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Climate change and income inequality: An I-O analysis of the structure and intensity of the GHG emissions in Mexican households

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ABSTRACT

Household consumption is not sufficiently studied in climate change research, despite the fact that it is a variable related to GHG emissions. The objective of this paper is to assess the amount, structure, and intensity of total GHG emissions (direct and indirect) related to Mexican household consumption by income level by means of an Input-Output analysis. Our study produced the following three main findings: 1) Large carbon inequality among household income groups, with the bottom household decile emitting 2.7% of the total CO_2e emissions, and the top decile emitting 26.8%. 2) Three needs are the main drivers of carbon emissions of Mexican households: transportation (39.9%), dwelling energy consumption (26.9%), and food (15.2%). The share of transportation (public and private) is higher when the households are in higher deciles (24% in the bottom decile vs 40% in the top decile). Private transportation in the top decile is of particular concern. The CO_2e emissions from private transport from the richest decile represent more than 10% of the total CO_2e emissions. 3) The total carbon intensity of the household expenditure is depicted in an obtuse inverted U curve as a function of income distribution. The top and the bottom deciles present the lowest carbon intensities because of the composition of their basket of consumer goods and services. In the top decile, there is a significant share of expenditure on financial and educational services (with low carbon intensity), while in the bottom decile there is a high proportion of low-carbon basic products such as food. From all these results, we concluded that, in order to be effective and sustainable from a social and economic point of view, the formulation of policy to mitigate GHG must take into account both household income inequality and the diverse quantity and structure of consumption as a function of income level.

Introduction

Energy is necessary to meet the people's needs to carry out their daily social and economic activities, but social energy demand is not neutral, and it has effects on climate change (Aall & Hille, 2010; Dubois & Ceron, 2015; Mundaca et al., 2019; Santillán, 2018). Although energy is strongly associated with climate change[1] and is widely studied in climate change research, analysis reveals that social demand for energy and household energy consumption have not been adequately studied. A series of figures illustrate the imbalance. Between 1990 and 2019, some topics related to energy and climate change and the number of published papers on these topics (in parentheses) in the Web of Science Core Collection were as follows: technology (7259), energy supply (4413), prices (2385), household energy consumption (736), social energy demand (610), and household carbon emissions (385).

A better understanding of household energy consumption and household carbon emissions might prove instrumental to addressing the challenging and complex climate problem (Dubois et al., 2019; Ivanova et al., 2016; Shwom & Lorenzen, 2012; Zhang et al., 2015). From a comprehensive approach, household energy consumption is related to both direct energy (i.e., electricity, gas, gasoline, etc.) and indirect energy (i.e., energy used to produce goods and services). Thus, household energy consumption is related to two types of emissions: 1) direct GHG emissions, which are derived from direct energy consumption; and 2) indirect GHG emissions, which are embodied in final goods and services that generated emissions during their production. Given that household energy consumption is not homogenous, it is necessary to identify the diversity of energy consumption patterns and its link to the GHG emissions.

Some research —using top-down or bottom-up methodologies— has studied the various responsibilities among households or individuals as drivers of climate change by estimating how much total energy (direct and indirect) or total GHG emissions (direct and indirect) are related

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[1] According to the IEA (2019), 74% of the greenhouse gas (GHG) emissions were related to energy at the global level in 2015 (energy includes IPCC categories *Fuel combustion* (1A) and *Fugitive emissions from fuels* (1B)). Energy includes the chain of activities beginning with extraction and ending with final consumption.

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to household consumption. On the one hand, top-down studies have generally analyzed total energy consumption or total GHG emissions at the international level[2] using data from consumption-based emission inventories[3] and assuming a GHG emission-expenditure elasticity value of 1 or nearly 1 (Chancel & Piketty, 2015; EcoEquity; Stockholm Environment Institute, 2015; OXFAM, 2015; Santillán & de la Vega, 2019). On the other hand, bottom-up studies assessing total energy consumption or total GHG emissions have analyzed different countries at different stages of development. For developed countries, where it is more probable that lifecycle data for products are available, some research has used this data to assess total energy or total emissions related to household consumption (Boucher, 2016; Green & Knittel, 2020; Reinders et al., 2003; Ummel, 2014; Weber & Matthews, 2008). Less data-intensive methods—generally applied for developing countries—rely on input-output (IO) analysis to identify the total energy or total emissions embodied in a monetary unit of production for each economic sector. Then, total energy or total emissions are assigned to household consumption based on data for household expenditure (Cohen et al., 2005; Fan et al., 2020; Gao et al., 2020; Golley & Meng, 2012; Lenglart et al., 2010; Lenzen, 1998; Liu et al., 2019; Pachauri, 2004; Parikh et al., 2009; Park & Heo, 2007; Salgueiro Perobelli et al., 2015; Shigetomi et al., 2020; Tomás et al., 2020; Zhong et al., 2020).

Both top-down and bottom-up studies (referred to in the previous paragraph) have suggested that the varying impacts of households or individuals on climate change could be dependent, among other things, on the income level of the different socioeconomic groups. These studies have found that rich people consume significantly more total energy, and generate more total GHG emissions, than poor people do. Income inequality is correlated with carbon inequality because of household consumption patterns. While both top-down and bottom-up methodologies can assess emissions by income level, only bottom-up methodologies can incorporate consumption structure and carbon intensity of consumption to obtain more accurate and detailed results.

In the case of Mexico, there is research on the direct energy consumption of households as a function of income level. Several authors have studied the nexus between income inequality and climate change by analyzing household energy expenditure, direct household energy consumption, and/or direct household carbon emissions by income group (Chapa & Ortega, 2017; Cruz Islas, 2012; Cruz Islas, 2016; Franco & Velázquez, 2017; Jiménez & Yépez-García, 2016; Jiménez & Yépez-García, 2017; Navarro, 2014; Pérez Peña, 2017; Rodríguez Oreggia & Yépez García, 2014; Rosas Flores, 2011; Rosas Flores et al., 2010; Sánchez Peña, 2012a; Sánchez Peña, 2012b; Sánchez Peña & Escoto Castillo, 2018). What these studies suggest is that, for households, increased income is associated with higher levels of one or more of the following: energy expenditure, direct energy consumption, and direct carbon emissions. Although some of these studies also identify the household income level-climate change correlation as positive but decreasing, and indicate that other variables also influence climate change (e.g., energy prices, sociodemographic aspects, the efficiency of the appliances), income level has been determined to play a significant role.

Regarding indirect energy consumption or indirect GHG emissions of Mexican households, to the best of our knowledge, only Santillán and de la Vega (2019) have analyzed these factors. They estimated the total CO_2 emissions (direct and indirect) of Mexican households by income level from 1990 to 2014 by means of an expenditure-CO_2 emissions elasticity model (i.e., a top-down approach). They found a high degree of carbon inequality during the period studied. For example, in 2014 the poorest decile (i.e. 1st decile) emitted 3.8% of the total CO_2, while the richest decile (i.e. 10th decile) emitted 26.4%. Even though the authors assessed the amount of total CO_2 emissions by income level, they did not include the varying structure of Mexican household consumption nor its carbon intensity because of the limited scope of the elasticity model that they used – a limitation that the authors themselves were quick to point out. This shortcoming restricts the possibilities for identifying specific products or consumer needs with high mitigation potential from a demand-side perspective.

