rise (reaching 3,035,000 tonnes in 2006) the footprint declined to 845,000 Ha.
These results have several potential contributions, both at the technical as well as at the policy implication level: 1) it supports decision and policy makers with information on the actual amount of terrestrial ecosystems they consume and directly depend; 2) it locates most of these supporting regions; 3) it quantifies the CO₂ embodied in overall consumption as well as consumption from specific sources. 4) It highlights the trade off between the land and energy footprint in each supporting region. And 5) emphasizes the potential of international trade management to reduce any nation’s footprint.

**Conclusion**

The case of grain is just one out of many commodities upon which we all depend. The approach taken here advances the benefits and accuracy of the ecological footprint analysis in measuring biocapacity needs and the carbon generated through the life cycle of commodities. Given the growing place of trade in all national footprints, the approach presented here can contribute to mutual sustainable management of the resources we depend on wherever these resources are located. Israel, like many other nations will continue to be dependent on external sources of supply (for grain as well as many other commodities). In a world going through processes of environmental changes, facing future resource scarcity and processes of climate change, it is crucial for every nation to minimize its footprints. The approach taken here emphasizes the scope of dependence and highlights some potential directions to managing and minimizing some of the impacts of that external dependence.

**References**


The risk of forced footprint reductions

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IIER (Institute for Integrated Economic Research)/Gund Institute for Ecological Economics

Keywords: de-growth, resource constraints, financial market constraints, non-linear systems, involuntary decline

Introduction
There is increasing recognition that we are currently overusing the world's resources. Individuals and organizations have started to develop and promote concepts to voluntarily reduce the footprint of the human race. While methods and ideas vary, they almost invariably involve active decisions on individual or institutional level to shift away from resource over-consumption. Almost no group discusses a future where footprint reductions are imposed on humans by reality, and the consequences and mitigation approaches required under such a scenario.

Hannes Kunz holds Masters degrees in Law and Economics and a Ph.D. in Economics from St. Gallen University. He worked in management positions in multiple industries and in management consulting, before founding IIER in 2008, an academic non-profit organization focused on understanding the dynamics of societies at times of decline.

Nate Hagens holds a Masters Degree in Finance from the University of Chicago. He is currently completing his PhD in Natural Resources at the University of Vermont. Previously he was President of Sanctuary Asset Management and was a Vice President at investment firms Salomon Brothers and Lehman Brothers

Methods
IIER operates as an academic research institution focused on interdisciplinary research in three key areas: resource and energy availability, financial systems dynamics and human societal behaviour. Our research has two key objectives:
- To develop a better understanding of “human ecosystem” dynamics with a focus on limitations to further expansion and provide educational inputs into academia and policymaking institutions (governments and international organizations)
- To identify future breakpoints for human ecosystems which insurmountable limits might impose, and understand possible dynamics resulting from those situations
- Identify most critical material (food, energy, others) and non-material (political stability, societal cohesion) aspects and define possible mitigation approaches.

Results and Discussion
In agreement with many other sources, our research so far points out that human societies have reached or overstepped physical resource limits across the entire planet. Societies will likely be unable to continue resource overuse for a long period, and once resource limits, for example in arable land, water, energy, minerals, etc. are reached, we
will be forced to adjust, unless new technologies become available, which we consider highly unlikely.

Unfortunately, this resource overuse has been accompanied by the build-up of an additional system which functioned as an enabler for even higher resource use - global credit markets. For each of the past 25-30 years, total credit on a global level has grown faster than total global output (the aggregate of global GDP), with the growth speed accelerating until the beginning of the current financial crisis in 2008, and picking up pace again in early 2010. It seems quite obvious that this situation of credit-fuelled growth is not sustainable in the long run, even if resources were unlimited.

The combination of the two realities of overextended resource use and overleveraged credit markets implies that a number of correction mechanisms otherwise possible will not be realistic. As credit (paying interest, and even more so the repayment of principal) requires future growth, voluntary or involuntary reductions in resource use will have immediate and highly disruptive consequences on credit markets and subsequently on the entire global economy. We assume that the global crisis of 2008/09 was significantly influenced by resource constraints (evidenced through higher prices).

**Conclusion**

With resource and monetary systems being overextended, we expect non-linear reactions once future growth becomes impossible. This reality will likely prevent voluntary action on a broader level, but also impose involuntary and self-reinforcing decline patterns in the near future - most likely within the next 3-10 years.

Given the results of our current research, we conclude that a larger portion of global research efforts should be devoted to the understanding of scenarios where human societies are forced to adjust to a lower economic and ecological footprint.

The stress imposed on societies by forced de-growth will pose significant challenges for the maintenance of basic supplies (food, energy, health, communications) and societal stability. In order to avoid most critical and unfavourable developments in both areas, both knowledge about possible outcomes and preparation efforts need to be increased.

**References**


Footprint by Income using Geographic Information Systems

Down to a Canadian Census Village Scale

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The City of Calgary

Keywords: GIS, income, ecological footprint, carbon footprint, census villages

Introduction
A strong correlation exists between ecological footprint, consumption and income (Mackenzie 2008). Statistics Canada carries out consumption surveys, the primary source of the GFN ecological footprint calculation for the City of Calgary, only for areas as fine as Census Metropolitan Areas (major urban cores and their adjacent areas); however, household income is measured down to Dissemination Areas (village size) and these census villages cover all of Canada. Distribution of the ecological footprint by income decile at a national level estimates the ecological footprint including components down to a census village level using a simple and consistent method. A Geographic Information System (GIS) creates maps of the resultant ecological footprint and ecological footprint components. Income stands out as a potentially addressable issue of sustainability.

Methods
Using data published by Messinger [3] for Canada of total ecological footprint as well as consumption categories and land uses by income decile at a national level, regional to national income ratios first adjust this data to better represent the region. Then equations are derived that define relationships between income and the ecological footprint and its components. These equations are applied to any areas in the region with a measured after tax median household income including census villages to estimate the ecological footprint and its components. Several checks with numbers from other sources evaluate the method’s numerical accuracy.

Results and Discussion
GIS maps of various scales and themes can be produced such as the sample here (see Map 1). These estimates of ecological footprint and its components include energy land use which is an estimate of the carbon footprint. This method uses the same basic principles of Standard 3 [1] where national patterns are applied to sub national units. One benefit is that data collection and processing methodology remain simple [7], thus cost is also kept to a minimum. Comparability is consistent across scales and data is readily available for a city’s region. This level of spatial detail may promote local policy decision support. Display of the ecological footprint in a local GIS based map stimulates discussion regarding social behaviour and responsibility as global hectares work well to communicate sustainability in terms of local action and global consequences [2]. The use of income as a proxy exposes income as a target of reduction for improved sustainability [4, 5]. Victor [6] points out the disconnect between happiness and increased income. This method has
several drawbacks. The ecological footprint is a less than perfect measure of sustainability now competing with the carbon footprint [5]. Income is an imperfect proxy: it excludes wealth which also allows consumption. The Statistics Canada census is limited to a five year cycle, some census village income data is suppressed and income alone misses the details and variations within consumption.

**Conclusion**

With Statistics Canada data, the ecological footprint and its components including the carbon footprint can be estimated based on median household income down to a census village scale. Though yet untried for local policy decision support, GIS based presentation maps can be used to effectively stimulate discussion at the scale of census villages, or any courser scale having income data. Income, the proxy for ecological footprint, stands out as a potential target of reduction in the context of increasing sustainability.

**References**

Bottom up Ecological Footprint Housing Component:

A Geographic Information System Analysis

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Keywords: GIS analysis, ecological footprint, household, planners, decision support

Introduction

The ecological footprint (EF) and its unit, the global hectare, share a reputation of effectively communicating the connection between local awareness and global impact. One use of a Geographic Information System (GIS) in urban planning is decision support, while the inclusion of ecological footprint in GIS remains a developing frontier [7]. Urban planners, interested in showing change in sustainability based on implemented policy at a local level, need accurate local data. Hunter [1] discusses the increasing interest in the household level of ecological footprint measurement. The smaller the spatial unit involved during public engagement the more likely citizens will relate to local issues [2]. As well, the smaller the spatial unit in GIS, the more accurate, detailed and flexible the available GIS mapping and analyses. The EF Housing component, of specific interest to planners [3], is estimated here by a bottom up or component method. This study suggests GIS EF map creation and analysis at the household level is possible and may allow planner GIS policy decision-making support.

Methods

Using GIS, six-digit postal code areas are created, each with an average of 17 dwellings within the city of Calgary. Average household energy use per six-digit postal code is purchased from local utilities companies in units of energy; Gigajoules for gas and Kilowatt hours for electricity (a more direct measure than dollars). The City Assessment department supplies dwelling size data for each household. Data is converted to GIS format allowing map creation and GIS analysis. The analysis here, in response to an urban planner request, is a comparison between the sustainability of inner city single family infill housing and older existing single family housing. This analysis functions at a household level by selecting only postal codes that entirely contain infill housing or entirely contain older existing dwellings. Analysis output shows, in terms of the EF Housing component, that gas energy use is lower, electric energy use varies little and dwelling size measures higher, resulting in a net increase in the use of global hectares by infill houses. Display of GIS maps and tabular numbers triggers urban planner debate.

Results and Discussion

Urban and regional planners have an interest in measuring local sustainability [6, 3] and measurements can be used to support policy decisions. As well as the benefits of the land use measure and global data at a local level, the EF is effective in raising awareness, education and policy debate [2, 4]. The objective here is to supply decision support
material for urban planner policy debate. Ground up or component based data are more sensitive to underlying data variations [5], and this may explain the added interest to planners. This method involves a direct measure of housing energy and materials consumption, yet one that may be expressed in global hectares. There is a common interest in residential electric and gas use [6, 2, 1] and Wilson [6] specifically lists dwelling size as a measure of the non-energy EF Housing component. Analysis output here shows improved building insulation standards and heating technology effecting gas consumption over time to be more than offset by increased house size. Display of the ecological footprint utilizing GIS maps is confirmed effective [7, 2], while one know study uses GIS EF data at the household scale [3]. Sustainability analysis is possible at a household level, adding subject material for urban planner policy debate. Shortfalls of this method include the missing analysis of increased density of infill housing through lot subdivision in this specific case. Lack of bottom up data for the Mobility component, also of interest to urban planners, and other components remains an issue.

**Conclusion**

Ecological footprint components, such as the Housing and perhaps Mobility components, of specific interest to urban policy planners can be used to stimulate policy debate and potential decision support. Bottom up data is of primary interest to urban planners; data they can measure and influence with policy. Valuable policy debate and decision support is available through GIS map creation and analysis sourcing household level data while retaining units in EF global hectares. The GIS analysis here, which spatially and numerically shows the difference in sustainability between infill housing and older existing housing, allows planners to formulate effective policy.

**References**


Rare Earth Elements: At the Root of Carbon Offset

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Keywords: Rare Earth Elements, China, Neodymium, Strategic Metals, Permanent Magnets, Hybrid Vehicles, Batteries, Lithium, Electric Cars, Wind Turbines, Technology Metals, Energy Storage, Department of Energy, Department of Defense, RESTART Act, Sustainability, Mining, Energy Efficiency, Catalyst, Phosphor, TREM, Baotou, Molycorp, Avalon Rare Metals, Great Western Minerals, Lynas, Arafura, Thorium, Inner Mongolia

Introduction

On the eve of a widespread boom in renewable energy markets, a growing number of investors, industry analysts and politicians are concerned that a shortage of rare earth elements—crucial additives in technologies like electric motors, wind turbines and rechargeable batteries—could spell doom for global energy security. As the new decade begins, China controls over 95% of rare earth element (REE) production [1] and has reduced exports of these key metals by 40% over the past seven years [2]. Worsening matters, are estimates that China’s domestic REE demand might outstrip its supply by 2012 [3], which could result in a complete export ban as China builds its own clean energy infrastructure.

With no major REE production outside of China, tech companies, policymakers and industry strategists are scrambling to establish non-Chinese mines and refineries to stabilize supply chains of these critical metals. In the mix are throngs of investors and private equity firms poised to make significant gains from what will ultimately be a federally supported industry. But to think that the fate of clean energy markets and technologies could depend on a handful of junior miners, is simply unsettling. This essay explores how collaborative efforts between government, academic and financial institutions can mitigate REE supply risks, while encouraging long-term energy strategies with environmental and diplomatic safeguards.

Methods

The 2009 Footprint Atlas states that non-renewable resources (such as metal deposits) are “…only addressed by the Ecological Footprint where their extraction, refinement, distribution, use, or disposal imposes a demand on the biosphere’s regenerative capacity.” While the extraction of these metals poses environmental threats typical of most mining processes, it is the usage of rare earth elements in almost every clean energy technology that relates directly to the Earth’s regenerative capacity.

Here I would argue that calculations of global carbon footprint and discussions of related policy are incomplete without consideration of the reverse metrics: estimations of our carbon reduction capacities. Though the scope of such an inquiry is certainly broad, there can be little disagreement that technologies such as wind turbines, photovoltaic cells, efficient lighting and electric vehicles are all significant factors; and again, each of these items either requires or achieves much greater efficiency using REE in its construction. For these reasons I propose the evaluation of realistic scenarios in which different rare-earth-based technologies could be mass-produced to mitigate carbon overshoot. Such analysis would require the calculation of a ratio comparing REE consumption to carbon offset. For instance, a commercial wind turbine using Rare Earth Permanent Magnets (REPM) for its electrical inverter requires about 200kg of elemental Neodymium for every 1 Megawatt of power generation capacity [4]. To understand what this might mean for a carbon offset scheme, let us consider some U.S. carbon emissions statistics:
In 2005, the CO2 output emission rate in the U.S. averaged 1,329.35 lbs CO2 per MWh of power generation [5]. However, this measure incorporates generation from solar, wind, nuclear, hydro and other clean energy sources. Removing clean power output from the equation (leaving only production from coal, oil, gas and other fossil fuels), raises the number to 1,843.60 lbs of CO2 per MWh. So if 200kg of Neodymium is needed for 1MW of carbon-free power generation capacity (via wind), we can estimate that each pound of Neodymium could represent a carbon offset of 4.2 lbs per MWh in the U.S.

1,843.60 lbs CO2 / (200kg Neodymium x 2.2) = 4.18121451 lbs Neodymium per MWh

This, of course, is a rough representation of only one scenario, but the value of precise metrics in this space would be immense, with direct relevance to overshoot remediation.

Results and Discussion
With REE/CO2 offset ratios established for different clean energy technologies, manufacturers and policymakers could better understand a more fundamental number: 150,000,000. This is the global reserve base of rare earth ore in metric tons as of 2008 [6]. As with any metal deposit, this number represents a non-renewable resource, but one that plays an essential role in the development of renewable energy technologies. Given the importance of these metals and the scarcity of recoverable deposits, it is essential that their production and consumption be closely tracked. Such information—coupled with the aforementioned REE/CO2 offset ratios—would allow policymakers to determine:

1. How much rare earth material should be reserved to help meet carbon offset targets.
2. Regulations governing the percentage of REE supply that should enter the free market.
3. The rate at which rare earth material alternatives must be developed.
4. How much of the rare earth reserve base should be left to future generations.

Conclusion
Many would agree that the key operative in today’s changing ecological paradigm is—and might always be—our method of harnessing and using energy. Given the recent advances in clean energy technologies, it is in our best interest to maximize the prospects of large scale and long-term implementation of such systems. Such can only be accomplished with strategic planning, and a secure supply of the proper materials. This proposal suggests new uses for the Footprint research model in three areas:

1. Update theory to include reverse metrics for overshoot remediation capacities.
2. Expand application of Footprint statistics to include supply/demand of critical metals.
3. Inform policy through demonstration of viable REE project and regulation scenarios.

References

A Framework for Strategic Sustainable Development to Complement Projects using the Ecological Footprint

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Keywords: Ecological Footprint, Framework for Strategic Sustainable Development (FSSD), Backcasting, community plans, The Natural Step (TNS), System Conditions.

Introduction

Ecological Footprinting has proven itself as an effective education tool and indicator of progress for supporting community wide sustainability projects (Barrett, Birch, Baiocchi, Minx, & Wiedmann, 2006). However, there are a number of limitations that need to be overcome to ensure that projects focusing on the Ecological Footprint can also be strategic in moving communities towards sustainability. These limitations of the Ecological Footprint include:

1. It lacks strategic and prescriptive suggestions for how to actually move from analysis to action. (Korhonen, 2009)
2. The Ecological Footprint is narrow in its recognition of a holistic definition of sustainability. (Holmberg, Lundqvist, Robèrt, & Wackernagel, 1999)

This paper explains how the Framework for Strategic Sustainable Development (FSSD) can complement the Ecological Footprint when working with communities to create a holistic strategic plan for moving the community towards sustainability.

Method

The FSSD, widely known as The Natural Step (TNS) framework, encourages dialogue, consensus-building and incremental change to create the conditions necessary for significant transition towards sustainability. Based on scientific consensus at the principle level, the framework provides a widely applicable approach to sustainable development at multiple scales and has been proven successful in planning towards sustainability in numerous endeavours. (Robèrt, et al., 2002)

Results and Discussion

The FSSD has the potential to be an effective way of ensuring that the Ecological Footprint is taking a systems approach to creating strategic plans built on a clear definition of sustainability. There are three areas where the FSSD could be helpful.

1) Strategic Framework
The Ecological Footprint is a tool for providing a baseline ‘snapshot’, it does not provide mechanisms to show how to move from existing unsustainability to a future sustainable state. Grounded in systems thinking, the FSSD is based on a generic five level framework for planning actions within complex systems - (i) the System, (ii) Success in the system, (iii) Strategies, (iv) Actions and (v) Tool-box. (Robèrt, et al., 2002). This framework could be used to create a strategic plan for using and implementing the state indicated by the Ecological Footprint analysis.

2) System Conditions for Sustainability
The Ecological Footprint principally relies on an ethical position to reach a ‘fair share’ of the earth’s resources, rather than defining what that state might look like. The system conditions provide a clear definition for sustainability and could be used fill the gaps in articulating a vision of sustainability. (Holmberg & Robèrt, 2000)
3) Backcasting from a vision of success
The FSSD uses the strategic approach of “backcasting” from success, i.e. imagining that the conditions for success are complied with, and then asking what we should do now to optimise the chances of getting to that desired future? (Robèrt, et al., 2002) In designing a strategic sustainability plan with a community we need to not only understand the current footprint of that community, but also define what a ‘fair share’ community may look like within a clear definition for sustainability (figure 1).

Figure 1: Using ‘Backcasting’ from a vision of success, to guide strategic plans from ‘overshoot’ towards creating a ‘fair share’ community framed by the systems conditions.

Conclusion
Measuring the footprint of a community is a useful snapshot, but unless there is strategic intent allied with the results, change is limited. Framing the Ecological Footprint within the broader FSSD framework allows project managers to not only ensure that the community project is strategic, but that there is a clear understanding of not just what unsustainability looks like but also what is required to move towards a sustainable future.

References
Ecological Footprint of New Zealand Lifestyles

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Keywords: Ecological Footprint, New Zealand, lifestyle, fair share, 8 Tribes

Introduction
The average New Zealand lifestyle is calculated to have the fifth largest ecological footprint in the world. This paper describes initial research in a more extensive and detailed 3-year investigation of the environmental impacts of current New Zealand lifestyles and engagement processes to assist in moving communities closer to a ‘fair share’ ecological footprint.

The project will engage multiple communities with varying geographic and socio-economic characteristics. Community footprints will be measured both before and after an education programme for local households and businesses. The research described below is an important first step in highlighting what can be achieved through effective community engagement encouraging voluntarily shifts in behaviour and what may need to be further encouraged through a wider range of policy mechanisms. The outcome will be a set of footprinting tools for use by communities and their local government agencies to help guide future development decisions. [4].

The importance of understanding the drivers of consumption at a smaller scale when engaging with specific socio-economic groups has been clearly articulated [1]. New Zealand is known as the ‘melting pot’ of the Pacific. With a variety of cultural and socio-economic backgrounds, the ‘8 Tribes’ research [2] provides some knowledge of those differing cultural behaviours as well as understanding the largest pressures of New Zealand lifestyles on our natural resources. The next step is to clearly identify those aspects of lifestyle that are most important to each tribe’s human needs and those tribal attributes that may provide ‘low hanging fruit’ with regard to lowering their overall footprints.

Methods
The research builds on existing research which breaks down the ‘typical New Zealander’ into the 8 Tribes or hidden classes of New Zealand. The baseline data for that research was used as the inputs into an Ecological Footprint calculator. Where data was not directly available, for example transport distances, national statistics were used with tribal preferences assuming their use of public transport or distances travelled.

The Redefining Progress calculator [3] is the only publicly available current and reliable Ecological Footprint calculator available for New Zealand. The global hectare calculations are much higher than those commonly used due to their use of the Footprint approach that employs net primary productivity, rather than those based on the GAEZ suitability indices [5].

