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העמותה לצדק סביבתי (ע"ר)
المنظمة للعدل البيئي
Association of Environmental Justice in Israel (AEJI)

Climate Justice and Economic Policy Report No. 3

December 2015

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Abstract

The human impact on Earth's climatic system is clearer than ever. The recent UN Climate Convention Conference held in Paris (COP21, December 2015) marked a milestone in the international effort to mitigate greenhouse gas (GHG) emissions, in attempt to address climate change. Israel, whose reclassification as a developed country is further underscored by its OECD membership, is required to contribute to the international effort and set ambitious targets for reduction of its emissions. When addressing emissions mitigation, the discourse as well as the majority of plans in the framework of climate policies, are generally directed at the producing sectors of the economy, with particular reference to building and construction, industry and energy generation. Indeed, industrial sectors are the primary energy consumers in the economy; but it should be considered that activity in these sectors is purposed to satisfy demands by final consumers. As these demands grow, production and its ensuing environmental impacts increase.

Households constitute the major share of consumers, and as such have a great impact on the structure of the economy. In order to minimize the economy's climatic influences, it is important to shift to more sustainable modes of production. In recent years, several researches focused their attention on the consumer angle of environmental impacts, attempting to quantify the energy and environmental pollution involved in supplying products and services that maintain a certain lifestyle. In order to assess the potential of reducing emissions by households, we must better understand their energy demands and other environmental impacts.

This paper is a summary of a research conducted in the framework of a multiannual research and policy project on Climate Justice by the *Association of Environmental Justice in Israel* (AEJI), and it aims to estimate the climatic impact of domestic consumption by households in Israel (in CO_2 terms); and to examine the variance between consumption patterns of different socio-economic groups according to income deciles, and their respective influence over quantities of GHG emissions to the atmosphere. The study examines the significance of demographic characteristics and consumption habits of households in assessing CO_2 emissions, by means of an Environmental Input-Output (EIO) Analysis. The EIO analysis provides a model for investigation of the relationship between both direct and indirect energy consumption (indirect consumption being the consumption of embodied energy in different products) of households and their expenditures.

The research results indicate that total average household emissions, including direct emissions from the consumption of energy products and indirect emissions from the consumption of products and services, is approximately 5 ton CO_2 per person per annum, ranging by income deciles between 2.7 and 7.8 tons CO_2 per person per annum. A significant variance is evident in the "emissions basket" (composition of emission sources) of households, differing between deciles. In low income households, most emissions emanate from consumption of basic products, such as food and electricity, which have a high emission coefficient. On the other hand, high income households consume more products and services that can be classified as luxuries, such as entertainment and education services, and have a lower emission coefficient.

Another study by Ro'ee Levy, in the framework of the Climate Justice Research and Policy Project, discusses the need to impose a carbon tax as a means of reducing GHG emissions in the Israeli economy, while taking measures to rectify the regressive impacts of such carbon pricing. The outcomes of the present research reinforce the importance of such correction policies, considering that carbon taxation would be a higher toll for low income households, compared with consumers from a higher socio-economic group.

* The full research paper was published in Hebrew. This document is a summarized translation.

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1. Introduction

The human impact on Earth's climatic systems is becoming increasingly more evident. In light of growing awareness of the climatic impacts of economic activities, increasing efforts are made worldwide to formulate policy measures to minimize environmental damages. Israel, as a developed country and member of the OECD, must contribute to the international effort to address climate change and set an ambitious emission reduction target. The Government of Israel submitted a mitigation target at the Paris Climate Convention Conference (COP21, December 2015), but is still developing its plan to meet these targets.

In the discussion of energy consumption and GHG emissions, the discourse is primarily directed at the productive facets of the economy. Efforts to formulate climate policies and develop measures for GHG emissions reduction focuses on technological developments, efficiency of production processes and reducing energy consumption in different industries. While industries are indeed the economy's greatest energy consumers, it should be noted that these great resources are invested in order to supply demands by the final consumer. As consumer demand grows, so will production and its environmental impacts. Consumers have a substantial impact on the structure of the economy, and shifting to more sustainable modes of consumption is of great importance in the effort to minimize the climatic impacts of households, who are the lion's share of end consumers. In order to have a good estimate of the emissions reduction potential of households, we must understand better their energy demands and its contribution to environmental impacts. Therefore in recent years, a growing number of studies have been examining the consumer aspect of environmental impacts, in attempt to quantify the levels of energy and environmental pollution needed to supply products and services that sustain a particular lifestyle.

This document is a summary of a recent research conducted in Israel as part of the Climate Justice Research and Policy Project by the *Association of Environmental Justice in Israel* (AEJI), addressing socio-economic aspects of GHG emissions in Israel according to a "consumption basket". It aims to evaluate the climatic impact of domestic consumption of households in Israel in terms of CO_2; and examine the variance between consumption patterns of different socio-economic groups as defined by income deciles, and their impact on the quantity of emissions to the atmosphere.

2. Domestic Consumption and GHG Emissions

This research addresses consumption through the prism of energy consumption. Energy is consumed both directly, by purchasing energy products such as gas for home cooking and fuels to power private transportation or house heating; and indirectly, when we purchase products and services. Indirect energy consumption is based on the concept of embodied energy preservation, which asserts that energy invested in the production process of a product is in fact stored within it, and therefore transferred with it throughout its lifetime, including its entire production cycle, distribution, marketing and sale to the final consumer. Energy consumed by private consumers, whether directly or indirectly, is generated in Israel primarily by burning fossil fuels, and therefore has numerous environmental impacts, including GHG emissions.

Households are the largest consumers in the economy. A study by Hertwich & Peters (2009) that assessed carbon footprints in 73 countries, indicated that some 72% of emissions result from household consumption, 10% from public consumption and 18% are investment related. The household "consumption basket" (composition of consumed products) is comprised of many products and services, with varying extents and patterns of consumption between households. Lifestyle plays a pivotal role in consumption choices, and much attention is directed in recent years to understanding the various factors impacting consumption (Solomon, Russell-Bennett, & Previte, 2012).

Consumers can be differentiated and described according to socio-demographic features such as gender, age, income and living environment, as well as by cultural and psychological characteristics addressing the consumer's lifestyle, values and personality. The marketing world also emphasizes consumer preferences, motivations and behavior patterns in order to segment the target market according to demographic, geographic and psychological characteristics (Gunter & Furnham, 2014). Whereas the segmentation of consumers by psychological and socio-cultural features is a challenging feat, it is easier to differentiate between household types according to socio-demographic characteristics. And that is indeed the research methodology most commonly used to evaluate energy consumption by households and their environmental impacts (Cohen, Lenzen, & Schaeffer, 2005; Munksgaard, Pedersen, & Wien, 2000; Vringer & Blok, 1995; Wier, Lenzen, Munksgaard, & Smed, 2001).

