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Abstract

This study analyzes the consumption-based carbon footprint of households in Sulawesi, Jambi and Indonesia as a whole. Combining the use of the GTAP data for emission intensities, of input-output tables for inter-industry linkages with household expenditure categories, we then estimate and calculate the carbon footprint from household consumption, including its drivers, pattern and decomposition of increasing household emission intensities. We find that the main driver of carbon footprint is overall household income, but that differentials in fuel, light and transportation expenditures are key drivers of the household carbon footprint. These expenditures also ensure that the carbon footprint of household in Jambi is higher than in Indonesia as a whole, despite lower per capita incomes. At the same time, substantially lower income inequality in Jambi ensures that the inequality in the carbon footprint is much lower in Jambi than in Indonesia as a whole; particularly noteworthy is the poorer quintiles in Jambi have substantially higher emissions than average Indonesian households in the same quintiles. In Sulawesi, average emissions are much lower and also not as unequal than in Indonesia as a whole. Overall expenditures are by far the most important driver of household carbon emissions, but in Jambi, emissions are higher at all expenditure levels, suggesting particularly carbon-intensive consumption patterns.

Keywords: Development economics, carbon footprint, household emissions, comparison of Sulawesi, Jambi, and National SUSENAS

JEL Codes: Q54, D12, O13

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1. Introduction

While a large share of the current stock of greenhouse gases is related to consumption and industrial activity in developed economies, the contribution of developing countries to global emissions has been rising considerably in recent years, with developing and emerging countries accounting for the bulk of the increase in global annual emissions of greenhouse gases since 1990 (IPCC, 2014). Indonesia is actually among the world's largest emitters of greenhouse gases. This is in large part related to emissions from land-use change (primarily deforestation), but CO2 emissions associated with rising consumption has played an increasing role in recent years (Jakob et al. 2014; Irfany, 2014). Thus is it important to understand the drivers of these increasing consumption-based CO2 emissions which make up 81% of global emissions (UNFCCC, 2010). Consumption behavior and decisions drive these household-based emissions (Girod and Hann, 2010). But what are the drivers of these rising carbon footprints in Indonesia and how do they differ across regions and time period? In particular, Indonesia's households differ greatly in their income sources and consumption patterns. While at the national level on average, non-agricultural income sources play an important role, access to modern energy is quite high, and the rate of urbanization is also high, different lifestyles and consumption practices prevail in more remote rural locations, with potentially sizable impacts on the carbon footprint. In this paper, we can compare the carbon footprint of Indonesian households with those prevailing in remote rural locations at the rainforest margin in Sulawesi and in remote rural locations of a cash-crop based economy in Jambi.

The objective of this study is therefore to answers the following research questions: (i) what is driving the consumption-based carbon footprint in Indonesia? How does Sulawesi and Jambi differ from the national average in Indonesian? (ii) which factors affect the household carbon footprint and how does role of rising affluence versus other drivers influence household emission?

To be able to calculate the CO2 emissions released by households, we incorporate the GTAP emission database with the IO table in order to create for emission intensities of CO2 for each sector. Survey databases on expenditure from Sulawesi, Jambi and three rounds of the national household survey Susenas then will be matched up to the previously generated-intensities. Details in the level of CO2 emission intensities from household are then employed to analyze the emission increase determinant from the household expenditure and consumption. We find that the main driver of carbon footprint is overall household income, but that differentials in fuel, light and transportation expenditures are key drivers of the household carbon footprint. These expenditures also ensure that the carbon footprint of household in Jambi is higher than in Indonesia as a whole, despite lower per capita incomes. At the same time, substantially lower income inequality in Jambi ensures that the inequality in the carbon footprint is much lower in Jambi than in Indonesia as a whole; particularly noteworthy is the poorer quintiles in Jambi have substantially higher emissions than average Indonesian households in the same quintiles. In Sulawesi, average emissions are much lower and also not as unequal than in Indonesia as a whole. Overall expenditures are by far the most important driver of household carbon emissions, but in Jambi, emissions are higher at all expenditure levels, suggesting particularly carbon-intensive consumption patterns.

The organization of the paper is as follows. After this introduction, section 2 will provide a literature review to understand how available research conducted in various countries identified determinants of the household carbon footprint in developed and developing countries. Chapter 3 presents the methodology used for the analysis. We presents how emission intensities are measured, the approach of deriving the carbon footprint for the analysis and to explain how drivers of household carbon footprint are studied. In section 4, we provides the data used in this study which include the National Indonesian Survey in Susenas in 2005, 2009, and 2013, and smaller household surveys at the rain forest margin in Sulawesi and in rainforest transformation systems in Jambi. Section 5 presents the result and discussion of our main findings. Lastly, section 6 provides a summary on our main findings and provides some remarks on policy implications.

2. Literature review

We review several studies available in relation with the household carbon footprint and its emission intensity in various point of discussion. Quite number of studies analyzing the GHGs emission derived from expenditure and consumption of households have been conducted in developed countries (e.g. Kok et al., 2006; Hertwich and Peters, 2009, Tukker and Jansen, 2006, Wier et al., 2001), while there are fewer studies for developing countries. Recent studies in India, China, the Philippines and Indonesia (Irfany (2014), Serino (2015), Grunewald (2012) have contributed to the literature on developing countries.

Methodologically, Lenzen (1998) used the intensity of carbon emissions of economic activities derived from input-output analysis for his study of Australia. He finds that household consumption of goods and services from industry contribute to the increase of emission as the major factor.

According to Kok et al. (2006), direct and indirect energy use of households, a key driver of carbon emissions, can be measured with several methods: National IO energy analysis, data on expenditure of households, and process analysis combined with IO analysis (hybrid analysis). From the available methods, in order to finally measure the energy cumulative of intensities of sectors, then the appropriate one to use in this study is analysis of IO analysis together with expenditure of household data. Hertwich and Peters (2009) analyze the GHGs emission contributed from 8 category of expenditures related to the final household expenditure on products (good and service)

Analysis of carbon footprint by Hertwich and Peters (2009) involve IO emission analysis combine with the GTAP database to estimate emission intensities. As the estimation model of carbon footprint, the apply multi regional input output. Almost 70% of overall emission of greenhouse gas contributed from living/shelter, transportation and food. These categories are considered to be expenditure items that emit the most emissions at the household level (see Girod and de Haan, 2010). A study by Kenny and Gray (2009) reveals that domestic energy requirement (light, electricity, etc), fuel and transportation related expenditure to be the most important drivers of a household carbon footprint in Ireland.

