A Lifecycle Assessment of U.S. Household Consumption

The Methodology and Inspiration Behind the "Consumer Footprint Calculator"

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ABSTRACT

This project uses an input-output lifecycle assessment approach to estimate the greenhouse gas and conventional pollutants related to the goods and services consumed by the typical U.S. household. Both direct and indirect sources of emissions are considered in five broad categories of consumption: transportation, housing, food, goods and services. The model reveals the relative contribution of some 200 individual consumer decisions to environmental degradation. An initial attempt is also made to attach a dollar value to these pollution streams based on published estimates of the societal costs of these pollutants. The purpose of this project is to develop the framework for creating an interactive online assessment tool, called the Consumer Footprint Calculator, that will allow users to understand the impacts of spending decisions on a broad range of environmental, economic and social indicators.

INTRODUCTION

In 1992, the UN Conference on Environment and Development (The Rio "Earth Summit") identified "sustainable consumption" as a primary objective of international development efforts. A distinctive message of the conference was that developed countries bear an unequal responsibility for the state of global environmental degradation and efforts should be made to curb unsustainable patterns of consumption and production to ensure equal development opportunities for future generations and the poor. As stated in Chapter 4 of Agenda 21, the conference's primary policy document, "…the major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production, particularly in industrialized countries…" Section 4.22 of Agenda 21 calls on nations to "…encourage the emergence of an informed consumer public and assist individuals and households to make environmentally informed choices…"

Well over a decade later, consumers remain largely unaware of the impacts related to their household consumption decisions. While researchers and scientists have recently assembled a massive body of evidence that ecological systems are being degraded[1], consumers lack tools to help them relate scientific information to their particular consumer choices.

The purpose of this project is to create a method of estimating a broad range of environmental indicators related to the spending behavior of a typical U.S. household, and to convert this information into an online assessment tool that can help consumers understand the relationships between their household decisions and the ecological systems that support the goods and services they consume. The tool could easily be adapted to businesses, organizations or communities making the assessment tool a versatile, inexpensive and comprehensive means of estimating environmental impacts.

The model developed for this project uses economic input-output lifecycle assessment software to determine the indirect impacts of consumer decisions throughout the production chain. This information is combined with an estimate of the "direct" impacts resulting from household demand for transportation and energy to account for a full lifecycle assessment of U.S. consumption behavior. The model currently contains the emissions of greenhouse gases and conventional (or criteria) pollutants, as well as the societal costs associated with these pollutants, but the model could be expanded to include a wide range of environmental, social and economic indicators including the release of hazardous waste, the use of water and other natural resources, health and safety data, as well as some economic data. This model could then be transferred to an online assessment tool to allow users to adjust the model to their particular household spending to estimate the impacts associated with their particular consumer decisions.

This paper will discuss the logic and initial findings of the Consumer Footprint model and suggest ways in which the tool could play a role in a broader context of education and social changes that will be necessary to meet the Agenda 21 development goals.

CONCEPTUAL FRAMING

The Consumer Footprint is an entirely demand-side approach at modeling the effects of consumer behavior. The model assumes that consumers are ultimately responsible for not only end-use impacts, such as air emissions from the burning of fossil fuels in automobiles, but also the *indirect* environmental impacts resulting from the production of goods and services throughout the commodity and service chains.

The question naturally arises then, "who is responsible for environmental impacts: consumers or businesses?" To date, no model has been able to successfully allocate responsibility for ecological impacts between relevant actors. Spangenberg and Lorek[2] suggest that allocation of responsibility is "virtually impossible" because the relationships of power between business and consumers vary in time, space and from product to product[3]. However, for the purposes of an assessment tool, it is not necessary to allocate responsibility. Rather, the model simply estimates the total lifecycle environmental impacts associated with, or "embedded in," the production of a good or service. Users of such an assessment tool can choose whether or not they want to take responsibility for all, none, or a portion of these impacts.

To be clear, the author does not seek to suggest that consumers ought to be considered responsible for 100% of environmental externalities in the economy. In fact, the model itself only accounts for between 60 and 80% of most pollution flows (see results below). Even products in which the majority of impacts are determined in the use phase (e.g. automobiles), a significant proportion of the impacts may be determined in the design phase. Inefficiencies, and thus increased pollution, in the production phase are also not the responsibility of consumers, who are generally unaware of the production conditions of the products they consumer. Indeed, businesses themselves may be unaware of missed opportunities[4].

The purpose here is not to suppose demand-side responsibility, but simply to estimate environmental impacts throughout the production chain and to let users decide the extent to which they will *take responsibility* for those externalities.