The most common model for evaluation of the relationship between energy consumption (both direct and indirect) of households and their expenditures is the Input-Output model. The methodology was first introduced by Herendeen in the early 1970s, and was implemented to study the US economy in 1960-61 (R. Herendeen & Tanaka, 1976); the Norwegian economy in 1973 (Harendeen, 1978); and once more for the US economy in 1972-3 (R. A. Herendeen, Ford, & Hannon, 1981). The key findings of these studies indicate that a significant part of total energy usage by households is consumed indirectly, by means of purchasing goods and services; housing, transportation and food consumption are major consumption areas in the US and Norway; when income increases, the direct energy consumption remains stable, while consumption of indirect energy grows. In other words, for poorer households most energy is consumed in the form of fuels, whereas for wealthier population groups, approximately two thirds of energy consumption originates from goods and services.

Other studies that focus more on climatic impacts than on energy consumption, had similar findings (Lenzen, 1998; Wier et al., 2001). These studies assert once more that household consumption patterns and lifestyles have a significant influence on the level of environmental impact. A Danish study (Wier et al., 2001) that examined the impacts of various socio-demographic characteristics, indicated that CO_2 emissions grew as income increased. An additional finding indicates that households in urban environments consume less direct energy than families residing in rural areas, and similar data applies for younger families as opposed to families of older ages.

2.1 Assumptions

This research addresses CO_2 emissions from domestic consumption by households in Israel, differentiating between ten socio-economic groups by level of household income (income deciles). Based on previous studies on the subject, we can make three main assumptions:

First, is that the lifestyle and consumption choices by households from a higher socio-economic group have a higher contribution to GHG emissions, compared to the consumption and lifestyles of lower socio-economic groups. In other words. Total CO_2 emissions from domestic consumption would be higher in higher deciles.

Second, is that the increase in total GHG emissions is not proportional to the growth in income per person but smaller. In other words, the emission flexibility vs. the monetary expenditure per person would be less than one.

The third assumption refers to the differences in consumer choices of households in the different deciles. Previous studies indicate that most monetary expenditure of low income households is directed at fulfilling fundamental needs such as food, electricity and home heating (Cohen et al., 2005; Wier et al., 2001). Higher income households, on the other hand, are greater consumers of goods and services that might be defines as luxuries, whereas the expenditure on fuels for domestic use and food constitutes a relatively small share

of their total expenditure. It can be assumed that the relationship between direct emissions emanating from direct use of fuels, and indirect emissions due to consumption of goods and services would vary between different socio-economic groups, whereas higher income households would have a more substantial share of indirect emissions, compared with lower income households.

A similar phenomenon is observed concerning the composition of fiscal expenditures by households in Israel. Figure 1 presents the distribution of expenditure per standard person in households of the highest and lowest deciles into 10 major consumption areas, according to National Bureau of Statistics (CBS) data (2012). In the lowest decile, most expenditure is on housing and food consumption (approximately 60% of total monthly expenditure per person), whereas in the highest decile, less than half of the expenditure is dedicated to these needs and the other half is directed to consumption of other goods and services. The figures of expenditure on vehicles by households are noticeable: 14% of monthly expenditure of households in the top decile, in comparison with a significantly lower 6% in the bottom decile. These expenses include car purchase payments and buying fuels and oils that contribute greatly to direct GHG emissions.

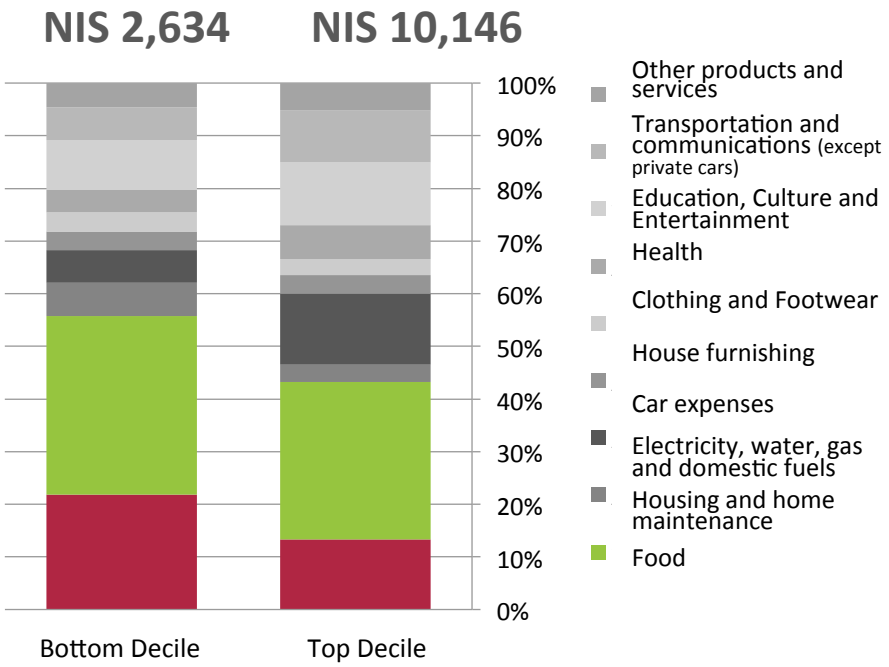

Figure 1: Comparison of Monthly Expenditure for Domestic Consumption, per Standard Person, Between Top and Bottom Deciles (2012 Data)

2.2 Selection of Methodology

Two primary approaches were considered to determine the best methodology for calculating GHG emissions by households in Israel (Pandey, Agrawal, & Pandey, 2011; Wiedmann & Minx, 2007). Process Analysis (PA) and Environmental Input-Output (EIO) Analysis. The PA model tracks emissions and the use of resources throughout a product's lifespan, from cradle to grave, including its production, marketing, distribution, use and destruction. It accounts for direct emissions (burning fuel) with very limited reference to indirect emissions. It is deemed appropriate for calculating emissions of singular products, but the analysis becomes too complex for large bodies such as companies, governments or households.

EIO Analysis offers an alternative approach. Input-Output tables are national accounting tables that describe the economic activity in the local economy according to existing production sectors. Inputs and outputs are

presented as a symmetric matrix, in which each line represents a sector, the distribution of outputs of the sector among other production sectors, and its final consumption. Each column represents inputs from the different economic sectors, required for the generation of outputs by the sector. Transfers between producers and consumers are presented in nominal terms. The integration of such economic data with environmental data of industrial sectors, enables the analysis of environmental and climatic impacts of the final consumer (households), considering both direct and indirect impacts.

Selecting the appropriate model to calculate environmental impacts depends on the goal of measurement and availability of data. (Tukker & Jansen, 2006). EIO analysis is preferred when undertaken for large bodies, such as an industrial sector, households, average private consumer etc. PA is preferable when observing smaller systems, such as a particular process, a single product or small group of products.

In view of the goals of this research, measuring CO_2 emissions from household consumption in Israel emanating from a large and complex basket of products, and in accordance with the availability of data and sources of information in Israel, this research is based on EIO Analysis as the most appropriate model.