Results and Discussion
Results in Graph 1 give the distribution of the tribes around the New Zealand average requirements of 57.6 global hectares. Preferences for the highest goods and services consumption, large houses and long distance travel put the North Shore tribe well ahead of the other tribes. Balculth is also high but this is due to their rural lifestyle, travelling large distances and being substantial meat eaters.
At the other extreme, a relatively small portion of New Zealanders share Raglan Tribe tendencies whereby preferences for ‘simple’ lifestyles and working from home with a reasonable level of self-sufficiency put them well below the New Zealand average. However all of these tribes have a level of consumption which greatly exceeds their ‘fair share’ of the 15.71 global hectares required to produce the resources they consume and absorb their waste.

Conclusion
This initial research has clearly highlighted the diversity of ecological footprints within New Zealand and therefore the importance of community engagement that relates to individuals and their lifestyles, rather than the homogeneous distribution of information. The range identified in the 8 tribes shows that it is important to understand the drivers of consumption when engaging with specific socio-economic groups and is an important first step in designing a community engagement process which promotes individual and local community behaviour change.

References
Ecological Footprinting in Healthcare in the United States

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*Keywords:* Healthcare, Ecological Footprint, Calculator, Facility Benchmarking

**Introduction**

Dartmouth-Hitchcock Medical Center (DHMC) developed The Health Care Footprint Calculator to gain a more comprehensive understanding of environmental impacts in a health care institution. The Calculator generates rates of resource consumption and greenhouse gas production that are used to make a global sustainability evaluation by considering them in the context of known natural capital limitations. In addition, these rates can be used operationally to assist with environmental priority and goal setting. DHMC has partnered with national organizations to test the applicability of the Calculator at other health care facilities and of the individual activity categories within the model.

**Methods**

We gathered facility specific data and developed footprint conversion factors in seven categories to encompass all institutional activities. These categories include products purchased, energy, transportation, waste, food, water, and built land. Described in this section are underpinnings of many of the conversion factors applied to select categories.

- **Products Purchased:** Carnegie Mellon University's "Economic Input-Output Life Cycle Cost Analysis" model provides Global Warming Potential (GWP) estimates, including metric tons of CO2 equivalent, for a wide variety of products. We developed a health care products matrix, which separates all of the products purchased by an institution into categories with an existing GWP factor or where a new GWP factor could be calculated. Often a new GWP factor was created by averaging multiple categories.
- **Waste:** Emissions factors for many waste streams are derived from USEPA's "WARM" model. We do not yet have factors for certain medical and hazardous wastes. The waste category results are relatively low due to materials' upstream or embodied energy being captured in the Products category.
- **Transportation:** We use average fuel efficiency from USEPA, and "uplift" by a factor to account for road building, auto manufacturing, etc. We chose the 145% uplift factor developed by Wackernagel & Reese, as it was approximately the median of the other factors we found. For air ambulance miles, we used the same factors as the U.K. *Material Health* study (.79 kg CO2/km).
- **Food:** The study done by Andrea Collins and Ruth Fairchild in 2007 provided us with a comprehensive analysis of global hectares of biocapacity per kilogram of food for many food types.
Results and Discussion
Results for DHMC are summarized as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Global MTCo2e</th>
<th>Acres</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>198,506</td>
<td>77,979</td>
<td>100%</td>
</tr>
<tr>
<td>Products</td>
<td>85,346</td>
<td>29,949</td>
<td>38%</td>
</tr>
<tr>
<td>Energy</td>
<td>52,304</td>
<td>18,354</td>
<td>24%</td>
</tr>
<tr>
<td>Waste</td>
<td>498</td>
<td>175</td>
<td>0.2%</td>
</tr>
<tr>
<td>Transportation</td>
<td>46,885</td>
<td>24,679</td>
<td>32%</td>
</tr>
<tr>
<td>Food</td>
<td>12,095</td>
<td>4,329</td>
<td>6%</td>
</tr>
<tr>
<td>Water</td>
<td>332</td>
<td>119</td>
<td>0.2%</td>
</tr>
<tr>
<td>Built Land</td>
<td>1,047</td>
<td>375</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Eight other major healthcare facilities have completed an Ecological Footprint evaluation using the DHMC calculator. The results have been analyzed, though not within margins of statistical significance of results.

Conclusion
The DHMC Footprint Calculator has been selected by two national organizations as the preeminent tool for measurement across and within healthcare institutions in the United States. However, footprinting as an evaluative tool in reducing the ecological impact of the healthcare industry is still in its infancy. Categories of measurement need improvement in accuracy and breadth before a meaningful assessment of the impact and efficacy of operational changes and solutions can be evaluated and deployed.

References
A comprehensive list of references is available upon request. Selected references include:


The Models of Ecological Footprint and Carrying Capacity of Water Resources—as example of Henan Province

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Keywords: Ecological Footprint of Water Resources; Biological Capacity of Water Resources; Henan Province, ecological deficit

Introduction

Previous literatures about ecological footprint and ecological capacity of water resources have little focused on ecological accounting classification of water resources and its equivalence factor and yield factor so that few work on ecological footprint of water resources are satisfactory. Water resources accounting are classified and region equivalence factor and yield factor present in this paper to calculate ecological footprint and ecological capacity of water resources in Henan province by using data in 2007.

Methods

2.1 Water resources accounts

Water consumption is classified into agricultural-forest-fishery, industry and urban-rural-environment in this paper depending on classification methodology in currently existed Water Resources Gazette in China. So ecological footprint of water resources are classified into three types covering ecological footprints of water resources of agricultural-forest-fishery, industry and urban-rural-environment.

2.2 Ecological Footprint Model of Water Resources

Water resources consumed by human is converted to bio-productivity land area of corresponding account, land area of water resources, which can be transformed by yield factor and equivalence factor to what is comparable at national or regional scales. Ecological footprint model of water resources is listed as the following formula (1):

$$\text{EF}_W = \text{ef}_W \cdot N = N \cdot a_W \cdot W_W / P_{GW}$$  \hspace{1cm} (1)

Where $\text{EF}_W$ is defined as ecological footprint of water resource at global scale (gha), $N$ as population, $\text{ef}_W$ as ecological footprint of water resource per capita (gha·cap\(^{-1}\)), $a_W$ as equivalence factor of water resource at global scale, $W_W$ as the volume of water resources consumed by human, and $P_{GW}$ as global average bio-productivity (m\(^3\)/ha). Here $a_W = 0.40$ is from “Calculation methodology for the national footprint accounts, 2008 edition”.

2.3 Ecological carrying capacity model of water resources

Average bio-productivity land area of water resources in different regions can not compare because regional conditions differ, so yield factor of water resources is introduced in this paper to make bio-productivity land area comparable when ecological carrying capacity of water resources is studied. After yield factor at global-average productivity scale is defined, bio-capacity of water resources at national or regional scale can be calculated. The model of bio-capacity of water resources is listed as the formula (2):

$$\text{EC}_W = \text{ec}_W \cdot N = N \cdot a_W \cdot \gamma_{lw} \cdot Q_W / P_{GW}$$  \hspace{1cm} (2)
Where $EC_W$ is defined as bio-capacity of water resources (gha), $N$ as population, $ec_W$ as bio-capacity of water resources per capita (gha·cap$^{-1}$) $aW$ as equivalence factor of water resource at global scale, $\gamma_{LW}$ as yield factor of regional water resource at global scale, $Q_W$ as total volume of water resources ($m^3$), $P_{GW}$ as average productivity of global water resources ($m^3$/ha);

Average bio-productivity of water resources differs between various land use types, as well as between regions for any given inland water. For comparability across different regions and land use types, ecological footprint and bio-capacity of water resources are respectively described in units of global average bio-productivity area and global average hectares to evaluate ecological footprint of water resources across different regions. So yield factor of water resources is defined as a ratio of average bio-productivity for any land type at a region and that at country or globe scale in order to make bio-productivity of water resources across region comparable. The parameter $P_w$, originated from Hydrology science, usually accounting for average bio-productivity of water resources, equals to the volume of water resources divided by administrative area, and average yield factor of water resources in each province in China is defined in this paper. The equation is as follows:

$$\gamma_{LW} = v_L \cdot v_G$$  \hspace{1cm} (3)

where $\gamma_{LW}$ is defined as regional yield factor of water resources in global scale, $v_L$ as regional yield factor of water resources in China scale, $v_G$ as China yield factor of water resource in global scale.

**Results and Discussion**

The findings show that there is an ecological deficit in water resources in most cities of Henan province, and there exists spatial difference not only in ecological footprint and ecological capacity but also in ecological footprint and ecological capacity per capita with great ecological deficit in most of regions. In ecological footprint accounting composition of water resources, ecological footprint of agricultural-forest-fishing is dominant. In ecological capacity accounting composition of water resources, ecological capacity of underground water resource is primary in the south and west of Henan province, but ecological capacity of surface water resource is primary in the north of Henan province.

**Conclusion**

According to the findings mentioned above, for the sustainable development of water resources in Henan province, so measurements should be taken to enhance efficiency of water resources use: 1) improve how water resources shared by agricultural-forest-fishery are used and establish agricultural production mode for saving society; 2) local governments should change currently existed management mode and build laws and price system of water resources management.
Carbon footprint and delocalisation of production. A case study for Italy, 1995-2006

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2) Istat, Istituto Nazionale di Statistica

Keywords: hybrid accounts, environmentally extended input-output, carbon footprint, decomposition analysis

Introduction
From the early 1990ies the Italian production system experienced a great improvement in its environmental efficiency, as far as air emissions are concerned. Indeed, the synthetic pressure index for greenhouse gases increased much less than value added and output, while those for acidification and tropospheric ozone precursors even decreased. In a previous study by the same authors [1], the reduction of the emissions per unit of energy use in some key industries was identified as a major determinant of these environmental efficiency gains, along with the reduction of the energy use per output unit. Moreover, a significant, though less important, contribution to the environmental efficiency improvement was given by the structural change of the economy.

This paper first quantifies the Italian carbon footprint from a consumption perspective, which includes environmental pressures associated with imports for domestic consumption; then it investigates the role of international trade, and in particular of the delocalisation of production in the reduction of the air emission intensity of GDP brought about by the structural change of the economy. Indeed, a change in the composition by industry of the output and the consequent change in air emissions may be due to genuine changes of production and consumption models, but also by the displacement of energy- and emission-intensive productions into other economic systems [2 – 4].

Methods
These issues are studied by means of an ad hoc integrated environmentally extended input-output model and by applying an input-output-based structural decomposition analysis [5] to NAMEA-type data on CO₂ emissions by economic activity.

The input-output model - industry-by-industry and “fixed product sales structure” assumption - is based on the Italian supply and use tables (1995-2006). For some activities that are not well represented in the Italian input-output tables (Mining of coal; Extraction of crude petroleum and natural gas; Mining of metal ores) the model is integrated by using data on the structure of intermediate inputs and emission intensities of the same activities in Norway and Australia, which have been selected on the basis of the relevance of the imports from these countries and of data availability.

Results and Discussion
As for the Italian carbon footprint provisional results in Table 1 show that CO₂ embodied in total imports, given as percentage of CO₂ in total final demand, increase in the period
1995-2006. In Figure 1, where the change in CO₂ emission activated by total final demand is decomposed in three components, most of the change is due to the volume of final demand.

**Table 1**: CO₂ emissions embodied in domestic final demand (Yd), exports (x), imports (m) trade balance (x-m) as % of emissions embodied in total final demand.

<table>
<thead>
<tr>
<th></th>
<th>1995</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yd</td>
<td>71</td>
<td>69</td>
</tr>
<tr>
<td>x</td>
<td>29</td>
<td>31</td>
</tr>
<tr>
<td>m</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>x - m</td>
<td>1</td>
<td>-2</td>
</tr>
</tbody>
</table>

**Figure 1**: Changes between 1999 and 2006 in industry-related CO₂ emission activated by total final uses by effect (million tons).

In order to study the effects on domestic emissions of the delocalisation of production a decomposition analysis will be carried out, focussing on the part of the changes in the structure of intermediate and final imports which is not explained by the exogenous dynamics of consumption and technology. In fact the changes may result from substitution between domestic and imported inputs or final products.

**References**


Diagnosis of separation and collection of waste in the INA, IP

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Keywords: Separation and collection of waste, recycling, green behaviour, Public Administration

Introduction
The environmental awareness is essential for companies able to achieve sustainable development models. The contribution of each person, no matter how small it is, may be vital for the preservation of our Planet. Changing a few habits and routines with regard to reducing consumption and waste separation, supplies could lead to a few years will be significant differences in terms of reduction in demand for natural resources.

In this context and with regard to government, it is necessary to dematerialisation of processes, in order to minimize the use of paper. Indeed, at a time when the electronic means is becoming more common, there are many processes that can streamline, including the reduction of paper use. These procedures are important for the environment, but are also very important to reduce excessive spending that often organizations are facing.

Methods
This study was based on quantitative and qualitative data collected through two analyse instruments:
- Interviews to managers and middle managers in order to involve them in the project so that they can also contribute to a membership of employees at this stage of consultation of opinions and perspectives on green behaviour in INA, IP.
- Survey by questionnaire to all employees of the INA, IP.

Results and Discussion
Amendment of certain rules and conduct of employees of the Public Administration may, within a short and medium time interval, the mean reduction of excess consumption, which will translate into economic gains for Public Administration and environmental protection.

The study considered the results of exploratory interviews and questionnaire to all employees of the INA, IP. The result was a diagnosis so that everyone could have a perception of the INA, IP in terms of the existing waste management and the changes that should be made to implement best practices within our organization that lead to the reduction of material and energy consumption and simultaneously reduce the use of natural resources, in order to contribute to a more sustainable Public Administration.

Conclusion
Change in attitudes can only occur in a systematic and continuing with the Education / Training of employees. Awareness alone does not lead to lasting change, serving rather
as a preparation for action on environmental education, fundamental in the pursuit of responsible environmental management and continuous. It is imperative the involvement and commitment of top management in order to be successful in the implementation of a new environmental education organization, to which should be present on a continuous nature. Indeed, the literature is often referred to as the critical success factors to apply in institutions such measures require greater commitment and guidance.

References

Applying a “New” Sustainability Paradigm to Water Resources Management: Okavango River Case Study.

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Department of Biological Sciences, University of Botswana

Keywords: Water resources management, sustainability model, ecosystem approach

Introduction
Article 2 of the UN Convention on Biological Diversity (CBD) explains sustainable use as “use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations”. Used with respect to water, sustainable use of water would be “use of water in a way and at a rate that does not lead the long-term decline in water resources, thereby maintaining the needs and aspirations of both present and future generations”.

Such use appears to be human centred and does not consider the need of ecosystem maintenance, especially in regard to inland water systems. The ongoing work on environmental flows - the amount of water needed in a watercourse to maintain healthy ecosystems, is our current answer to the inadequacy of defining sustainable use of water from a human use perspective only. Much of the sustainable use debate has been shaped around the concept of sustainability represented in the diagram below:

The diagram on the left is meant to depict a sustainable state of any resource – in this case of water. The one on the right is meant to depict what seems to obtain in reality in many situations – indicating the “unsustainable” use of resources, e.g. water. IUCN - the International Union for Conservation of Nature has proposed to change this unsustainable...
state by increasing the focus, attention, effort etc given to the environment circle. The thinking is that as the environment circle “grows”, we move towards sustainability.

**A “new” model of sustainability.**

The CBD developed Principles of Sustainable Use (www.cbd.int). The 5th of these principles states that:

**Sustainable use management goals and practices should avoid or minimize adverse impacts on ecosystem services, structure and functions as well as other components of ecosystems.** The rationale behind this being that “For use of any resource there is a need to take into account the functions that resource may fulfil within the ecosystem in which it occurs, and that use must not adversely affect ecosystem functions”. The model for sustainability proposed provides a framework for achieving this rationale.

The model in Fig. 1 (left) is premised on balance. If one were to use a financial budget as an example, a balanced budget would be one in which expenditure exactly balances with income. There is nothing for the proverbial rainy day.

In the case of water resources management, this would be analogous to all water being allocated to some use - every drop accounted for. Such a balanced “budget” is likely to collapse should there be any shock, however slight. A budget that has “savings” has provision for the rainy day and can, therefore, take in the the unexpected shocks when and if they occur. So it should be with water resources management. The challenge is “how much reserve should be set aside in a river system”?

For a river to remain a river, there ought to be a certain amount of flow that closely follows any natural seasonal variation.

**Environmental flows of the Okavango River.**

The Okavango River has its source in Angola, flows through Namibia and finally ends in an inland delta in Botswana. Both Namibia and Botswana are countries with extreme water deficiency and have both looked to the Okavango River as potential “savior”. Angola has experienced peace over the last decade and is looking to improve the livelihoods of its own people. The water resources of the Okavango River are therefore subject to a variety of actual and potentially conflicting demands.

This paper will consider the demands of water of the Okavango River and advocate for a “water reserve” to sustain and maintain the aquatic and wetland ecosystems associated with the river. The paper will highlight the potential of applying the ecosystem approach as a tool for implementing the sustainability model proposed above. The main issue to be discussed is:

*What water flows are required to maintain a healthy ecosystem on the Okavango Delta*
Any sustainable decoupling in the Finnish economy?
Comparison of the pathways of GDP and ecological footprint between 2002-2005

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Finnish Environment Institute, Thule Institute/University of Oulu

Keywords: ecological footprint, gross domestic product, input-output analysis, structural decomposition, sensitivity analysis

Introduction
Globally there is a need to find examples of decoupling economic growth and resource consumption for models of sustainable development. The Finnish economy would seem to serve as a good example since during the beginning of the 2000s, the economy grew but the ecological footprint decreased by one third. In the most recent footprint atlas, Finland had the highest ecological footprint reserve in Europe [1]. However the recent economic crisis has raised the question, whether the growth of the gross domestic product in itself was sustainable during the period. In this article we analyse the main pathways for economic and ecological footprint growth and discuss whether any of those pathways could be identified as a model for sustainable decoupling.

Methods
Environmentally extended input-output (EEIO) analysis [2] was used as the basic framework for identifying the drivers and causal chains behind ecological footprint and gross domestic product indicator results. Analytical methods were applied to a detailed Finnish EEIO-model (ENVIMAT) [3] in order to extract the most important pathways [4] and highest sensitivities [5] from the interaction network between economic sectors. The identified main pathways and linkages were then compared to the impacts of the recent economic crisis in order to see, if the sustainable economic production subsystems were also economically sustainable.

Results and Discussion
Based on the preliminary results, very few of the interactions between industries showed significant sensitivities for influencing the ecological footprint. The main interactions were those with very high land use coefficients (i.e. wood products) or carbon intensities (i.e. cement and electricity). The decoupling between GDP and ecological footprint was caused mainly by three components: a decrease in the production of pulp and paper, increased margins in apartments and retail sales and a reduced consumption of fossil fuels due to a good hydropower year in Scandinavia. None of these main components could be considered as an example of sustainable decoupling. However sustainable development was found in some smaller pathways mainly through more efficient use of energy. The comparison of ecological and gross domestic product was found problematic, since the first is based on a consumption approach (including imports, but excluding exports),
while the other is based on national production [6]. Therefore export production increases GDP but not the ecological footprint.

**Conclusion**

A more detailed analysis of the pathways of both GDP and ecological footprint development trends revealed that a large share of the change was caused by anomalous development, which can not be repeated elsewhere or on other time periods. Major solutions for decoupling were not found, but several small trends were identified for reducing the ecological footprint without reducing gross domestic product.

**References**


The potential of ecological footprint in measuring the sustainability of CDM projects

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Environmental Legal Team- University of Siena- Department of Economic Law

Keywords: climate change, Clean Development Mechanism (CDM), mitigation, sustainable development, sustainable development indicators, sustainable development tools, DNA, Ecological Footprint, Biocapacity, CDM improvement, ecological reserve improvement, ecological deficit minimization.

Introduction
This paper intends to describe the links between ecological footprint, climate change related measures such as CDM projects and sustainable development, showing how ecological footprint and biocapacity may improve and complement the current state of the art of sustainable development indicators for CDM. The UNFCCC and the Kyoto Protocol call for a stabilization of the greenhouse gases concentrations in the atmosphere at 1990 levels so to limit harmful effects of climate change. To this end, the so called Annex I Parties to the UNFCCC are compelled to reduce their greenhouse gases emissions to the percentages set by Annex B to the Kyoto Protocol by 2012, firstly by means of effective national measures of mitigation curbing domestic emissions and secondly by recurring to the three flexible mechanisms. Among them, a paramount role is played by the CDM that, as envisaged by article 12 of the Kyoto Protocol, relies on a project-based activity establishing a link between developed and developing Countries. In fact, the two-fold objective of the CDM is to help Annex I Countries in reaching their quantitative targets at the same time supporting Non Annex I Countries in achieving sustainable development. Since 2005 CDM project have being increasingly growing and catalyzing the interest of investors and Governments. However the CDM has attracted also many criticisms, mostly related to their real capability to concur to the achievement of sustainable development by acting as effective tools of mitigation at a global level. To this respect both the International community and the European Union have been recently rising the attention on the necessity to renew and rethink the concept of sustainable development and identify a new, reliable set of indicators. The EU, in particular, is calling for establishing internationally recognised data and indicators for measuring sustainable progress that would complement the traditional ones, most notably, GDP, and would support policy and decision makers paving the way to a low-carbon and resource efficient economy. Such indicators, incorporating ecological footprint and carbon footprint criteria and methodologies could be used alongside with the others sustainable development indicators to assess the sustainability of CDM projects as tools to respond to climate change challenges.