There is thus clearly a gap in knowledge of the specific consumption aspects by income group – information that could prove useful for mitigating GHG emissions for the case of Mexico. The present paper addresses this gap by assessing the amount of total CO_2 emissions related to Mexican household consumption by income level. We do this by identifying households' GHG emissions structure and their GHG emissions intensity, utilizing for this purpose a bottom-up methodology based on input-output analysis. Although similar methodologies have been used for other nations,[4] applying it to the case of Mexico represents an original contribution capable of providing timely information on the GHG emission structure and intensity as a function of final products, consumer needs, and household income groups. In order to accomplish this, the remainder of this paper is organized as follows. The Methodology and data section presents the methodology applied, specifying the calculation model and data used. The Results and discussion section shows the main results and discussion. Finally, we present our conclusions in the Conclusion section.

Methodology and data

We applied an IO analysis—a bottom-up approach—to assess the amount, structure, and intensity of total GHG emissions (direct and indirect) of Mexican households by income level. First, we established the reference year, based on data availability. Then, we followed the model applied by Golley and Meng (2012) and adapted it to the available Mexican data for the purpose of estimating direct and indirect CO_2e emissions.

Reference year and data

Four types of data are necessary for this kind of analysis: household income-expenditure, IO matrix, GHG emissions inventory, and energy prices. For Mexico, all of these data are available for the year 2012, so this year was established as the reference year. We used the four databases listed below as follows.

1) The 2012 "Household Income and Expenditure Survey" (Encuesta Nacional de Ingresos y Gastos de los Hogares, ENIGH) conducted by the National Institute of Statistics and Geography (Instituto Nacional de Estadística y Geografía, INEGI). The ENIGH reports quarterly income and expenditure data of Mexican households in nominal Mexican pesos. The sampling scheme used by the ENIGH is probabilistic, stratified, two-stage and clustered, where the last selection unit is the housing unit and the observation unit is the household. Consequently, the results of the survey can be generalized to the entire population (INEGI, 2013). Given that the analysis of this paper is based on annual data, we assumed that the quarterly data reported in the ENIGH were the same for all quarters for the purpose of deriving annual data as regards household income and

[2] Top-down methodologies can also be used at the national levels, especially when there is no enough information to make a bottom-up analysis.

[3] Consumption-based emission inventories take into account emissions directly derived from energy consumption (direct emissions) and emissions embodied in the domestic demand for final goods and services of a country (indirect emissions). For estimates and discussions on consumption-based emission inventories, see, for example, Davis and Caldeira (2010), Le Quéré et al. (2016), Munksgaard, Minx, Christoffersen, and Pade (2009), Stadler et al. (2015), Supasa et al. (2017), Wiebe and Yamano (2016), Wiedmann (2009), and Wiedmann et al. (2007).

[4] Australia (Lenzen, 1998), Brazil (Cohen et al., 2005; Salgueiro Perobelli et al., 2015), China (Fan et al., 2020; Gao et al., 2020; Golley & Meng, 2012; Liu et al., 2019), Francia (Lenglart et al., 2010), India (Pachauri, 2004; Parikh et al., 2009), Japan (Shigetomi et al., 2020), Latin America (Zhong et al., 2020), Republic of Korea (Park & Heo, 2007), and Spain (Tomás et al., 2020).

expenditure.[5] We classified households by income level in ten groups (deciles) according to total income, and we computed disaggregate total expenditure (762 expenditure types) for each decile from ENIGH microdata using Stata software. We conducted a survey analysis using Stata software, which allows specification of the survey design characteristics such as a weighting factor.[6]

2) The 2012 Input-Output Matrix (IOM) from the National Accounts System, which provides data regarding Mexican economic activity by sectors, subsectors, and industry groups using the 2007 North American Industry Classification System (NAICS) and product-by-product tables[7] (INEGI, 2014). For the purposes of this paper, we used the 2012 IOM by subsectors, a 79 × 79 matrix.
3) The National Greenhouse Gas Emissions Inventory (Inventario Nacional de Emisiones de Gases y Compuestos de Efecto Invernadero, INEGyCEI), which reports GHG emissions using the IPCC classification (INECC-SEMARNAT, 2018). For the purposes of this paper, we obtained data for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions from fossil fuel combustion (1A category of the IPCC classification), which amounted to 447.62 MtCO_2e in 2012.
4) Energy Information System (Sistema de Información Energética, SIE), which aggregates official reports of energy data (SIE, 2020). For the purposes of this paper, we mainly used data on energy prices.

Total (direct + indirect) GHG emissions calculation model

Following Golley and Meng (2012) with a few adaptations,[8] total CO_2e emissions from household income decile k (TC_k) are calculated as follows:

$$TC_k = DC_k + IC_k \tag{1}$$

where,

DC_k = direct CO_2e emissions from household income decile k
IC_k = indirect CO_2e emissions from household income decile k.

Direct CO_2e emissions from household income decile k (DC_k) are calculated as follows:

$$DC_k = \sum_{i=1}^{n} f_i DE_{ik} \tag{2}$$

where,

DE_{ik} = direct consumption of energy i from household income decile k
f_i = emission factor for energy type i
n = number of energy type i.

Indirect CO_2e emissions from household income decile k (IC_k) are calculated as follows:

$$IC_k = I^{C\prime} y_k \tag{3}$$

where,

I^C = vector of indirect CO_2e emission intensities per unit of production in each economic subsector t
y_k = vector of expenditure of household income decile k in each economic subsector t.

The vector of indirect CO_2e emission intensities in each subsector t (I^C) is obtained from I-O analysis via the following formula:

$$I^C = D^C (I - A)^{-1} \tag{4}$$

where,

D^C = vector of direct CO_2e emission intensities in each subsector t[9]
A = inter-industry matrix of direct input coefficients
$(I - A)^{-1}$ = Leontief inverse matrix.

Using the Leontief inverse matrix allows us to estimate all the emissions embodied in the final goods and services. The resulting I^C reflects CO_2e emitted during the production of goods and services as well as CO_2e emitted during the production of intermediate inputs that were used in the production of goods and services, and the CO_2e emitted in the intermediate inputs of those intermediate inputs, and so on.

Applying the model to the Mexican case

Direct CO_2e emissions

Estimates of direct household CO_2 emissions by income level are often used in climate change research. For the case of Mexico, for example, Cruz Islas (2016) and Rosas Flores et al. (2010) applied this methodology. We estimated Mexican direct household emissions by income level in 2012, improving upon previous estimations in three ways: 1) estimating emissions from energy used at the dwelling and for transport instead of only the former; 2) using all energy price data instead of an average energy price; 3) considering GHG emissions (CO_2, CH_4 and N_2O) instead of only CO_2.

Estimating direct household CO_2e emissions by income level requires data for direct household energy consumption and emission factors for each energy type used. Given that there is no official disaggregated information on household energy consumption in Mexico, we calculated it based on energy expenditure reported in ENIGH (2013) and the energy prices reported in SIE (2020). Regarding energy expenditure, we considered four energy types used at the dwelling (electricity, L.P. gas, natural gas, and kerosene)[10] and three energy types used for transport (Magna gasoline, Premium gasoline, and diesel).[11] As regards prices, we considered several prices for electricity and natural gas and a single price for the rest of the energy types.[12] We allocated the electricity tariffs to each household based on its municipal location (CFE, 2018), and we assumed that if a household exceeded the maximum consumption limit, it paid the DAC (*Doméstica de Alto Consumo*) tariff.[13] We allocated natural gas prices to each household based on average prices by region. Once we had estimated the household energy consumption by energy type and by

[5] The 1984 ENIGH is the only one to have obtained data for all four quarters of the year (Cortés, 2012). The subsequent ENIGHs have only pertained to the third quarter because it is considered the most stable. Given the lack of annual information from the 2012 ENIGH, the most logical option was assuming equal household income and expenditure for all quarters of 2012.