2.3 Determining Research Parameters

CO_2 is one of the primary factors causing the greenhouse effect, and constitutes the majority of GHG emissions in Israel. The abovementioned methodology enables consideration of other GHGs and additional environmental impacts, but for simplification and due to lacking data on GHG emissions in the different sectors, this research focuses on CO_2 emissions only, and does not consider additional GHGs.

3. Methodology and Data Collection

As mentioned, the model found appropriate, in accordance with availability of data and goals of the research, analyzing climatic impacts resulting from domestic consumption by households in Israel, is the EIO model, based on national accounting tables. The model was developed in the 1930s by Leontief, and is based on the assumption that commodities are sold not only to a final consumer, but also to firms for interim uses and future production. Input-output tables are constructed based on supply and demand, and provide information on transfers between different economic sectors in nominal terms. In the Symmetric Input-Output Table, the total column equals the total line, and is a platform for the calculation of Leontief's Inverse Matrix and Coefficients. The coefficients enable analysis of the direct and indirect impacts of generating a production unit for end uses. The symmetrical input-output table is presented in base prices, after deducting taxes and marketing and transportation costs.

Previous studies in Israel have made use of national IO Tables only with regard to aspects of taxation of carbon emissions. We have found no documentation in literature for research addressing the contribution of end users to GHG emissions in Israel using an EIO environmental-economic model.

EIO Analysis is an expansion of the IO economic model, enabling an analysis of environmental impacts of the economy and their transfers between different economic sectors. Indirect environmental impacts can be measured in terms of the embodied energy found in final use of products, by using input flows (in physical or nominal terns), between different economic sectors required to manufacture a product. The correlation made by the model between final consumption and economic activity in the economy and different environmental impacts, enables analysis and evaluation of climatic influences on different scales, starting with embodied CO_2 in international commerce, via the analysis of environmental impacts and GHG emissions

contribution in the local level, through to evaluating the environmental impact of households (Munksgaard, Wier, Lenzen, & Dey, 2008).

Integrating the EIO model and household expenditure data enables an estimation of the contribution of private consumption to environmental pollution and in particular GHG emissions. Additionally, analysis of the relevant data allows an examination of the differences in climatic influences of households belonging to different socio-demographic groups by level of income, education, age and family size. This analysis enables an evaluation of the environmental impact of different lifestyles and recognizing those with a higher contribution.

The model incorporates environmental pollution data with data on commerce between the economic sectors in the economy, whereas for each sector both direct emissions caused by burning fossil fuels and indirect emissions emanating from the purchase of goods and services from other sectors are accounted for. The indirect emissions are calculated using Leontief's coefficients[1]. Integration of the data provides us with the carbon costs of goods in each of the sectors in terms of total CO_2 emissions per NIS 1 cost of commodity, and enables an evaluation of emissions by households, based on data addressing the composition of their financial expenditure.

As described in previous studies (Gay&Proops, 1993; Munksgaard et al., 2000; Wier et al., 2001), there are three main phases to the methodology:

1. Calculating the direct intensity vector for 42 economic sectors in the Israeli economy: by multiplying the total fuel consumption in the sector and the appropriate emissions coefficients (in accordance with data availability). The total direct emissions by each sector are divided by the total output of the sector to calculate the direct intensity, depicting the amount of direct emissions caused by manufacturing production worth NIS 1 in a given sector. This was carried out for all major 42 sectors of the economy.

2. Calculating the total intensity in 42 economic sectors, when intensity represents the total emissions (or other environmental impacts), both direct and indirect, required to generate production costing NIS 1 to the final consumer by a given sector. The total intensity vector is represented by the equation: $F = f(I - A)^{-1}$, when f presents direct intensity of an economic sector (as described above), F is the total intensity vector, and $(I - A)^{-1}$ is a matrix of the coefficients, which describe the relationship of inputs and outputs between the different sectors and enables an analysis of the direct and indirect impact of manufacturing one production on its end uses. The coefficients matrix is published by the CBS in Israel with the IO Tables, but adaptations had to be made and the matrices recalculated, to comply with data availability on the distribution of fuel uses, which are available for only 42 sectors in the economy. Total intensity, representing the carbon demand for production worth NIS 1, was calculated for all 42 sectors, in terms of gCO_2/NIS. The outcomes of these calculations are available in Appendix 2.

3. Calculating CO_2 emissions from domestic consumption by households for each consumption category: household expenditure for products in a category multiplied by the intensity coefficient of the sector, provide the total emissions caused by households as a result of consuming goods in the given category. For example, to calculate emissions associated with buying a shirt, we multiply the price paid for said shirt by the intensity coefficient of the "clothing" sector. A sum of the emissions in all categories provide the total emissions resulting from household consumption. In order to calculate the total environmental impact of households in terms of CO_2, we have defined major consumption categories. This research focuses on 12 consumption categories, on which the fiscal expenditure constitutes approximately 95% of

[1] The Hebrew document details information on the collection of data, it's adaptation into categories and the methodology applied to calculate the coefficients, as this methodology is generally unknown in Israel.

total household expenses, including two categories of direct fuel emissions and ten categories of consumption of goods and services.

1. Diesel fuel, gas and electricity for domestic use
2. Fuels for private transportation
3. Housing (home ownership, rent, water and maintenance)
4. Food (including beverages and tobacco products)
5. Furniture and home equipment
6. Textiles, clothing and footwear
7. Transportation (public transport, flights, vehicle related expenses (except fuel))
8. Hospitality and catering services
9. Education, culture and entertainment
10. Health services
11. Other products
12. Other services

Direct emissions

Indirect emissions

As mentioned, the composition of fiscal expenditure varies between households in different socio-economic groups. This research views these by income deciles, and the calculation of emissions was made focusing on ten groups of households in accordance with their income levels, based on a household expenditure survey data by the Central Bureau of Statistics.

4. Findings

The outcomes of applying the model provide us with a picture of CO_2 emissions attributable to domestic consumption of households in Israel, and enables us to compose a socio-economic profile of emissions by income decile groups. The contribution of households to GHG emissions averages 4.696 ton CO_2 per person per annum. Most emissions emanate from direct energy consumption – electricity and fuels for domestic uses, whereas indirect emissions constitute an average of 30% of total emissions.

The table depicting data on carbon intensity of economic sectors in Appendix 2 presents the external costs of consuming products and services by economic sector. Thus we can ascertain the consumption of outputs of which sectors would lead to higher emission quantities. It is evident that the electricity sector has the highest carbon intensity, considering electricity production is abundant with energy generated by fossil fuels. Other sectors of high carbon intensity are water, the food industry, agriculture, hospitality and catering services. On the other hand, sanitation services, communication and education generate a relatively low environmental impact. In other words, food consumption costing NIS 100 would lead to a greater increase of emissions, compared with the consumption of communication services at the same cost.

4.1. CO2 Emissions from Domestic Consumption of Households by Income Deciles

- As income increases, so do emission quantities and the relative share of indirect emissions in total emissions.