Alternative Impact Models

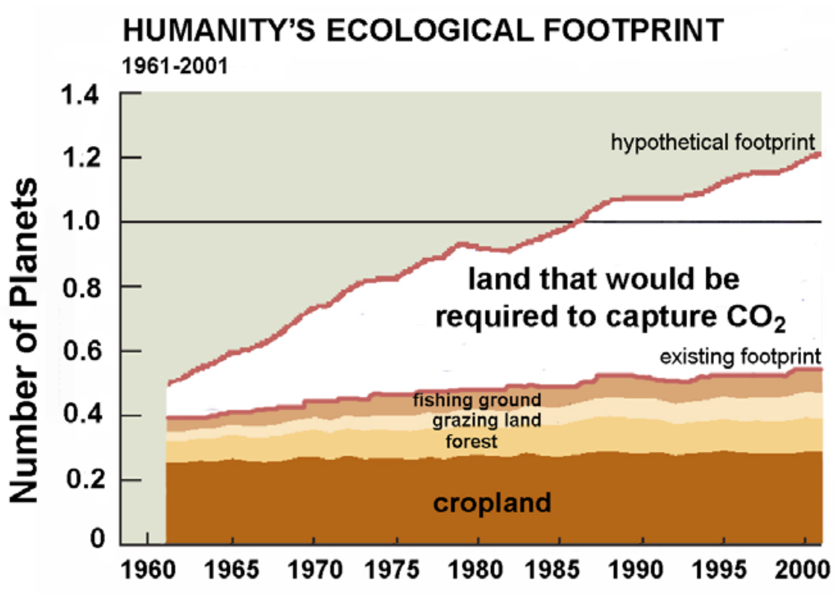
To date, the number and variety of impact assessment tools available to consumers, policy makers and businesses has been limited. One approach, the Ecological Footprint[5], has gained wide acceptance as a metric for monitoring sustainability. The term "ecological footprint" has become practically synonymous with environmental impact and is now used by a wide range of policy makers, businesses and individuals throughout the world. This model, however, has serious limitations which are worth briefly considering here.

According the Global Footprint Network[6], The Ecological Footprint (EF) "measures how much land and water area a human population requires to produce the resources it consumes and to absorb its wastes, taking into account prevailing technology". A global Ecological Footprint assessment by Wackernagel et. al[7] suggests that humans are using more biological capacity than the Earth is capable of regenerating, resulting in "ecological overshoot" of 120% of the Earth's regenerative incapacity. The message of the Ecological Footprint is thus a powerful one: human consumption is unsustainable. However, the methods used to draw this conclusion are seriously flawed.

The principle defect of the Ecological Footprint is that roughly half of the calculation, its CO_2 component, is completely hypothetical. Figure I demonstrates Ecological Footprint data in a new way. Notice that while about 50% of the global Ecological Footprint (WWF. 2004) is based on the current estimated actual use of biological capacity (including cropland, forests, grazing land and fisheries), the remaining 50% is an estimate of how much land *would be* required to absorb CO_2 in biomass, presumably through massive afforestation efforts (or to harvest a fuelwood equivalent of CO_2 in some assessments). Thus, more than 50% of the Ecological Footprint, its CO_2 component, is hypothetical; it imagines a world that does not exist.

The best conclusion we can draw from the Ecological Footprint is that there is no ecological overshoot now, but there would be if we attempted to use the remaining 50% the planet's biological capacity to grow trees. The troubling result of the Ecological Footprint is that it sends the message that humanity is consuming more natural resources than are being regenerated by the Earth, when in fact, according to EF calculations, humanity is only currently using roughly half of those resources.

Figure I. Ecological Footprint Highlighting the Hypothetical CO_2 Component



Adapted from WWF, 2002. "Living Planet Report"

There are other important flaws in the Ecological Footprint analysis. A major concern is that the Ecological Footprint itself is unsustainable. If fossil fuel consumption continues to grow at anywhere near the current rate, we will soon be using many Earth's worth of biological capacity each year. Thus the metric will soon stop making intuitive sense. Additionally, land that is degraded or used in cultivation does not lose all of its biological capacity. In fact, more sustainable land use practices, such as multicropping or agroforestry, could significantly improve yields. More importantly, while the EF likely overestimates resource limits to growth, it underestimates or confuses “sink,” or pollution, limits (e.g. greenhouse gases, conventional pollutants, hazardous waste, ozone). Pollution causes real and serious health impacts and threatens to significantly warm the planet which will lead to a host of other potentially serious societal and environmental impacts. By measuring sustainability in terms of use of biological capacity, these more serious environmental problems are hidden from view.

In short, incorrect information is not helpful information. The Ecological Footprint, as currently conceived, shifts our attention away from the most critical environmental issues by suggesting a threat that is not real. Yet these glaring faults have not prevented the measure from gaining wide use and acceptance. This shows that sustainability indicators fill a need for people to understand ecological impacts. However, a more accurate approach to understanding ecological impacts is greatly needed.

Project Goals

The goal of this project is to create a comprehensive environmental impact model that measures both natural resources consumed (e.g. land, water, energy, ores) and pollution generated (e.g. criteria pollutants, greenhouse gases, hazardous wastes) by a given population. The goals of the current working paper, however, are much more modest. The questions this paper seeks to answer are the following:

1) How much greenhouse gas and conventional (or criteria) pollution is released to the atmosphere to meet the demand of goods and services for the typical US household?
2) Which consumer decisions contribute the most to these pollution streams? Which decisions contribute the least?
3) What would be a reasonable estimate of the societal costs associated with these impacts?
4) Is the model developed for this study appropriate as the foundation for an online assessment tool to measure household environmental impacts?