In the UK case, a study by Druckman and Jackson (2009) found that manufacturing process of products (including good and service) contributed to the increasing trend of CO2 emission released. There is a large inequality in emissions between the poor and the rich, mainly related to differences in incomes. Other studies in different countries include Weber and Matthews (2008) and Bin and Dowlatabadi (2005) for the US, Danish household expenditure (Wier et al. 2001) and the Netherlands, UK, Sweden, and Norway by Kerkhof and Moll (2009) by incorporating input-output analysis with household expenditure data using the hybrid approachwe use here as well.

Analysis of carbon footprint in the developing country is still limited. Some studies exist on India (Parikh et al., 1997; Pachauri, 2004; Lenzen et al., 2006), Brazil (Lenzen et al., 2006), and China (e.g. Pachauri and Jiang, 2008). The more recent study in the developing economy were for Indian Household (Grunewald et al., 2012) and for the Philippines (Serino and Klasen, 2015) and for Indonesian setting (Irfany, 2014, Irfany and Klasen, 2015).

The study by Parikh et al. (1997) is considered as one of the initial analysis of the carbon footprint of Indian households. Employing IO analysis combined with the distribution data on the total household expenditure, the study calculated the emission intensities derived from product both direct and indirect to the household consumption decision. The result shows that direct household expenditure is the major factor to the CO2 emission release, the rest is caused by the indirect consumption of goods and services. Consumption of carbon intensive product happen very large among the rich group. The rich carbon-intensive lifestyle counted to 15 times more in magnitude than what rural poor household expenditure have.

The study by Grunewald et al. (2012) on the household carbon footprint for Indian households incorporates survey data from 2004 and 2007. Applying regression analysis and analysis of income elasticities, they find that income of the household is the main determinant of the carbon footprint, both between households in the cross-section as well as over time. At the same time, other determinants, including location, household size and education also affect the household carbon footprint, with urban more educated households having a higher carbon footprint, even controlling for household incomes. The estimated income elasticity of the carbon footprint is close to 1.

For the Philippines setting, the study by Serion and Klasen (2015) also utilized the IO table combine with the GTAP emission intensities for survey waves in 2000 and 2006. The carbon footprint was derived from matching every expenditure category to the IO table. Fuel, light and transport are found to be the sectors with highest CO2 emission. Also here, household income is found to be the most important driver of emissions between households and over time.

For some developing countries, the changes in consumption pattern and lifestyle of household are likely to increase carbon footprint as the household gets richer. The study by Irfany (2014) analyzes the Indonesian household carbon footprint, its affluence and trade-offs attributed from the consumption and expenditure. The IO emission expenditure combine with GTAP analysis in the study found that fuel, light and transportation to be the most emission intensive economics sectors. The 2 survey waves in 2005 and 2009 using the national survey database revealed that the most important determinant of the household carbon footprint is the income level while a decomposition analysis resulted that elasticity of expenditure contributed primarily by the total increase of house expenditure amount and the shift of expenditure items play little role in the increase of household emission. Irfany (2014) also suggest that high fuel subsidies substantially increase the household carbon footprint and contribute to rising emission inequality between households as the rich benefit more from these subsidies.

While these studies have, on the whole, revealed that income is the most important driver of emissions, other determinants do matter. It is therefore of some interest to study whether different regions within a country have different determinants of a household-based carbon footprint. The Indonesian case is interesting for two reasons: there is great heterogeneity in production and consumption patterns between different regions. For example, while Indonesia as a whole is progressively urbanizing where agriculture is playing a declining role, in rural Sulawesi, agriculture is still dominant and the main cash crop is cocoa, while in Jambi, agriculture is also of great important with oil palm being the main cash crop. Second, the production-based carbon footprint is also differing greatly between different parts of Indonesia with oil palm having a substantially higher production-based carbon footprint due to the associated deforestation and the release of carbon from peat lands. Thus considering both the production as well as consumption-based carbon footprint allows policy-makers to understand the total difference in carbon footprints across regions. For that, one needs to also understand different determinants of the household-based carbon footprint.

3. Methodology

3.1 Measuring emission intensities

In order to calculate carbon footprint for Indonesian household, we follow the approach by Lenzen (1998) and much of the 'hybrid' literature discussed above, which estimated intensity of carbon that was inherent in the final consumption in an Australian household. Emission of CO_2 that released in the component of final consumption of the household is then traced back to its intermediates and factor (direct and indirect emission) using IO analysis.

According to Kok et, al. (2006), there are three methods to account for analysis energy input-output to the environmental load of GHG emitted by household consumption activities, namely basic, expenditure and process approach. In this study, we use the expenditure approach that combines the account of IO emission account with the database. This method can also nicely link expenditures to the IP table and emission intensities. The expenditure approach is also used because of the use of several household expenditure surveys both from Sulawesi, Jambi and the national one.

The below **Figure 1** maps how expenditure approach is used to trace back the intensities of CO_2 from goods and services using IO analysis. Deriving the good and service emission require IO table and expenditure database from household consumption activities.