Figure 2 presents total CO_2 emissions of households by socio-economic deciles, and quantities of direct and indirect emissions. Some substantial differences can be observed in emissions by households according to their income levels. It is evident that CO_2 emissions increase with income, as do the relative share of indirect emissions from total emissions. For the bottom decile, direct emission constitute 73% of total emissions, whereas the top decile contributes to emissions by direct fuel consumption only 66% of total emissions and the rest from indirect emissions. In other words, higher income earners contribute to emissions indirectly, by consuming products and services, more than low income earners. These results are consistent with the research assumptions, according to which total emissions increase with income, as well as the relative share of indirect emissions compared with that of direct emissions.

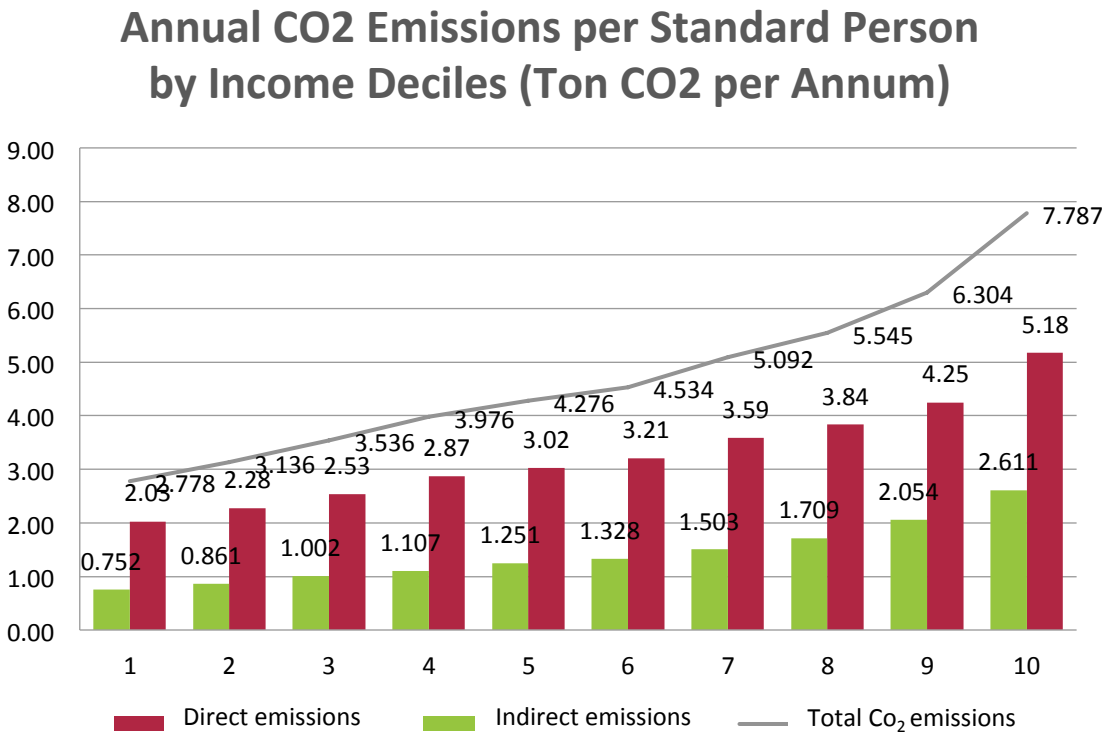

Figure 2: CO_2 Emissions per Annum per Standard Person, by Income Deciles, Direct and Indirect Emissions

4.2. CO2 Emissions by Consumption Categories

- In lower deciles, most emissions are caused by consumption of basic products (electricity and food, approx. 64%).
- High income earners contribute more to emissions by consumption of products and services.
- Significant disparities in fuel consumption for private transportation: 5 times higher in top decile than bottom decile

Figure 3 presents a clearer picture of the consumption characteristics of different socio-economic groups and their environmental impacts. In lower deciles, most emissions result from the consumption of electricity and food (approx. 64%), whereas higher income earners contribute more to emissions by consuming products and services. The relative share of emissions from transportation also increases with income. Table 1 demonstrates that total emissions from fuel use for private transportation is significantly higher – 5 times greater – in households in the top decile, compared with households in the lowest decile (1074 and 186 $KgCO_2$ per person per annum respectively). Similar trends were exhibited by other studies, indicating that transportation and consumption of goods and services constitute a greater share of carbon footprints of households in developed countries, while food and home maintenance are more significant in developing countries.

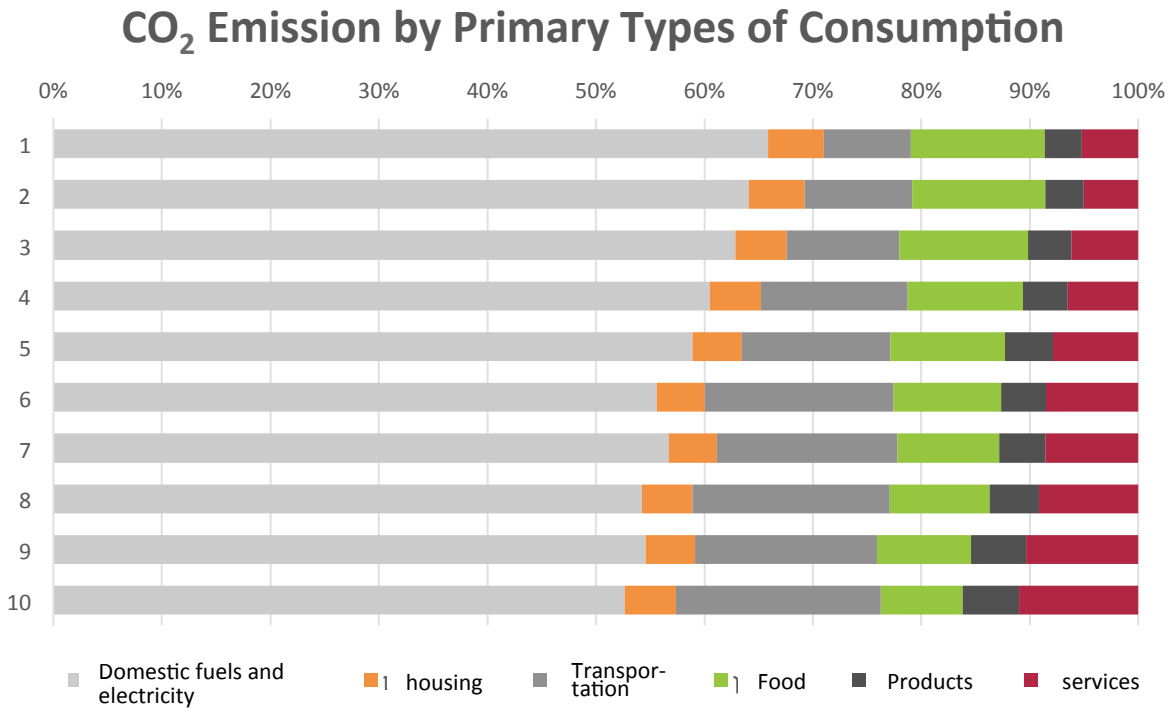

Figure 3: CO_2 Emissions, by Income Decile, Distribution by Consumer Goods and Services