Methods
Starting from the assumption that indicators used by DNAs for assessing the capacity of CDM to support Host Countries in achieving sustainable development should be improved and that Ecological Footprint should be regarded as a measure complementary to others to provide a full picture of sustainability, this paper maintains that current national sustainable development indicators used to assess CDM should be integrated with the Ecological Footprint. To this end, taking into consideration that ecological Footprint is not a score card but rather an accounting procedure measuring impacts on biocapacity, this
paper shows that climate change effects negatively affect global as well as national biocapacity and that current human activities provoke high carbon uptake land and energy footprint. It applies the Ecological Footprint measurements to CDM projects activities and therefore proposes to broaden the current application of footprint studies and measurements. In applying the Ecological Footprint tool to assess CDM sustainability, this paper poses the following main research questions: “How much/to what extent the CDM project positively/negatively affects the biocapacity of the Host Country?”; “How much human demand for resources as compared to available biocapacity would rise from the CDM project proposed?”; “Would the proposed CDM concur to enhance the Host Country biocapacity?”; “What is the Ecological Footprint of the CDM?”; “Will the ecological reserve of the Host Country be improved as effect of the CDM?/will the ecological deficit of the Host country be minimised as a consequence of the CDM project activity”?

**Results and Discussion**

Since the current framework of sustainable development indicators to assess CDM projects lacks of completeness and effectiveness, the main expected result of this paper is to advocate its upgrade through an integration with Ecological Footprint criteria and methodologies. This would shade some lights on the real effects of climate change on biocapacity at the same time giving new impetus to the CDM as a mitigation tool capable to achieve high degrees of ecological reserve.

**References**


Asymmetry in the Effects of Economic Contractions and Expansions on the Ecological Footprint

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**Keywords:** Ecological Footprint, recession, asymmetry

**Introduction**

Traditional explorations of the impact of national measures of production on environmental indicators have usually attempted to fit the interaction to an Environmental Kuznets Curve (EKC) framework. While there has been some limited success in establishing EKCs for some indicators, prior studies have often failed to address three key issues: (1) the potential for environmental impacts to shift from one area to another; (2) that the biosphere responds to total impacts, not per capita; (3) the possibility that economic output may contract as well as expand. These issues can be corrected for by using total aggregate environmental indicators on a country scale and by allowing for asymmetric effects from economic expansions and contractions.

An analysis that corrects for these three deficiencies will help to determine more accurate pathways for future economic and environmental development, as well as inform policies that seek to minimize economic cycles or eliminate contractions.

**Methods**

High quality data on the total Ecological Footprint of consumption (EFc) for 87 countries were taken from the 2009 National Footprint Accounts from Global Footprint Network. These were combined with GDP per capita values (GDP) from Penn World Tables to create an unbalanced panel dataset of 3523 records.

A fixed effects regression was run using the following model:

$$EF_{tc} = \beta_0GDP_{tc} + \beta_1(GDP_{tc})^2 + \beta_2\Delta GDP_{tc} + \beta_3(GDP_{tc})^2 + \alpha_i + \eta_t + \epsilon_{tc}$$

Where $EF_{tc}$ is the log of the total Ecological Footprint for country $i$ in year $t$; $GDP_{tc}$ is the log of cumulative per capita GDP increases ($\$PPP$ 2000); $\Delta GDP_{tc}$ is the log of cumulative per capita GDP decreases; $\alpha_i$ is a nation-specific fixed-effect, $\eta_t$ is a period-specific effect, and $\epsilon_{tc}$ is assumed to be an i.i.d. error term. Robust standard errors were used to compensate for potential heteroskedasticity and autocorrelation. Significance in any asymmetry will be tested for with post-estimation linear restrictions.

**Results and Discussion**

Economic expansions and contractions, as measured by increases and decreases in GDP per capita, were found to have a significantly asymmetric effect on the Ecological Footprint. No Environmental Kuznets Curve was found, since the coefficient on the quadratic term for was positive and the linear term was negative; both were significantly
different from zero. Both the linear and quadratic terms on were insignificantly different from zero; a reflection of the low impact that economic contractions have on the Ecological Footprint and the low sample size of countries undergoing contractions.

\[ \beta_1 = -0.178 \text{ (p-value 0.035)} \]
\[ \beta_2 = 0.024 \text{ (p-value 0.001)} \]
\[ \beta_3 = -0.011 \text{ (p-value 0.854)} \]
\[ \beta_4 = 0.001 \text{ (p-value 0.940)} \]

When non-decomposed GDP per capita is used, a weakly significant linear effect on EF\(_C\) is seen, with a 10% increase in GDP per capita corresponding to a 3.1% increase in EF\(_C\).

**Conclusion**

The environmental impact of economic contractions would be expected to be different than a simple reversal of the impact seen under expansion. Yet, the majority of the literature assumes this reversal, and consequently mis-specifies the impact of economic activity on the environment. It has been shown that, when decomposed, an increase in economic output has a continually increasing impact on the Ecological Footprint; conversely, a decrease in economic output has an effect insignificantly different from zero but significantly different than a reversal of the expansion impacts.

In the global economic downturn that began in 2007, many commentators have seen a silver lining in that the environmental impact will decrease along with output. However, if the results from this study are generally applicable, it appears that there is significant ‘stickiness’ to the level of throughput of ecological resources even during contractions.

**References**


Projecting future human demand on the Earth’s regenerative capacity

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²) Department of Mechanical Engineering, University of Bath, UK

Keywords: Scenario analysis, Ecological Footprint, impact projection

Introduction
Scenario analysis of future trends in Ecological Footprint and biocapacity have the potential to inform today's policies aimed at creating a sustainable future. Additionally, these analyses demonstrate potential areas of constraint and mitigation strategies. International agencies, such as the United Nations and the International Energy Agency, frequently release their own projections for the future but these are focused on narrow spheres of interest. These projections often only pay cursory attention to each other and occasionally present outcomes that directly conflict with each other.

Since Global Footprint Network's National Footprint Accounts (NFA) are structured to monitor the combined impact of anthropogenic pressures more typically evaluated independently, they already present a framework for combining historical datasets from diverse sources [1]. This framework can thus be extended to utilize datasets projecting the future. A global level scenario calculator based on this principle has been constructed with funding from the World Business Council on Sustainable Development (WBCSD) as part of their Vision 2050 initiative, with the ability for user modification of the data underlying the projections and illuminating outcomes for humanity's future.

Methods
Projection data have been drawn from international sources including the Food and Agriculture Organization (FAO), United Nations Population Division (UNPD), International Energy Agency (IEA), and the Intergovernmental Panel on Climate Change (IPCC). All data not already disaggregated were converted into per capita values, using the UNPD median variant estimate if not otherwise indicated.

Projections of food consumption by category were taken from FAO, adjusted to fit with NFA data, and converted to physical cropland and grazing land areas and global hectares (gha). Baseline yields were taken to be constant in the absence of high quality projections. Consumption of fish was obtained from projected production quantities. Projections of total power demand by fuel/source were taken from IEA, according to their baseline estimates. These were converted into total carbon emissions and net carbon emissions using carbon intensity and Carbon Capture and Storage data. These net emissions were then converted into gha. Forest product consumption estimates and forest yields were obtained from a WBCSD participating company. Built land areas were projected using a constant physical area required per person.

The influence of a non-constant environment through climate change was accounted for through the modification of land suitability. Net carbon emissions data were passed
through the B2 climate scenario from IPCC to get an effective projected temperature increase. This temperature increase then passed through FAO’s GAEZ model to give an impact on land suitability and the consequent effect on agricultural yields.

**Results and Discussion**
The baseline estimates project humanity’s Ecological Footprint to increase to over 30 billion gha by 2050 (3.4 gha per capita). The composition of the Ecological Footprint would be similar to that of today, with approximately 60% coming from the carbon Footprint component. Total biocapacity would rise through 2030, peaking at 13.4 billion gha (1.6 gha per capita) largely due to the effects of increased availability of land suitable for agriculture due to the initial effects of climate change. Total biocapacity then decreases as the climate warms further, reaching 12.7 billion in 2050 (1.4 gha per capita). As land becomes constrained, agricultural land is given preference over forest land and forest biocapacity drops from 5 to 3 billion gha between 2030 and 2050. These effects combine to project humanity requiring the regenerative and absorptive capacity of 2 planets by 2036 and nearly 2.5 planets by 2050. In comparison, if humanity followed the IEA’s BLUE map scenario [2] (requiring emissions to stabilize at 50% of 2005 levels by 2050) but kept other consumption (such as food, fibre, etc) and yield estimates at the baseline, humanity would require less of the Earth’s capacity by 2050 than now, at just over 1.3 times the resources and ecological services provided by the Earth.

**Conclusion**
Addressing the global sustainability challenge requires assessing and managing the trade-offs between guaranteeing human well-being in the short term and preserving the Earth’s regenerative capacity in the long term. Constructing believable scenarios of humanity’s future path is thus fraught with difficulties and can be subject to much criticism. Despite this, major international institutions have seen fit to construct models to assess current policies and identify areas of potential limitations to current trends. By using a variety of these models, and placing them into the Ecological Footprint framework, we can not only determine a plausible projection of future demands on the Earth’s ecosystems, but also highlight areas where institutional projections are incompatible with each other. The conceptually simple model presented here already highlights that increased caloric demands for food are incompatible with maintained forest areas in a warming environment.

**References**


In the battle of climate change - policy measures or economic transformation? How can methodology help?

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Keywords: Embodied Carbon Footprint, International Trade, Input-output model

Introduction
Carbon Footprint is often associated with offsite, indirect impact, stemming from the production phase and imports. Though the results of calculation do not always reflect this dimension properly. This issue has high relevance in Hungary, as in 2009 an initiation has started in order to put in the Hungarian Climate Act, which could be the second Act of this kind in Europe to be codified, after the failure of the COP-15. When analysing the Carbon Footprint and its international trade-related impacts, there is still a need to refine its methodology. As it is shown in this research, Carbon Footprint interpreted within the geographical limits of a country can bias its own and the regional results because the trade-related impacts and the sectoral impacts are not completely shown in the analyses. Therefore a methodological improvement is proposed. My hypothesis is that import plays a significant role in the Carbon Footprint and the underlying causes need to be defined as well.

Methods
At the first stage of the research, studies about Carbon Footprint and its applications have been analysed, the most important ones are that of Druckman-Jackson [2]; Wiedman [3] and Lenzen et al. [4]. The next step was the calculation phase of the Carbon Footprint which is based on the method of Wackernagel et al. [1] combining it with input-output tables. The symmetric input-output tables and the import input-output tables of the OECD database were used for year 2005. After, using the data of the import input-output table, the Carbon Footprint embodied in imports and CF embodied in production were calculated and compared, by allocating the results to final consumption categories. Then the Carbon Footprint intensities for these were calculated, showing how much Carbon Footprint is generated after each currency unit. To understand the underlying factors of the result, the import demand of production and expenditure were calculated from the import input-output tables using the Leontief matrix.

Results and Discussion
The empirical results of the Carbon Footprint show that the household consumption of food and beverages, housing utilities, moreover the transport sector are responsible for a significant part of the Carbon Footprint. Examining the Carbon Footprint intensities of imports, it is visible that the housing and utilities have a high intensity value, the Carbon Footprint generated by the import needed for consumption is very high. It is due to the specific structure of the Hungarian energy sector, which is extremely import-dependent and thus giving rise to the Carbon Footprint embodied in imports. The furniture and household consumption’s direct import intensity is striking as well, here the machinery and manufacturing industry’s import need plays a prominent role. Comparing these results to the Carbon Footprint of production/ production value, it can be seen that the imported goods generate higher Carbon Footprint.
<table>
<thead>
<tr>
<th>Consumption categories</th>
<th>Share of Total Carbon Footprint (%)</th>
<th>CF embodied in imports/Import value (gha/ HUF million)</th>
<th>CF embodied in production/Production value (gha/ HUF million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and beverages</td>
<td>26%</td>
<td>2.30</td>
<td>0.11</td>
</tr>
<tr>
<td>Clothing and footwear</td>
<td>4%</td>
<td>1.59</td>
<td>0.03</td>
</tr>
<tr>
<td>Housing and utilities</td>
<td>18%</td>
<td>8.65</td>
<td>1.26</td>
</tr>
<tr>
<td>Furniture and household</td>
<td>10%</td>
<td>3.80</td>
<td>0.24</td>
</tr>
<tr>
<td>Transport</td>
<td>23%</td>
<td>0.11</td>
<td>0.70</td>
</tr>
<tr>
<td>Other products and services</td>
<td>9%</td>
<td>-</td>
<td>0.10</td>
</tr>
</tbody>
</table>

It is the household and utilities consumption sector and the transport, where the production intensity is relatively high. Interpreting the results, it should be noted that though the import dependency of the country is significant, the results can bear distortions. Looking at the import demand of expenditure, as an underlying factor, the export has high import need, especially at the agricultural and manufacturing sector. It appears as a high import value and it will be further exported with some value-added. It is because of the specific structure of the Hungarian economy that the import necessity of the export products in those sectors is rather high. So, I propose that the cross-effects of export on import expenditure should be calculated in the Carbon Footprint, modifying it by the export’s demand and the material flow’s value. Thus the country’s footprint would not be underestimated and the real Carbon Footprint contribution of the sectors can be incorporated.

**Conclusion**

The importance of this analysis was to reveal the importance of Carbon Footprint embodied in imports and its sectoral impacts, and the need for refining the calculation. It has been revealed that the energy sector and manufacturing industry’s impact is rather high due to its heavy import need, generating higher Carbon Footprint after each currency unit. Two major messages can be concluded. First, the import dependence of the country should be a warning sign and it became clear that without economic transformation, only with political measures the country will not be able to decrease its Carbon Footprint. Second, as the import need is rather high in the agricultural and manufacturing sector for the exported goods, it gives distortions to the footprint data, as the environmental load of the exported products counts to the footprint of the regional countries. The distortion present in the Carbon Footprint because of the specific economic-and trade structure should be revised, and refining the method is proposed.

**References**

Comparing the environmental impacts of intensive and extensive agricultural practices

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Keywords: Ecological Footprint, Extensive, Intensive Agriculture, Yield factor

Introduction
After calculating the environmental impacts of different sectors in Hungary using the tool of input-output analysis, combined with ecological footprint methodology [1], results show that the agricultural contribution to the national footprint amounts to 15.8% of the total Footprint. We draw attention to calculations on the environmental effects of agriculture - which plays a prominent role in Hungary. The real environmental load generated by agriculture is not revealed properly through EF indicators, as the type of agricultural farming (thus the nature of the pollution it creates) is not incorporated in calculation processes. It is commonly known that extensive farming uses relatively small amounts of labour and capital. It produces a lower yield per unit of land and thus requires larger areas than intensively cultivated land to produce similar yields, so it has a larger Crop and Grazing EF. However, intensive farms, to achieve higher yields, apply fertilizers, insecticides, herbicides, etc., and cultivation and harvesting are often mechanized. In this study we highlight the different environmental impacts of extensive and intensive farming practices, and present proposals for changes to the way EF is calculated for this sector.

Methods
In order to analyze the difference between extensive and intensive cultivation practices we compared the substantial indicators of agriculture and the Ecological Footprint of two countries. Hungary was chosen to represent a country where farming is mainly extensive, and the Netherlands to represent intensive farming practices. To reveal the environmental load and sustainability of these agricultural types, we created different indicators and compared them, focusing on mean and process-based effects. Analysis was conducted for the year 2005, using data from Eurostat and FAO.

Results and Discussion
As previously stated, we conducted a cross-country analysis, where we tried to determine the origins of the different ecological footprint data for Crop and Grazing land in Hungary and the Netherlands focusing on the nature of the agricultural practices. Table 1 shows the total biocapacity and the ecological deficit for both countries. The biocapacity of crop and grazing land is larger in Hungary, but looking at the Ecological Deficit data, we can conclude that Hungary still maintains a positive balance while the Netherlands is in severe deficit, which indicates sharp structural differences.

<table>
<thead>
<tr>
<th>Biocapacity and Ecological footprint indicators 2005</th>
<th>Hungary</th>
<th>The Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland [gha per person]</td>
<td>1,99</td>
<td>0,31</td>
</tr>
<tr>
<td>Grazing land [gha per person]</td>
<td>0,15</td>
<td>0,08</td>
</tr>
<tr>
<td>Crop and Grazing land/Total Biocapacity</td>
<td>76%</td>
<td>35%</td>
</tr>
<tr>
<td>Ecological Deficit per person (gha)</td>
<td>66%</td>
<td>-101%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The scale of intensity of farming in 2005</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of utilised agricultural area to total area</td>
<td>83%</td>
<td>58%</td>
</tr>
<tr>
<td>Proportion of arable land to total area</td>
<td>49%</td>
<td>33%</td>
</tr>
<tr>
<td>Proportion of cereal area to total arable area</td>
<td>65%</td>
<td>19%</td>
</tr>
<tr>
<td>Nitrate content in rivers (mg/l)</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>Phosphate in rivers (mg/l)</td>
<td>0,07</td>
<td>0,08</td>
</tr>
<tr>
<td>Ammonia emissions (t)</td>
<td>94252</td>
<td>121000</td>
</tr>
<tr>
<td>Livestock density index (livestock units per hectare)</td>
<td>0,58</td>
<td>3,26</td>
</tr>
<tr>
<td>Labour force (1000 person employed full time)</td>
<td>229,40</td>
<td>173,90</td>
</tr>
<tr>
<td><strong>Yield 2005</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato (kg/ha)</td>
<td>25877,5</td>
<td>43442,3</td>
</tr>
<tr>
<td>Wheat (kg/ha)</td>
<td>4499,9</td>
<td>8593,1</td>
</tr>
<tr>
<td>Maize (kg/ha)</td>
<td>7557,1</td>
<td>12200,3</td>
</tr>
<tr>
<td>Sugar beet (kg/ha)</td>
<td>57035,9</td>
<td>64961,6</td>
</tr>
<tr>
<td><strong>Yield factors 2005</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1,58</td>
<td>3,03</td>
</tr>
<tr>
<td>Maize</td>
<td>1,54</td>
<td>2,49</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>1,23</td>
<td>1,40</td>
</tr>
<tr>
<td>Potato</td>
<td>1,53</td>
<td>2,56</td>
</tr>
<tr>
<td><strong>GHG emissions in agriculture in 2001 (t, CO2eq per ha)</strong></td>
<td>0,75</td>
<td>10,17</td>
</tr>
<tr>
<td><strong>Modified yield factor by nitrate content</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1,79</td>
<td>1,86</td>
</tr>
<tr>
<td>Maize</td>
<td>1,74</td>
<td>1,53</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>1,39</td>
<td>0,86</td>
</tr>
<tr>
<td>Potato</td>
<td>1,72</td>
<td>1,58</td>
</tr>
</tbody>
</table>

As biocapacity in Hungary is greater, there is a rationale for extensive farming. For the Netherlands, land is a scarce resource, so intensive farming processes are utilised. The features of the different types of farming are shown in Table 1 where it can be seen that the Netherlands has smaller scale labour force and lower agricultural labour input and the share of agricultural product-specific inputs is lower as well. Comparing extensive farming with intensive, environmental impacts can be seen through the listed categories. Because of intensive farming, spending on fertilizers and soil improvers is 2.55 times higher, and spending on plant protection products is 5.6 times higher in the Netherlands than in Hungary. It is the same story with natural elements when considering the supply of nitrogen and phosphates, and ammonia emissions. After comparing these figures, we may conclude that intensive farming processes contribute to a higher environmental burden, which is not indicated through Ecological Footprint-derived results. We would thus propose that the yield factor should be modified by incorporating the polluting features of agriculture: more precisely, that the national yield factors should be divided, for example, by the proportion of national nitrate content in rivers/average nitrate content, as an indicator of pollution derived from fertilizer usage. Though intensive agriculture gives higher yields at the moment, in the following decades harmful effects such as soil degradation, soil acidification, groundwater pollution, etc. are liable to become significant. These pollution-related damages do not appear in the EF calculation, but it is important to take them into account.