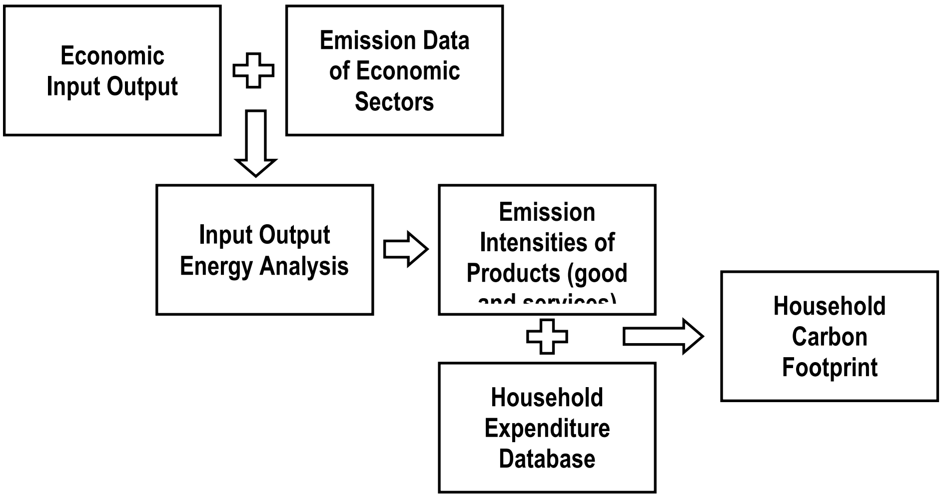

Figure 1. Expenditure Approach: Analysis of Emission
Source: Kok et al. (2006) in Irfany, 2014

There are several stages how the emission analysis on the expenditure approach could be estimated. This study using Leontief inverse of IO table that derived the intensities of CO_2 emission, then multiplied to the GTAP's table of calculated carbon intensity. We firstly estimate the intensities of CO_2 from every Indonesia IO sector (in local currency, Rp). As we also presume that emission released by products both domestic and imported are calculated in the same way as they are produced in the similar technology –which is the Single Region Model.

3.2 Deriving the household carbon footprint

The next stage is where intensities of CO_2 emission from each sector were categorized to the expenditure of household in the database. This expenditure firstly should be aggregated from around 340 expenditure category to a new matched category. Using the IO sectors with the household expenditure classification, then it will only consist of 175 economic sectors in Indonesia which were further mapped using 57 sectors that aggregated from GTAP sectors.

To match these sectors, questionnaire of Susenas 2013 database is used together with GTAP's sector category, so then expenditure consumption items (from Sulawesi, Jambi and Susenas) can be multiplied to obtain the intensity of CO2 emission. Then at the end carbon footprint be obtain as this summed up.

This approach assumes that domestic energy and level of technology in production of goods and service are similar as abroad, direct and indirect emissions of CO2 from the final demand of industrial sector can be calculated. Now the direct and indirect emission intensities from final demand can be expressed:

$$CO_2^{fd} = c' E^{fd} y \qquad (1)$$

where c', E^{fd}, and y represent the inverse of the coefficient vector of its emission, energy use matrix, and final demand vector.

Now the indirect emission (CO2ind) can be classified as three source: (1) domestic product of domestic final demand, (2) intermediates from abroad, (3) imported products for domestic final demand (not to count exported product). By multiplying every sector final demand y, the transposed emissions coefficients, c′, the matrix of industrial energy use, E^{ind}, and with the domestic Leontief inverse $(I\text{-}A)^{-1}$ the estimation intensity of emission of sectoral CO2 can be obtained. The formula expressed:

$$CO_2^{ind} = c' E^{ind} \begin{bmatrix} (I-A)^{-1} y_{\neq exp} + ((I-A_{tot})^{-1} - (I-A)^{-1}) y_{\neq exp} \\ +(I-A_{tot})^{-1} y_{imp_{\neq exp}} \end{bmatrix} \qquad (2)$$

where A_{tot}=A+A_{imp}, and y_{tot}=y+y_{imp}. (2)

$y_{\neq exp}$ and I symbolize domestic final demand and identity matrix, where A represent the matrix of technical coefficients as the intermediates' contribution to one unit of final output.

Hence the direct and indirect CO_2 emission intensities can be calculated as follows:

$$CO_2 = CO_2^{fd} + CO_2^{ind} \qquad (3)$$

$$CO_2 = c' \{ E^{fd} y + E^{ind} [(I-A)^{-1} y_{\neq exp} + ((I-A_{tot})^{-1} - (I-A)^{-1}) y_{\neq exp} + (I-A_{tot})^{-1} y_{imp\neq exp}] \} \qquad (4)$$

As final step, consumption of household from Jambi, Sulawesi and Susenas databases (in Rp.) are multiplied with the intensities of carbon from every sector (kg CO2/Rp). This carbon intensities from every sector has one-to-one classification with the database and therefore all good and service from categories can be summed up for every household. For each household, the carbon footprint $CO2^{hh}$ calculated as follows:

$$CO_2{}^{hh}{}_i = \sum_i^j \left(CO_{2_j} * Exp_{ij} \right) \qquad (5)$$

where i and j respectively represents household and expenditure item.

3.2 Drivers of the household carbon footprint

In this part, we look at the effects of emissions, characteristic of household and how household take decision on their consumption pattern. Carbon footprint and expenditure and consumption choice together will be determined from intensity of carbon from a basket of good and product consumed. List of consumption product from Susenas will be the source to estimate the driver of household carbon-intensive expenditure and consumption choice, as well as the other preference made by household like transportation, electricity-fuel etc. This study use the analysis based on this formula below:

$$\ln CO_2^{hh}{}_i = \alpha + \beta_1 \ln EXP_i + \beta_2 X_i + \varepsilon_i \quad (6)$$

We first utilized the Ordinary least square (OLS) method in order to regress the log of household carbon footprint $CO2^{hh}$ on log of household expenditure, lnEXP, to proxy income, and several control variables X. The expenditure, household size and age will be in a squared term function to handle for the effect of nonlinearity on the household CO2.

Addressing the concern of high in-built correlation on our expenditure variable resulted from deriving from the fact that missions are directly calculated from expenditures on different items (where, for example, measurement error will generate an in-built correlation), we can use the expenditure proxy along with quintile dummy Q. By formula then the previous regression (6) will be calculated partially, as follow:

$$\ln CO_2^{hh}{}_i = \alpha + \beta_q \sum_{q=1}^{5} Q_{qi} + \varepsilon_i \quad (7)$$

and

$$\varepsilon_i = \alpha + \beta_1 X_i + \gamma_i \quad (8)$$

where ε_i is the regression residual (7).