Consumption Category \ Income Decile	1	2	3	4	5	6	7	8	9	10
Electricity & domestic fuels	1829.27	2010.00	2222.66	2405.33	2518.34	2521.45	2888.92	3008.70	3440.94	4101.44
Fuel for transportation	196.51	265.34	310.40	464.23	506.29	684.05	701.03	826.92	809.00	1074.79
Food, beverages and smoking	342.90	384.84	420.06	423.08	449.61	447.99	478.48	511.29	548.20	586.08
Housing	142.79	160.76	167.60	187.50	193.81	200.81	223.49	256.86	289.05	366.62
Home furnishing	21.44	25.12	43.23	48.26	40.82	36.60	51.83	70.02	78.59	108.48
Textile, clothing, shoes, leather & products	44.79	52.97	57.71	68.76	76.96	87.48	89.57	93.23	125.70	161.69
Transportation (except fuels)	27.10	46.40	55.51	72.95	80.96	105.29	147.02	181.07	245.59	396.05
Hospitality and catering services	28.14	18.74	48.69	57.14	86.82	94.62	121.45	148.81	220.61	328.40
Education, culture & entertainment	58.51	69.63	86.51	100.01	131.57	153.61	166.12	197.19	236.05	274.02
Health services	32.33	40.07	43.13	53.44	56.70	67.83	78.99	84.06	102.57	162.47
Other products	28.76	33.30	40.43	48.17	72.36	64.58	76.23	87.63	114.35	134.27
Other services	25.40	28.95	39.62	47.44	61.52	69.33	69.37	78.71	93.51	92.60
Total	2777.94	3136.11	3535.54	3976.33	4275.76	4533.64	5092.50	5544.50	6304.16	7786.91

Table 1: CO_2 Emissions ($KgCO_2$ per standard person per annum) by Consumption Categories, Distribution to Income Deciles

- Indirect emissions: emissions of low income households emanate primarily from housing and food consumption; among high income earners, a large share of emissions resulting from the consumption of services and products.

Figures 4-6 present the distribution of indirect emissions between different consumer goods and services, for the top decile, bottom decile and average household. Here too it can be discerned that in low income households most emissions result from the consumption of food and housing, whereas in households of higher socio-economic status, the contribution to emissions resulting from the consumption of services and products is higher. 64% of total emissions in households of the bottom decile result from the consumption of "basic" products such as food and housing, whereas only 36% of total emissions of households belonging to the top decile result from consuming these products, and the rest of the emissions result from the consumption of luxuries such as hospitality and catering services, private car maintenance, entertainment etc.

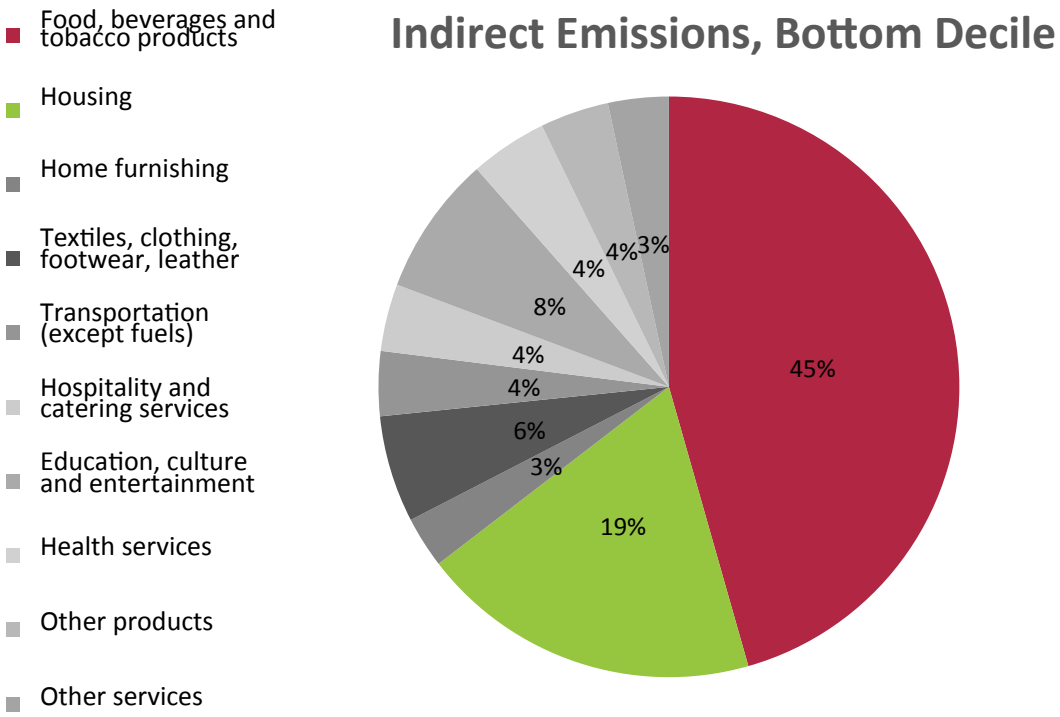

Figure 4: Indirect Emissions (excluding electricity and fuels), Bottom Decile

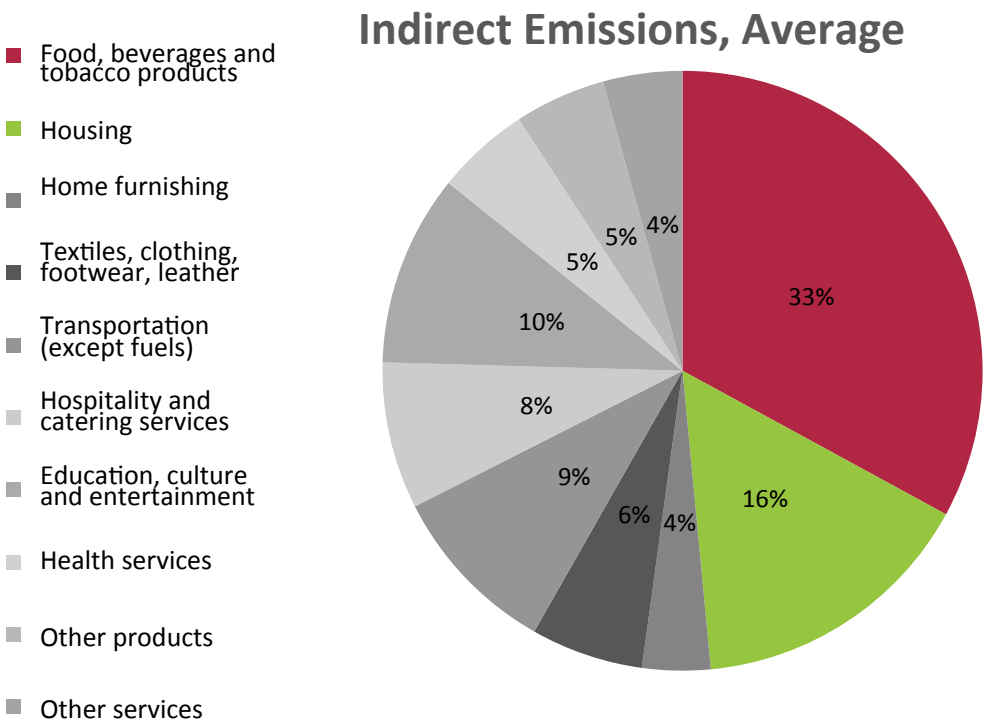

Figure 5: Indirect Emissions (excluding electricity and fuels), Average Household

