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Survey

A household carbon footprint calculator for islands: Case study of the United States Virgin Islands

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ABSTRACT

Island regions are at a heightened level of vulnerability to climate change impacts and recently a great degree of political attention has been given to planning low-carbon economic strategies for Small Island Developing States (SIDS). To develop useful mitigation strategies, an understanding of greenhouse gas emissions currently attributable to various social sectors is necessary. We use consumption-based life cycle accounting techniques to assess the carbon footprint of typical households within the US Virgin Islands. We find the average carbon footprint in the territory to be 13 tCO_2e per year per capita, roughly 35% less than the average US per capita footprint. Also, electricity and food are much larger contributors to total footprint than in the US. Results highlight scope for behavioral and technological changes that could significantly reduce the footprint. The model has been developed into an open access online tool for educational purposes.

1. Introduction

Energy access is widely acknowledged as a major economic driver for social development and economic growth (Goldemberg and Johansson, 1995). Given the constraints of distance and scale that islands face, energy has an intensified impact on islands and their macroeconomic management (United Nations Economic and Social Council, 1996). Its availability thus plays a vital role in the cost and quality of electricity and transportation, and also impacts the provision of basic goods and social services (Kristoferson et al., 1985). The IPCC also highlights the vulnerabilities of island resources to a warming climate (Mimura, 2007). Recent cost assessments project that increased hurricane damages, loss of tourism revenue and infrastructure damages alone will cost the Caribbean $22 billion annually by 2050, representing 10% of the current Caribbean economy (Bueno et al., 2008). Concerns for these broad consequences of climate change vulnerability and energy security have led to action on various islands, through government policy and commercial enterprise, to promote efficiency and introduce indigenous energy resources into local fuel mixes (Weisser, 2004a,b).

The United States Virgin Islands (USVI) is one such territory where action is already being taken to develop new energy strategies. In total, the islands consist of just over 1900 km^2 of rugged terrain with very limited amounts of flat land for agriculture or other primary and secondary sector activities. Tourism accounts for roughly 80% of economic activity, and 30% of the land area has elevation less than 5 m (Trading Economics, 2010), placing significant importance on the territory's 190 km of coastline (CIA, 2011). Furthermore, the USVI consumes about 85,000 bbl oil/day to meet electricity, desalination and transportation needs (CIA, 2011). This is largely because the islands' generation systems are 100% dependent on fuel oils. Thus, not only are the islands' coastlines vulnerable to climate impacts but the territory's economy is also vulnerable to the volatility and availability of foreign energy resources.

The local government has attempted to address this situation through the USVI Legislature's recent passing of Act 7075 (Bill No 28-0009). This Act amends previous VI Code by expanding the capacity of various energy efficiency and renewable energy incentive programs available within the territory and highlights the immediate need for strategic energy policy (VI Legislature, 2009). Soon after in 2010 the governor of the USVI signed a memorandum of understanding with the US Department of Energy to create a clean energy development strategy for the territory. The goal of this strategy is to achieve a 60% reduction in fossil fuel reliance by the year 2025 (Lantz et al., 2011). To catalog where opportunities to implement meaningful energy conservation and efficiency measures or renewable energy integration truly exist, it is important for decision makers to develop an understanding of the territory's energy landscape beyond utility boundaries. However, to date few local agencies collect data related to metrics on household and commercial resource use. Exploring how energy is being used both directly and indirectly by households for transportation, food, goods and services and household utility is thus a useful exercise.

The data collected for energy allocation is also useful for understanding how emissions are being generated across the island as a result of household consumption. Such carbon footprint analysis is useful as island territories take deliberate strides toward low carbon

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economies. A carbon footprint calculator would also serve as an educational tool for encouraging awareness and promoting behavior change among island residents. A recent study by the CoolClimate Network at the University of California, Berkeley compared the carbon footprints of average US households in 28 metropolitan regions, which range from 38 to 52 metric tons CO_2e per year (Jones and Kammen, 2010). However, as a US island territory, the USVI finds itself in a particular context of isolation from the mainland, limited land for local arable produce and a 100% fuel oil electricity generation mix. Here we attempt to account for such peculiarity and identify the size and composition of typical USVI household carbon footprints.