These research questions may be thought of as intermediate goals towards the broader long-term goal of developing teaching tools and educational materials that provide useful information for individuals to help them understand the environmental impacts associated with their consumption behavior. The quality of individual consumers' decisions depends upon the quality of information consumers use to make those decisions. This tool seeks to help fill an important knowledge gap for a wide audience of concerned consumers and policy makers interested in addressing environmental problems.

RESEARCH METHODS

This project consists of both a spreadsheet-based environmental impact assessment model for the typical U.S. household, and an online interface/calculator that allows users to estimate environmental impacts associated with their particular consumer decisions. This section will describe the model, which is the quantitative basis for the calculator, and not the calculator itself, which can be created in many formats, e.g. spreadsheet, HTML, Javascript, Flash, or several web-based programming languages. [An updated version of the calculator can be found at www.consumerfootprint.org]

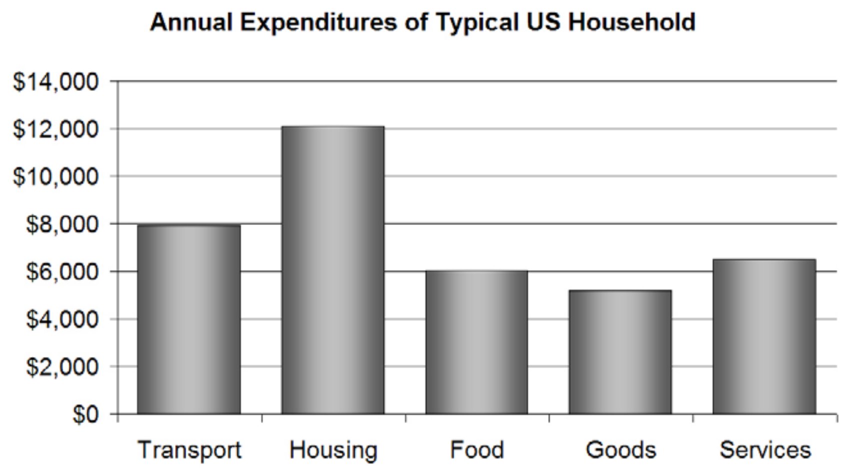
The current Consumer Footprint Model (CFM) estimates "direct" and "indirect" emissions of greenhouse gases (CO_2, CH_4, N_2O and CFCs) and conventional pollutants (SO_2, NO_x, CO, volatile organic compounds and particulate matter 10 microns or less). Direct emissions refer to pollution caused by sources over which users have direct control, specifically through the burning of fossil fuels in internal combustion engines and through household energy use. Strictly speaking, households do not *directly* cause pollution when consuming electricity (indeed they may not be aware of, nor take an active role in deciding, the energy mix that produces that their electricity); however, because energy providers produce energy on demand, consumers can be thought to have direct control over resulting emissions. Indirect emissions are all impacts occurring throughout the production chain before and after consumers purchase the products or services. Sources of indirect emissions include (but are not limited to) mining, extraction or cultivation of natural resources; refining of raw materials; manufacturing or assembly of intermediary and finished goods; transportation; marketing, management and commercialization of products and services; and waste.

Defining household characteristics

The first step in determining average household emissions was to define the consumption characteristics of the typical American household. The Consumer Expenditures Survey (CES), published by the Bureau of Labor Statistics, provided the foundation for this assessment. A detailed version of the 2003 CES[8] contains roughly 1,500 individual line items of consumer expenditures. These expenditures were grouped into five primary categories (Transportation, Housing, Goods, Services and Food), 33 groups, 88 subgroups and 208 sub-subgroups. While the finest level of disaggregation was necessary for estimating direct and indirect emissions, the larger groupings are necessary for creation of the calculator, allowing users to select between simple and more advanced models.

A summary of consumer spending in the five categories is shown in Figure II, Housing accounts for roughly one third of consumer spending, with the remaining four categories split somewhat more evenly. Total spending for all categories totals $39,200 with an average household size of 2.5 persons. This formulation excludes taxes. The total number of such households in the United States is roughly 115,000,000[9].

Figure II. Distribution of Consumer Spending



Direct Emissions

Direct emissions from transportation and energy were estimated using either a *bottom-up*, or *top-down* approach, depending on the data available. A bottom-up approach starts with consumer decisions, e.g. dollars spent on energy, or miles driven, and derives emissions based on conversion factors provided by government databases. A top-down approach starts with national accounts of emissions from a particular sector, e.g. residential electricity, and allocates a proportional amount to individual households. In general, a bottom-up approach was preferred in order to be consistent with the methodology used for calculating indirect emissions, which is also bottom-up; however, this approach depends on the quality of conversion factors available, which may show significant variability over time (e.g. fuel prices) and depends on various accounting methodologies[10].