**Conclusion**

We conclude that the structural differences in agriculture have a great impact on the calculation of biocapacity, which indicates rethinking the way this indicator has been estimated so far. We suggest that the long-term environmental impacts of intensive agricultural practices should be built into the EF model - in this case in the national yield factors, which can represent the dominant agricultural structure of a country.

**References**

Implication of stock-flow distinction on National Footprint Accounting: a conceptual overview

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Keywords: ecological footprint, depth, natural capital, stock vs. flows, sustainability.

Introduction
In the last decades several indicators have been proposed to guide decision makers and help protect natural capital. Among such indicators is the Ecological Footprint, a resource accounting tool with a biophysical and thermodynamic basis. In a recent paper, a three dimensional Ecological Footprint model (³DEF) has been proposed to better explain the difference between human demand for stocks and flows. This distinction has a profound impact on sustainability and the aim of this paper is thus to investigate the implications of distinguishing between the use of natural capital flow and the depletion of natural capital stock. Preliminary considerations for national Footprint accounting are offered to give insight on societies’ progress towards minimum sustainability conditions.

Methods
The ³DEF is a volume-based indicator with two relevant dimensions: the surface area (or Footprint size) and the height (or Footprint depth). The Footprint size (EFsize) deals with the human appropriation of the annual income from natural capital (all resource flows and ecological services annually produced by the biosphere and its biogeochemical cycles). EFsize is an area, it is expressed in global hectares (gha) and it can assume all values between zero and the annual biocapacity (BC) of the planet: 0<EFsize ≤BC. The Footprint depth (EFdepth) represents the excess demand for bioproducive land to meet human needs, which is served by depleting stocks of natural capital, or accumulating stocks of wastes. It can be considered as the number of years necessary to re-generate resources liquidated in one year (and to absorb CO₂ emissions) or as the number of planets necessary to support the total consumption of mankind. EFdepth is a dimensionless ratio, calculated as: 1+EO/BC. It can take any value equal or greater than 1, where 1 is a reference value termed natural depth and EO is the ecological overshoot.

Results and Discussion
Global trends in EFsize and EFdepth for the period 1961-2006 were analyzed. Absolute EFsize doubles from 1961 to 1986. After 1986, it reaches an asymptotic value equal to the Earth BC and remains constant. Conversely, EFdepth is constant at the natural depth until 1986, the year in which global EF exceeded Earth’s BC. A growing trend is observed after that.
The 3D EF model enables comparisons between the behaviors of different nations. Four hypothetical cases can be detected when comparing any nation’s demand for ecological assets with its own biocapacity (BCN), in a given year (Figure 1). Only environmental aspects are here considered; additional measures would be needed for comprehensive pictures of nations and to assure that wealth and well being were also being met.

**Case A:** nations in this category can be considered to be meeting a minimum biophysical condition for sustainability as they consumes less ecological assets than those locally available (EFsize<BCN) and do not deplete stocks (EFdepth=natural depth=1). A surplus of resource flows for exports could be also potentially available.

**Case B:** here the total EF value is higher than in case A. Any country falling into this case consumes a larger flow of resources than that which is locally available in a specific year. It thus requires additional flows (an “extra size”) from elsewhere (EFsize>BCN), though internal stocks are not liquidated.

**Case C:** the total EF value is again higher than in case A. The Footprint size is lower than BCN (EFsize<BCN), nevertheless a depth appears (EFdepth>1). This means that local resources could be used more effectively without compromising local stocks and, that stocks from other countries are being imported.

**Case D:** the total EF value is high as EFsize is higher than BCN, and a depth higher than 1 exists. This is due to both overconsumption of local stocks and import of both flows and stocks. It is probably the less ecologically sustainable of the four cases. In this situation, local resources are exhausted and a big portion of EF is compensated by importing size and liquidating local and/or global stocks.

**Conclusion**

The stock-flow distinction here proposed allows drawing preliminary considerations to then define a new Footprint geography based on both size and depth information. The distinction between depletion of natural capital stocks and the use of natural capital flows is gaining particular interest, especially in dealing with open systems such as nations. The 3D EF model is thus more suitable in considering this distinction while maintaining the structure and advantages of the classical Footprint format.

**References**


The CEW environmental label for typical products:

the case of the “Cinta Senese” pig

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Keywords: carbon footprint, cinta senese, ecological footprint, environmental labelling, pig, water footprint

Introduction
Ecological labels are documented recognition that activities, products or services comply with certain environmental standards. The most reliable examples in Europe are Eco-Labels and Environmental Product Declarations (EPDs). The latter are currently being developed as a way of communicating environmentally-relevant information in a comprehensible, yet value-neutral manner over the entire production chain of a product. A good ecological label should be a mix of EPD and Eco-Label: it should provide relevant and suitable information as EPD does in the manner of an Eco-Label. The aim of this paper was to provide a new scheme for environmental labelling of products, based on an integrated footprint approach called CEW. The CEW is an LCA-based approach characterized by the joint use of three indicators of the so-called footprint family: Carbon (CF), Ecological (EF) and Water Footprint (WF). All three indicators are aimed at evaluating environmental impact in terms of appropriation of natural resources needed to sustain the supply chain of a generic product. Specifically, the three indicators highlight the effect of resource consumption on different environmental compartments: air (in terms of greenhouse gas emissions), water (in terms of volume of water consumed and/or polluted) and land (in terms of land use).

Methods
The CEW was evaluated for a typical product of the Siena area: the “Cinta Senese”, a traditional breed of pig with high quality meat. The pig is black with a pink belt between shoulders and front legs. The pigs are usually raised extensively (in a wild state in forests and pastures) and with a closed loop (fattening and reproduction). Their diet is generally characterized by woodland fruits (chestnuts, acorns) and forage and some imported feeds. For this study we analyzed a pig farm located in the south of Siena Province. All data was kindly provided by the farmer.

Results and Discussion
Preliminary CEW results are summarized in Table 1. Results are referred to 1 kg live. The CF calculations showed emission of 2.56 kg CO$_2$eq per kg of meat, most of which is from feed production. The value was quite similar to that of pig farming in Denmark (3.30 kg CO$_2$eq).
EF analysis indicated that about 105 $\text{gm}^2$ of land were needed to support meat production. This figure was compatible with those of a case study on pork. Moreover, comparative analysis with different types of meat showed that pork was intermediate between beef (181 $\text{gm}^2$) and chicken (66 $\text{gm}^2$). Most of the land required was cropland (73%) needed for maize, barley and other grains for daily diet. Forest (woodland) for foraging was 18% and energy land for the various types of processing was 7%. An important aspect was a lower contribution of energy land with respect to the above case study. This was primarily due to the farmer’s policy of preferring local resources. The WF results showed a total demand of 6070 L of water per kg live, higher than other data for pigs in the literature. The ranking was similar to that found for EF.

Table 1: The main CEW results for Cinta Senese pigs raised near Siena compared with data for other animals from the literature (per kilogram live)

<table>
<thead>
<tr>
<th></th>
<th>CF</th>
<th>EF</th>
<th>WF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg CO$_2$-eq</td>
<td>$\text{gm}^2$</td>
<td>L</td>
</tr>
<tr>
<td>pork (Cinta Senese race)</td>
<td>2.56°</td>
<td>104.7°</td>
<td>6070°</td>
</tr>
<tr>
<td>pork (White race)</td>
<td>3.30°</td>
<td>92.5°</td>
<td>4800°</td>
</tr>
<tr>
<td>chicken</td>
<td>-</td>
<td>66°</td>
<td>3900°</td>
</tr>
<tr>
<td>beef</td>
<td>-</td>
<td>181°</td>
<td>15,500°</td>
</tr>
</tbody>
</table>

Legend: ° this study; °° our calculation from GFN data; °°° Water Footprint data; °°°° Dalgaard et al., 2007 DFJ report. Animal Sciences 82.

The CEW approach has the advantage of highlighting the different environmental impacts of a product for consumers, by measuring greenhouse gases emissions, ecologically productive land use and water consumption. On the other hand, certain limitations have yet to be overcome. A fundamental topic for future research is to normalize the three indicators, providing a footprint performance for goods and services.

Conclusion

Since consumer choices can play an important role in environmental conservation, ecological labels should be developed and encouraged. A label based on the CEW approach informs consumers about important environmental aspects, providing numerical values, which can be used to compare, for example, different brands of the same good. This indicator is not intended to inform consumers about the environmentally friendliness of a product, but it is a fuller way of informing them about the environmental consequences of their choices.

References


When bigger is not worse: the Ecological Footprint analysis of organic vs conventional poultry production

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2) Dept. of Economic and Food Sciences, University of Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy.

Keywords: ecological footprint, poultry, sustainability, conventional vs organic production

Introduction

As reported by OECD-FAO agricultural outlook 2009 poultry meat production will have in the future a major growth. Increasing impacts are expected on many aspects. The paper aims at applying the Ecological Footprint analysis as an ecological sustainability accounting method for poultry production. Three different farming methods are investigated and compared in respect of their ecological sustainability. An economic and strategic view on the specific poultry meat production sector is reported in respect of the indicators results.

Methods

The Ecological Footprint of poultry farming is calculated according to the Process-based Life Cycle Assessment approach (P-LCA) as suggested by the Standards 2009 document. The three systems investigated have different dimension and way of production: a conventional broiler rearing system (hereafter Conventional), an organic rearing system (hereafter Bio) and a more restrictive organic rearing system (hereafter BioPlus). All of them are located in the centre of Italy. The system boundaries are from cradle (i.e. from the arrival of the chicks) to gate (i.e. to the leave of the animals from the farm). The main activities considered are loading and unloading of the animals, feeding and shelters sanitization. Transportation to the slaughtering house, slaughtering, processing of carcases and distribution were not included. The temporal boundary is one year. The Functional Unit is one kilo of poultry meat. Due to the moderate dimensions of the rearing systems the Product Footprint is reported in global square meters per kilo of meat produced in one year. All data were collected from the farms. A life cycle inventory collecting production inputs need is then provided.

Results and Discussion

The Ecological Footprint per functional unit of the three rearing systems grows in the following order: Conventional, Bio, BioPlus (see column B / A in the table 1).

Table 1: Main Footprint results for the three different poultry productions.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>A Total poultry meat production</th>
<th>B Ecological Footprint</th>
<th>C Poultry farming owned area</th>
<th>B / A Ecological Footprint / Poultry meat production</th>
<th>C / A Poultry farming owned area / Poultry meat production</th>
<th>(B / A) (C / A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>kg yr</td>
<td>gm yr</td>
<td>g m² yr</td>
<td>g m² / kg</td>
<td>g m² / kg</td>
<td>adimensional</td>
</tr>
<tr>
<td>Conventional</td>
<td>6.79E+05</td>
<td>8.28E+06</td>
<td>4.20E+04</td>
<td>12.19</td>
<td>0.07</td>
<td>163.73</td>
</tr>
<tr>
<td>Bio</td>
<td>2.48E+05</td>
<td>4.88E+06</td>
<td>8.53E+04</td>
<td>19.68</td>
<td>0.41</td>
<td>47.51</td>
</tr>
<tr>
<td>BioPlus</td>
<td>4.98E+05</td>
<td>1.25E+07</td>
<td>7.61E+05</td>
<td>25.09</td>
<td>1.84</td>
<td>13.62</td>
</tr>
</tbody>
</table>
The main land type required by the three farming is cropland (about 90% of the total EF) and the production inputs affecting the cropland required, as shown in the pie charts below, consist of the feed of the birds.

![Pie charts showing feed components for three farming systems: Conventional, Bio, and BioPlus.](image)

**Figure 1:** Ecological Footprint of poultry production disaggregated by production input.

Two main factors explain the rank of the three rearing systems in respect of the Ecological Footprint per kilo of meat produced: the different amount of land necessary for organic feed components and the feed index of the animals’ strains (every farming system differs from the other in respect of the birds breed). Although the conventional farming appears as the most resources-use efficient system it is not the most sustainable. When considering the ratio between Ecological Footprint and Biocapacity the rank of the farming systems inverts showing the BioPlus as the one depending less on imported ecological resources. The bigger resources use efficiency of conventional farming is one concomitant cause of poultry production boosting in developing countries.

**Conclusion**

The ecological sustainability of the three rearing systems increases in the following order: BioPlus, Bio and Conventional. Moreover the analysis provides a frame to further develop economic conclusions in terms of consumer choices orientation in a sustainable direction and food sectors strategic thinking.

**References**


Footprint: climate, water, energy and city

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Keywords: Water, Sustainable planning, Water footprint, Climate Change, Run off, Greenbuilding, Energy

Introduction
The Brundtland Report on environment and development, takes start underlining as the world is in front of one "global challenge" to which can be answered only through the assumption of a new model of "sustainable" development. But what are we doing for escaping to the announced catastrophe and partly happened of the climate changes? Wolfgang Sachs has underlined that are the populations themselves to risk more and the same human rights to be threatened (food safety, housing, water health and life itself). It becomes concrete as Sachs says, above all to put to the center of the ethics and the environmental politics the language of the human rights and not only the "energy saving" expressed in kw / sqKm /year or in liters of fuel to sqmeter. Water is a scarce good more and more - as it emerges from the data stored by the UE- and the greatest part of the present water on the planet is that salty of the oceans: only the remaining 2,5% of the total one are sweet (35 million Km³) water. The Consumption of sweet water is already sextupled between 1900 and the 1995 (with a rhythm equal to more than the double one of the level of growth of the population) and 1/3 of the world population lives in Countries considered in water emergency. If this trend had to continue, 2/3 of the population of the earth will live under these conditions in the 2025.

Methods
Our method consists of using the indicators of the "the ecological footprint" and of the "Water footprint" as indicator of the sustainability. The ecological footprint used for measuring the human application towards the nature, connects the human consumption of natural resources with the ability of the earth to regenerate: in our case in specific the consumption of ground for new constructions or urbanizations. The "water footprint" (or water's imprint) of an individual, of a community or of a Nation, you/he/she has been conceived and introduced in 2002 by the UNESCO, and is defined as the total volume of fresh water used for producing goods or useful services to the individual, to the community or to the Nation, (expressed in terms of meters annual cubes per capita) how following we will synthesize with (WFP, m³/annu). The volume of total water of a Country includes two components that that falls inside the State (Internal Water Foot Print=IWFP) and the part that it reverts on other States (External Water Foot Print=EWFP). The components of the total WFP are BLUE, GREEN and GREY WATER and precisely water's Volume evaporated by the water surfaces of the globe (blue); that one from the green surfaces, from the rains and from the ground (green); and water's polluted Volume related to the production of the goods and services (grey). The climate change, the permeable surfaces or less, the run urban off, the different methodologies of river restoration directly influence these factors of measure. Nevertheless one of the principal objectives of our method, are without doubt the predisposition of a Tool-kit, to face the effects of the "climatic chaos" from a bottom up perspective.
A simple and comprehensible tool, a Guide to the principal elements of the Change Climatic, mainly in comparison to the perspective of the management of the waters. The strategic elements of a possible answer must be connected to an adaptive answer that overcomes the simple IWRM, Integrated Water Resource Management. Such answer includes also other elements sometimes not considered as essential, as the correct regional planning, the planning of the built (the architectures and the installations) physical space and the land use.
Results and Discussion

The Research has an articulated Program in various phases and also has multiple purposes. Italy has a Water Footprint (WFP) equal to 2.332 m³s per capita / year of which 51% it reverts on States you express (EWFP). Otherwise, in order to satisfy the requirement of water that we use, it would be necessary to use a territory equal to the double one Italy. The imprint of global water footprint at average value, is equal to 1.243 m³s per capita / year. What to do? Is there above all perhaps need of great sensitization, awareness e/o knowledge? Some sceneries on the urban waters for the next millennium, based on the use of innovative (or sustainable) solutions, they foresee that the fittings centralized for the water (of supply, distribution and purification) will lose importance in our cities more and more. It can be hypothesized that in a future next only the 5-20% of the consumers will be laced to a centralized net. They will affirm new based sanitary technologies on the use of so called service waters (es: rain or reclaimed waters) and not more on the undiversified use of the drinkable water. The new constructions will use meteoric and grey waters for a 20%. They will increase the toilet-without water (zero-water toilet) and the toilet that use water of service. To urban level the quality of the available water will condition the residential choices and the real estate prices. Waste water' measurers and new urban prescriptions will be introduced besides as the payment for the disposal of the rain waters. The private houses to heat the water, will use the solar technologies. The experts foresee an increase of the price of the such water to force the consumers to make use of all the available possibilities to reduce their consumptions.

Conclusion

The World President of the Council of the water, French Loic Fauchon, has aimed the finger against "the habits" and the "eccentric consumptions" that contribute to waste all over the world the water resources. In fact it emerges that the nets and the fittings for the supply of water in the dwelling of our cities, are not only a technical or sanitary matter, but that for thousand of years they have intimately been tied to our culture. Many technological developments are based on the spirit of the epoch and on the social conditions and only in second time they are determined from rational motives or from technical necessity. Architects and planners must think about the water understood as "Blue Energy", with unity of measure the liters or m³ for mg of surface builds / recovers or m³ for volume of built. "The "blue energy" it will serve to define the environmental sustainability of the built settlements and the territorial modifications. It is hoped a reduction of the values of the indicators that form the WFP as the withdrawal of per-capita water, a diminution of the domestic collecting, a diminution of the relationship between withdrawn water and availability of the resource, a diminution of the index of consumption of the water for unity of product and a diminution of the meters water's cubes used in agriculture: indicators which for Italy are higher than in many E.U. Countries.

References

Coupling biocapacity and ecological footprint using the emergy approach: Study of Yamaguishi Eco-Village

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Keywords: Ecological footprint, agro ecology and emergy

Introduction
In currently days the humanity requires more biomass production resources than the supply of natural Agroecosistems. This anomalous situation can only happen while non-renewable resources (fossil fuels and mineral deposits) have low price and while the biosphere is still able to maintain their resilience. In other words, we are "eating oil changed" and reducing the geographic areas for the production of vital environmental services. The solution of this anomaly requires an understanding of the functioning of biogeochemical cycles of the areas altered by human society through The use of ecological systems, thermodynamics and modeling of open systems, agro-ecology and politics. The analysis of production systems (biocapacity) and consumption (footprint) must consider all factors involved in systems and to quantify them correctly, and this quantification can be obtained from the emergy accounting. This study describes, using the emergy approach, the operation of an ecovillage using agroecological methods and maintains a considerable area of native forest to absorb the environmental impacts and also generate, environmental services. We obtained the emergy indicators from ecovillage and held a discussion on the carrying capacity of "rural and urban people" that it can support.

Methods
The emergy methodology [3] it was carried out to evaluate the perfomance of Yamaguishi village located in Jaguariuna -SP- Brazil as an agro-ecological system. The property preserves an area of 27 ha of forest, which is responsible for supplying the impact of human activities of ecovillage (agriculture and chickens) [8].The emergy analysis of the system of egg production of village Yamaguishi performed by Takahashi et. al [8] compared the production of organic eggs with a conventional egg production in the United States [2]. The objective of this work was to assess the Yamaguishi village as a whole, using the emergy methodology and determine the carrying capacity that an ecological system can provide to population, through the correlation of the data obtained in this study with data from Abel [1], which calculated the emergy per person in certain cultures.

Results and Discussion
The Transformity calculated for the system (Tr = 7.88 E +06 seJ/J) shows a high ecosystems efficiency. The Emery Investment Ratio (EIR) had a value of 0.40, indicating a low dependence of the economy's resources. The renewability of the system is high
(75%) showing that the agroecological production system uses 75% renewable emergy. This demonstrated that the system has a good degree of sustainability. The main factor responsible for this high renewability is the preservation of native forest in almost 40% of its area. The calculated value of Emergy Loading Ratio (ELR) was 0.49, showing the low environmental impact of the system. The Emergy Exchange Ratio (EER) shows who wins and who loses in the commercialization of products. The calculated value of EER was 0.10, which means that the producer wins on the sale of the product. To be a fair exchange value of this index should be equal to 1.

Considering the emergy per person of residents and workers of Yamaguishi village as $2.44 \times 10^{15}$ seJ/person, the 68 ha of the system has a capacity to support 2303 people. If the emergy/person ratio of Campinas population (Yamaguishi Village products consumers) is $1.13 \times 10^{15}$ seJ/person, the farm production allows to support to 590 people. Assuming a more intense consumption rate ($1.13 \times 10^{16}$ seJ/person), the carrying capacity is reduced to 59 people.

Conclusion
Through the emergy assessment of Yamaguishi Village was possible to verify that the management used in this agro-ecological system can absorb the impacts of their activities and also can produce environmental services such as water infiltration and sequestration of CO$_2$. Moreover, the system has the ability to support people in the urban area, but this support ability depends heavily on the intensity of consumption of people.