To put it differently, emission on the expenditure quintiles (7) will be regressed, then other residual from control variable will be regressed one more time in (8). As this regression take place, the household characteristic can show their true effect on the emission that occur, once the effect of incomes is taken out.

3.3 Expenditure elasticites of emission

The change in demand for specific good and service as result of the income change can be measured by the analysis of demand. The build up based on the consumers's utility maximization function, which is relied on the individual income and good price (Deaton and Muellbauer, 1980). This demand analysis could be a tool to estimate the emission. We take the place of good and replace the function with value of CO2 emission from generated from the good consumed by household. Therefore we are able to later estimate the change of emission from household expenditure classification to its change in their income (as proxy).

The estimation of expenditure elasticities should include price as the variable. Conventional Engel curve requires price as the independent variable. However, Susenas database provide us no data on price, therefore in order to calculate the electicities of expenditure, we will left the calculation of elatisicities emission without price variable. This will cause to the dependency of responsiveness of CO2 emission to the household's socio economic level. The estimation will be done as follows:

$$sCO2_{ij} = \beta_0 + \beta_{1_{ij}} \ln EXP_i + \beta_{2_{ij}} X_i + \varepsilon_{ij} \quad (9)$$

where $sCO2_{ij}$ reflect the share of CO_2 emissions of j-th consumption category to overall CO_2 emissions by the i-th household, $\ln EXP_i$ is the natural logarithm of household i expenditure. X_i is a vector of household characteristics where ε_{ij} is error terms.

4. Data

Several database will be used to estimate and calculate the carbon footprint. For this purpose we utilize the Indonesian Input Output (IO) table, the Global Trade Analysis Project-Environmental Account (GTAP-E) consist of CO2 emission from fossil fuels burning and cement output, and the Indonesian household expenditure survey (Susenas) in 2013. More importantly, we use the consumption-based carbon footprints of household survey data of households at the rainforest margin in Sulawesi, and for households producing rubber and palm oil in Jambi. The survey in Sulawesi consists of about 280 rural households living in 14 villages at the rainforest margin in South Sulawesi. Most households are engaged in agriculture with cocoa production being by far the most important cash crop, replacing coffee that was an important cash crop previously (see Klasen, Priebe, and Rudolf, 2013). The survey in Jambi consists of some 500 agricultural households that are predominantly engaged in rubber and oil palm production. The national data we use to compare the household-based footprint are the Indonesian national household expenditure survey SUSENAS, a large nationally representative survey that is conducted annual by the national statistical authority.

As mentioned, emission of carbon released from the household consumption side can be either direct or indirect. Household activity in goods and services consumption involving transportation and fuel, lighting, electricity, etc. considered as a direct source of emission where clothing, appliance and other goods production will be categorized as the indirect one.

5. Result and discussion

5.1 Descriptive Analysis

Before calculating the carbon footprint, we have to combine the GTAP matrix on energy use with the Indonesia IO table. This give us possibility to acquire the emissions intensity of CO2 from the 175 economic sector. The quantity of CO2 emitted from production of the products in the Indonesian economy is captured by the CO2 emission intensity (calculated in kilotons per million Rp (gram CO2/Rp).

While there are 175 sectors in total, some of them can be categorized as the most intensive sectors of CO2 emitter and the lowest one. According to Irfany (2014), we have on one side electricity, gas, cement, other items and non-metallic materials, etc which release the most CO2 per unit of expenditure, whereas on the other side, Indonesian least carbon-intensive sectors are including the agricultural crops sector. This can be understood since this agricultural sector required considerably small energy amount in their production process. **Table 2** provides the 10 most and least carbon-intensive sectors.

Table 2. CO_2 intensity of economic sectors: top and bottom 10

Quintiles	**Sectors**	**gram CO_2/Rp**
Top 10		
1	Electricity and gas	1.04962
2	Cement	0.44619
3	Other items of non-metallic materials	0.39552
4	Glass and glass products	0.38542
5	Ceramics and building materials from clay	0.37331
6	Ceramics and items made of clay	0.36825
7	Air transport services	0.20421
8	Railway services	0.17156
9	Marine transportation services	0.16338
10	River and lake transport services	0.16153
Bottom 10		
10	Other nuts	0.00380
9	Other animal products	0.00374
8	Soybean	0.00287
7	Cassava	0.00280
6	Vegetables	0.00266
5	Beans	0.00218
4	Fruits	0.00185
3	Sweet potato	0.00102
2	Grains and other foodstuffs	0.00078
1	Fiber crops	0.00031

Source: Irfany, 2014 based on IO 2005 and GTAP-E 2005.

Susenas provides the consumption classification to match with the derived CO2 emission intensities. To represent the major expenditures of household, about 340 items listed as consumption products were grouped to match with the GTAP and the IO data. Major expenditure classification based on this are then analyzed further. Average emission of CO2 from Sulawesi, Jambi and Susenas National 2013 can be seen in **Figure 2**. We can see how the household CO2 emissions by consumption category provide different results for the three samples. The highest emission originated from the fuel, light and transportation sector and this is particularly the case in Jambi. On the other hand, emissions associated with recreation and ceremonies are a large source of emissions in the national data. Oilfat, clothes, tax and retribution as well as cereal are shown as the lowest provider for CO2 emission.

Looking closely at the consumption on the fuel and light for all database, the average household in Jambi emit twice than average national, followed by Sulawesi. Jambi emission data for fuel and light amounted to 4,417 kg. For the emission in transportation, Jambi accounted for 1,259 kg follow by the national average on 1,038 kg and, respectively, Sulawesi with 737,3 kg. On the national level, emission from recreation and ceremony have three time the emissions compared to Jambi, where Sulawesi has very low CO2 emissions in this category.