Indirect Emissions

Indirect emissions were estimated using the Economic Input-Output Lifecycle Assessment (EIOLCA) software created by the Green Design Initiative at Carnegie Mellon University[11]. For any given dollar purchased from any sector of the economy, EIOLCA will generate a list of environmental, economic and social indicators based on the entire product chain, or lifecycle. Tracking the full upstream impacts of a particular production process requires eliminating boundaries in the analysis so that all sectors of the economy are considered in the approach. EIOLCA accomplishes this by combining input-output tables generated by the U.S. Department of Commerce with government emissions data to estimate economy wide impacts. Input-output tables track buyer-seller relationships from each sector of the economy to all others such that the output from any sector of the economy will include the cumulative value of all inputs to that sector, plus the value added from the sector itself. Due to the multiplier effect as inputs move from one sector of the economy to the next, the total value of a good to society will be greater than the purchase price of the good. Wassily Leontiff[12], the creator of input-output economics, used input-output tables to show how the total employment from one sector of the economy, e.g. agriculture, was larger than the employment generated from the agricultural sector alone. By the same reasoning, the pollution created from one sector is also greater than the pollution directly related to that particular industry.

Determining the total household indirect emissions was accomplished by inputting the average values for consumer purchases in the appropriate categories in the EIOLCA. The Consumer Expenditures Survey lists some 1,500 individual categories, while the EIOLCA offers 491 individual sectors. Mapping the CES codes to EIOLCA codes (actually these are from NAICS – North America Industry Classification System) was a primary methodological component of the project.

RESULTS

This paper reveals two principle findings: 1) the distribution of greenhouse gases and conventional pollutants across selected categories of consumption; and 2) an estimate of potential societal costs associated with those impacts.

Distribution of Emissions by Group and Subgroups

Figure III summarize the greenhouse gas contribution of each of the most significant consumer decision categories. Transportation and housing represent the largest emissions categories with 20.0 tons (40%) and 14.8 tons (30%) per household per year, respectively. Cumulatively, food (8.1 tons), goods (4.5 tons) and services (2.5 tons) add an additional 30% to total household GHG emissions. Emissions from all energy sources total 11.8 tons (24%). Direct and indirect emissions from motor vehicles total 17.6 tons CO_2e, or 35% of all household greenhouse gas emissions. Airline travel, housing construction, meat, eating out, fruits & vegetables, snack food, dairy and clothing are all significant sources of household GHG emissions. Direct emissions account for 44%, while indirect emissions account for 56% of total household GHG emissions.

The distribution of conventional pollutants across five broad categories of consumption can be seen in figure IV. The pattern of NO_x releases across the five emissions categories is largely consistent with greenhouse gases, due to the prominence of mobile sources with additional significant releases from power plants. Carbon monoxide and volatile organic compounds are more heavily influenced by mobile sources. It should be noted that mobile sources are not restricted to transportation, but are also embedded in agricultural products, goods and services through transportation of freight. Particulate matter, however, reveals a strikingly different pattern with food being the primary emissions category. Land use practices significantly affect particulate matter releases, with smaller emissions generated from the incomplete combustion of fossil fuel and through chemical reactions from industrial processes. Releases of sulfur dioxide also differ markedly from greenhouse gas emissions, with power plants responsible for the most significant emissions.

Figure III. Summary of Greenhouse Gas Emissions

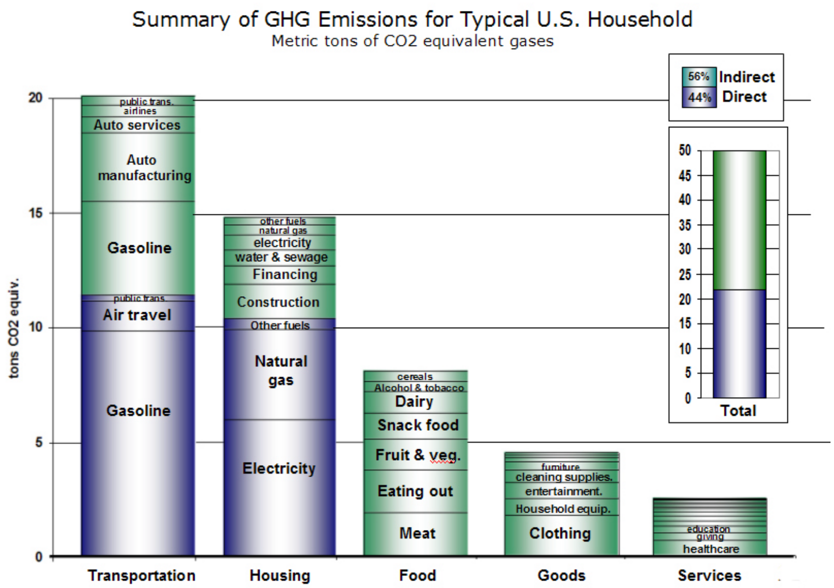
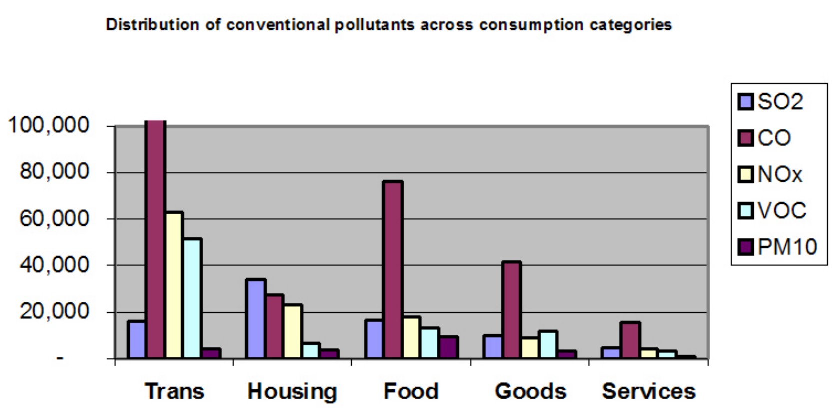