References
The Ecological Footprint of Fisheries Products: A Case Study of Reduction Fisheries for Meal and Oil

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Keywords: Fisheries, Aquaculture, Reduction fisheries, Uncertainty

Introduction
Fisheries and aquaculturists are facing continued pressure to assess and communicate the environmental performance of their products. The Ecological Footprint (EF) has been used to measure and communicate sustainability in the context of fisheries and aquaculture products. Previous researchers have employed the EF to assess and compare various aquaculture systems (e.g. Folke [2]; Berg et al. [2]; Kautsky et al. [3]). Results of this research indicate that reliance on fisheries-derived feed inputs is a major contributor to the EF of aquaculture systems. For example, Folke [2] estimated that salmon cage culture required a marine area 40,000-50,000 times larger than the surface area of the cage, to sustain the catch fisheries which provided meal and oil aquafeed inputs.

Methods
Here, we evaluate a number of fishery-based feed inputs to modern aquaculture using the EF, and critically assess the primary drivers at play behind the EF of seafood products and the uncertainty associated with each. Fisheries in the study include those for Peruvian Anchovy (Engraulis ringens), Atlantic Herring (Clupea harengus), Gulf Menhaden (Brevoortia patronus), Blue Whiting (Micromesistius poutassou), and Antarctic Krill (Euphausia superba). These species cover a wide range of biological characteristics, from large zooplankton to predatory fish. They also vary widely in source locale, spanning the Southern, Pacific and Atlantic oceans, as well as fishing technology and annual catch. Together, the five fisheries considered account for approximately half of the global harvest of marine species destined for reduction into meal and oil, and three of the top four reduction species harvested in 2003 [4]. Variables influencing the EF include: meal and oil yield, energy content of meal and oil, species trophic level, carbon transfer efficiency between trophic levels, and net primary productivity of source ecosystems. The relative role of these variables and the uncertainty associated with them was evaluated using Monte Carlo analysis.

Results and Discussion
Results indicate the importance of trophic level (TL) - or position within aquatic food webs - of each species in determining its marine footprint (fig. 1). Higher trophic level species such as Atlantic Herring (TL ~3.23) or Blue Whiting (TL ~4.01) not only have higher median marine footprints, but are also associated with much greater uncertainty in the results. Carbon transfer efficiency, which varies widely between ecosystems, also influences the EF significantly, and is a major source of uncertainty in the results.
Figure 1. Marine footprints for combined meal and oil product from five reduction fisheries, with ranges reflecting uncertainty. Middle line represents median value, lower and upper boundaries of boxes represent 25th and 75th percentiles (thus containing 50% of results), and lower and upper boundaries of whiskers represent 10th and 90th percentiles, respectively. Note the break in Y-axis, to show the high range of values for Blue Whiting (median value for Blue Whiting = 330 ha.)

Conclusion

It is clear that the EF of fish meal and oil cannot be generalized, but rather that the source of meal and oil can greatly influence the ecosystem support required, and in turn the EF of aquaculture raised on products from reduction fisheries. The EF, while a useful single measure of relative sustainability of seafood products, is not a holistic determinant of sustainability, and needs to be used in conjunction with other tools such as MSC certification and life cycle assessment to capture the elements of sustainability not included in spatial representations of ecosystem support.

References

The Ecological Footprint of Italian Drinking Water: a comparison between tap and bottled mineral waters

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Keywords: bottled water, tap water, ecological footprint

Introduction
Water is a critical resource without a natural substitute. It plays a central role in the whole biosphere’s life and can be considered as the biosphere’s bloodstream. Water is a key production factor for many other resources and it is also essential for every biological aspect and the survival of mankind. As most of the world’s resources (e.g., oil), water is approaching its peak: the point where half of the stock has been already consumed and withdrawal is no longer convenient. Italy is rich in water resources: according to FAO, the total water resources availability in 2008 was 3210 m³ per capita. Due to this richness and to the different quality and chemical composition of waters, Italy has an important production of bottled drinking water. According to Rodwan [1], humans are increasingly relaying on bottled water and, in 2008, Italy was the second highest per capita consumer of bottled water with 224 litres per person. The aim of this work is to evaluate the Earth’s regenerative capacity required to provide end users with 1.5 litres of natural drinking water from tap and to compare it with the same volume of bottled water.

Methods
The Ecological Footprint (hereafter EF) is an environmental accounting tool able to measure the load imposed on the biosphere by a population or a production activity, in terms of total bioproductive area demanded. The EF of water cannot be calculated as water is considered an enabler of bioproductivity rather than a product of ecosystems by the EF methodology [2]. However, it is possible to estimate the amount of ecologically productive land required to make water drinkable. Aqueducts can be considered as production process as they withdraw, make drinkable and distribute water to the end users through pipelines. The total EF of a product is defined as the sum of the EF of all activities required to create, use and dispose that product. In this paper EFs for tap and PET bottled water (as average of a sample of six different Italians brands) were evaluated. The calculation was performed according to the process-based life cycle assessment (P-LCA) as suggested by the Ecological Footprint Standards [3].

Results and Discussion
Table 1 reports the weighted EF of six Italian bottled waters [4] and the EF of an Italian aqueduct [5], in terms of global m². The functional unit is per 1.5 litres of water provided. The results indicate that the total bioproductive land required to produce bottled water is higher than the land required to make drinkable water available at home. On average the
EF of bottled water is about two orders of magnitude higher than the EF of tap water. Analyzing the EF by component, it emerges that for the bottled water the major contribute is the materials component (about the 95% of the total EF) while for the tap water energy flows are the predominant component. This is due to the fact that in order to withdraw, distribute and make the spring water drinkable a huge amount of energy is required while the quantity of materials required is negligible. Moreover, the bottled waters analyzed are marketed in PET bottles and all plastics materials are energy intensive and responsible for a huge quantity of CO₂ emissions. The energy land required is therefore higher. The lack of the transport component in the tap water contributes to the lower Footprint value of this water type. However, transport’s contribution is risible also in bottled water (less than 3% of the total EF).

These results are in line with those founded by Niccolucci et al. [6] where authors have analyzed the environmental impact related to a bottled water applying three different footprint-based indicators (Ecological, Carbon and Water Footprint).

**Conclusion**

The EF results show that the bottled water requires more ecologically productive lands than tap water. This is primarily due to the container (in this case a plastic material) and the packaging needed to trade and, secondarily, to the transfer process from the spring to the market. Even if the impact in terms of land appropriation is lower than other productions, the evaluation of environmental consequences of the use of this kind of resource over time should be investigated especially when this resource is becoming scarce. While the EF method is able to capture this aspect, it does not consider the limitedness of resources. Finally, evaluating the environmental impacts related to alternative materials as glass or PLA (Polylactide) is an ongoing study.

**References**


Ecological Footprint Method using Emergy Analysis for the evaluation of sustainability: the case study of Brazil

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Keywords: Ecological Footprint, Emergy Analysis, Brazil, Load Capacity Factor

Introduction
As the concept of sustainable development is more accepted and incorporated by the institutions, it becomes necessary to evaluate economy’s performance based on new methods and not only on economic indicators. Despite the importance of sustainability to the preservation of natural ecosystems and services, there isn’t a standard in the world scientific community concerning a methodology to evaluate that concept. In the last decade, two scientific tools have been extensively used worldwide to measure the human impact on nature: Ecological Footprint (EF) and Emergy Analysis (EA). Papers trying to combine them, and obtain more accurate results have appeared in scientific literature, in which Zhao’s et al. [14] approach is an important one. Unfortunately, some weak points of the original methods still remain on the new approaches proposed.

Methods
The aim of this paper is to discuss weak points found both in the EF and EA, trying to overcome some of them through a new approach that uses potential improvements concepts. The proposal is to evaluate the system based on the comparison of the natural demand and anthropic consumption. Biocapacity stands for the natural area’s capacity and was estimated in terms of renewable inputs. A new category called “areas not occupied by humans” was included in the biocapacity. It is composed by open ocean, deserts and frozen land (areas excluded from the conventional footprint method). Consumption stands for the load imposed by human on the environment and was grouped in categories: cropland, forestry, animal products and energy resources.

Results and Discussion
After discussing it through comparisons with other approaches, EF using EA was used to assess Brazil as a case study, resulting in a Biocapacity of 62.2 gha person\(^{-1}\) and a Footprint of 41.9 gha person\(^{-1}\), with 2004 data. The main limitations of the approach proposed here are: (i) it is not possible to make comparisons between the biocapacity and footprint for each category; (ii) a need for a handbook with emergy intensity factors with good quality. On the other hand, this approach have as positive aspects: (i) its easiness of application in global and national scales; (ii) its final indicators account for all the previous energy used to make something; (iii) a new category considering areas excluded from the conventional method was included in the biocapacity calculation, which can be a valid step towards the evaluation and assessment of services provided by nature.
Conclusion
The use of several indicators from different methodologies should be a correct approach aiming to show the system's sustainability. Nevertheless, Ecological Footprint has many strong points that can even help improving other methodologies (including the Emergy Analysis). However, for that, it should be better explained, understood, standardized and open-diffused around the world, preferentially in a participatory way.

References
The Government Procurement like instrument to improve the Environment and to diminish the ecological footprint

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Keywords: Government procurement, environment, ecological footprints, international trade rules

Introduction
It is certain that there is a danger of degeneration of life on the planet because of abuse of the material and technological resources, but in practical terms not much has been achieved because the established commitments, social and economic interests, among others of individuals and States are stronger than the interest of all mankind to maintain the sustainability of the planet. It can cope with the aforementioned danger based on an economic perspective, in which production is oriented according to the preferences of consumers, ie if the consumer habits change, the goods and services should also change, this aspect is important. In this context we see that one of the largest consumers in the world is the state itself, so it is necessary to study how states could gradually lead change by positively influencing the forms of production which damage the planet.

There are initiatives in several countries in the field of public procurement, to improve production conditions aimed at reducing environmental damage, which are important but isolated efforts that could be considered within a comprehensive and global strategy.

Methods
The method used explanatory (Constructive research)

Results and Discussion
A preliminary investigation has allowed to know that care of the environment has an endorsement from the levels of grand statements such as the Millennium Declaration of September 2000, the Doha Ministerial Declaration, November 2001, the Monterrey Consensus of March 2002, meetings between the EU and Latin America in particular the Vienna 2006 and de Lima 2008 and also more specific levels, but nevertheless at the time, do not show significant return results and deadlines that are set are not met.

To reach such results must go beyond the statements and analyze the roots of the necessary changes, such as customs and practices which are reflected in consumer habits. Researchers have found that one of the most important consumer is the State conducting engagements in the amount of 5 549 billion in 1998, and such contracts contain items like office including papers, furniture, uniforms, vehicles, machinery etc. Furthermore there is a strong tendency to improve the tools used in government procurements, including framework agreements, reverse auctions, which help improve the
efficiency in these procurements and make more difficult the existence of corruption, all of which creates a fertile ground to start or deepen the change to procurement of goods and services which do not harm the environment.

It is necessary to make a coordinated effort among countries that takes into account the relationship of environmental policies and international trade rules, avoiding unnecessary barriers and discrimination.

The international cooperation is other element that will have to intervene and will have the option of obtaining tangible results and better indexes, which are important requirements for establishing the proper use of such cooperation that is a concern and a target of the Paris Declaration.

Conclusion
It concludes that concerns about the sustainability of the planet exists at all levels but that the habits and interests are still so much strong to replace consumption practices, that the problem lies in the economic, educational and cultural among others and that in such reason the effort should be done in various fronts, nevertheless can begin himself for a consumer whose preferences can change in function of the welfare of the humanity, this consumer is the State.

For that purpose, must develop a strategy of progressive change for the government procurement that should include the international organizations of countries linked to these procurements, to the international trade and integration, the countries, the national institutions, the officials and the producers, besides the policymakers. It is clear that the effort should include the harmonization of environmental policies with international trade rules, which is very difficult but necessary to obtain results that can be met.

This strategy should also be available to developing countries, for which it must develop the necessary international cooperation.

References
Giving Effect to Footprint Information

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Keywords: Promoting Radical Social Change, Systems Thinking, Public Management, Ecological Footprint, Democracy.

Introduction
Ecological Footprint data are by no means the only information showing that, if we are to survive as a species, we have to radically change the way we live. In fact, by the mid 1980s, some 40% of the British population knew we had to get rid of our cars, our “defence” system, our centralised manufacturing and distribution system, our banking and insurance system, our chemical and energy intensive agriculture, etc. [1].

Despite these survey results, attendance at meetings rarely gives the impression that many participants are aware of just how great are the changes that are needed. Nevertheless, some discussions do sometimes bring to light something else: despairing resignation. The problems are too big. And there is no possibility of tackling them through current social management arrangements. (The film Lions for Lambs captures this position.)

In effect, what is being acknowledged is that we are dealing with a systems problem in which any attempt to change one part on its own is promptly negated by the reactions of the rest of the system. Furthermore attempts to introduce change via centralised command arrangements tend to be counterproductive. Systems change is something very different from mandatory system-wide change grounded, at best, in “common sense” rather than systems knowledge. Indeed, the inexorable drift, over millennia toward centralised, command and control based, societal management arrangements is, as Bookchin [2] has most forcefully argued, part of the network of systemic processes that need to be understood if the necessary changes are to be introduced.

This paper will summarise some of our conclusions about (1) the methodology required to elucidate and map the networks of social forces that constitute social control systems and (2) the public management arrangements required to move forward.

Methods
The research to be presented derives from 50 years’ study of the educational system. Over this time we progressively clarified the educational objectives to be achieved, how they are to be achieved, and the barriers to their achievement. To avoid misunderstanding it is necessary to be clear that we are not here talking about the conveyance and assessment of temporary knowledge of smatterings of information but about the nurturance of high level generic competencies like initiative and the ability to understand and influence the workings of organisations and society ... and the nurturance of diversity in particular.
Results and Discussion
It emerged that there are endless, mutually supportive, barriers to providing genuine education – ie to drawing out the diverse talents of the students. But our most important observation was that these do not operate independently but reinforce and support each other, forming a self-perpetuating system: the attempt to change any part on its own is either negated by the reactions of the rest of the system or produces unanticipated consequences elsewhere. The system not only reproduces itself but extends and elaborates itself. It is, in a word, autopoietic.

One question for social scientists is, then, how to understand, map, harness, damp down, or amplify these social forces. They won’t go away. This is a task for socio-cyberneticians. (Cybernetics is the study of the, largely invisible, guidance and control systems of animals and machines. So socio-cybernetics refers to the study of the, largely invisible, guidance and control systems in society – and the design of better ones.)

A related question is how to create a pervasive climate of innovation within the educational system. So many - mostly as yet unclear - things need to be done by so many people that they could not possibly be centrally decreed. There can be no blueprint. How to design a system which will innovate and learn without central direction? Crudely, we need new forms of democracy and bureaucracy. It emerges, for example, that it is not the job of politicians to tell public servants what to do. Rather, it is the job of public servants to create a ferment of experiment, innovation, and learning … learning through public choice based on good information about all the short and long term, personal and social, consequences of the options available. So new job descriptions and staff appraisal systems are required. And, to give teeth to such information, new, network-based, forms of public supervision are needed.

Conclusion
Our conclusion is that it is precisely this network of developments that is to give effect to ecological footprint and other data that point to the need for radical change in the way we live. They point to the need for a great deal of non obvious research (and especially research into the operation of socio-cybernetic systems) and to a swathe of actions that are not at all obvious to “common sense”. These conclusions are elaborated in my New Wealth of Nations [3] and other publications available at www.eyeonsociety.co.uk.

References
Inclusion of intertemporal yield factors in time series
Ecological Footprint assessments

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Keywords: Ecological Footprint, yield, time series, constant global hectares

Introduction
Ecological Footprint and biocapacity calculations at national and sub-national levels are usually presented in units of global hectares (gha), defined as hectares of land at global average bioproductivity [1]. Currently, most Ecological Footprint analyses utilize a yield factor for each land use type to capture the difference between local and global productivity. The various land use types are then converted into global hectares using a global Equivalence Factor for each land use type, which expresses the relative suitability for supporting bioproductivity of the land occupied by each land use type. This calculation method results in a biocapacity per unit mass of each primary product which is globally constant in any given year. However, the yield and equivalence factors may change from year to year as a result of changes in productivity and land cover, respectively. This renders time series comparisons difficult, as the global hectare equivalent of each ecosystem product varies over time [2]. An alternative method was proposed by Haberl et al [3] to account for changing yields in time series by employing yields from a selected base year. Drawing upon the pros and cons of this method, Kitzes et al [4] developed an alternative approach which uses a single coefficient to represent changes in yield across multiple land use types. WWF [5] presents time series of the ratio of Footprint to biocapacity, also effectively introducing a single coefficient to account for yield changes. The latter two approaches, however, have a distinct drawback in that changes in the yield of one product will affect the biocapacity per unit mass of other products. The aim of this paper is thus to introduce an Intertemporal Yield Factor (IYF), allowing the number of global hectares per tonne of a given product to be held constant over time as well as between countries.

Methods
For products $i$ in a given year $j$, with a selected base year $b$, IYF is calculated as:

$$\text{IYF}_{N,j} = \frac{\sum_i \frac{P_{N,i,j}}{Y_{W,i,b}} \cdot EQF_b}{\sum_i \frac{P_{N,i,j}}{Y_{W,i,j}} \cdot EQF_j}$$

where $P$ is the amount of a product harvested (or CO$_2$ emitted), $Y$ is the product specific yield, and the subscripts $N$ and $W$ denote national and world values, respectively. IYFs are calculated for each country, year, and land use type and are proposed to serve a function that complements the function of the Yield Factors (YF) currently employed in the National Footprint Accounts. While YFs compare the yield of a given land use type in a given nation with the world-average yield for that same land use type, IYFs account for changes in the yield of each land use type over time. Ecological Footprint time series are therefore calculated as follows:
\[ EF = \sum_j \frac{p_{N_i,j}}{Y_{N,j}} \cdot YF_{N,j} \cdot IYF_{N,j} \cdot EQF_j \]

Results and Discussion
Intertemporal Yield Factors for each year and land use type have been calculated for the period 1961-2006, based on data and results from the 2009 edition of the National Footprint Accounts. The use of IYFs in calculating Footprint and biocapacity time series results in a calculation similar to the constant yield approach proposed by Haberl et al [3]. However, the method proposed in this paper has the advantage of also accounting for changes in the Equivalence Factors between years. We have also aggregated across all ecosystem products to produce a single index showing overall change in productivity, though we note that this single index may not be the most appropriate for disaggregated time series.

Conclusion
Normalizing Ecological Footprint time series to the biocapacity per tonne of each product in a given base year gives a more intuitive representation of changes in demand on the biosphere over time. Under this method of calculation, Equivalence Factors normalize various types of biomass, rather than diverse land areas, to a common unit of measure. Thus, the "constant global hectare" representation of the Ecological Footprint may be most suitable as an indicator of the composition of human economic throughput, and of its scale relative to regenerative capacity of the biosphere.

References
Ecological Footprint as large-scale pasta producer Key Performance Indicators (KPI)

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Keywords: Ecological footprint, pasta production, durum wheat, LCA, Environmental Product Declaration

Introduction
The evaluation of sustainability is becoming an important aspect in the study of agricultural systems although there are no widely accepted standards for sustainable food production. There are also different concepts of sustainability: in agriculture a common definition may be that a sustainable farm must produce adequate yields of high quality, be profitable, protect the environment, conserve resources and be socially responsible in the long term. Furthermore, sustainability research in food production depends on the scale, the market channels, and the geographic context of location. Thus, rather than giving an absolute indication for the sustainability of an agricultural system, it is preferable to compare various scenarios with specific assessment or environmental tools. The objectives of this work are to quantify the environmental appropriation of each phase of pasta production, including also, separately the phase of final consumption, to verify the application of the Ecological Footprint Analysis as KPI of the world’s largest pasta maker.

Methods
During this last decade, EF accounting has been further refined and complemented to became one of the most widely used accounting system in physical unit. Although EF was initially applied to quantify the use of natural resources of regions and territories, more recent methodological development make possible the application also to productive systems, where the resulting footprint value estimate the amount of natural services and resources directly and indirectly required to create the final product. Here, the analysis of pasta ecological footprint has focused on Barilla, a leading company in the production of wheat based products worldwide.

Results and Discussion
The total footprint for dry durum semolina pasta made by Barilla is 1.63 gha/t of final product at the platform (this result regards the part of productive chain from cradle to gate). It is interesting to compare this result with the value used in normal analysis performed by Global Footprint Network at national level that is evaluated on the basis of the average yield of crop productivity, average embodied energy of the cultivation and production phases and quantification of the impacts of post-harvest management.
National Footprint Accounts’ footprint for pasta is considered to be 1.5 gha per ton of product. Considering that Barilla is the greatest world producer of pasta, the comparison highlights a probable little underestimation of the value of EF of pasta used in normal calculations.

The largest contribution, 77.6%, is due to durum wheat cultivation, followed by packaging (14.4%), while more industrial processes, such as milling, pasta production and transport, usually associated with heavier pressure on ecosystems, are far less land intensive, covering in their whole only 8%.