There are two predominant methods for calculating carbon footprints: Process Analysis and Economic Input Output (EIO) Analysis (Wiedmann and Minx, 2008). Using an EIO methodology similar to that developed by the CoolClimate Network, this paper presents a top-down consumption-based accounting model for USVI households. The model uses life cycle assessment (LCA) to approximate greenhouse gas (GHG) emissions during the extraction, processing, transport, use and disposal phases of various commodities and maps this to their respective consumption by households. Consumption-based LCA attempts to provide a complete picture of greenhouse gas emissions related to individual consumer spending choices and is therefore well suited for development of consumer-oriented carbon management tools (Wier and M, 2001). Benchmark carbon footprints are calculated for the three major inhabited islands of the USVI, five household sizes and five income brackets for a total of over 75 different household groups. The results of the model have been incorporated into an open access online tool for educational purposes.[1]

2. Material and Methods

2.1. General Household Characteristics

The US Virgin Islands (USVI) has an estimated population of 115,800 persons. St. Croix and St. Thomas comprise 47% and 49% total population respectively. St. John is considerably smaller, with less than 4% of the total population. According to the 2007 Community Survey conducted and published by the Eastern Caribbean Center (ECC) (Eastern Caribbean Center, 2007) mean household size and income are 2.2 persons and $41,884 per annum, respectively. Similarly, the annual per capita income as reported by the Bureau of Economic Research (BER) is roughly $21,600 (Bureau of Economic Research, 2010a), about half of the US average. With an unemployment rate of more than 9% at the end of 2011 (Bureau of Economic Research, 2011), 11% of all households live on less than $10,000 per year, compared to 7% for the US, and about half of USVI households live on less than $35,000 a year in comparison to a third of all households in the US (Bureau of Economic Research, 2010b). Only 25% of households have air conditioning, roughly half the households have computers and two thirds use bottled or tanked gas rather than electricity for cooking purposes.

2.2. Estimating Household Consumption

While the impacts of household consumption extend to land use issues, water management, waste management and pollution (Mimura, 2007), we focus on estimating the carbon footprint of household consumption. The total household carbon footprint (HCF) can be expressed as the product of consumption, which we approximate by spending, and the emissions per unit of consumption summed over each commodity or activity included in the model. We use data collected to estimate default values for the various household size and income bracket groups (discussed below) and the online footprint calculator assumes these values where user input is not provided.

$$\mathrm{HCF}(\mathrm{tCO_2e}) = \sum\nolimits_{\mathrm{commodities}} \mathrm{Average\ Annual\ Spending} \times \mathrm{Emission\ Factor} \quad (1)$$

We consider only the three predominantly inhabited islands: St. Thomas, St. Croix and St. John. Annual household consumption values for each commodity were calculated for each household group based on data from the most recent Household Income and Expenditure Survey, conducted by the ECC in 2005 (Eastern Caribbean Center, 2005). Given the small population sizes on each island and concerns over confidentiality, the results of the survey are cited as territorial household averages and no distinction between household income brackets or sizes is made. Data on household characteristics was also taken from the Community Survey (Eastern Caribbean Center, 2007). We determine the average household income and size and map average monthly and annual spending to this group.

As a proxy for resolution on differences in consumption across household types, we assume that the relative differences in spending between major income brackets and the average household income bracket are proportional to the differences observed in the continental US. This assumption is also made for spending differences across household sizes. US consumption trends were taken from the 2008 US Consumer Expenditure Surveys (US Bureau of Labor Statistics, 2008). The spending values for each household type are then a combination of these two influences. A third data set, the 1997 Consumer Expenditure Survey (Eastern Caribbean Center, 1997), is older but reports on average household spending by island. The ratios of spending for each island compared to the territorial average were used to create multipliers for each commodity. The product of these multipliers and the expenditure values for each household type are the default values for spending used in the model.

The ECC Household Income and Expenditure Survey provides data on household utility expenditures including electricity, gas, water and sewage disposal. It also provides household expenditures on gasoline for private transportation as well as spending for public transportation fares. We chose goods and services categories based on the commodities reported in the ECC survey and therefore model spending related to furniture and household appliances, clothing, entertainment, personal care, auto care and medical goods. The services we model include vehicular services, household maintenance and repair, education, health care, communication, personal business, entertainment and recreation.

We model food consumption based on dietary intake rather than spending. The food production and supply sector is highly complex. Because of variations in methods of production, processing, transportation, distribution, waste management and compounding factors such as locality and seasonality, many popular carbon calculators opt to base emissions on quantities of food consumed by users or by categorizing users through dietary lifestyles (Kim and Neff, 2009). Furthermore, one of the major limitations of EIO-LCA is the assumption of linear correlation between spending on a commodity and environmental impacts (Kim et al., 2008). As Jones and Kammen show in an analysis of 2009 US Consumer Expenditure Surveys, there is little correlation between spending on food and dietary intake across income brackets. Increased spending is likely related to consumption of higher quality or branded food products (Jones and Kammen, 2010). Following this argument and in the absence of consumption estimates specific to the Virgin Islands, data for dietary trends in the Caribbean Region and international Caribbean communities were used to approximate caloric intake (Ramdath et al., 2010; Sharma et al., 2002, 2009).

[1] http://coolclimate.berkeley.edu/usvi_calc