[6] The ENIGH reports the "factor" variable, which is the weighting factor that denotes the inverse of the probability that the observation is included because of the sampling design.

[7] There are not industry-by-industry tables for the 2012 IOM because it is updated from the 2008 IOM.

[8] Golley and Meng (2012) estimated CO_2 emissions per capita by household income level. In contrast, we estimated GHG emissions (CO_2e) per household by income level.

[9] Direct CO_2e emissions intensity of productive subsectors is the ratio of direct CO_2e emissions to the production value for each subsector.

[10] We excluded biomass because the biomass expenditure reported in the ENIGH is not a good indicator of biomass consumption, due to the fact that a lot of households that use biomass recollect it, and therefore do not report any biomass expenditure.

[11] Given that the ENIGH reported diesel and gas expenditure as a single category and gas consumption in transport is marginal, we assumed that all the expenditure reported in this category referred to diesel.

[12] There were several prices for electricity, natural gas, and L.P. gas, but only the prices of electricity and natural gas had a high dispersion. For that reason, we considered the national average price of L.P. gas. There were single prices for Magna gasoline, Premium gasoline, and diesel. There was no data for kerosene prices (we estimated kerosene consumption by income level through the proportions of kerosene expenditure by income level reported in the ENIGH and the residential kerosene consumption reported in the SIE).

[13] The DAC tariff is applied to households with high electricity consumption and is not subsidized by the Mexican government.

income level, we converted energy consumption in CO_2e emissions based on the emission factors for each energy type[14] using Eq. (2). Table 4 in Appendix A shows the data used to arrive at this estimate.

Indirect CO_2e emissions

Estimating indirect household CO_2e emissions as a function of income level is not common and, to the best of our knowledge, this is the first estimation for Mexican households. We estimated the indirect household CO_2e emissions as a function of income level by associating economic subsectors of ENIGH (2014), emission subsectors of INECC-SEMARNAT (2018), and expenditures of ENIGH (2013) (see Table 5 in Appendix A) in order to obtain the three vectors required to follow the IO model previously presented. We obtained the vector of direct CO_2e emission intensities through the ratio CO_2e emissions by economic production in each economic subsector, which is expressed in tons of CO_2e per million Mexican pesos (tCO_2e/MM$). We obtained the vector of indirect CO_2e emission intensities through Eq. (4). We obtained the vector of household *k*'s expenditure in each economic subsector by classifying each household expenditure according to economic subsector. Then, based on these estimates, we calculated indirect household CO_2e emissions by income level using Eq. (3).

Results and discussion

In this section, we first show the vectors obtained (D^C, I^C, y). Secondly, we present the estimates of total CO_2e emissions by household income deciles, their structure, and the carbon intensity of the expenditure. Detailed estimates of direct CO_2e emissions by energy type and indirect CO_2e emissions by productive subsector can be consulted in Tables 6 and 7 of Appendix A of this paper.

Table 1 displays the vectors of direct and indirect CO_2e intensities (vectors D^C and I^C, respectively) of every economic subsector and the vector of total household expenditure in each subsector (vector y). Indirect CO_2e intensities are higher than direct CO_2e intensities in all economic subsectors. Subsector 221 (Electric power generation, transmission, and distribution) shows high carbon intensities because the electric sector in Mexico is widely based on fossil fuels. Among the 10 subsectors with the highest CO_2e intensities, 324 (Petroleum and coal products manufacturing) and 485 (Transit and ground passenger transportation) register high household expenditure.

Total GHG emissions related to Mexican household consumption in 2012 accounted for 199.3 MtCO_2e, which represent 45% of the CO_2e emissions from fossil fuel combustion reported by INECC-SEMARNAT (2018). While this figure could be an underestimate because it is based on the sub-reported expenditure data of the ENIGH,[15] it offers a reasonable way to analyze the structure of household carbon emissions. In fact, the ENIGH is the only Mexican database that offers a way to analyze household characteristics by income level. Total CO_2e emissions by decile show a consistent positive correlation with income level, which suggests a direct relationship between income and carbon through household expenditure. The Gini Index for total CO_2e emissions is 0.36. Although this index does not seem high, it is necessary to analyze carbon inequality carefully because the Gini Index does not capture well what happens at the extremes of the distribution. In fact, we found that there was a marked carbon inequality. There are contrasting results between the top and the bottom household income deciles, both in absolute terms and in relative terms (i.e., per household and per capita,[16] see Table 2). The first decile (the poorest) emits 2.7% of total CO_2e emissions, while the tenth decile (the richest) emits 26.8% of total CO_2e emissions. Moreover, the carbon level associated with the consumption of the top decile is by far the largest among all deciles. The average total emissions per household in the top decile (16.9 tCO_2e) is 1.7 times that in the ninth decile (10.5 tCO_2e) and 9.9 times of that in the first decile (1.7 tCO_2e). The average total emissions per capita in the top decile (4.3 tCO_2e) is 1.7 times that of the ninth decile (2.5 tCO_2e) and 7.2 times that of the first decile (0.6 tCO_2e).

Regarding the structure of CO_2e emissions, 57% of the total CO_2e emissions are indirect and 43% are direct. The share of indirect CO_2e emissions is greater in low-income households (Table 2). This situation could be the result of the important share of direct CO_2e emissions derived from gasoline consumption in high-income households, which we will discuss later.

In order to obtain a fuller picture of the structure of total CO_2e emissions, we classified them according to need. The “Total” bar of Fig. 1 shows that the main drivers of carbon emissions from the demand side are three specific needs: transportation[17] (39.9%), dwelling energy consumption[18] (26.9%), and food[19] (15.2%). The rest of the bars of Fig. 1 show the structure of total CO_2e emissions by income level. These bars show that the share of carbon related to “transportation” is greater in higher deciles than in lower deciles, while the share of carbon related to “dwelling energy consumption” and “food” steadily decrease lower to higher deciles. The share of the “Other” category is relatively stable until the ninth decile (16% average), and it reaches 23% of total CO_2e emissions in the tenth decile. The lines of Fig. 1 show total CO_2e emissions in absolute terms (right axis) by household income deciles according to need. These lines show a direct relationship in all categories between income level and CO_2e emissions, with a concave upward curve (i.e., household CO_2e emissions increase more quickly when household income is higher, a consequence of increasing expenditure levels). The change in the slope is more evident when moving from the ninth to the tenth decile as a result of a dramatic increase in expenditure.

In order to facilitate a deeper comprehension of total CO_2e emissions composition, Table 3 shows how much carbon was related to specific “satisfiers” (i.e., goods and services for meeting needs) by household income decile. It should be noted that these data include both direct and indirect emissions. The former is derived from direct energy consumption and the later from the emissions embodied in goods and services. In the transportation category, the significance of private transport is evident because of the high amounts of CO_2e emissions derived from gasoline and car purchases, mainly in households with high incomes. In fact, around 40% of CO_2e emissions derived from private transport are allocated to the tenth decile (20.1 MtCO_2e), and these CO_2e

[14] For electricity, we estimated the grid emission factor by dividing CO_2e emissions of electricity generation (INECC-SEMARNAT, 2018) by electricity production (SIE, 2020). For the rest of the energy types, we used the emission factors utilized in INECC-SEMARNAT (2018).