Conclusion
The ecological footprint has been used as a voluntary KPI during the pasta environmental product declaration certification following the International EPD™ system and for this reason its calculation was reviewed by an external party and published in the same document available at www.environdec.com. Besides that, it is important to highlight that the application of footprint (both ecological and water) as big company’s KPIs is quite innovative and for this reason in BARILLA is still studied also under a methodological point of view.

References
What is better for you is better for the Environment?

The BCFN Double Pyramid

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Keywords: nutrition, environmental impacts of food production, ecological footprint

Introduction

It is generally known that proper nutrition is an essential condition to health. This is a natural law that; however, has not received due attention in the last few decades. Indeed, the growing impact of disorders related to overeating serves as testimony of this last observation. Common disorders are: obesity, diabetes and cardiovascular pathologies - in people of all ages, including the younger portion of the population.

Aimed at commencing nutritional education, at the start of the 1990s the US Department of Agriculture elaborated and disseminated the first “food pyramid”, based on the scientific studies of Ancel Keys. This structure provided a synthetic and efficient explanation on how to adopt balanced nutrition, serving as a general guideline.

Since then, there has been an enormous increase related to confirmation of disease prevention through proper nutrition. Despite this, public awareness seems to lag well behind.

This is the first reason that leads the Barilla Center for Food & Nutrition (BCFN) to the re-proposal of the food pyramid, 20 years after its conception, which has gained ample recognition and foothold in the scientific and nutritional world. This elaboration of the food pyramid put forth by BCFN has been updated to carefully integrate the latest findings by research.

The second reason involves global warming and, more in general, the impact of man’s activities on the environment.

Methods

It has been demonstrated that agriculture and animal farming are among the sources that yield the greatest amounts of greenhouse gases (beating out transportation). Therefore, as is explicitly emphasized and suggested by the paper “Climate Smart Food” - drafted in November 2009 by SIK - the Swedish Institute for Food and Biotechnology as charged by the current mandate of the Presidency of the European Union, held by Sweden – environmental variables must also be taken into account in regards to food and nutritional diet selection. Thereby, analysis of the food pyramid and its categories reveals a wide array of values concerning the environmental impact of each category in terms of Ecological Footprint.

There is a reclassification of food that goes beyond their positive impact on health, encompassing their impact on the environment, as well. These values are overlapped in descending order to obtain an upside-down pyramid that, in good measure, re-proposes the same succession of foods. Such elaboration is called “Double Pyramid”.

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Results and Discussion

Use of the Life Cycle Assessment method places all environmental markers on the same level for the duration of the analysis: in this work, carbon, water and ecological footprint have been studied as key performance indicators of food production chains. However, once results have been obtained, a need for both communicational conciseness and clarity imposes a simple method that accounts for all outcomes. This is why the ecological footprint served as base indicator in the construction of the double pyramid. All motivations shall be illustrated in the main paper; but it can be briefly stated that these essentially depend on the ability to easily convey the environmental impacts linked to food chains.

Conclusion

The evidence of true interest that emerges from this new elaboration is the coincidence, in a single food model, of two different objectives that share fundamental importance for man: health and environmental protection. In other words, it has been demonstrated that following a diet put forward by the traditional food-nutrition pyramid not only leads to an improvement in quality of life (longer life-span and enhanced health conditions), but also yields a decisively lower impact, better expressed as Ecological Footprint, on the environment. Indeed, food that should be consumed in greater quantities, for example following the Mediterranean diet, fits into the category that inflicts less environmental impact overall. Vice-versa, foods falling into a recommendation of limited quantity consumption have also the higher impact on the environment.

References

Carbon footprint and the vulnerability of international trade: 
the Latin American case

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Economic Commission for Latin America and the Caribbean

Keywords: carbon footprint, international trade, vulnerability, Latin America

Introduction
In developing countries, like the Latin American and the Caribbean countries, the production processes are generally less clean. Compared with developed countries with significant emissions reduction targets, this situation is perceived as asymmetry in the internalization of external costs. This has led the Organization for Economic Co-operation and Development (OECD) countries to take actions that might restrict the trade flow based on the carbon footprint as a means to level the competition conditions between national and imported goods and services and as a means to comply with their international commitments. Therefore this document will review and set the possible implications for the development path of the developing countries.

Methods
Bibliographic review and data analysis.

Results and Discussion
According to Schneider and Samaniego [3] the carbon footprint in exports in Latin American is recently been recognized as an issue. Thus, responding to specific demands of buyers or transnational corporations, specific initiatives have been taken in order to quantify it in some export products.

So far, the region has emphasized the Clean Development Mechanism without significant action on carbon footprint methodologies or reductions as a national strategy. This situation will soon become critical requiring transparency in emissions accounting processes of exports to countries with reductions targets. Given the importance of carbon contained in exports to developed economies, as evidenced by Peters and Hartwich [1] in a study on emissions embedded in trade in Norway, that shows that half of the emissions related to imports came from developing countries, which represented only 10% of the total imported value. In this regard, several initiatives are under way, such as carbon footprint labeling required by France since 2011, the Ecolabel, in force since February 2010 in the European Union, the United States Markey-Waxman Clean Energy and Security Act of 2009 provisions, and other restrictions that bring concern on the trade of significant variety of products.

Conclusion
Some of these early unilateral trade initiatives in developed countries have increased the visibility of climate change within the international trade agenda, and aim at creating technical barriers based on production and circulation processes and their carbon content,
an historical conflict of the World Trade Organization (WTO) around processes and production methods, which has met resistance in developing countries [2]. This also raises questions on the effects of these initiatives on Free Trade Agreements. All of the above would have significant impacts on the economies of exporting countries that do not have emission reduction commitments, so they must be acknowledged, considered and translated into specific strategies.

In the short run, as a way of moving forward it is necessary to precise the definitions and scope of the carbon footprint, its methodological limits and decide what issues have to be considered at every step of the different production life cycles. To precise the export related production of carbon of developing countries, their particular situation regarding the adoption of the different regulations and methodologies implemented by the major importing countries in order to recognize and control their commercial vulnerability and the impacts on their own development.

References


The assessment of urban sustainability with regard to optimum urban governance using Ecological Footprint technique

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Keywords: Assessments, urban environment, Ecological footprint, Sustainable development, Urban governance.

The investigation of current urban environmental conditions indicates an extraordinary destruction unsustainability status. The consequences of this unsustainable development invite many urban policy makers equipped with assessments techniques regarding urban environmental- ecological impacts.

The major objective of this paper is to apply ecological footprint technique for measuring urban- environmental impacts and mutual human environment relations.

This study suggests that London's EF and Santiago's is 5.3 and 2.6 ha respectively as opposed to world's figure (2.3). However, Tehran's EF is amounted to be 3.7 ha. This means that all of these metropolitans are in the state of unsustainability and dictate un proper urban management and governance.

References

Introduction

Australia is a country, even a continent, of extremes. It is one of the world's driest continents, is expecting high impacts of Climate change on its water resources, has one of the most liberalized market economies and is one of largest virtual water exporters. This continent is also the home of one of the world's water hot spots– the Murray Darling Basin. The Murray Darling Basin is also an example for the implementation of resource intensive restructuring programs to restore the basin. The basin got to a state of emergency as it could not carry the water footprint of its socioeconomic environment, especially, with an intensified situation by ten years of drought. The case demonstrates that essential decisions resulted in the development of a growing socio economic structure highly dependent on water irrigation, which did not consider the link between economical growth and water resources to provide sustainable long term usage. The first areas like the Campaspe Irrigation District have begun to close down their irrigation systems [1] as the majority of farmers decided to sell their water entitlements. A joint agreement was reached in 2009 and Aus $ 3.1 billion was allocated to the buying back of water rights from willing sellers and Aus $ 12.9 billion to a nationwide Water Future plan focusing on the Murray Darling Basin[2]. Not included in these programs are social costs for the transition of the economic structure of an area populated by over 10% of the Australian population [3] and the downturn of water dependent industries also affecting other industries. Apart from these social economical transition costs, an estimate of only 10% of the indigenous fish population is left and soil salination increased [4]. The hypothesis is that water management relying on free market mechanisms causes even more drastic and costly governmental interventions. As a market becomes more unregulated, social and environmental costs eventually become higher. The case study picks up three historical turning points which highly influenced the growth of the region's water footprint. These three points are: settlement and building up the irrigation system, the water trading scheme and the recent future water plan. The analysis will consider to which level the essential questions on environmental suitability of agricultural production were considered, which influence the volume of the internal water footprint of a country: When, where, what, how and how much is produced?

Methods

The research will use historical documents, newspaper articles and statistical data on the Murray Darling Basin from archives and involved authorities. Policy papers and secondary literature will be employed for the analysis. Papers and speeches made on the OZ Water 2010 conference will be included. The more recent developments in particular will be supported by interviews with decision makers and parties affected in the area like water trading agencies, farmers, representatives of the water agencies and politicians or local initiatives. The theoretical framework will combine Arjen Hoekstras [5] water footprint concept with an analysis of the political economy in the Murray Darling Basin area employing the method of a critical discourse analysis on how certain policies were communicated. In order to explain the switch from different water regulatory frameworks...
and their impact on socio political and ecological environments a Post-Keynesian approach will be employed.

**Results and Discussion**

Irrigation Systems were established in The Murray Darling area from the late 19th century onwards and resulted in populating the area and developing a highly irrigation water dependent socio economic infrastructure. The design and usage of irrigation systems reflect a mentality of water seen as an infinite resource. A high density of stock and dairy farming in addition to growing water intense crops such as cotton and rice imply that climate conditions and the need for irrigation did not influence the choice of what and how production was conducted. The amounts of production and international exports increased. According to Arjen Hoekstras research, products from this region would have a greater water footprint than those produced in more suitable conditions. From a liberal economic point of view the market should have regulated itself, as products from this region would be less competitive since more resources are needed in their production. However, the opposite occurred and the Murray Darling Basin was exploited to its limits. The Federal and State Government stepped in and resource intensive programs are being implemented.

**Conclusion**

The situation could have been prevented and teaches lessons on the importance of setting thresholds oriented on environmental requirements for sustainable usage and to direct the usage with knowledge of the water and environmental footprint. The case study shows the societal barriers to implementing regulations providing long term sustainable usage and establishes that for the successful implementation of regulations based on the water footprint social restructuring programs are necessary to shift the production and workforce.

**References**


The Development of Sustainable Communities: A Case For The Co-Design Methodology

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Keywords: Sustainability, Community based design, Co-design, Native American

Introduction
Globally, significant attention is being placed upon designing and implementing sustainable products and technologies, to improve an individual's level of sustainability and mitigate the negative impacts of energy consumption, water consumption, and climate changing greenhouse gas (GHG) emissions associated anthropogenic activities within communities. In order to meet the goal of developing sustainability communities, federal and local governments have undertaken a technology driven new product development process of creating sustainability focused products and services including energy efficient compact fluorescent light (CFL) bulbs and green building standards for adoption by residential communities. The Pinoleville Pomo Nation, located near Ukiah, CA, is an example of a Native American government that used the Co-Design methodology to aid in its infrastructure development and implementation of culturally inspired, sustainable housing for its members.

This paper lays out the intellectual framework and the principles of the Co-Design methodology developed by the authors. A case study of the application of the Co-Design methodology is presented in the Pinoleville Pomo Nation and UC Berkeley's Community Assessment of Renewable Energy and Sustainability (CARES) partnership to co-design sustainable housing that reflects the long-standing culture and traditions of the PPN and utilizes sustainability best practices and renewable energy technology.

Methods
The Co-Design (CoD) methodology, created by the authors, has similar aspects of the Human Centered Design methodology. The central tenet of the Co-Design (CoD) methodology, however, is to create products that meet the full range of consumer requirements/needs while maximizing profits by giving both the end user and the designer shared control during the NPD.

The principals of the Co-Design methodology are that (1) the end user is considered to have expertise in the domain of determining their needs and what is appropriate for their environment, (2) the knowledge that the end users possession has the same level of important as the knowledge of the designer(s) in the design process, (3) the end users and the designer(s) should be given agency throughout all stages of the NPD, (4) the end users and designer(s) should work together determine if a need exists at all for the new product; focus should be given to need identification and not problem creation, (5) the idea creation or concept generation should be done collaboratively amongst the end users and designer(s), and (6) the idea creation or concept generation should be done in the same environment that the idea or creation will be used.
Results and Discussion
As a result of the work with CARES, the Pinoleville Pomo Nation became empowered to make more informed decisions about renewable energy options and sustainability best practices for their community. PPN used the culturally sensitive home design to apply for and receive federal funding to build more sustainable homes and buildings and perform renewable energy feasibility studies of wind, solar, and biogas technologies.

The Co-design process allowed a greater number of community members to influence community decisions regarding housing. It also introduced community youth to some of the work performed by UC Berkeley students in a way that makes it attractive and encouraging for them to possibly take part in the future. The UC Berkeley students who worked on the PPN design as a class project also greatly benefited from the collaboration and from learning human-centered design techniques. Adding the actual people influenced by your design adds a major aspect to the design process which is many times ignored in academic studies.

Conclusion
This Co-design process approach typically involves spending a significant amount of time working directly with members of a community in order to build trust and understand the particular needs of a community as the major generator of the design solution. We have found that the concept of sustainability and the priorities of sustainable living are subjective and therefore must be defined by the end user(s) in a community-context. The Co-design approach utilized by CARES changes the power dynamic to the extent that everyone involved in the design process was considered to have expertise in certain domains and the participants collective intelligence was harnessed to produce solutions that meet the needs and requirements of the end users.

We found that the approach of fore-fronting the end user as an expert of their needs and co-designing with members of the community leads to the development of quality designs that share the community’s cultural values and are more likely to have high adoption rates as well as post-occupancy satisfaction During the co-design innovation workshops, the members from CARES and UCB were able to identify three major aspects that frame sustainability for the tribe: Tribal Sovereignty, Economic Independence, Environmental Harmony

References
Combining a Multi-Regional Input-Output Database with Production Data for Primary Products and Environmental Footprint Indicators

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Keywords: input-output analysis, human impact assessment, one planet economy

Introduction
The EU’s One Planet Economy Network (OPEN: EU) project [1] is an EU FP7 funded project involving eight international partners, aiming to help transform the EU to a ‘One Planet Economy’ – an economy that is environmentally, socially and financially sustainable – by 2050. One of the main outcomes of the project will be the EUREAPA scenario modelling and policy assessment tool. It will be founded on a model which combines a multi-regional input-output (MRIO) database with statistical data on production and trade of primary products in physical units from the Food and Agriculture Organization of the United Nations (FAO) and three different footprint indicators [2-5].

Methods
The MRIO database contains records of all financial transactions conducted between s industrial sectors in r regions of the world for a given year. The OPEN: EU model will implement the EXIOPOL MRIO database [6], which when completed will contain data for around 129 sectors in 44 regions of the world. By using trade shares from the MRIO database, production of a range of crops, livestock, fish and forest products in all countries of the world can be allocated to the consuming region and sector, creating a detailed use table for primary products in physical units. Using input-output analysis methods, a model is created which, when an arbitrary demand is placed on any primary product or any industrial sector in any country, calculates the resulting required output of primary products in all countries. By combining this with known footprint intensities for the primary products, the associated ecological, water and carbon footprints of the specified external demand is estimated.

Results and Discussion
By using input-output analysis techniques, a complete bill of production resulting from any external demand, including all upstream activity can be consistently tracked. However, since the input-output databases are typically based on national tables compiled by national statistical offices, they are generally not very detailed, dividing entire economies into a limited number of industrial sectors. This model should, however, be able to give a physical representation of the MRIO results, showing flows of a large range of individual primary products, as well as their associated environmental impacts as measured by the footprint indicators included in it. This should enable decision-makers to assess the environmental impacts of any project or investment, and provide them with an indication
of what the implications will be in terms of land appropriated, water consumed and CO2 emitted - both directly and indirectly. Even more, with the help of the MRIO dynamics, the model should show just where in the world the primary production and the environmental impacts would occur, given the trade patterns assumed.

Conclusion
If the EU is to be transformed to a ‘One Planet Economy’ within 2050, tools will be required that researchers and decision-makers can use to investigate and compare different strategies and solutions in terms of their sustainability. Such tools should consider not only one environmental stressor, but rather keep an overall perspective, to avoid problem shifting. They should also rely on a robust scientific evidence base. The goal for the OPEN: EU project is to provide one such tool.

References
Introduction
Aquaculture and fisheries are important renewable resources in agro-food production sector along the north Adriatic coast. Mussel farms use a substantial fraction of the coast. In the gulf of Trieste (Italy) there are 16 small medium enterprises, some of them grouped in small cooperatives. They utilize 15 km of long-line mussels' ropes. Our study is aimed to analyze and evaluate the sustainability of this activity, also in relation to its productivity, and to contribute to the development of a tool for the optimization of ecological sustainability of mussel production. The sustainability evaluation was performed by the use of two different methods: Ecological Footprint and Emergy Analysis.

Methods
The evaluation of long line mussel sustainability is based on a data set obtained by combining official information by local authorities and information from interviews and questionnaires directly submitted to the mussel farmers, in order to evaluate annual production, materials, technologies, methods of production and commercial chain. Annual production data, estimated using both sources of information have been used to evaluate the biocapacity of the coastal zone and for a characterization of the local marine productivity. We have chosen for this study two sustainability indicators: Emergy Analysis and Ecological Footprint. Emergy is the evaluation of sustainability of a process in terms of solar energy used to sustain that process. Every input, both natural and antropic, is evaluated in the common base of solar energy, converting the energy flow of each input through its specific transformity (sej/J or sej/g). The transformity of the product is given by the total eMergy of the system divided by the energetic amount of the product expressed in Joule or mass unit. The transformity gives the information about efficiency of the system and hierarchy quality of the product. The Ecological Footprint is a “land memory” indicators as it takes into account for all lands, directly or indirectly necessary, to support a productive process.

The Footprint unit is gha yr, or hectares with world average productivity per year. Emergy and Footprint indexes have been computed applying the standard methodology to the specific study case. This requires the compilation of a detailed inventory for the materials used in each step of the production chain.
Results and Discussion

Both values of Ecological Footprint and Emergy Analysis are low compared to values found in similar studies on intensive or semi-extensive marine cultures. In the application of Emergy Analysis is founded a transformity's value of $9 \times 10^5 \text{ seJ}/\text{J}$ for mussels culture. In comparison with similar studies the value is low indicating a good efficiency of the productive system. The index ELR (Environmental Loading Ratio) give an indication on the stress level of the system on environment and in this study its value is very low too indicating a prevalence of natural and local input for the marine extensive production of mussels. The first pilot application of the Ecological Footprint on the same activity give a value of $1370 \text{ gha yr}$ (or $0.77 \text{ gha yr t}^{-1}$) necessary to sustain this kind of production. This area result one third of total biocapacity of the Gulf. The Biocapacity was calculated on the total marine production (fishing, mussels culture, mariculture) of the area for the year 2008. This first application of Ecological Footprint has to be more improved to obtain a more accurate tool for comparison with other studies. At the actual densities, the anthropogenic stress induced by the materials used for long line structure and the fishing effort do not have a relevant impact on the coastal ecosystem. The value of transformity obtained for mussels and the comparison between the extension of Ecological Footprint and marine Biocapacity of the area confirm that mussel farming activity in the Gulf of Trieste produces a low impact on the environment.

Conclusion

Emergy Analysis entails comparison of this activity with other types of aquaculture (or agriculture), which utilize different methods to obtain the same final production, in terms of energy and allows to demonstrate the relative sustainability of this kind of activity. The Ecological Footprint index computation, which has been seldom applied to marine systems, highlights that mussels aquaculture in the Gulf of Trieste mostly depends on natural local resources. Both indexes analysis, as well as social analysis conducted by means of interviews and questionnaires show the possibility of development.

References


The Real Wealth of Nations:

Mapping and Monetizing the Human Ecological Footprint

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Keywords: Ecosystem Services, Net Primary Productivity, Impervious Surface Area

Introduction
The earth provides myriad ecosystem services or 'benefits' that enable and enhance human existence. Humanity, in turn, imposes myriad environmental impacts or 'costs' on the earth. We explore the idea of mapping these 'costs' and 'benefits' using proxy measures. We set the total value of the world's ecosystem services to be equal to the total cost of anthropogenic environmental impacts at fifty trillion dollars (roughly the global GDP in the year 2000). A global representation of ecosystem service value is mapped at 1 km$^2$ resolution using Net Primary Productivity (NPP) as a proxy measure of ecosystem service value [3]. A similar global representation of environmental impact is mapped using pavement (aka impervious surface area or ISA) as a proxy measure of 'cost' [2]. Subtracting the 50 trillion mapped onto ISA from the 50 trillion mapped onto NPP produces a 1 km$^2$ resolution map of those areas where: 1) Human imposed costs exceed naturally supplied benefits, 2) Human costs balance with environmental benefits, and 3) Environmental benefits exceed human costs. Mapping this difference produces a spatially explicit and monetized representation of sustainability that can be aggregated to national, sub-national, and regional levels. Aggregations of this map at the national level are compared with other national measures of sustainability such as the Global Footprint Network's 'Eco-Deficit'. An additional benefit of this approach is that the national values derived from this difference map suggest a starting point for discussions of the dollar values and costs of both sustainable and non-sustainable behavior on the part of the nations of the world.