Figure IV. Summary of Conventional Pollutant Emissions



Estimate of Societal Costs of Household Consumption

Comparing the relative contribution of these impacts requires a common metric. Without such a metric, users are left to weigh the importance of each of these emissions individually. We know that pollution leads to health problems, lost productivity and other forms of economic and social costs. One way to weigh the societal cost of these impacts is to estimate the number of lost work days due to health related problems from pollution streams. One could also try to quantify the number of asthma attacks or other illnesses associated with a particular level of pollution. Assuming these impacts are linear[13], a value could be placed on pollution streams for each of the expected impacts.

While it may not be possible to assert the number of individual events that will likely be the result of a level of emissions, studies can aggregate a set of societal cost, representing true costs paid by society, to particular pollution streams. This gives a rough idea of the relative contribution of each outcome and allows us to weigh emissions streams with a common metric, in this case dollars.

Mathews[14] collected societal cost studies to determine societal impacts related to the pollutants described in this study. Table I shows the range of estimates presented by Mathews. The greatest uncertainty is demonstrated in carbon monoxide emissions, which are less well understood in the literature. Future estimates of societal costs will add further studies to the list, to minimize variability in the impact factors. The studies aggregated by Mathews undoubtedly use a variety of methods and set different boundaries when considering societal costs. It is not uncommon, however, to use a range of impact factors from the literature to set a range of possible impacts. The IPCC, for example, uses a similar approach for determining the range of possible future climate impacts related to global warming.

Table I. Range of societal costs for pollutants

	# studies	low ($/t)	median ($/t)	mean ($/t)	high ($/t)
CO	2	1	520	520	1,050
N0x	9	220	1,060	2,800	9,500
PM_{10}	12	950	2,800	4,300	16,200
SO_2	10	770	1,800	2,000	4,700
VOC	5	160	1,400	1,600	4,400
CO2	4	2	14	13	23

Source: Mathews et al. 2001[15]

Applying these estimated societal costs to total emission of each pollutant in the study leads to the societal costs outlined in figure V. A mean estimate of $1,783 dollars per household per year is obtained with this approach. By comparison, the typical household spends $2,414 per year on health care related expenses[16]. The cumulative impact of all 115 million US households is roughly $200 billion, which is in agreement with EPA's published estimates for air quality related social costs[17].

Figure VI shows the distribution of societal costs across types of emissions. Greenhouse gases result in the largest contribution, with CO, and NO_x also resulting in relatively high societal costs This range of estimates should be taken as cautionary and only an initial attempt to evaluate societal costs related to household consumption behavior.