[15] There are large discrepancies between the ENIGH data (INEGI, 2013) and the national accounts data (INEGI, 2014). On the one hand, there is a truncation in both tails of the distribution due to deficiencies in the sample design and the implementation of the ENIGH (i.e., neither the poorest nor the richest households are reported in the surveys). On the other hand, respondents tend to declare, voluntarily or involuntarily, lower income than actually received. Both events are more accentuated in households with higher income. This is a longstanding problem that has been widely studied in inequality and poverty research (Cortés, 2001; Cortés & Vargas, 2017; Damián, 2007; Leyva Parra, 2004; Villatoro, 2015). Income and expenditure are underreported in the ENIGH (INEGI, 2013), and there is no consensus on the way to correct them.

[16] Per household and per capita CO_2e emissions were estimated based on the data on the number of households and members per household from the ENIGH. In the case of Mexico, the population share in each household decile is not very contrasting.

[17] It includes direct CO_2 emissions from gasoline (Magna and Premium) and diesel consumption as well as indirect CO_2 emissions from the consumption of goods and services produced by the following economic subsectors: 324-Petroleum and coal products manufacturing (only the share of transport fuels), 336-Transportation equipment manufacturing, 481-Air transportation, 482-Rail transportation, 483-Water transportation, 484-Truck transportation, and 485-Transit and ground passenger transportation.

[18] It includes direct CO_2 emissions from electricity, gas (L.P. and natural), and kerosene, as well as indirect CO_2 emissions from consumption of goods and services produced by the following economic subsectors: 221-Electric power generation, transmission, and distribution, 222-Natural gas and water distribution (only the share contributed by natural gas), and 324-Petroleum and coal products manufacturing (only the share contributed by gas L.P. and kerosene).

[19] It includes indirect CO_2 emissions from consumption of goods and services produced by the following economic subsectors: 111-Crop production, 112-Animal production and aquaculture, 114-Fishing, hunting, and trapping, 311-Food manufacturing, 312-Beverage and tobacco product manufacturing, and 722-Food and drinking services.

Table 1
Direct and indirect CO_2e intensities and total household expenditure by economic subsector in Mexico 2012.

Subsector (NAICS code[a])	CO_2e intensities (tCO_2e/MM$)		Total annual household expenditure (MM$) ($y^k$)	Subsector (NAICS code[a])	CO_2e intensities (tCO_2e/MM$)		Total annual household expenditure (MM$) ($y^k$)
	Direct (D^C)	Indirect (I^C)			Direct (D^C)	Indirect (I^C)	
111-Crop Production	18.22	31.12	151,777.92	486-Pipeline Transp.	0.00	42.57	0.00
112-Animal Production	0.00	15.09	36,926.50	487-Sightseeing Transp.	128.58	147.51	0.00
113-Forestry	18.22	25.33	2332.98	488-Support for Transp.	0.00	11.28	2476.20
114-Fishing	18.22	42.01	15,704.45	491-Postal Service	0.00	9.96	0.00
115-Support activities for agric. & forestry	18.22	33.79	0.00	492-Couriers	0.00	23.06	201.51
211-Oil & gas	0.00	3.54	0.00	493-Storage	0.00	24.45	0.00
212-Mining	37.15	55.18	0.00	511-Publishing Ind.	0.00	8.91	11,995.87
213-Support activities for mining	0.00	15.53	0.00	512-Motion Picture and Sound Industries	0.00	20.95	19,601.69
221[b]-Electric power	374.53	403.14	71,298.12	515-Broadcasting	0.00	13.64	0.00
222-Gas & water distrib.	0.00	11.09	40,748.28	517-Telecommunications	0.00	12.14	174,657.27
236-Construction	0.00	15.39	20,327.48	518-Data Processing & Hosting Serv.	0.00	8.95	0.00
237-Civil Engineering	0.00	17.64	0.00	519-Other Inform. Serv	0.00	8.97	0.00
238-Specialty Contractors	0.00	14.32	0.00	521-Central Bank	0.00	4.11	0.00
311-Food Manuf.	1.29	20.81	653,565.41	522-Credit Intermediation	0.00	7.75	420,277.48
312-Beverage & Tobacco	1.29	22.16	98,770.14	523-Financial Activities	0.00	8.62	4304.16
313-Textile Mills	0.00	35.88	155.42	524-Insurance Carriers	0.00	5.87	26,049.79
314-Textile Product Mills	0.00	23.22	7423.87	531-Real Estate	0.00	5.07	159,429.58
315-Apparel Manuf.	0.00	19.38	138,797.88	532-Rental & Leasing Serv.	0.00	14.04	0.00
316-Leather Manuf.	0.00	18.90	71,610.19	533-Lessors of Nonfinancial Intangible Assets	0.00	3.34	0.00
321-Wood Product Manuf.	0.00	26.58	0.00	541-Professional Serv.	0.00	6.92	6219.33
322-Paper Manuf.	9.87	47.93	53,605.43	551-Mgmt. of Compan.	0.00	2.83	0.00
323-Printing	9.87	36.45	25,762.63	561-Administrative Serv.	0.00	5.46	18,351.98
324-Petroleum & Coal Prod.	39.82	65.44	220,197.18	562-Waste Management	0.00	11.35	0.00
325-Chemical Manuf.	13.20	33.90	241,117.23	611-Educational Serv.	0.00	8.17	274,151.00
326-Plastics and Rubber Manuf.	10.33	41.34	9669.66	621-Ambulatory Health Care Serv.	0.00	12.22	55,563.34
327-Nonmetallic Manuf.	10.33	40.54	26,321.66	622-Hospitals	0.00	17.47	42,379.14
331-Primary Metal Manuf.	9.33	48.99	0.00	623-Care Facilities	0.00	20.00	0.00
332-Fabricated Metal Prod.	10.33	43.49	2359.82	624-Social Assistance	0.00	34.71	3877.93
333-Machinery Manuf.	0.00	27.70	5387.99	711-Performing Arts, Sports	0.00	3.72	7925.68
334-Comp. & Electronic	10.33	48.08	35,353.65	712-Museums and Similar	0.00	14.95	0.00
335-Electrical Equipment	10.33	43.77	27,007.32	713-Amusement, Gambling, and Recreation	0.00	19.67	13,518.47
336-Transp. Equipm. Manuf.	1.94	29.56	75,071.30	721-Accommodation	0.00	23.63	27,129.19
337-Furniture Manuf.	10.33	31.89	14,662.40	722-Food & Drinking Serv.	0.00	18.50	463,727.80
339-Miscellaneous Manuf.	10.33	38.42	24,971.40	811-Repair & Maintenance	0.00	17.47	22,990.06
431-Trade	1.66	11.87	0.00	812-Personal Serv.	0.00	14.60	45,361.46
481-Air Transp.	60.50	94.78	14,294.46	813-Religious, Grantmaking, Civic, Professional Organiz.	0.00	14.83	9053.81
482-Rail Transp.	44.90	62.50	28.10	814-Private Households	0.00	0.00	44,551.34
483-Water Transp.	144.69	155.38	4628.01	931-Executive, Legislative, & Government Support	0.00	15.04	7204.13
484-Truck Transp.	128.58	145.62	308.24	932-Internat. organizations	0.00	56.88	0.00
485-Ground Passeng. Transp	128.58	154.25	172,882.69				