Methods
Both the ISA and NPP images were summed and then normalized using $50$ Trillion dollars based on a global estimate of the total value of the world's Ecosystem Services and Natural Capital [1]. Additionally, this number is approximately the global GDP for the year 2000 and the ISA data sets are for the years 2000 and 2001. Once converted into the same resolution and projection the two images were subtracted. Normalized NPP - Normalized ISA = Natural Production Minus Human Impact. Figure 1 shows the resulting image which is a measure of Natural Production Minus Human Impact represented in US dollars.
Results and Discussion

Aggregation of these surplus/deficits ($ value of NPP - $ cost of ISA) from 1 km$^2$ pixels to national levels correlates strongly with measures of ‘Ecological Deficits’ [5], and; tables of these national aggregations are a measure of the “Real Wealth of Nations” (Table 1).

### Table 1

#### Top 20 ‘Surplus’ Nations

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>HG (2015)</th>
<th>HG ($ per km$^2$)</th>
<th>NPP Surplus ($)</th>
<th>NPP Surplus ($)</th>
<th>%</th>
<th>SC Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>2,043,298</td>
<td>5,000,000,000</td>
<td>500,000,000</td>
<td>500,000,000</td>
<td>50</td>
<td>500,000,000</td>
</tr>
<tr>
<td>Canada</td>
<td>3,519,040</td>
<td>5,000,000,000</td>
<td>500,000,000</td>
<td>500,000,000</td>
<td>50</td>
<td>500,000,000</td>
</tr>
<tr>
<td>Mexico</td>
<td>2,514,114</td>
<td>5,000,000,000</td>
<td>500,000,000</td>
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<td>50</td>
<td>500,000,000</td>
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<tr>
<td>Chile</td>
<td>2,514,114</td>
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</tr>
</tbody>
</table>

#### Top 20 ‘Debtor’ Nations

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>HG (2015)</th>
<th>HG ($ per km$^2$)</th>
<th>NPP Surplus ($)</th>
<th>NPP Surplus ($)</th>
<th>%</th>
<th>SC Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1,219,040</td>
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<tr>
<td>Japan</td>
<td>1,219,040</td>
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</table>

### Conclusion

This study presents a new method for monetizing natural capital and human impact on that capital. Using this method a global 1km resolution map of natural capital value (surplus/deficit) can be generated. This map is easily compared with other global and regional data sets, which are often produced at a resolution of 1km$^2$. Given the amount of data needed to generate Ecological Deficit numbers and the fact that data are not available for some countries this may be a good supplement to Ecological Deficit Analyses. There are several paths of exploration that are likely worth future examination. It would be useful to explore the relationship between Human Appropriation of Net Primary Productivity (HANPP) and “NPP Minus ISA” [4]. It seems that this data and HANPP might help answer different questions associated with broader ideas of sustainability and could be used in tandem to inform policy decisions.

### References


Soil ecosystem health scenarios - Evaluation of ecological indicators susceptible to chemical stressors

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Keywords: Soil ecosystem health, ecological requirements, vulnerability, chemical stress

Introduction
This paper presents a conceptual system model for describing soil ecosystem health scenarios in terms of suitability for use with focus on deriving ecological indicators of ecosystem vulnerability to chemical stress. A classification of vital ecological indicators enables a simple ranking analysis deriving a core set of vulnerability criteria. The relative susceptibility of the soil ecosystems to chemical stressors may then be evaluated according to the derived vulnerability criteria. The conceptual system model and multi-criteria methodology is illustrated implementing the system model using defined ecosystem services as proxies for soil health. Vulnerability criteria for three types of grassland ecosystems are ranked and available data on multiple chemical stressors, i.e. nickel, cadmium, diazinon, lindane and chlorpyriphos, are discussed in terms ecological requirements. The system model may be used for the identification of high-concern areas in need of soil ecosystem health improving intervention strategies

Methods
System model
A systematic approach for deriving scenario descriptions has been developed by Thomsen et al. [1] and further improved in Sorensen et al. [2] as a tool for defining worst case. In the present paper, this approach is illustrated for identifying highest-risk scenarios in respect to ecological requirements for land use according to available information. Ecological requirements for land use being defined as conditions that need to be fulfilled in order for the soil ecosystem to provide the ecological services desired by society regarding a particular use of land.

The system model consists of the following sub-models:
1. Model for problem analysis (Problem Decomposition Model, PDM).
   - Includes all sub-problems that may contribute to the cause of the risk problem; i.e. preserving and enhancing the soil ecosystem services suggested to be based on a set of ecological requirements for land use and associated ecological indicators.
2. Model for scenario composition (Scenario Composition Model, SCM).
   - Estimates a reduced set of sub-problems assumed to reflect the most important aspects in relation to highest risk conditions; in this study soil ecosystem health sub-problems identified as ecological indicators susceptible to chemical stressors.
3. Model for criteria setting (Criteria Model, CM).
- Finds analogies between the sets of sub-problems included in SCM and data sets that will form criteria of higher/lower risk condition; in this study, quantification of sub-problems susceptible to chemical stressors by ecotoxicological data sets as approximations of sub-problems in SCM.

4. Model for scenario selection (Scenario Selection Model, SSM).
   - Predicts the highest risk scenarios based on the criteria values; in this case-study vulnerability criterion with respect to chemical stressors.

5. Model for risk quantification (Risk Quantification Model, RQM).
   - Predicts the risk level for each of the selected scenarios.

Step 1-4 of the system model have been used for deriving ecological indicators vital for future soil ecosystem health assessment, using ecosystem services as proxies for soil health [3, 4]. Three grassland ecosystems are included in the study; dairy farming, natural meadows and recreational parks.

Results
For a future sustainable use of the soil resource and changing land uses, soil properties in terms of ecosystem structure and functioning, biodiversity and soil processes needed for the soil ecosystem to remain healthy have been defined in terms of 77 ecological indicators susceptible to chemical stress.

A combination of listings for ecological indicators of soil ecosystem health and available data sets to estimate those shows highly critical data gaps. This is undermining any analytical and theoretical approach for soil health evaluation to evaluate future nature preservation, management and legislation.

In general, little knowledge on the impact of chemical stressors on soil health is available, and uncertainty due to data gaps highly critical.

References
Interregional Cap and Trade Using Ecological Footprint for Improvement of the Environmental Balance

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2) University of Tsukuba, Japan.

Keywords: interregional cap and trade, ecological footprint, environmental balance, land-use planning

Introduction
National lands are separable into two parts by their usage: source areas (CO₂ emissions and food consumption in urban areas) and sink areas (nature absorbs environmental loads in rural areas). Urban areas are environmentally dependent on the land use of rural areas. The concept of the environmental balance is a key perspective. Land-use planning based on that concept can address environmental problems comprehensively. Social concerns related to Cap and Trade systems of environmental loads such as CO₂ have been growing for several years. Land-use planning can become an effective tool to solve widely various environmental problems if an interregional cap and trade system is established for land use. An environmental indicator—the Ecological Footprint (EF)—is related to land consumption [1]. The EF can represent different environmental loads such as CO₂ emissions and food consumption comprehensively on an areal basis. Moreover, this indicator can represent the intra-regional relation between environmental capacity (forests, farmland, etc.) and environmental loading, and enable estimation of the environmental balance.

This study proposes interregional cap and trade system on the land use using the EF, and creates a new framework for national land use in pursuit of a balanced environment. In addition, the study assesses the possibility of a system based on the impact of financial resources for urban and regional planning.

Methods
1. Proposal of an interregional cap and trade system using the EF.
2. Creation of a new framework supporting national land use for a balanced environment.
3. Feasibility study of the system based on the impact of financial resources for urban and regional planning.

Results and Discussion
This study proposed an “Interregional Cap and Trade” system using EF. The proposed framework (Figure 1) including the system is outlined below.

1) First, the EF is introduced into the master plan for deciding the future guidelines for land use. The use of EF enables the local government to reassess land use in a region based on the comprehensive environmental balance.

2) Second, based on results of 1), the local government discusses and implements land-use measures such as Urban Compaction and Land Recycling, for improving the
environmental balance. Both 1) and 2) shall establish a foundation for participation in
an interregional cap and trade system at the national level without the need for new
calculations of environmental loads.
3) Finally, the newly created “Interregional Cap and Trade” must build a banking system
for managing necessary information such as the environmental load excess ratio $\gamma$ and
the situation of measures in various regions. This banking system enables interregional
trading of footprints in national areas. Furthermore, a cap—the Limit of Environmental
Load Excess Ratio $\gamma$—is established as a first step to an achievable goal. The cap is
subsequently tightened using incentives for local governments.
Through repetition of 2) and 3) using a long-term perspective, the framework is intended
to form environmentally balanced regions and national lands ($\alpha > \gamma (1.0)$).

Next, this study examines the possibility of implementation of each measure, such as
urban compaction, using trading prices on the assumption of introduction of an
interregional cap and trade system using EF. Results of this feasibility study present the
possibility that obtainable trading prices for the environmental burden amounts cover the
costs of respective measures such as urban compaction and land recycling.

**Conclusion**
This study proposed “Interregional Cap and Trade” using EF toward improvement of the
environmental balance. Based on results of a feasibility study specifically addressing
trading prices of the system, introduction of this system can implement processes leading
to improvement of the environmental balance.

**References**
Ecological footprint, ecosystem services and biodiversity: an analysis of global indicators

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Keywords: Ecological Footprint, ecosystem services, biodiversity, indicators, sustainability

Introduction
The Ecological Footprint (EF) is a leading indicator of biophysical or ecological dimension of sustainability. Ecological Footprint is interpreted as a metrics of human demand on ecosystem services [1]. Previous versions of EF also included biodiversity reserve area as a 12% proportion of available biocapacity or biodiversity buffer as an insurance securing resilience and stability generated by biodiversity [2]. However, the EF has been often criticized as not including a full account of human interactions with nature and the services provided by ecosystems [3]. The EF has been already analyzed with respect to socioeconomic wellbeing measures, biodiversity trends or selected sustainability indices [4], [5], [6], [7]. However, the analysis of how the EF relates to other dimensions of ecological sustainability, especially ecosystem services and biodiversity, are still rare. The aim of this work is to review and analyse the interlinkages between the EF, related indices of environmental sustainability, and selected ecosystem services and biodiversity indicators.

Methods
Data for the analysis were downloaded from Compendium of Environmental Sustainability Indicator Collections [8]. Data were integrated in the spatially-explicit dataset in GIS (ESRI ArcInfo 9.3). SPSS for Windows (Version 12.0.1) was used for the statistical analysis of data. Besides the Ecological Footprint data (National Footprint and Biocapacity Accounts), we included for example the Environmental Performance Index, Environmental Vulnerability Index or Ecosystem Wellbeing Index. We extracted also indicators used as components or subindices in the construction of these indices, which are related to ecosystem service and biodiversity. We created datasets in GIS and exported tables for correlation analysis (Spearman's rho rs). We mapped and tabulated selected indicators nation-by-nation, created scatter-plots and actualized our datasets with the most recent data available. This provides material for further analysis.

Results and Discussion
We found that the total Ecological Footprint is significantly positively correlated for example with Environmental Performance Index (rs =0.789), Wellbeing Index (rs =0.544) or Environmental Vulnerability Index (rs = 0.352). Moreover, the EF positively scales with GDP both in absolute terms and per capita. The Ecological Footprint was negatively correlated especially with Ecosystem Wellbeing Index (rs = -0.651) as a composite measure of ecosystem health. We detected weaker negative correlations with Biodiversity and Habitat or Endangered Species. Patterns of results indicate that the Ecological Footprint is a meaningful indicator and relates to equivalent measures of environmental sustainability. Moreover, the analysis suggests that the EF is rather an indicator of pressures on ecosystems and hence an indicator of weak biophysical sustainability. As the EF increase, so the pressure on
ecosystems increases, as evident from negative relationship with the Ecosystem Wellbeing Index or some other ecosystem and biodiversity subindicators. Results for EPI indicate that nations with higher environmental and economic standards have probably higher footprints.

**Conclusion**

Ecological Footprint of nations was analyzed with regard to the interdependence with other indices of environmental sustainability and sub-indices of ecosystem services and biodiversity. The development of the accounting of ecosystem services is regarded as the most critical issue in integrated environmental and economic accounting [9]. Our analysis provide some evidence that the accounting of ecosystem services is complementary to the Ecological Footprint accounting. We found the EF to be a meaningful indicator as it both positively as well as negatively scales with complementary dimensions of environmental sustainability. Our results contribute to the discussion about the position of the Ecological Footprint in sustainability indicator sets, assessments and strategies.

**References**


Ecological Footprint – Analysis of the Biocapacity and Carbon Footprint

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**Keywords**: Ecological Footprint, Biocapacity, Carbon Footprint

**Introduction**

This work concerns two aspects of the Ecological Footprint calculation, the Biocapacity and the Carbon Footprint. The analysis is done according to the methodology presented in two workbooks released by the Global Footprint Network: NFA 2008 and the EQF Updated. This work is done on a global scale and considering 2006 values.

In the **Biocapacity** item, the present work only considers the land area, namely, cropland, built-up, forest land and grazing land. These are also the land types considered in the calculation of the equivalence factors (in the equivalence factor calculation workbook, worksheet "calcs"). According to this calculus, there is a remaining area that is not occupied with cropland or forest or grazing land. This remaining area is mainly land classified as “Not suitable” but, nevertheless, has a non zero factor of bioproductivity. According to what we were able to understand this remaining area is not considered in the Biocapacity calculation, but since it was a non zero productivity, it should be accounted for.

Regarding the **Carbon Footprint**, by now, it is considered that the total carbon emitted should be sequestered in forest. According to Meinshausen et al. (2009) a global warming limit of 2°C or below (comparative to pre-industrial levels) can be permitted. Limiting cumulative CO₂ emissions over 2000-50 to 1000 Gt CO₂ yields a 25% probability of warming exceeding 2°C given a representative estimate of the distribution of climate system properties [1]. This indicates that maybe there is no need to sequester all the CO₂ emissions. There is also other ways to reduce the CO₂ emissions, namely using renewable energies to produce electricity.

**Methods**

Regarding the Biocapacity, the calculus is done considering the area classified in the Workbook EQF Updated as “Remaining Available Area not Cropland or Forest or Grazing Land”. Following exactly the same methodology, we re-calculate the equivalence factors including a new one for the remaining area. After that, the Biocapacity is calculated following exactly the same procedure. The world area of the remaining area is considered equal to the one for the 156 countries accounted for in the “calcs” worksheet. This leads to an underestimation of the Biocapacity associated to the remaining area.

Considering the Carbon Footprint, we gathered the total emissions of carbon dioxide, but, instead of admitting the sequestration of them all, we subtract the corresponding annual emissions allowed, considering a 2°C raise in temperature over 2000 – 2050 [1].
allowed emissions are calculated considering that 2000 – 2006 CO$_2$ emissions were 234 Gt [1], and over 2006 – 2050, it is allowed to emit about 17 Gt CO$_2$ yr$^{-1}$.

**Results and Discussion**

The results regarding the Biocapacity issue shows a 20% increase in the bioproductive available land area. This leads to an Ecological Footprint to Biocapacity ratio of 1.2. Carbon Footprint decreases about 66% (relatively to the total value of Carbon Footprint for 2006) considering the possibility of a maximum of 2°C increase in temperature over 2000-2050 and that between 2000 – 2006 were emitted 234 Gt CO$_2$. This correction leads to an Ecological Footprint to Biocapacity ratio of 0.9, which indicates that humans are consuming less and producing fewer residues than those that the planet earth has the ability to produce and assimilate. Of course that a raise of 2°C cannot be considered a “safe level” and that, for example, small island states and least developed countries are calling for warming to be limited to 1.5°C [1]. There are consequences more or less severe associated with this temperature raise, namely in terms of biodiversity and sea level. Instead of considering a raise in temperature, it is also possible to admit the use of photovoltaic panels to electricity production, instead of the traditional mix. This hypothesis would lead to a reduction on the CO$_2$ emissions.

If we consider both corrections simultaneously the Ecological Footprint to Biocapacity ratio assumes the value of 0.8.

**Conclusion**

According to our analysis, the Biocapacity, as calculated in the NFA 2008, does not consider the remaining area (not cropland, or forest, or grazing). Since this area has a non zero productivity it should be accounted for and represents an increase in 20% in Biocapacity.

If we consider that there is no need to sequester all the carbon emissions, and a 2°C raise in temperature over 2000-2050 is allowed, there is a 66% decrease in the Carbon Footprint.

**References**

Responsibility Allocation Over Time within Ecological Footprint Analysis: A Case Study of Nuclear Power Generation

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Keywords: Responsibility Allocation over Time, Prolonged Impact Management (PIM) Costs, Nuclear Power Generation

Introduction

In recent years, nuclear electricity generation has been held up as a good alternative energy source in the time when we human-beings are faced with global climate change. This global phenomenon is widely believed to be caused by humanity’s excessive emission of greenhouse gasses. This revival of nuclear energy is sometimes called ‘Nuclear Renaissance.’ This perspective is based on the belief that the CO₂ emission from the operation of nuclear reactors is much smaller compared with that of thermal power plants using fossil fuels. However, future generations will continue to be forced to pay the costs of confining highly-radioactive wastes so that those toxic substances will not be filtering into the ground water and the natural environment. This future demand should be allocated to the activities which take place today which are responsible for that demand [1].

This paper discussed whether it is possible to effectively and equitably allocate responsibility of current activities which is normally imposed onto the future generations within the framework of Ecological Footprint analysis.

Methods

Firstly, I identified various costs of nuclear electricity generation in Japan which will be imposed to the current and future generations within Japan and abroad, though field observations and literature review. Secondly, those costs were translated into Ecological Footprint. Finally, the comparison was made between the Ecological Footprint and Biocapacity figures.

Results and Discussion

I identified varieties of short-term and long-term costs associated with nuclear power generation. Those include: energy costs of mining of uranium ore, uranium enrichment processes, construction and maintenance of nuclear reactors as well as pumping-up hydraulic power plants, demolishing nuclear reactors, monitoring and confining highly-radioactive nuclear wastes (for one million years), monitoring and controlling of uranium mining sites (for ten thousand years), and so on. I also included the energy costs of police and security services for preventing ‘nuclear terrorism’ at nuclear power plants as well as waste storing sites and uranium minesites. I call these long-term costs ‘Prolonged Impact Management (PIM) Costs’ [2, 3].

Tentative calculation results were astonishing. Table 1 shows the calculation results of net energy costs of one typical Japanese nuclear reactor (PWR, 1 million kW, operation
period: 30 years). The energy costs were approximately 22 times more compared with the electricity generated by that nuclear reactor.

<table>
<thead>
<tr>
<th>Table 1: Net Energy Cost Calculation of a Typical Nuclear Power Reactor in Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Energy</td>
</tr>
<tr>
<td>Energy Generated</td>
</tr>
</tbody>
</table>

Total Ecological Footprint associated with nuclear electricity generation in Japan as a whole was calculated to be 7,459,000,000 gha/year. This is approximately 78 times as large as the total Biocapacity of Japan (Table 2). These calculations include various costs associated with nuclear power generation. But some of the costs are still not included. One example of these costs is the energy cost of health care services for those who become sick due to the exposure to the radioactivity.

<table>
<thead>
<tr>
<th>Table 2: Ecological Footprint of Operating 54 Nuclear Reactors in Japan until their full life expectancy (total capacity; 47,700,000 kW).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ecological Footprint of Japanese Nuclear Power Generation as a whole</td>
</tr>
<tr>
<td>Per Capita Ecological Footprint of Japanese Nuclear Generation</td>
</tr>
</tbody>
</table>

**Conclusion**

The broad-based and long-term analysis revealed that the nuclear power generation will impose huge costs to the future generations to come. These costs should be and can be allocated as the Ecological Footprint of the present generation who benefit from the energy generated from nuclear reactors. In this way, more equitable and rational comparison will be possible between different technologies and policies which incur long-term expenditures into the future.

**References**


Introducing the Footprint in Information Systems Education

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Keywords: Global Footprint Calculators, Information Systems Education, Sustainability Education

Introduction

The potential of smart deployment of Information and Communication Technologies (ICT) to address global warming and environmental sustainability issues is enormous. By one estimate [1], ICT strategies could reduce 'business as usual' global carbon emissions up to 15% by 2020 through substitution of virtual equivalents for goods and services and increased energy efficiency. Our imperative, as educators in ICT, is thus to challenge students to think creatively about the changing world they will face and to apply their skills and talents in meaningful and responsible ways.