Figure V. Summary of Annual Societal Costs by Category

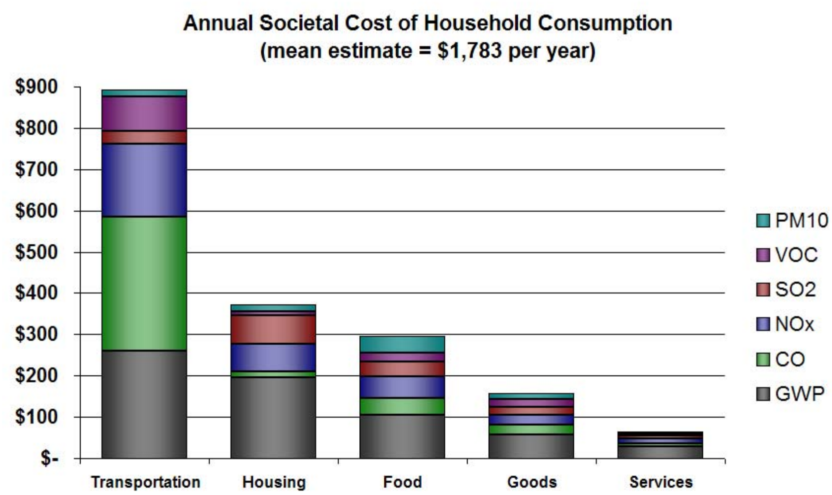
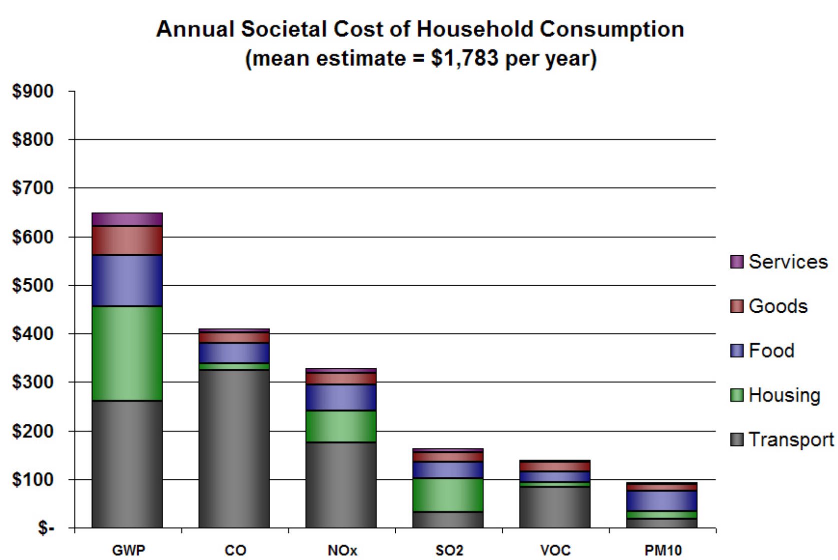


Figure VI. Summary of Annual Societal Costs by Pollutant



DISCUSSION

Distribution of Household Emissions

The distribution of total household emissions may not be particularly surprising in academic and professional sustainability circles, but rather a confirmation of what was already generally understood. It is well known that transportation and housing are the primary causes of household emissions due to both direct and indirect sources. Food and clothing also generally well recognized as priority areas[18]. For those not accustomed to thinking about emissions on a lifecycle basis, however, the results may be very surprising. People generally do not consider lifecycle impacts when thinking about their household energy consumption. In fact, lifecycle thinking at all will be new for most. As an educational tool, these results serve to help users begin to think about their contribution to environmental problems in a much more holistic manner.

Societal costs

The author is not aware of any other study that attempts to estimate total societal costs directly and indirectly related to consumer behavior, thus this initial approach represents a step in the direction of quantifying these impacts. There may be significant uncertainty in both the model itself, explained above, and the impact coefficients given by Mathews. Further work will be necessary to determine whether this is a viable approach for assessing impact of consumer related behavior. Although there is uncertainty in the results, the model proposed may be the first attempt at such an assessment and should therefore be taken as cautionary but instructive.

Societal costs may be the most effective way for consumers to understand and potentially reduce the environmental impacts related to their behavior. This suggests a strong incentive to achieve the best possible model in order to facilitate the creation of an effective sustainability tool. While this study concentrates on the impacts from a household perspective, the model could be easily adapted to businesses or communities using the same social cost factors.

General Discussion

As stated above, the goal of the project is to feed this data into an assessment tool to help users evaluate their own environmental impacts, measured in units of pollution, or in dollars. Users will then use the tool to determine the lifestyle changes that would be necessary to reduce their environmental impact.

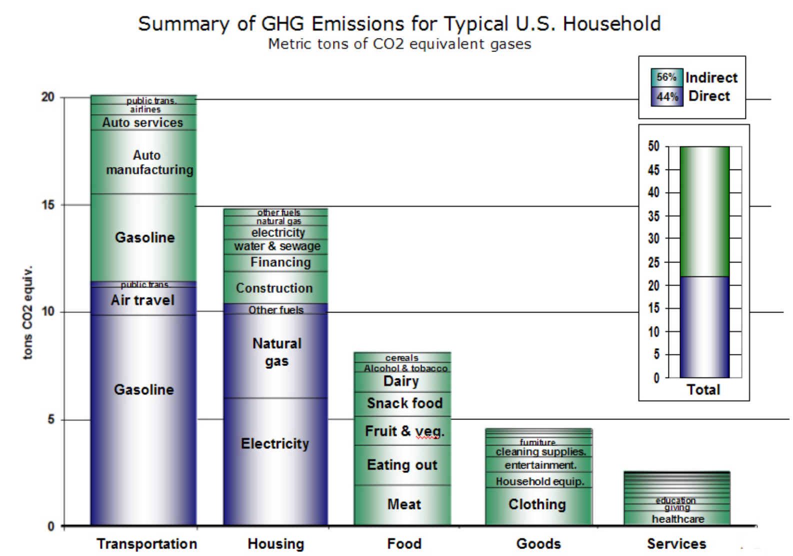
Consider, for example, a climate footprint analysis for the typical household. The user might use the tool to see what would happen if she reduced her household energy consumption by purchasing energy efficient appliances or replacing light bulbs with compact florescent bulbs. An aggressive approach could potentially reduce electricity consumption by 50%. The user would quickly realize that electricity only accounts for roughly 15% of total household greenhouse gas emissions. Even reducing electricity emissions by two-thirds, or 5 tons total, would still leave a greenhouse gas burden of 45 (out of 50) tons. At this point it is important to consider the change in overall household consumption with particular decisions. If these energy efficiency improvements require spending money on additional equipment, then the emissions from those sources should also be accounted. Similarly, if the extra $500 per year average savings in electricity costs were spent on travel or eating out, the greenhouse gas savings could be greatly reduced or even eliminated. One important lesson of using the calculator will be that dramatically reducing total household emissions requires a comprehensive approach.