[a] For details on NAICS codes, visit https://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007.
[b] Direct and indirect CO_2e intensities of subsector 221 are only reported for informational purposes. Given that we previously estimated direct CO_2e emissions from electricity consumption, we considered the indirect CO_2e intensity of this subsector to be the difference between indirect and direct CO_2e intensities (28.61 tCO_2e/MM$).

emissions represent more than 10% of the total CO_2e emissions associated with the consumption of all households. In the dwelling energy consumption category, CO_2e emissions related to electricity and L.P. gas are more abundant than those related to other energy types. In the food category, CO_2e emissions related to the food produced by industry are the highest. CO_2e emissions related to both dwelling energy

Table 2
Total CO_2e emissions by household income deciles in Mexico 2012.

Household income deciles	Population share (%)	Total expenditure (MM$)	Total CO_2e emissions ($MtCO_2$)	Share in total CO_2e emissions (%)	Total CO_2e emissions per household (tCO_2)	Total CO_2e emissions per capita (tCO_2)	Share of direct CO_2e emissions (%)	Share of indirect CO_2e emissions (%)	Total CO_2e emissions intensity (tCO_2/MM$)	Total CO_2e emissions elasticity
1st	7.8	136,521	5.4	2.7	1.7	0.6	36.9	63.1	39.45	
2nd	8.9	190,064	8.3	4.2	2.6	0.8	39.0	61.0	43.67	1.30
3rd	9.3	229,422	10.3	5.2	3.3	0.9	39.5	60.5	44.73	1.13
4th	9.8	275,358	12.2	6.1	3.9	1.1	39.9	60.1	44.18	0.93
5th	10.3	317,979	14.3	7.2	4.5	1.2	38.6	61.4	44.97	1.12
6th	10.5	376,955	17.3	8.7	5.5	1.4	42.1	57.9	45.77	1.10
7th	10.5	448,736	20.2	10.1	6.4	1.6	41.8	58.2	44.93	0.89
8th	11.1	551,047	24.9	12.5	7.9	1.9	44.2	55.8	45.19	1.03
9th	11.1	770,450	33.2	16.6	10.5	2.5	45.2	54.8	43.05	0.86
10th	10.6	1,552,660	53.4	26.8	16.9	4.3	45.5	54.5	34.37	0.69
Sum/average*	**100**	**4,849,193**	**199.3**	**100.0**	**6.3***	**1.7***	**43.0***	**57.0***	**41.09***	**1.01***

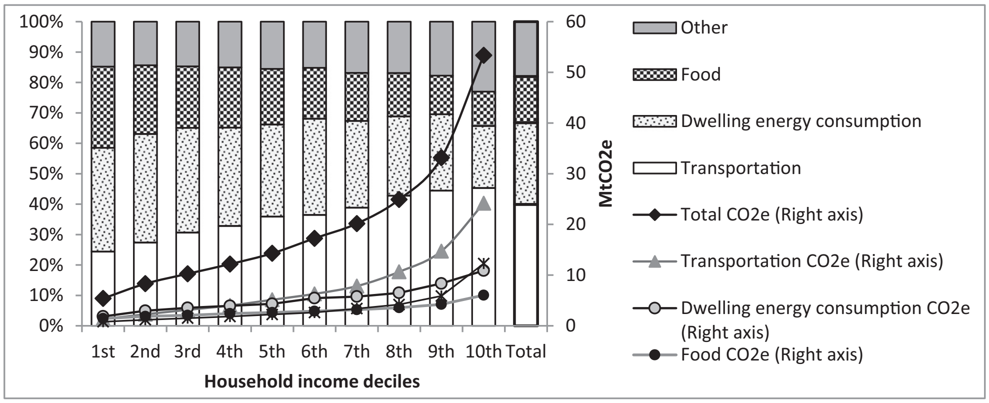

Fig. 1. Total CO_2e emissions structure by household income deciles according to needs in Mexico 2012. The bars show proportions on the left axis. The lines with markers show $MtCO_2e$ from each decile on the right axis.

Table 3
Total CO_2e emissions structure by household income decile, classified by specific satisfiers, Mexico 2012 ($MtCO_2$).

	Household income deciles	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total
Transportation	Magna gasoline	0.38	0.72	1.03	1.64	2.08	2.78	4.03	6.17	8.77	15.61	43.23
	Premium gasoline	0.04	0.03	0.11	0.06	0.04	0.23	0.16	0.36	0.85	3.24	5.12
	Cars	0.00	0.01	0.02	0.02	0.04	0.05	0.04	0.18	0.62	1.23	2.22
	Ground passenger transportation	0.83	1.46	1.87	2.22	2.87	3.18	3.53	3.75	4.23	2.73	26.67
	Air transportation	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.04	0.14	1.12	1.35
	Others	0.06	0.05	0.11	0.05	0.09	0.04	0.05	0.14	0.11	0.25	0.95
Dwelling energy	Electricity	1.20	1.82	2.05	2.28	2.51	3.36	3.26	3.94	5.04	6.31	31.78
	L.P. gas	0.63	1.10	1.40	1.51	1.70	1.89	2.22	2.16	2.71	3.33	18.65
	Natural gas	0.01	0.03	0.07	0.12	0.12	0.20	0.26	0.37	0.58	1.24	3.00
	Kerosene	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.09
Food	Food, beverage and tobacco from industry	0.73	1.02	1.15	1.35	1.46	1.57	1.72	1.88	2.09	2.81	15.79
	Food and beverage outside the home	0.25	0.36	0.40	0.54	0.61	0.75	0.86	1.07	1.41	2.34	8.58
	Farm products	0.39	0.41	0.44	0.43	0.45	0.45	0.48	0.48	0.55	0.65	4.72
	Food from other primary sectors	0.07	0.09	0.09	0.10	0.10	0.13	0.12	0.14	0.16	0.23	1.22
Other	Cleaning, personal care and medicine items (325)	0.30	0.42	0.51	0.57	0.64	0.73	0.87	0.99	1.20	1.95	8.17
	Credit and financial services (522)	0.01	0.03	0.04	0.05	0.08	0.12	0.18	0.26	0.51	1.98	3.26
	Clothing (315)	0.07	0.10	0.13	0.15	0.18	0.22	0.25	0.34	0.43	0.83	2.69
	Napkins, paper and sanitary napkins, diapers (322)	0.10	0.16	0.19	0.22	0.23	0.26	0.27	0.34	0.38	0.42	2.57
	Telephone, internet, TV services (517)	0.03	0.05	0.07	0.10	0.13	0.17	0.21	0.29	0.41	0.65	2.12
	Educational services (611)	0.02	0.05	0.06	0.08	0.11	0.13	0.17	0.25	0.40	0.96	2.24
	Computers, cell phones, cameras, watches, electronic accessories (334)	0.02	0.02	0.05	0.04	0.09	0.13	0.21	0.20	0.36	0.58	1.70
	Shoes, bags, belts (316)	0.04	0.06	0.08	0.08	0.11	0.11	0.13	0.19	0.21	0.36	1.35
	Appliances, light bulbs and electrical generation equipment (335)	0.03	0.04	0.05	0.08	0.09	0.10	0.14	0.12	0.21	0.33	1.18
	Other	0.18	0.27	0.33	0.46	0.57	0.65	0.95	1.22	1.79	4.20	10.61
Total		**5.4**	**8.3**	**10.3**	**12.2**	**14.3**	**17.3**	**20.2**	**24.9**	**33.2**	**53.4**	**199.3**

consumption and food categories increase with increasing levels of household income, but their distributions are considerably more balanced than that of CO_2e emissions related to transportation.