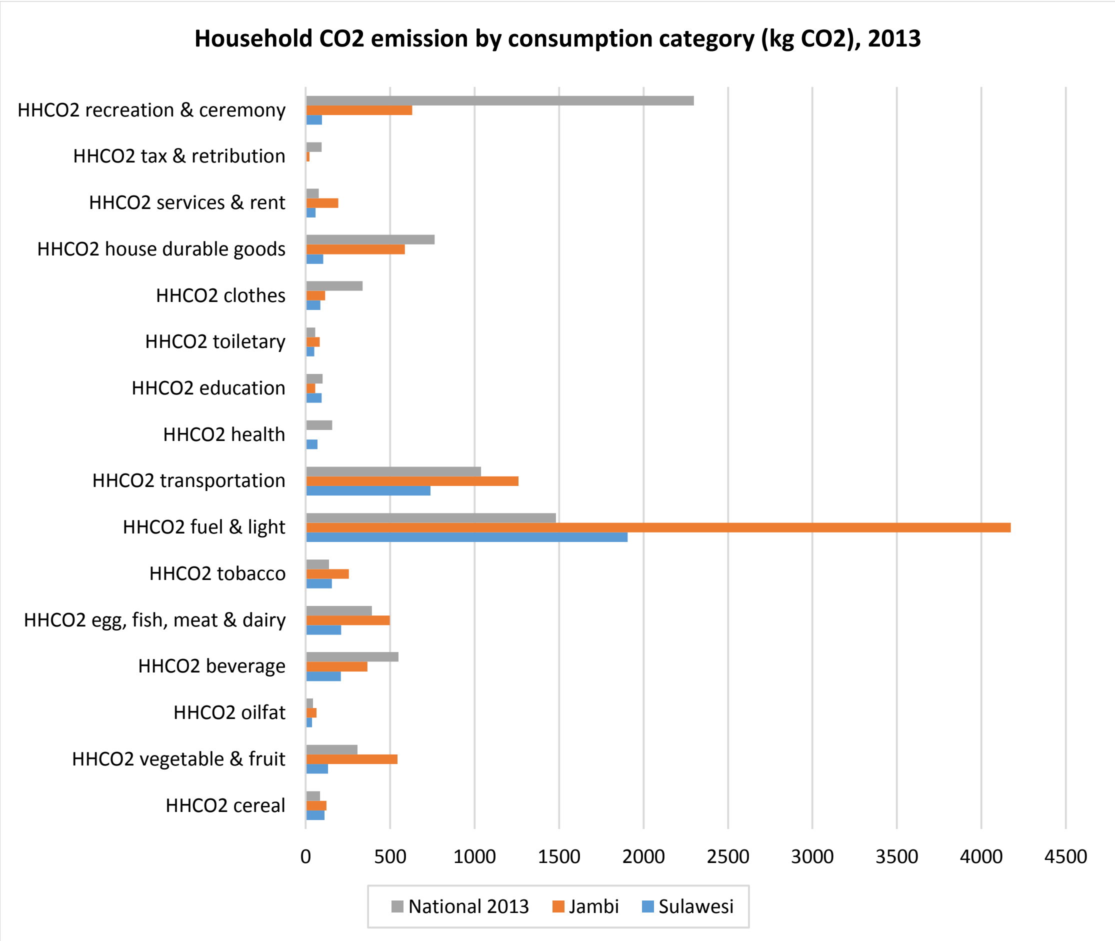

Figure 2. HH CO2 emission by consumption category (kg CO2), 2013
Emission in Expenditure subgroup (National 2013, Jambi and Sulawesi)
Source: Author's computation based on Susenas 2013, Jambi and Sulawesi Survey Data, IO 2005, GTAP-E 2005

Having 13 sector categories household CO2 emission pooled in only aggregated food and nonfood category will give us information on how actually household consumption decisions between food and non-food contribute to the CO2 intensity of emission. **Figure 3** presents average household CO2 emission food, non-food and total average of both categories. Household CO2 on food from cereal, vegetable and fruit, oilfat, beverage, egg, fish and meat as well as tobacco. In non-food category, fuel and light, transportation, health, education, toilerty, clothes, house durable good, service and rent, tax and retribution and recreation and ceremony. In total household CO2 emission intensities in non-food items is almost 3 times higher than in the food. Jambi household average CO2 emission is twice that of Sulawesi in both categories, and Jambi also has slightly higher emissions than the national average.

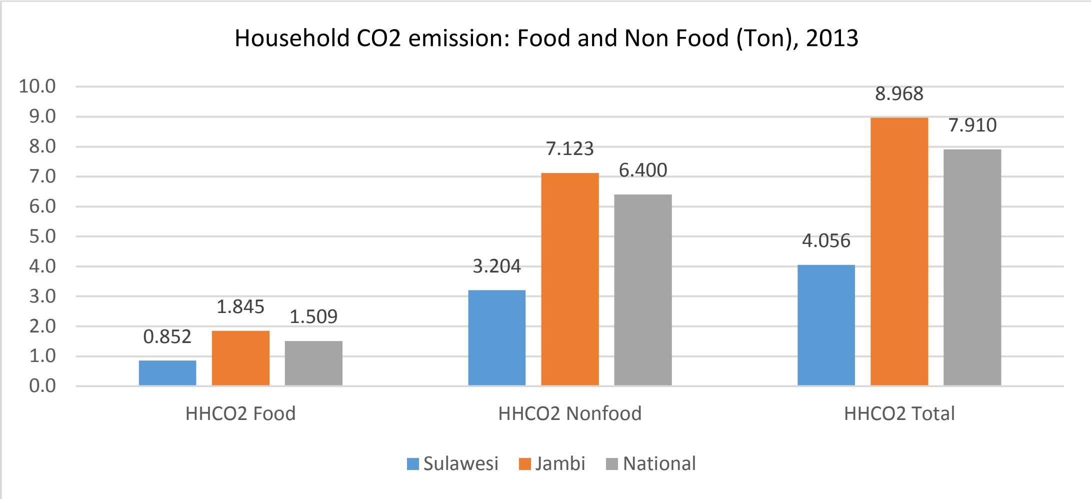

Figure 3. Household Emission: Food and Nonfood classification (Ton)
(National 2013, Jambi and Sulawesi)
Source: Author's computation based on Susenas 2013, Jambi and Sulawesi Survey Data, IO 2005, GTAP-E 2005

To give a better idea of how household CO2 emissions from fuel and light and transportation differ from the rest, **Figure 4 and Figure 5** put fuel and light and transportation next to the previous table. We can observe that even on average CO2 emission from these categories are higher than total CO2 emissions f all food expenditure categories. This explain that total CO2 emission of household in Sulawesi, Jambi and National on average are driven primarily by these sectors. And it is noteworthy that Jambi has the highest carbon footprint in these two categories, particularly the fuel and light one.