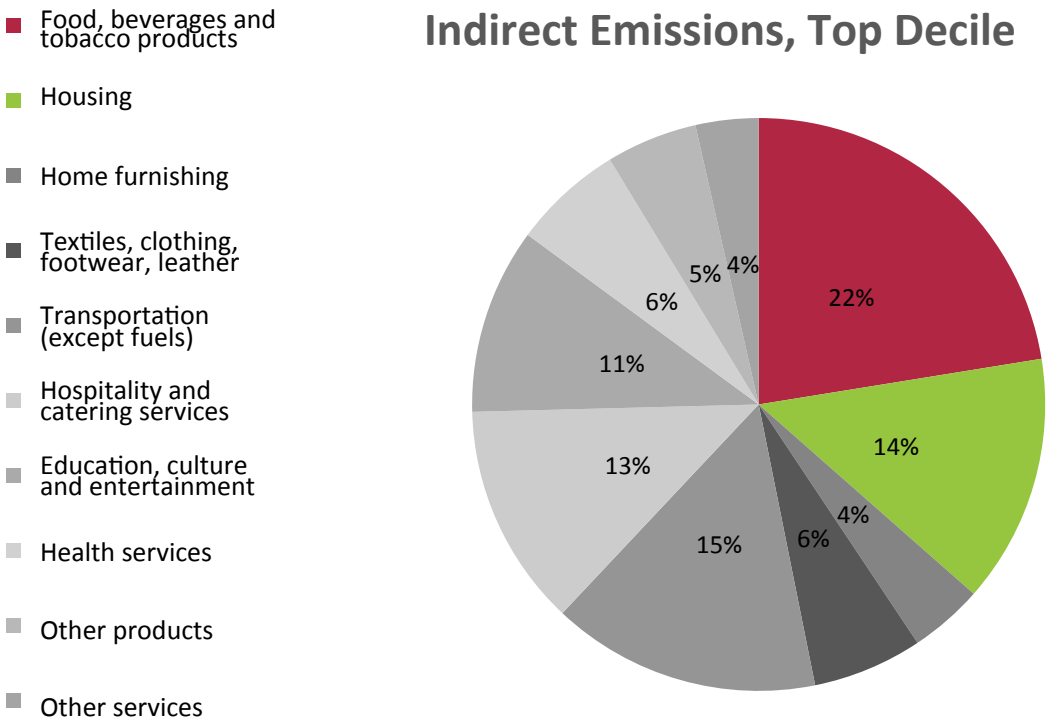

Figure 6: Indirect Emissions (excluding electricity and fuels), Top Decile

4.3. Correlation between Household Expenditure and Total CO_2 Emissions

- The flexibility of household fiscal expenditure and CO_2 emissions is smaller than 1:
  Households from a low socio-economic status consume primarily basic consumer goods that have high intensity; whereas households from a high socio-economic status consume more luxuries, of lower carbon intensity.

In order to determine the dependence between the monthly household expenditure and the quantity of emissions, the correlation between the carbon demand of household and their total expenditure can be calculated. The flexibility of expenditure compared to total emissions was calculate as follows (Lenzen, 1998; Wier et al., 2001): $\eta_{X,\varepsilon} = \frac{\partial \varepsilon / \partial X}{\varepsilon / X}$

X represents household expenditure, $\mathcal{E}$ represents total CO_2 emissions, and $\eta_{X,\varepsilon}$ is the flexibility. A flexibility of $\eta_{X,\varepsilon} = 0.9$ means that in case of a 100% increase in household expenses, total emissions would only grow by 90%. The flexibility can be calculated as regression, represented by the following equation, in which k and $\eta_{X,\varepsilon}$ are fixed numbers: $\varepsilon(\mathrm{X}) = \mathrm{k}X^{\eta_{X,\varepsilon}}$,

The regressivity results are presented in Figure 7. The flexibility of CO_2 emissions and fiscal expenditure of households is $\eta_{X,\varepsilon} = 0.74$. In other words, for a 10% increase in household expenditure, total emissions would increase by 7.4%. This outcome corroborates one of the assumptions, according to which the flexibility of CO_2 emissions and the fiscal expenditure for households is smaller than 1. This means that the consumption of goods and services by households of high expenditure causes a smaller contribution of emissions relative to their income, than the consumption of a household of low socio-economic status. This phenomenon can be explained by the composition of consumption by households in different socio-economic groups. Low socio-economic status households consume mostly "basic" consumer products, such as food and electricity, which have high energy and carbon intensity; whereas households from a high socio-economic status consume more luxury goods such as entertainment or communications, which are low carbon intensity products.

It should be noted that the model applied by this research does not differentiate between different products in any given sector, but assumes that their carbon requirements are price proportional. In other words, a fashion item costing NIS 1,000 would have a carbon demand 10 times higher than a fashion item costing NIS 100, while in practice this is not always an accurate assumption. Since households from higher socio-economic groups consume more expensive products, the flexibility might in fact be lower than presented by Figure 7.