Finally, the "Other" category lists goods and services that produce at least 1% of indirect CO_2e emissions, and the economic subsector associated with their production is indicated in parentheses (Table 3). These goods and services are diverse in nature, and they have an impact on CO_2e emissions, either because of high spending in them or because of high carbon intensity in their production subsectors. CO_2e emissions related to all satisfiers listed under "Other" increase with household income level. High carbon concentration is found in particular in the subcategories "credit and financial services" and "educational services", where the share of the tenth decile was substantial (61% and 43%, respectively), while the most balanced carbon distribution within the "Other" category is observed in the subcategory "napkins, paper and sanitary napkins, diapers".

Total CO_2e emissions intensity of total household expenditure[20] ranges from 34 to 46 tons of carbon dioxide equivalent per million Mexican pesos ($tCO_2e/MM\$$) (Table 2). Total carbon intensity increases between the first and the second decile, shows minor changes between the second and the ninth deciles, and decreases between the ninth and the tenth deciles. The most drastic change in carbon intensity is a drop by about 20% between the ninth and the tenth deciles. The richest 10% of Mexican households have the lowest rate of carbon emissions per unit of expenditure; the poorest 10% have the second-lowest rate; the 80% intermediate income households display broadly similar total carbon intensities. Due to these factors, the expenditure-CO_2e emissions elasticity along the income curve[21] is almost always close to 1, except when going from the ninth to the tenth decile, where the elasticity value is 0.69 (Table 2). Expenditure-CO_2e emissions elasticity values of 1 indicate that when household expenditure increases 1%, CO_2e emissions also increase 1%.

The trend as regards total CO_2e emissions intensity is similar to the indirect CO_2e emissions intensity, and different from the direct CO_2e emissions intensity (Fig. 2). Total and indirect carbon intensities yield

[20] CO_2e emissions intensity of household expenditure can be estimated for direct carbon intensity (DI), indirect carbon intensity (II), or total carbon intensity (TI) by applying the following formulas: $DI = \frac{Direct\ CO_2e\ emissions}{Energyexpenditure}$; $II = \frac{Indirect\ CO_2e\ emissions}{Totalexpenditure}$; $TI = \frac{Total\ CO_2e\ emissions}{Totalexpenditure}$.

[21] Expenditure-CO_2e emissions elasticities (e) along the income curve (when going from one decile to the next immediate superior) were estimated by the midpoint formula: $e = \frac{CO2e_2 - CO2e_1/[(CO2e_2 + CO2e_1)/2]}{E_2 - E_1/[(E_2 + E_1)/2]}$, where CO_2e: total CO_2e emissions by decile, and E = total expenditure by decile.

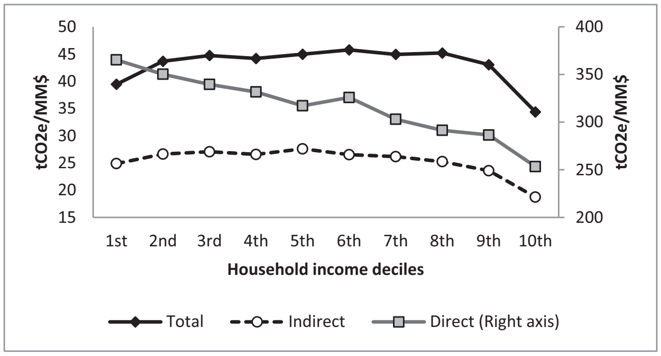

Fig. 2. Total, direct, and indirect CO_2e emission intensities by household income deciles in Mexico 2012.

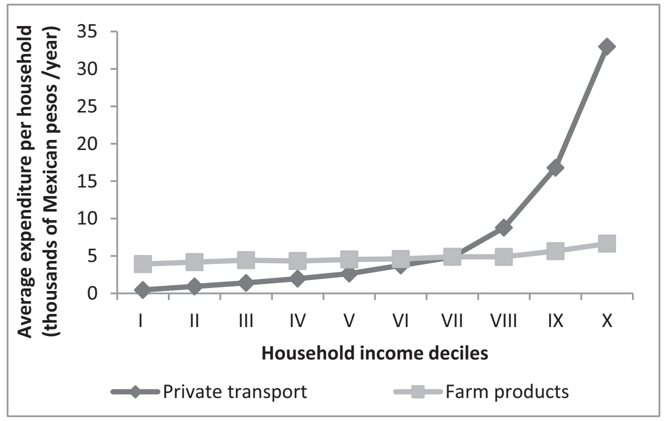

Fig. 3. Engel curves for basic and non-basic goods in Mexico 2012.

an obtuse inverted U curve along the continuum of income distribution, while direct carbon intensity shows a downward trend as household income is higher. The path of direct carbon intensity can be explained by the shares of gasoline and electricity expenditures on total energy expenditure by household income deciles. On the one hand, gasoline expenditure constitutes a higher proportion of total energy expenditure as household income increases,[22] while gasoline expenditure shows relatively low carbon intensity.[23] On the other hand, electricity expenditure constitutes a lower proportion of total energy expenditure as household income increases,[24] and electricity expenditure carries the highest carbon intensity among all energy types considered in the present study.[25] The path of indirect CO_2e emissions intensity is a result of the composition of the basket of consumer goods and services by income level. It is worth noting that indirect carbon intensity does not show drastic changes along the income curve until the tenth decile, where a significant share of expenditure in financial and educational services (with low carbon intensity) drives indirect carbon intensity downward.

Although low carbon intensity is a factor that limits the increase of CO_2e emissions, and consumption structure at the tenth decile could be considered the most appropriate for mitigation purposes, consumption levels are a problem at that highest income level. The tenth decile, which presents the lowest carbon intensities (direct, indirect, and total) and the lowest expenditure-CO_2e emissions elasticity, emits more CO_2e emissions than any other decile. Thus, both the quantity of consumption and the structure of consumption are drivers of carbon emissions.

The analysis of all these data gives rise to important concerns about the role of household consumption in fostering climate change. It is necessary to improve the living conditions of people in the poorest deciles, but future income growth could also increase CO_2e emission levels because of higher household expenditure and changes in consumption structure. Engel's law teaches us that when household income rises, consumers increase their expenditure in a heterogeneous way. The proportion of income spent on basic goods such as food falls, while the proportion of income spent on non-basic goods (e.g., complex manufactured goods and cars) rises. Fig. 3 shows an example of Engel curves for farm products and private transport - including gasoline and cars (representing basic and non-basic goods respectively). Farm product expenditure rises slightly as household income increases, while private transport expenditure rises exponentially. Unfortunately, complex manufactured goods generally carry higher carbon intensity than basic goods.