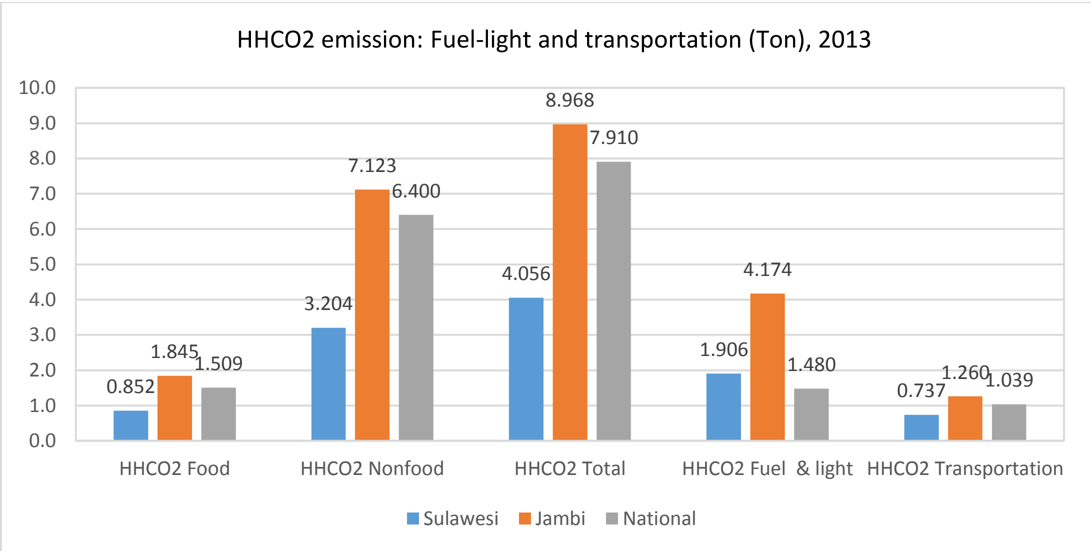

Figure 4. Household CO2 Emission: Fuel-light and Transportation (Ton)
(National 2013, Jambi and Sulawesi)
Source: Author's computation based on Susenas 2013, Jambi and Sulawesi Survey Data, IO 2005, GTAP-E 2005

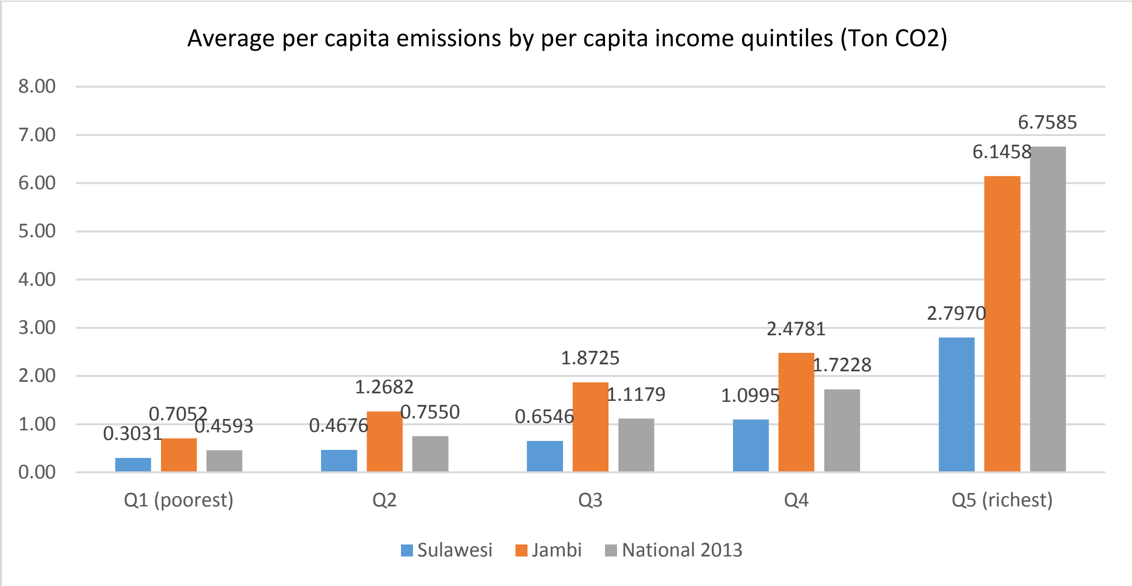

Figure 5. Average per capita emissions by per capita income quintiles (Ton CO2) (National 2013, Jambi and Sulawesi)

Source: Author's computation based on Susenas 2013, Jambi and Sulawesi Survey Data, IO 2005, GTAP-E 2005

Looking at the average per capita emission by per capita income quintile, we find that per capita emissions are increasing as one moves from the poorest to the richest quintile. The highest quintile shows very high average compare to the rest. But the inequality in carbon footprints differs between the three regions. It is highest at the national level, where the richest quintile has about 15 times the emissions per capita of the poorest quintile, while the differential is smallest in Jambi where the ratio is less than 9:1 (in Sulawesi it is a bit more than 9:1). It is not so surprising that national emission inequality is largest, given that the richest quintile consists largely of urban households with high energy and transport needs (see also Irfany and Klasen, 2015). At the same time, it is of particular interest that even the poorest quintile in Jambi has per capita emissions that are substantial, suggesting relatively carbon-intensive life-styles even for poor households there.

Same case also happen when we want to put National Susenas 2005 and 2009 (taken from Irfany, 2014) side by side with previous current quintiles setting. **Figure 6** shows that level of emission captured within the quintiles are at the similar pattern and strongly increasing overtime.