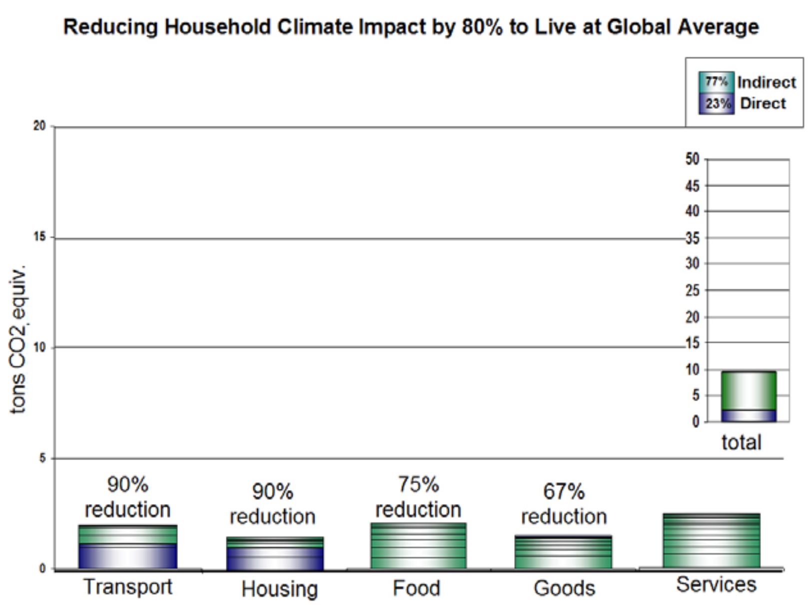
Let us further consider a household that wishes to reduce its total climate footprint by 50%. One option would be to reduce all consumer expenditures by half. However, supporting sustainable consumption means encouraging sustainable forms of consumption as much as discouraging unsustainable forms. Reducing education or healthcare makes little sense when other choices can be made that lead to less detriment to overall quality of life. Preserving this essential spending means decreasing consumption of more harmful and less essential goods. Transportation and housing stand out as the primary levers to make substantive changes in household environmental impacts.

Figure VII demonstrates the lifestyle choices that would be necessary to reduce greenhouse gas emissions to the global average. If we were to consider services (which primarily include healthcare, education, financial services, and giving –e.g. to churches or charities), as essentials, a typical user would have to reduce both transportation and housing spending by 90%, food by two-thirds and goods by 50% (see figure 4.1). This would essentially mean relying exclusively on public transportation, purchasing green sustainable energy, reducing food impact by giving up meat, eating out, and purchasing primarily organic and locally grown food, and reducing overall consumption of goods. While this bill would probably seem fairly outrageous for many consumers in developed countries, it is a good representation of how the majority of the Earth's inhabitants actually live. Yet, even if everyone on the planet changed their lifestyle to live at this global average, we would still have the existing greenhouse gas problem. In fact, an equitable and sustainable solution to climate change would entail going far beyond these changes if we were to rely on changes in consumption patters alone to do the job.

The previous example illustrates the level of commitment it would take on the part of consumers to dramatically limit climate impact. An alternative approach for consumers is to use their power as global citizens (and not simply consumers) to work for policies that encourage sustainable consumption. As Christer Sanne[19] notes, most consumers are willing to make changes in their lifestyles where possible, but most find themselves "locked in" to a pattern of unsustainable consumption that is difficult to break. Sanne suggests minimizing work hours as the best direct way to reduce ecological pressures. This would not only limit travel time, but would also decrease wages and thus spending which, according to this analysis, is a reasonable way to limit climate impact. Essentially, everything consumers do leads to some level of environmental impact. Reducing these impacts requires a comprehensive and aggressive approach, be this by policy, technology, or though through changing consumption patterns. The best societal approach would likely require all three.