Conclusion

We have presented a bottom-up approach to analyzing household GHG emissions by income level in Mexico in 2012 through an Input-Output analysis, following the model applied by Golley and Meng (2012). We found a high carbon inequality (the poorest household decile emits 2.7% of the total CO_2e emissions, while the wealthiest decile emits 26.8%) and a heterogeneous carbon structure among households at different income levels (transportation, mainly private transportation, is an important driver of CO_2e emissions at the higher deciles, while CO_2e emissions related to dwelling energy consumption and food are more relevant at the lower deciles). We also found that the carbon intensity of household expenditure is lower at the extremes of income distribution, while the rest of the deciles do not vary all that much among one another. From all these results, we concluded that both the quantity of consumption and the structure of consumption are drivers of carbon emissions. The importance of this observation should not be underestimated, given that climate change mitigation efforts rarely consider the quantity of consumption as a driver of GHG emissions. The formulation of policy to mitigate GHG must take into account the factor of household income inequality in order to be effective and sustainable from a social and economic point of view.

There are no precedents of assessing in detail CO_2e emissions related to specific consumer needs and satisfiers by income level in Mexico, and this research could contribute to design customized climate change mitigation strategies and policies focused on household consumption complementing and boosting the scope of mitigation efforts in the country. This is a necessary step in Mexico as a country that has progressed in policies like mandatory targets, standards, and regulations, which constitute the early stages of policymaking (Zhang & Wang, 2017). Considering demand-side options such as the consumption patterns of households in efforts to mitigate GHG emissions could widen the scope of such efforts.

Consumption patterns and GHG emissions related to household consumption represent a big challenge in the context of sustainable development. On the one hand, it is important to improve the living conditions of the poorest, and to reduce social inequity. On the other hand, it is also necessary to mitigate climate change. A possible option to reconcile these two aspects that arises from our analysis is to pay attention to the carbon emissions related to the consumption at high-income levels, which represents a large proportion of household carbon emissions. This option is feasible,

[22] At the tenth decile, gasoline (Magna and Premium) expenditure accounts for 66% of total energy expenditure, while at the first decile that share is 26%.
[23] Direct CO_2e emission intensities of Magna and Premium gasoline expressed in tCO_2e/MM$ are 238.1 and 219.3, respectively.
[24] At the tenth decile, electricity expenditure accounts for 21% of total energy expenditure, while in the first decile, that share is 40%.
[25] Direct CO_2 emission intensity of electricity is 417.2 tCO_2e/MM$. This high value is a consequence of subsided electricity tariffs for Mexican households.

given that the carbon emissions of low-income households are mainly for essential needs, and the carbon emissions of high-income households are from the consumption of many goods and services that are nonessential, or that could be replaced for goods and services with less CO_2e emission intensity. Yet it remains necessary to analyze the public acceptability in Mexico of this kind of option and what could be the best way to implement mitigation strategies focused on certain socioeconomic groups. These topics constitute contemporary research lines that should be explored for developing countries such as Mexico.

Declaration of Competing Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Appendix A

Table 4
Data of energy consumed at the dwelling and for transport in Mexico 2012.

Energy type		Average price between May and August 2012[a]	Electricity consumption limit to change to DAC tariff (kWh/month)	Conversion factor	Net calorific value (MJ/b)	Emission factor (t/PJ)		
						CO_2 (HP = 1)	CH_4 (HP = 28)	N_2O (HP = 265)
Electricity by tariff[b]	1 Residential	1.08 $/kWh	250	3.6 GJ/MWh	–	153,290 tCO_2e/PJ		
	1A Residential	0.95 $/kWh	300					
	1B Residential	0.97 $/kWh	400					
	1C Residential	0.96 $/kWh	850					
	1D Residential	0.97 $/kWh	1000					
	1E Residential	0.86 $/kWh	2000					
	1F Residential	0.86 $/kWh	2500					
	DAC Residential High Consumption	3.63 $/kWh	–					
L.P. gas	National	11.26 $/kg	–	11.60 b/t	4175	65,083	5	0.1
Natural gas by region	Northeast	189.95 $/GJ	–	–	–	57,756	5	0.1
	Northwest	182.45 $/GJ						
	Center	165.41 $/GJ						
	West Center	136.33 $/GJ						
	South-Southeast	188.70 $/GJ						
Kerosene		N.D.	–	–	–	71,900	10	0.6
Magna gasoline		10.2021 $/l	–	6.29 b/m3	5122	73,791	3.8	5.7
Premium gasoline		10.8580 $/l	–	6.29 b/m3	5122	73,791	3.8	5.7
Diesel		10.5200 $/l	–	6.29 b/m3	5650	72,851	3.9	3.9

Based on BP (2016), INECC-SEMARNAT (2018), SENER (2013), and SIE (2020).
[a] We used an average price between May and August because we assumed that the expenditures reported in the ENIGH corresponded to the quarter before the survey (the 2012 ENIGH was applied between August 27th and November 24th 2012).
[b] Tariffs 1, 1A, 1B, 1C, 1D, 1E, and 1F are applied to the residential sector with minimum average temperatures in summer of <25, 25, 28, 30, 31, 32, and 33 °C, respectively. HP: heating potential.

Table 5
Association among IOM, INEGyCEI, and household expenditures.

Economic subsector (NAICS code[a])	Emission subsector (IPCC code[b])	Household expenditure (ENIGH code[c])
111	1A4c	A001, A101–A104, A107–A132, A137–A141, A144, A147–A170, A203–A204
112	–	A093–A094
113	1A4c	G013
114	1A4c	A066–A067, A071–A073
115	1A4c	–
211	–	–
212	1A2i	–
213	–	–
221	1A1a	-R001
222	–	R002–R003
236	1A2k	K039, K041, K043, K045
237	1A2k	–
238	1A2k	–
311	1A2e	A002–A065, A068–A070, A074–A092, A095–A100, A105–A106, A133–A136, A142–A143, A145–A146, A171–A202, A205–A214, A242, T901
312	1A2e	A215–A241
313	1A2l	I024
314	1A2l	C010, I016–I022, I026, K035
315	1A2l	H001–H083, H125, H130, H134–H135, T909
316	1A2l	H084–H119, H123–H124, H128
321	1A2j	–
322	1A2d	C006, D014–D016
323	1A2d	E014
324	1A1b, 1A1c	F007–F010, G009–G012, G014

Table 5 (*continued*)