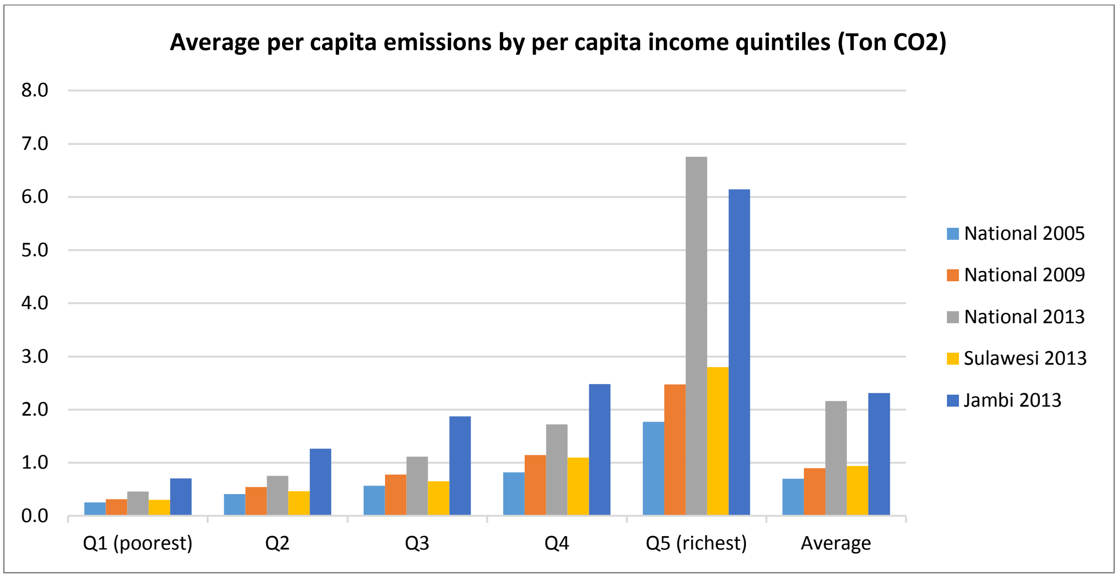

Figure 6. Average per capita emissions by per capita income quintiles (Ton CO2) (National 2005, National 2009, National 2013, Jambi and Sulawesi)
Source: Author's computation based on Susenas 2013, Jambi and Sulawesi Survey Data, IO 2005, GTAP-E 2005

As we have the per capita emission share, now we compare the average per capita expenditure share on the quintile. From the below **Figure 6,** we can observe expenditure inequality closely resembles emission inequality. Expenditure inequality is highest in the national data and lowest in Jambi (with Sulawesi following closely behind). But it is particularly noteworthy that households in Jambi appear to lead overall a particularly carbon-intensive lifestyle. Despite the fact that their average incomes are lower than the national average (see Figure 6), their household emissions are higher. As demonstrated above, this carbon-intensive lifestyle is largely related to high energy consumption of households and high expenditures for transportation.

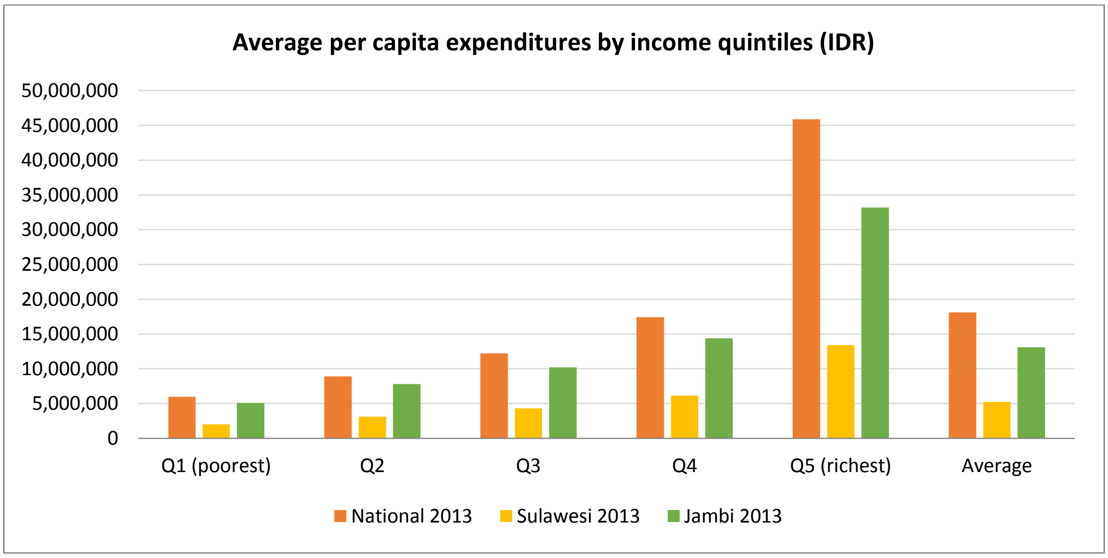

Figure 7. Average per capita expenditure by income quintile (IDR) (National 2005, National 2009, National 2013, Jambi and Sulawesi)
Source: Author's computation based on Susenas 2013, Jambi and Sulawesi Survey Data, IO 2005, GTAP-E 2005

5.2 Drivers of household carbon footprint

In order to further analyze the drivers of the carbon footprint, we do a regression analysis to study the influence of various demographic and economic determinants. **Table 2** provides the result of regression analysis of the drivers from the household carbon footprint.

In all regressions the log of the total household carbon footprint is used as the dependent variable in all regressions. Regression I provide the log of expenditure and other variables as controls. To see the nonlinearity effect on the expenditure, in Regression II, we also include the squared term of log of expenditure. Both in Regression I, we include dummy variables for household size while we include it as continuous variable in regression II. In regression III, we include expenditures as dummy variables (to reduce, as discussed above, the potential in-built correlation).