In this abstract, we describe initial steps in integrating the theme and key concepts of global and local sustainability into an introduction undergraduate course in Information Systems. Traditionally, first courses in Information Systems (IS) focus on the basics of ICT and applications in typical business environments. Our course was intended to heighten student awareness of global warming and environmental sustainability, while discovering how technology can be deployed to address critical needs and opportunities in these areas.

Methods

Carnegie Mellon University has identified research and education in sustainability as key objectives in its recent ten-year strategic plan [2]. In keeping with this important theme, we offered a course "Concepts of Information Systems" during the Spring Semester, 2010. Forty-three first year Information Systems students enrolled. In addition to the usual objectives for a first IS course, we added these specific points to create the explicit link to sustainability:

1. Identify the nature and impact of ICT on people, organizations and societies; in particular, appreciate the importance of ICT to support regional and global sustainability.
2. Recognize how various Internet-based tools and systems can help individuals, communities and decision makers increase awareness of their 'global footprints.'
3. Explain and illustrate through examples how ICT can support a 'smarter planet' initiative.

Through examples the class saw how ICT can be used to monitor, report, manage, control and optimize logistics, local transportation and make us more aware of the patterns and consequences of consumption. Students read about ICT basics, sustainability, and Energy Management Information Systems. Students were asked to complete four projects during the term: 1) to calculate and discuss either their individual
or family global footprint using a variety of on-line calculators, 2) to evaluate various
business process simulations with an eye toward reducing emissions, 3) to review a large
database of monthly electric utility billings for two large student apartment buildings, and
4) to propose an IT solution to a sustainability. Each project included an individual
statement of reflection to comment on findings.

**Results and Discussion**
In this course, we challenged and encouraged students to see the bigger picture. They
developed a basic appreciation for the urgency and importance of sustainable living. They
have seen how individual, community and national ecological footprints are constructed.
They explored and imagined how ICT can be used to mitigate excess consumption and
tune business processes and logistics for efficiency.

Student responses to the class were very positive. Informal feedback and written
reflections suggest that this cohort of students is ready to discover the connection
between their field of study and global sustainability. One student wrote this: “I was really
impacted by one of the lessons on global footprint calculators in this class. I learned that I
am guilty of contributing to the depreciating condition of the environment with my carbon
footprint, but nevertheless, I remain optimistic. I am comforted by the fact that there are
IS solutions out there that we can implement to dampen our environmental impact. I
think this IS class has unknowingly taken the first step on the long yet achievable walk
towards making a difference.”

**Conclusion**
This first step toward infusing the notion of sustainability into the beginning IS curriculum
is just that - a first step. It is our intention to refine and improve this particular course for
future offering and to begin weaving the theme throughout the undergraduate IS
curriculum.

Our students will be, in the words of Nobel Laureate Herbert Simon, the "authors of the
future." Exposing them, early and often, to this key issue is essential. We look forward to
reporting additional results, progress and assessments in future forums.

**References**
by The Climate Group on behalf of the Global eSustainability Initiative (GeSI).
Creative Commons 2008.  
March 22, 2010).
Ecological Footprint, Entropy, Steady State Economics and Sustainability

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Keywords: Ecological Footprint, Entropy, Steady State Economics, Sustainability

Introduction
Present economic discourses are based on a Newtonian Paradigm where "Potential Energy and Kinetic Energy is replaced by Utility and Expenditure", which is ill-equipped to deal with increasing crisis in the environment. However, more appropriate tools such as Green Accounting, Ecological Footprint have been developed within the Newtonian Paradigm to deal with some aspects of the environmental crisis. Nevertheless, economic discourses should be based on Thermodynamics while incorporating other paradigms in Physics, with due consideration for Bio Diversity. This is an affirmation of the Bio-Physical nature of the Economics which goes beyond the scope of present Newtonian Economics.

Methods
Thus, in order to account for Entropy associated with Thermodynamic Paradigm as a measurement of sustainability, a new Human Sustainability Index is proposed which is the average of Energy Index, Education Index and Life Expectancy Index. Incidentally, as suggested by D.F. Styer [1] Entropy could be best described by combining similes “entropy as disorder” and “entropy as freedom”. This Human Sustainability Index, which attempts take into account "Limits to Growth", is in lieu of the familiar but marginalizing Human Development Index which is based on the Newtonian Paradigm. Furthermore, within the Energy Index, Emphasis is on renewable energy.

Discussion
Strictly speaking, Human beings come under the branch of Non Equilibrium Thermodynamics (NET), where human activities invariably tend to increase the Entropy. Thus, the concept of equilibrium in Economics is only an apparent phenomenon at the macro level, and a so called truly free market can lead to thermal death as it tend to destroy Entropic Capital, if not for the constant influx of Entropic Capital via Solar Radiation. Besides, as the world's Ecological Footprint has exceeded its Bio Capacity at least by a factor of 1.5, it is imperative that so called developed countries should reduce their Ecological Footprints so that some of the so called lesser developed countries could increase their Ecological Footprints by a modest amount in order to obtain more equitable and a sustainable level of economic consumption. It also implies that more localization or at least a regionalization of the Economies is warranted instead of the present day excessive Globalization. In this regard, it is imperative that most subsidies on Agriculture should be removed as well as movement towards organic Agriculture is encouraged in order to reduce Carbon Footprints. This has to be the most likely foundation on which more sustainable economic system could be build. In addition, as an interim measure
"Energy Entitlement Trading" is proposed instead of "Carbon Trading" or "Trading on Ecological Footprints" until a Steady State Economy is reached.

**Conclusion**

Hence, while it is possible that Ecological Footprints and Green Accounting would be associated with mainstream Economics in the future which is the desired trend to follow, it would be more appropriate to go beyond them concentrating on Entropic Footprints and Steady State Economics. In addition, emphasis would also be on broader aspects of the environment such as water, air and Bio Diversity etc.

**References**

Evaluation of Sustainable Human Development Using Ecological Footprint and Human Development Index: A Case Study of Chinese Provinces

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Keywords: Ecological Footprint; Human Development Index; Sustainable development

Introduction and Methods
There is a general agreement that if we use more resources, we could live a comfortable life. In general, countries which have high Ecological Footprint (EF) show a high Human Development Index (HDI). However, it should be noted that we should lower our EF while increasing the HDI, if we need to approach on sustainable human development. In this regard, there is high concern about development of China, whether she could approach this target. According to the latest Living Planet Report China shows a 2.1gha/cap [1] in EF, while having 0.777 [2] in HDI, positioning her in a category of medium human development countries. However, according to the Living Planet Report 2006, 1.8gha/cap is the permissible EF for a sustainable society, if we consider the total available bio capacity and the total population of the world. On the other hand, HDI should be more than 0.8, in order to accredit a country as a “high human development.” Though China has shown moderate EF and HDI as a whole, the individual provinces have shown considerable disparity.

In this research, EF and HDI of four selected Chinese provinces were calculated using data published in Chinese Statistical Year Books 2005 and 2008; and the methodologies given elsewhere [3, 4]. The authors have divided the EF-HDI coordinate plane into 4 different quadrants, namely, best, worst, modest and popularist as shown in the Figure 1 and plotted the four selected provinces on the coordinate plane. Figure 1 illustrates that Guizhou province is in the popularist quadrant (low EF and low HDI), Henan and Hunan provinces in the worst quadrant (high EF and low HDI) and Zhejiang province is in the modest quadrant (high EF and high HDI). Among these four provinces Henan and Hunan are the most inconsistent, because their high EF while having low HDI, i.e. the worst quadrant. Why Henan and
Hunan provinces in the worst quadrant? How can they escape from the worst quadrant? The purpose of this research was to find reasonable answers for above questions through a quantitative approach and to suggest the methods for sustainable human development of these provinces.

**Results and Discussion**

Calculated results of HDI showed that Zhejiang province qualifies to enter to high human development, while Henan, Hunan and Guizhou provinces belong to medium human development. From the view point of sub-indexes of HDI, life expectancy index and education index in Henan and Hunan showed better values i.e. 0.8 and above; only the GDP index is significantly lower than 0.8. However, all sub-indexes of HDI of Guizhou are lower than 0.8. Industry structure indicates that, both share of GDP and employment by primary industry of Henan and Hunan provinces are still much higher, and proportion of tertiary industry is lower. However, GDP growth rate of four provinces is more than 10% since 2003.

EF of all provinces except Guizhou is higher than world average BC available per person in year 2003, i.e. 1.8gha, and even more than the local BC; therefore, they all are locally and globally ecological debtors. Subdivisions of EF indicate that fossil energy footprint fills the largest proportion in common. It should be noted that Henan and Hunan provinces’ energy intensity of industries is also higher than Zhejiang.

**Conclusion**

According to the analysis that mentioned above, the authors suggested three shortest escaping paths from the worst quadrant for Henan and Hunan. Path 1 in the Figure 1 is the horizontally right movement to the “modest” quadrant, by improving the quality of life. Henan and Hunan have big chance to move on this path, because only the GDP index is lower than 0.8. In accordance with the current development trend, authors forecast that Henan and Hunan will reach high human development level between 2011 and 2021. Path 2 is the vertically down movement to "popularist" quadrant, means that lowering the EF while keeping constant HDI. This can be done by improving energy intensity of industries. Path 3 is the way to achieve the ideal condition, sustainable human development, by decreasing EF and increasing HDI. Besides the methods mentioned in above two paths, Henan and Hunan should change their industry structure by switching to tertiary industries to achieve this goal. This brings smart income to the people while reducing energy intensive industries.

**References**

Network Analysis of Japanese Ecological Footprint based on Input-Output Table for the 47 Prefectures in Japan


Tokyo University of Information Sciences, JAPAN

Keywords: Japanese Ecological Footprint, Complex Networks, Input-Output Table, 47 Prefectures in Japan, Relational EF Network

Introduction

The ecological footprint (EF) indicator which had been presented by Wackernagel and Rees in 1990’s has attracted larger attention as a numerical assessment value for sustainable development in recent years. Same as another area of Asia, the huge environmental changes have been repeated in every Japanese district because of economic development, these have brought an increasing EF to Japan. Our new try to analyze Japanese EF based on 47 prefecture’s Input-Output table via complex networking tool has led us both deeper understanding and expanding progressive research on EF.

Methods

We use "Multi-regional Input Output Table for 47 Prefectures in Japan" in 2000 [1]. First we transform this Chenery-Moses type IO table to the Isard type [2]. Next we allocate the ecological footprint calculated by EFN to each sector of each prefecture in proportion to the total input/output. For Energy land, we use 3EID table [3] and allocate the ecological footprint in proportion to the total CO2 emission. The influence from one sector of one prefecture over other sector of other prefecture is difficult to understand, because, in our analysis, the dimension of the table is large, such as \(2256 = 48(\text{sectors}) \times 47(\text{prefectures})\).

On the other hand, recently developed complex networks is one of the tool to display complex relationship among a lot of subparts [4].

\[ W^j = D^j [I - A]^{-1} F^j, \]

where \(D^j\) is the diagonal Direct Intensity Matrix whose elements are \(R_i / X_i\), \([I - A]^{-1}\) is the Leontief Inverse Matrix and \(F^j\) is the diagonal Final Demand Matrix whose elements are \(F_i\). \(W^j\) describes the direct use of environmental resource by a sector in a prefecture owing to the Final Demand of a sector in a prefecture. We make a network by considering a sector in a prefecture as a node and the connection \(W^j\) larger than a given threshold as a link.

Figure 1: Degree Distribution of EF network
**Results and Discussion**

Fig. 1 shows the degree distribution of a network where $W_{ij} \geq 0.0001$. We found the scale-free distribution with the exponent of -0.87. Fig. 2 shows a visualization of a network where $W_{ij} \geq 0.001$. We can see large hubs and will explain more feature at the Conf.

**Conclusion**

Since various EF has been calculated in Japan [5], it strongly expected those indicators will demonstrate effective abilities to regional, domestic or international environmental policy making. Complex networking method over EF will help those promotion. For more detail analysis of EF, it is expected to build up profound layer over such kind of network.

**References**


Assessment of Beijing water footprint using Interregional Input-output model

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Keywords: water footprint, virtual water, interregional input output model, China

Introduction
Beijing, the capital of China, is under severe water resource pressure due to rapid economic development and growing population. To satisfy the increasing water demand of Beijing, there have been not only engineering measures like “the South to North Water Diversion” project which direct provides water to Beijing but also “hidden” or “virtual” water supports from other regions to Beijing in the form of interregional product trade. With the more frequent interregional exchange of goods and services, the virtual water embodied in interregional trade has become an important water resource supplement to Beijing.

This paper aims to quantitatively evaluate water footprint of Beijing by applying an Interregional Input-Output model. The evaluation distinguishes the local (from Beijing itself) water footprint and external (from other regions of the country) water footprint. This study makes it possible to determine the main “hidden” water provider for Beijing’s consumption, indentify key water consumption sectors, and specify the interregional water resource connections between Beijing and other regions. The result of this study provides new insights and scientific reference for achieving water security in Beijing.

Methods
This study is based on China IRIO2002, a 30-region, 33-sector interregional input-output table which is compiled based on the Chenery-Moses model, using hybrid approach of survey and non-survey. The process of calculating Beijing's water footprint is shown in Figure 1.

Results and Discussion
a. The total water footprint of Beijing is 4687 million m\textsuperscript{3}/year including the local water footprint of 2302 million m\textsuperscript{3}/year and the imported interregional water footprint of 2385 million m\textsuperscript{3}/year. The imported interregional water footprint accounts for 51\% of the total water footprint of Beijing.

b. At sectoral level, the total water footprint of sector 1 (agriculture) is 1713 million m\textsuperscript{3} which is the highest among all the sectors. The secondary sectors, like sector 21 (Electricity, steam and gas production), sector 12 (Chemicals), sector 14 (Metal smelting and products) and sector 10 (Paper, printing, toys and stationary related products) are of relatively high total water footprint.

c. The main water consumption sectors have high proportions of imported interregional water footprint. The proportion of imported interregional water footprint of sector 1 (Agriculture), sector 21 (Electricity, steam and gas production) and sector 4 (Fishery) are respectively 56\%, 52\%, 65\%.

d. Hebei province is the main water resource provider for the final consumption of Beijing. The imported interregional water footprint from Hebei province to Beijing is 392
million m³/year which accounts for 16% of the water footprint imported from other regions.

\[
x_i^R = \sum_{s=1}^{m} \sum_{j=1}^{n} x_{ij}^R + \sum_{s=1}^{m} y_i^R a_{ij}^S = \frac{x_i^R}{x_i^S}
\]

\[
x_i^R = \sum_{s=1}^{m} \sum_{j=1}^{n} a_{ij}^S x_j^S + \sum_{s=1}^{m} y_i^S
\]

\[
W^b = E^b \left[ (I - A^*)^{-1} Y^* \right]^b
\]

\[
X^* = A^* X^* + Y^*
\]

\[
X^* = \left( X^1 \cdots X^m \right)^T
\]

\[
X^R = \left( x_i^R \cdots x_n^R \right)^T
\]

\[
A^* = \begin{pmatrix}
A^{11} & \cdots & A^{1m} \\
\vdots & \ddots & \vdots \\
A^{m1} & \cdots & A^{mm}
\end{pmatrix}
\]

\[
Y^* = \left( Y^1 \cdots Y^m \right)
\]

\[
Y_i^* = \begin{pmatrix}
y_i^{R1} & \cdots & y_i^{Rm}
\end{pmatrix}
\]

\[
E^b = (e_1^b \cdots e_i^b \cdots e_n^b)
\]

**Figure 1**: The calculation process of Beijing water footprint

**Conclusion**

The study shows that the Interregional Input Output model is an effective tool for quantification of water footprint distinguishing local source and external sources. It specifies the total water footprint of Beijing from local water footprint and from the other 29 regions of China. The result shows that the imported interregional water footprint is a substantial component of Beijing’s water footprint. As the key virtual water provider for Beijing, Hebei province’s trade relations with Beijing should be taken into consideration in decision makings to alleviate the water resource crisis in Beijing.

**References**


The Water Footprint of crop production in Cyprus

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Keywords: Agricultural Water Use, Internal Water Footprint, Virtual Water Exports.

Introduction
In recent years, the concepts of virtual water and water footprint are considered as important policy tools as they break fresh ground towards sustainable water management, especially in water-scarce countries. The present study contributes to the existing literature by providing for the first time a year-to-year analysis of agricultural water use in the semi-arid island of Cyprus for the period 1996-2008. Furthermore, the study identifies the contribution of irrigation and effective precipitation in crop production, quantifies the amount and identifies the source of exported virtual water and estimates the total internal water footprint of crop production in the country.

Methods
Estimations were undertaken using state-of-the-art methodology [1]. Crop water requirements for each of the 62 crops cultivated in Cyprus were calculated through the CROPWAT model [2], using year-to-year (rather than average) monthly climatic data from local weather stations; the USDA SCS method available in the model was used to estimate effective precipitation (ET$_{\text{green}}$) and irrigation requirements (ET$_{\text{blue}}$). Crop production and yield data were obtained from FAOSTAT [3] to estimate blue (CWU$_{b}$) and green (CWU$_{g}$) crop water use (Mm$^3$/year) and the virtual water content for each crop (m$^3$/ton). Total agricultural water use in Cyprus was calculated by summing up all crop water used. Data on Cypriot exported crop products were obtained from COMTRADE [4] to quantify virtual water exports. The internal crop water footprint of Cyprus (Mm$^3$/year) was calculated by subtracting the exported virtual water from crop water use.

Results and Discussion

![Figure 1: Agricultural Water Use in Cyprus](image-url)
Figure 1 illustrates the year-to-year variation of agricultural water use in Cyprus. It is evident that crop production relies heavily on irrigation. The fluctuation in mean annual precipitation determines the available green and blue crop water; overall agricultural water use peaks during the wettest hydrological year 2003-04. Table 1 shows the average distribution as well as the source of agricultural water use. It is interesting to note that on average 29.6% (90.3Mm³) of irrigation (blue) water use flows in foreign markets every year as virtual water embedded in exported crop products. Given that Cyprus suffers from severe water scarcity problems and that irrigation water originates either from costly water development works or from groundwater overexploitation, this finding needs to be considered by policy-makers. Finally, the average total internal water footprint of crop production is 340.6Mm³/year of which 214.8Mm³ (63.1%) originates from blue crop water use.

<table>
<thead>
<tr>
<th>Crop Group</th>
<th>CWUblue</th>
<th>CWUgreen</th>
<th>CWUg</th>
<th>CWUbg</th>
<th>CWUblue</th>
<th>CWUgreen</th>
<th>CWUg</th>
<th>CWUbg</th>
<th>Total WFinternal (Mm³/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>5.2</td>
<td>81.4</td>
<td>0.5</td>
<td>2.6</td>
<td>4.7</td>
<td>78.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus Fruits</td>
<td>37.1</td>
<td>11.7</td>
<td>24.9</td>
<td>7.9</td>
<td>12.2</td>
<td>3.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deciduous Fruits</td>
<td>23.5</td>
<td>7.5</td>
<td>2.1</td>
<td>0.6</td>
<td>21.4</td>
<td>6.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>107.8</td>
<td>16.1</td>
<td>43.0</td>
<td>7.0</td>
<td>64.8</td>
<td>9.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuts</td>
<td>33.2</td>
<td>13.4</td>
<td>3.0</td>
<td>0.8</td>
<td>30.2</td>
<td>12.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oilcrops</td>
<td>67.8</td>
<td>11.4</td>
<td>5.5</td>
<td>0.9</td>
<td>62.3</td>
<td>10.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulses</td>
<td>3.7</td>
<td>0.3</td>
<td>0.5</td>
<td>0.1</td>
<td>3.2</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roots &amp; Tubers</td>
<td>16.4</td>
<td>5.7</td>
<td>9.9</td>
<td>3.6</td>
<td>6.6</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stimulants</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0</td>
<td>0</td>
<td>0.2</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>10.1</td>
<td>3.0</td>
<td>0.9</td>
<td>1.3</td>
<td>9.1</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>305.1</td>
<td>150.5</td>
<td>90.3</td>
<td>24.7</td>
<td>214.8</td>
<td>125.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion**

The analysis raises questions on the allocation of irrigation water and the existing cropping patterns in Cyprus. Producing and exporting crops with high evaporative demand in a semi-arid country with limited water resources is both unsustainable and inefficient. Sustainable agricultural water use can be achieved by formulating an appropriate crop matrix that maximises environmental, social and economic benefits and that considers the existing climatic conditions and the water availability of Cyprus. Both the virtual water and the water footprint are important policy tools that can be used towards this direction.

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Even the most moderate UN scenarios would require humanity to use twice the capacity of planet Earth by 2030. This is physically impossible. Those who are recognizing this reality and are preparing themselves will be the winners of the 21st Century.

Are you ready?