Economic subsector (NAICS code[a])	Emission subsector (IPCC code[b])	Household expenditure (ENIGH code[c])
325	1A2c	C001–C005, C011, C014–C016, C019, D001–D013, D017, H121, J004, J009–J010, J014, J020–J035, J037–J038, J042, J044–J059, J061, J063–J064, T903–T904
326	1A2m	C007, C018, I003, I007, M012, M016
327	1A2m	I001–I002, I004, I006, K033, K038, K040, K042, K044, T910
331	1A2a 1A2b	–
332	1A2m	C017, I005, I009–I012
333	1A2h	K005, Q013
334	1A2m	F002, H129, I008, J066, K002–K003, L001–L015, L017–L021
335	1A2m	C012–C013, D019, K001, K004, K007–K024, M013, T912
336	1A2g	M007–M011, M014–M015
337	1A2m	I014–I015, K006, K026–K032, K034, K036
339	1A2m	C008–C009, D018, D021, E017, E020, G015–G016, H122, H126–H127, H131–H132, I025, J060, J065, J067, L023–L027
431	1A4a	–
481	1A3a	M003
482	1A3c	M002
483	1A3d	B007, M006
484	1A3b	M004
485	1A3b	B001–B006, E013, M001, T902, T914
486	–	–
487	1A3b	–
488	–	M005
491	–	–
492	–	F005
493	–	–
511	–	E022–E026
512	–	E027
515	–	–
517	–	F001, F003–F004, R005–R011, T906
518	–	–
519	–	–
521	–	–
522	–	Q001–Q005, Q011
523	–	Q006, Q015, T916
524	–	J071–J072, N008–N009, Q007
531	–	G001–G004, G101, Q009–Q010, Q100
532	–	
533	–	
541	–	N001, Q016
551	–	
561	–	C023–C024, F006, G005–G008, R013, T907
562	–	
611	–	E001–E007, E009–E011, E015–E016, E018–E019
621	–	J003, J005–J008, J011, J013, J015–J019, J036, J041, J043, J062, J069, T905, T911
622	–	J001–J002, J012, J039–J040, J070
623	–	
624	–	E008, E012
711	–	E028, E030
712	–	
713	–	E031–E034, T913
721	–	N004–N005
722	–	A243–A247, E029, N003
811	–	D020, E021, F011, F013–F014, H120, H133, H136, I013, I023, J068, K025, K037, L016, L022, L028, M017–M018
812	–	C021–C022, D022–D026, F012, L029, N002, N010
813	–	N006–N007, N014
814	–	C020
931	–	N015–N016
932	–	
–	–	G102–G106, N011–N013, Q008, Q012, Q014, R001, R004, R012, T908, T915

[a] NAICS codes can be found at https://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007.
[b] IPCC codes can be found at https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8_Ch8_Reporting_Guidance.pdf.
[c] ENIGH codes can be found at https://www.inegi.org.mx/contenido/productos/prod_serv/contenidos/espanol/bvinegi/productos/metodologias/ENIGH/ENIGH2012/702825051105.pdf

Table 6
Direct CO_2 emissions by household income decile according to energy type in Mexico 2012 ($MtCO_2$).

Energy type/decile	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total
Electricity	1.13	1.72	1.94	2.16	2.36	3.18	3.07	3.70	4.73	5.74	29.74
L.P. gas	0.51	0.89	1.13	1.23	1.38	1.53	1.80	1.75	2.19	2.70	15.12
Natural gas	0.01	0.03	0.07	0.12	0.11	0.19	0.23	0.35	0.51	1.07	2.69
Kerosene	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.09
Magna gasoline	0.30	0.56	0.81	1.29	1.63	2.18	3.16	4.84	6.88	12.25	33.91
Premium gasoline	0.03	0.02	0.08	0.05	0.03	0.18	0.13	0.28	0.65	2.50	3.94
Diesel	0.00	0.00	0.01	0.00	0.01	0.00	0.02	0.06	0.03	0.03	0.15
Total	**1.99**	**3.24**	**4.06**	**4.85**	**5.53**	**7.26**	**8.42**	**10.99**	**15.00**	**24.29**	**85.63**

Table 7
Indirect CO_2 emissions by household income decile according to productive subsector in Mexico 2012 ($MtCO_2$).

Subsector/decile	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total
111	0.39	0.41	0.44	0.43	0.45	0.45	0.48	0.48	0.55	0.65	4.72
112	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.56
113	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.06
114	0.03	0.04	0.03	0.04	0.04	0.07	0.06	0.08	0.10	0.18	0.66
221	0.06	0.10	0.11	0.12	0.15	0.18	0.19	0.24	0.31	0.58	2.04
222	0.01	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.07	0.11	0.45
236	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.07	0.17	0.31
311	0.64	0.90	1.01	1.18	1.27	1.36	1.50	1.62	1.78	2.35	13.60
312	0.09	0.12	0.14	0.17	0.19	0.21	0.23	0.26	0.31	0.46	2.19
313	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
314	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.05	0.17
315	0.07	0.10	0.13	0.15	0.18	0.22	0.25	0.34	0.43	0.83	2.69
316	0.04	0.06	0.08	0.08	0.11	0.11	0.13	0.19	0.21	0.36	1.35
322	0.10	0.16	0.19	0.22	0.23	0.26	0.27	0.34	0.38	0.42	2.57
323	0.01	0.02	0.03	0.04	0.09	0.05	0.11	0.17	0.13	0.30	0.94
324	0.22	0.39	0.53	0.67	0.81	1.03	1.37	1.88	2.66	4.85	14.41
325	0.30	0.42	0.51	0.57	0.64	0.73	0.87	0.99	1.20	1.95	8.17
326	0.01	0.01	0.01	0.02	0.03	0.02	0.03	0.05	0.07	0.15	0.40
327	0.01	0.02	0.03	0.04	0.06	0.06	0.10	0.12	0.19	0.42	1.07
332	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.10
333	0.00	0.00	0.00	0.02	0.00	0.02	0.01	0.00	0.01	0.09	0.15
334	0.02	0.02	0.05	0.04	0.09	0.13	0.21	0.20	0.36	0.58	1.70
335	0.03	0.04	0.05	0.08	0.09	0.10	0.14	0.12	0.21	0.33	1.18
336	0.00	0.01	0.02	0.02	0.04	0.05	0.04	0.18	0.62	1.23	2.22
337	0.01	0.01	0.01	0.03	0.03	0.03	0.05	0.05	0.11	0.15	0.47
339	0.04	0.05	0.05	0.05	0.07	0.06	0.10	0.12	0.15	0.28	0.96
481	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.04	0.14	1.12	1.35
482	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
483	0.05	0.05	0.10	0.05	0.07	0.04	0.03	0.07	0.06	0.21	0.72
484	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.04
485	0.83	1.46	1.87	2.22	2.87	3.18	3.53	3.75	4.23	2.73	26.67
488	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03
492	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
511	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.06	0.11
512	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.07	0.08	0.17	0.41
517	0.03	0.05	0.07	0.10	0.13	0.17	0.21	0.29	0.41	0.65	2.12
522	0.01	0.03	0.04	0.05	0.08	0.12	0.18	0.26	0.51	1.98	3.26
523	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04
524	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.11	0.15
531	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.09	0.12	0.31	0.81
541	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.04
561	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.05	0.10
611	0.02	0.05	0.06	0.08	0.11	0.13	0.17	0.25	0.40	0.96	2.24
621	0.02	0.02	0.03	0.03	0.04	0.05	0.07	0.07	0.13	0.23	0.68
622	0.00	0.01	0.01	0.03	0.02	0.05	0.08	0.08	0.14	0.31	0.74
624	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.04	0.04	0.13
711	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03
713	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.04	0.05	0.12	0.27
721	0.00	0.00	0.01	0.01	0.01	0.01	0.03	0.05	0.08	0.45	0.64
722	0.25	0.36	0.40	0.54	0.61	0.75	0.86	1.07	1.41	2.34	8.58
811	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.04	0.07	0.23	0.40
812	0.01	0.02	0.02	0.02	0.03	0.05	0.06	0.08	0.12	0.24	0.66
813	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.13
931	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.06	0.11
Total	**3.40**	**5.06**	**6.21**	**7.31**	**8.77**	**10.00**	**11.74**	**13.91**	**18.16**	**29.07**	**113.63**

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