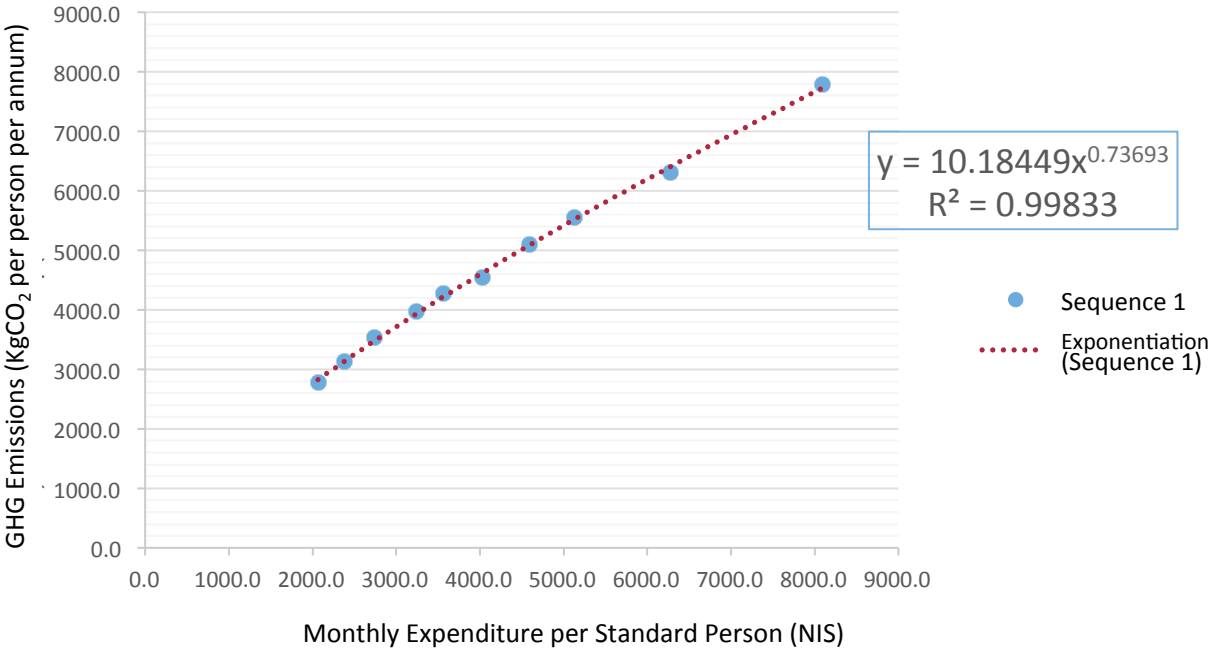

Figure 7: CO_2 Emissions as a Function of Monthly Expenditure per Standard Person

4.4. Research Limitations and Suggestions for Future Research

- The study does not differentiate between goods and services produced in Israel and those imported, and assumes that the structure of the local economy and carbon coefficients of the sectors are identical between different countries. Imports and exports are not addressed by the research due to low availability of data and difficulties in analyzing such data.
- Fuel consumption data is presently only available for 42 sectors in the Israeli economy, and valid for the year 2005. More up-to-date data and detailed differentiation into economic sectors are needed in order to examine more accurately the impacts of consumption habits on GHG emissions by households.
- The research estimates the climatic impact of domestic consumption for 2006, in accordance with availability of data. Input-output tables for Israel were produced in 1995 and 2006 only, and were not composed again in recent years. More updated data is required.
- In order to better understand the impact of lifestyle and consumption habits on total CO_2 emissions by households, the differences between socio-economic groups can be examined by other features in addition to income deciles, such as education level, household size and degree of urbanization.
- The environmental impacts of households as a result of consumption are not limited to CO_2 emissions, but include other GHGs and additional environmental damages. Future research can examine these further.

5. Summary and Conclusions

Our consumer choices influence the environment greatly. Much energy and resources are invested to enable the supply of different products and services that sustain the standard of living embraced by private consumers. In a world relying primarily on finite, non-renewable resources, the investment of energy entails heavy environmental costs, such as increasing emissions of GHGs into the atmosphere, environmental pollution and health hazards. It has become clearly evident that significant steps must be taken to minimize the environmental damage emanating from human activity. However, decision makers must attend to an additional challenge while generating changes to consumption habits, and address aspects of climate justice.

In order to evaluate the potential for mitigating emissions by changing consumption patterns, we must have a better understanding of the composition of the "consumption basket". Its composition and resulting distribution of emissions vary between different socio-demographic groups.

The research presented in this document aims to composite a socio-economic profile for CO_2 emissions from domestic consumption by households in Israel. The research focuses on ten socio-economic groups by level of household income, namely income deciles, and presents the differences between the deciles in terms of emission quantities and their composition. The selected research methodology is an Environmental Input-Output (EIO) Analysis, examining the relationship between household expenditure and direct and indirect energy consumption.

Total emissions by households, including both direct emissions from the consumption of energy products and indirect emission from the consumption of other goods and services, vary between deciles and range between 2.7 and 7.8 ton CO_2 per person per annum, and average approx. 5 ton CO_2 per person per annum. Research findings indicate substantial differences in the "emissions basket" of households in different deciles; in low income households, most emissions emanate from basic products, such as food and electricity that have a high emissions coefficient. Whereas high income households consume more products and services that might be considered luxuries, such as entertainment and education services, that have a low emissions coefficient.

This study forms a basis for the understanding of distribution of emissions between household sub-groups in Israel, and can assist in formulating policy measures to mitigate emissions while considering social issues. In another research conducted by AEJI's Climate Justice Research and Policy Project, researcher Ro'ee Levy examines possible measures for mitigating GHGs in Israel, without harming vulnerable weakened populations and deepening inequalities. In his work, Levy differentiates between behavioral means to mitigate emissions, which would lead to more sustainable consumer choices, and more "stringent" carbon pricing measures (Levy, 2013). In a recent policy document (Levy, 2015) he explores options for carbon pricing in Israel, and concludes that the most effective way would be by means of a carbon tax. However, by analyzing the composition of consumption by different socio-economic groups, it ensues that such a step would not be equitable and harm lower income population groups. Since most fiscal expenditure of households in low socio-economic groups is directed at carbon extensive products, such as home electricity and food products, levying a carbon tax on energy products would charge a relatively higher toll from these households, than from higher socio-economic consumers.

Behavioral and regulatory measures are needed to generate change in consumption habits and ensure a more sustainable lifestyle. But it should also be remembered that the extent of environmental impact varies between socio-economic groups, and policy measures must be considerate of these differences (Rabinowitz, 2012). The Government of Israel is committed to formulating an extensive national plan to mitigate its emissions, as part of the Paris Accords. In order to generate a considerable transformation of its economy, Israel must develop tools that ensure substantial mitigation targets are met, yet are considerate of climate justice aspects and minimize inequalities.

Bibliography

Cohen, C., Lenzen, M., & Schaeffer, R. (2005). Energy requirements of households in Brazil. *Energy Policy*, 33(4), 555–562. http://doi.org/10.1016/j.enpol.2003.08.021

Eggleston, H. S., Buendia, L., Miwa, K., Ngara, T., & Tanabe, K. (2006). IPCC guidelines for national greenhouse gas inventories. Institute for Global Environmental Strategies, Hayama, Japan.