Figure VII. Comparison of GHGs for Lifestyle Scenarios





CONCLUSION

Indicators are necessarily simplifications of complexity, whereas natural systems are complex naturally. Currently, being an environmentally responsible consumer means being able to find and digest a large body of information about global or regional environmental patterns or particular products and processes and trying to infer one's relationship to these concerns. The messages that get through are generally over-simplistic ones. Recycling is good. Cars are bad. And while concerned citizens debate the merits of "paper or plastic" the U.S. economy, largely influenced by consumer decisions, continues to dump billions of tons of toxics into the environment. Informing people in a simple way of their environmental impact will, hopefully, allow people to begin to think more holistically about their relationship to environmental and human systems outside their immediate control. Perhaps more importantly, this project seeks to serve as a platform to encourage people to ask relevant questions about the relationships between consumption, the environment and our dependence on the environment's services.

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NOTES

[1] See the Millennium Ecosystem Assessment. Downloadable in PDF format at http://www.millenniumassessment.org

[2] Spangenberg, J.H. and S. Lorek (2002). "Environmentally sustainable household consumption: from aggregate environmental pressures to priority fields of action." Ecological Economic 43(2-3): 127-140.

[3] Businesses can argue, from a classical economic perspective, that they are merely filling demand, and if they did not produce the good or service demanded by consumers, then another business surely would. However, consumers can (rightly) argue that they have no control over, or likely even

knowledge of, the particular decisions firms make with respect to resource flows and pollution. From the first viewpoint, this is irrelevant, since firms operate in a state of perfect competition such that all inefficiencies are minimized. Waste is minimized to limit product and disposal costs and energy is conserved to maintain competitive advantage. Similarly, any action to go beyond standard practice would result in loss of competitiveness. Consumers, therefore, ultimately have the power to determine environmental outcomes through purchasing decisions. Porter and van der Lind (1995) have convincingly argued that this is not always the case. Many opportunities exist to improve both environmental outcomes and competitiveness. Businesses do not always act rationally. They react negatively to forms of government regulation that could ultimately help their bottom line. From this perspective, and also from a strict view of the polluter pays principle, businesses should be responsible for the environmental impacts of production. Because both of these viewpoints can not simultaneously be valid, a balance between the two seems necessary. To resolve this issue, the assessment tool could simply offer users the option of accepting all, or only a portion of responsibility for these impacts.

[4] The "Porter Hypothesis" stresses missed opportunities for environmental improvement and economic gains. See Porter, M.E. and van der Lind, C. 1995. "Towards a New Conception of the Environment-Competitiveness Relationship," Journal of Economic Perspectives 9 (1995), 97-118

[5] See http://www.myfootprint.org/

[6] See the Global Footprint Network website (accessed 5/11/05): http://www.footprintnetwork.org/gfn_sub.php?content=footprint_overvie w

[7] See Wackernagel, Mathis; Niels B. Schulz, Diana Deumling, Alejandro Callejas Linares, Martin Jenkins, Valerie Kapos, Chad Monfreda, Jonathan Loh, Norman Myers, Richard Norgaard, & Jørgen Randers. 2002. "Tracking the Ecological Overshoot of the Human Economy". Proc. Natl. Acad. Sci. USA, Vol. 99, Issue 14. July 9, 2002

[8] BLS (2004). "Consumer Expenditures Survey. Size of consumer unit: Average annual expenditures and characteristics". Available only upon request from the Bureau of Labor Statistics. Requested on March 23, 2005.

[9] ibid

[10] See Appendix 1 of this document for a full description of the accounting procedures for all direct emissions. Jones, Christopher. 2005. "A Lifecycle Assessment Model of U.S. Household Consumption: The methodology and inspiration behind the "Consumer Footprint Calculator". Masters thesis. Department of Energy and Resources. UC Berkeley.

[11] See eiolca.net

[12] Input Output tables were first created by Wassily Leontiff, who won the Nobel Prize in Economics (1973) for this work. See Leontiff, Wassily, "Input-Outut Economics". 1986. Oxford University Press.

[13] However, impacts do not always exhibit a linear donor response. An increase in a certain species of pollution may or may not lead to a specific outcome. With criteria or conventional pollutants local conditions also play a key role in the ultimate effect of pollution streams.

[14] Matthews, H. Scott. 1999. "The External Costs of Air Pollution and the Environmental Impact of the Consumer in the US Economy". Dissertation. Carnegie Mellon University

[15] Matthews, H. S., Hendrickson, C. T., and Horvath, A. (2001), H"External Costs of Air Emissions from Transportation."H J. of Infrastructure Systems, ASCE, 7(1), pp. 111-117

[16] Households do not bear the full cost of health related impacts. Government is expected to contribute a significant portion of healthcare costs that are not present in this study.

[17] Matthews, H. Scott. 1999. "The External Costs of Air Pollution and the Environmental Impact of the Consumer in the US Economy". Dissertation. Carnegie Mellon University

[18] See Spangenberg, J.H. and S. Lorek (2002). "Environmentally sustainable household consumption: from aggregate environmental pressures to priority fields of action." Ecological Economic 43(2-3): 127-140.

[19] Sanne, C., 2002. "Wiling Consumers –or locked in? Policies for a sustainable consumption". Ecological Economics 42 (2002) 273-287