Faitelson H.(2010) "Greenhouse Gases Abatement Policy Alternatives for the Israeli Economy: A General Equilibrium Analysis". Master's thesis, University of Haifa, Israel

Gay, P. W., & Proops, J. L. R. (1993). Carbon dioxide production by the UK economy: An input-output assessment. *Applied Energy*, 44(2), 113–130. http://doi.org/10.1016/0306-2619(93)90057-V

Gunter, B., & Furnham, A. (2014). *Consumer Profiles (RLE Consumer Behaviour): An Introduction to Psychographics*. Retrieved from https://books.google.com/books?hl=iw&lr=&id=60m2BQAAQBAJ&pgis=1

Herendeen, R. A., Ford, C., & Hannon, B. (1981). Energy cost of living, 1972–1973. *Energy*, 6(12), 1433–1450. http://doi.org/10.1016/0360-5442(81)90069-4

Herendeen, R., & Tanaka, J. (1976). Energy cost of living. *Energy*, 1(2), 165–178. http://doi.org/10.1016/0360-5442(76)90015-3

Hertwich, E. G., & Peters, G. P. (2009). Carbon Footprint of Nations: A Global, Trade-Linked Analysis. *Environmental Science & Technology*, 43(16), 6414–6420. http://doi.org/10.1021/es803496a

IPCC. (2014). Climate Change 2014 Synthesis Report

Lenzen, M. (1998). Energy and greenhouse gas cost of living for Australia during 1993/94. *Energy*, 23(6), 497–516. http://doi.org/10.1016/S0360-5442(98)00020-6

Lenzen, M. (1998). Primary energy and greenhouse gases embodied in Australian final consumption: an input–output analysis. *Energy Policy*, 26(6), 495–506. http://doi.org/10.1016/S0301-4215(98)00012-3

Levy, R. (2012). Social Prism Analysis of Greenhouse Gas Mitigation Policies And Recommendations for Advancing Climate Justice in Israel. *Climate Justice and Economic Policy Report No. 1*, The Association of Environmental Justice in Israel

Levy, R. (2013). Suggestions for Israel's Climate Policy – Behavioral Tools and the Possible Introduction of a Carbon Tax, *Climate Justice and Economic Policy Report No. 2*, The Association of Environmental Justice in Israel

Levy, R. (2015). Implemeting an Equitable Carbon Tax in Israel, The Association of Environmental Justice in Israel (In Hebrew, English translation to be published)

Munksgaard, J., Pedersen, K. A., & Wien, M. (2000). Impact of household consumption on CO2 emissions. *Energy Economics*, 22(4), 423–440. http://doi.org/10.1016/S0140-9883(99)00033-X

Munksgaard, J., Wier, M., Lenzen, M., & Dey, C. (2008). Using Input-Output Analysis to Measure the Environmental Pressure of Consumption at Different Spatial Levels. *Journal of Industrial Ecology*, 9(1-2), 169–185. http://doi.org/10.1162/1088198054084699

Pandey, D., Agrawal, M., & Pandey, J. S. (2011). Carbon footprint: current methods of estimation. *Environmental Monitoring and Assessment*, 178(1-4), 135–60. http://doi.org/10.1007/s10661-010-1678-y

Palatnik, Ruslana, and Mordechai Shechter. "Can climate change mitigation policy benefit the Israeli economy? A computable general equilibrium analysis." (2008).

Rabinowitz, D., Lubanov, C., (2010). Inequality in Greenhouse Gas Emissions from Domestic Electricity Consumption and Private Car Use. *Climate Justice in Israel - Position Paper no. 1*, The Association of Environmental Justice in Israel

Rabinowitz, D. (2012) Climate Injustice: CO2 from Domestic Electricity Consumption and Private Car Use by Income Decile. *ENVIRONMENTAL JUSTICE* Volume 5, Number 1

Shechter, M., Palatnik, R, Feitelson, E. (2011). Analysis of the Impacts of Economic Incentive to Mitigate GHGs in a Computable Synamic General Equilibrium Model of the Israeli Economy. Haifa University, The Natural Resources and Environmental Research Center (NRERC) (in Hebrew)

Solomon, M., Russell-Bennett, R., & Previte, J. (2012). *Consumer Behaviour*. Retrieved from https://books.google.com/books?hl=iw&lr=&id=ajDiBAAAQBAJ&pgis=1

Tukker, A., & Jansen, B. (2006). Environmental Impacts of Products: A Detailed Review of Studies. *Journal of Industrial Ecology*, 10(3), 159–182. http://doi.org/10.1162/jiec.2006.10.3.159

Vringer, K., & Blok, K. (1995). The direct and indirect energy requirements of households in the Netherlands. *Energy Policy*, 23(10), 893–910. http://doi.org/10.1016/0301-4215(95)00072-Q

Wiedmann, T., & Minx, J. (2007). A Definition of ' Carbon Footprint. *Science*, 1(01), 1–11. Retrieved from http://www.censa.org.uk/docs/ISA-UK_Report_07-01_carbon_footprint.pdf

Wier, M., Lenzen, M., Munksgaard, J., & Smed, S. (2001). Effects of Household Consumption Patterns on CO2 Requirements. *Economic Systems Research,* 13(3), 259–274. http://doi.org/10.1080/09537320120070149

Appendix

Emission Coefficients of Economic Sectors in the Israeli Economy

Economic sector	CO_2 intensity (gCO_2/NIS)
Electricity	2281.19
Water	384.98
Other mining and quarrying products	221.89
Oil refining and it byproducts, crude oil and natural gas production, and coal mining	172.81
Non-metal mineral products	163.44
Paper and cardboard and their byproducts	131.18
Chemical industry and products	103.48
Food products, beverages and tobacco industry	83.77
Agriculture	83.67
Hospitality and catering services	83.32
Plastics and rubber industries	81.47
Textiles, clothing, shoes, leather and its byproducts	67.67
Community and social organizations, and religious services	61.71
Furniture	59.49
Real estate activities	52.28
Basic metal and metal product industries	52.05
Electronic components	50.34
Cultural and sports activities and recreation	50.11
Sale, possession and mending of motorized vehicles, motorcycles and bicycles and wholesale commerce	42.84
General expenses and credit banking services	40.24
Sanitation services	40.16
Product industries not mentioned elsewhere	36.99
Welfare and aid services (not-for-profit, public and business)	35.83
Construction and civil engineering works	31.87
Electric motors and electricity distribution accessories	31.43
Transportation tools industry	31.40
Health services (not-for-profit, public and business)	31.03
Land, air and sea transportation, transportation services, storage, parking lots and cargo terminals	30.27
Education services (not-for-profit, public and business)	28.97
Communication services	28.39
Public services	27.66
Machinery and equipment, office machines and automatic data processing machines	27.56
Electronic communication equipment	23.43
Other business services	23.32
Industrial equipment for control and supervision and medical and scientific equipment	21.61
Other personal services and household services by individuals	19.38
Software and research	18.25
Mail and courier services	17.90
Rental of machinery and equipment, personal and economic goods	15.37
Banking, insurance and other financial institutions	10.66
Home ownership	2.65
Diamonds	0.00

The Association of Environmental Justice in Israel (AEJI) is a non-partisan, independent body, set up in 2009, focusing on basic issues of environmental justice. It focuses on the inter-connectedness of society, environment and the decision-making framework in Israel to produce policy recommendations that are real and acceptable while promoting the strengthening of democracy, equality and environmental justice values. It also aims to promote active deliberated civic participation especially of minorities and residents of the periphery. The Association is active in three main fields:

1. Data collection, initiation of research and working papers that attempt to elucidate the core issues of society, environment and the decision-making framework and develop acceptable solutions.
2. Development of policy tools that promote a policy based on the values of democracy, equality and environmental justice.
3. Increasing civic participation in matters of environmental justice and decision-making processes regarding environment and society, as well as empowering civil society especially among vulnerable groups such as minorities and residents of the periphery.

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