Table 2. The determinant of household carbon footprint, Sulawesi, Jambi and National Susenas 2013

	I			III			III		
	Sulawesi	**Jambi**	**National 2013**	**Sulawesi**	**Jambi**	**National 2013**	**Sulawesi**	**Jambi**	**National 2013**
lnexp	0.932***	0.888***	1.189***	1.855***	1.931***	1.076***			
lnexpsq				-0.024***	-0.028***	0.003***			
Expenditure quintiles									
2							0.591***	0.455***	0.502***
3							0.897***	0.741***	0.849***
4							1.364***	0.984***	1.202***
5							3.168***	1.932***	2.034***
HH education									
Elementary	0.024**	-0.160***	0.089***	0.001	-0.01	0.090***			
Secondary	0.063***	-0.006	0.117***	0.058***	0.125***	0.119***			
High school	0.303***	-0.077***	0.115***	0.272***	0.052***	0.115***			
At least college	0.086***	-0.011	0.112***	0.085***	0.131***	0.112***			
HH size									
3	0.230***	0.144***	-0.040***						
4	0.253***	0.223***	-0.085***						
5	0.174***	0.166***	-0.115***						
6	0.210***	0.002	-0.145***						
7+	0.141***	0.087***	-0.186***						
HH age									
25-44	0.111***	0.041***	0.013***						
45-64	-0.113***	0.070***	0.059***						
65+	0.408***	0.233***	0.091***						
Married	-0.080***	0.046***	-0.013***	-0.029***	0.079***	-0.017***			
Female	0.019***	0.068***	0.061***	0.007	0.060***	0.061***			
Employment status									
Non-farm	0.102***	-0.079***	0.085***	0.116***	-0.104***	0.085***			
Still scholing	0.119***	0.049***		0.004	0.021				
Others	0.031**	-0.054***	0.014***	0.013	-0.104***	0.014***			
Local ethnic dummy	-0.273***	0.022***		-0.228***	0.028***				
Urban dummy			0.016***			0.015***			
hhsize				0.128***	0.175***	-0.044***			
hhsizesq				-0.014***	-0.021***	0.001***			
Age				-0.012***	-0.013***	0.003***			
agesq				0.000***	0.000***	-0.000***			
Number of observations	23,744	38,845	696,311	23,744	38,845	696,311	54,040	92,532	2,903,826
R2	0.913	0.625	0.853	0.913	0.625	0.853	0.554	0.367	0.548
Adjusted R2	0.913	0.625	0.853	0.913	0.625	0.853	0.554	0.367	0.548
F	10,764.10	1,729.40	139,220.20	14,895.34	3,828.41	195,789.52	12,635.29	10,988.63	671,730.79

Source: Author's estimation.
*Note: * (**, ***) indicates significance at the ten (five, one) percent level.*

The first regression captures the very strong influence of expenditures on the household carbon footprint. This relationship is positive and significant in all three databases; the elasticity is below 1 in Sulawesi and Jambi while it is slightly larger than 1 in the national data, suggesting that changes in lifestyle of richer households lead to rising proportionate footprints. Control variables for education, household size, age, married and female household head, employment status and ethnicity are also significant for the carbon footprint. In Sulawesi and national cases, higher household's education (household head) increases emissions while the effect of education (controlling for expenditure) is mostly insignificant in Jambi. Also noteworthy is the role of ethnicity. In Sulawesi, households that are considered as from the local ethnic group have a negative impact on the carbon footprint, but a positive sign appears in Jambi.

In regression II, we include the square term for expenditures. We find that nonlinearity effect in expenditure on the carbon footprint happens for Sulawesi and Jambi, whereas this effect is not pronounced in the National Susenas database. Thus while the data from Sulawesi and Jambi suggest an inverted U shape (consistent with the hypothesis of the Environmental Kuznets Curve), this is not the case for the national data in 2013.

In the last regression, we use household quintiles. All quintiles are positively significant with the household emission and as the quintile shift from the bottom to the top.

6. Conclusion

The purpose of this paper has been to investigate the levels and determinants of the consumption-based carbon footprint of households in two rural areas from two very different settings and compare them with national data of Indonesia.

We apply the national IO table and GTAP data and then match it with the household expenditure classification from Sulawesi, Jambi, National Susenas databases. This way we are able to estimate the intensities of CO2 emissions of different expenditure categories and derive the carbon footprint of households. Additionally, we also analyze the determinant of household carbon footprint.

Matching household expenditure with IO table and GTAP, we indicate that the most CO2 emissions are contributed from the fuel-light and transportation consumption-based expenditure items. The amount of these particular expenditure considered to be the biggest share of the household total carbon footprint source. The lowest share of CO2 emission and comes from the expenditure on food-agriculture category.

We also note that the household carbon footprint in Jambi is higher than in Indonesia as a whole, despite lower per capita expenditures. Our analysis of emission expenditures suggest that this is heavily affected by relatively high emissions in lower quintiles. And it is largely related to high expenditures on energy (fuel and light) as well as transportation. Thus households in Jambi who already contribute substantially to emissions on the production side (related to conversion of forests to oil palm) also contribute substantially on the consumption side.

When it comes to drivers of the carbon footprint, we find that household income (or proxied here by expenditures) is the largest driver of emissions in the cross-section as well as in the comparison between the regions, as well as over time (see also Irfany, 2014). Thus suggests that rising incomes will be associated with further increases in the carbon footprint unless major changes occur on the way energy is being produced and used (see also Jakob et al. 2014).

The household-level of emissions in a developing country like Indonesia is still below the one in the developed country, but it nevertheless has serious impacts on threatening the future global climate condition. And as development proceeds, this impact will rise as well. For that reason, promoting energy efficiency through the reduction of fuel subsidies, green policies to support for better infrastructure (especially sustainable mass transport), low-carbon energy system and promoting decarbonisation of the energy system is critical.

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Appendix 1. CO_2 Emission Intensity (gram CO_2/Rp), domestic technology, domestic emission

IO code	*Sectors*	*CO_2 intensity*
1	Paddy	0.006820
2	Corn	0.004500
3	Cassava	0.002800
4	Sweet potato	0.001020
5	Other tubers	0.024600
6	Bean	0.002180
7	Soybean	0.002860
8	Other nuts	0.003790
9	Vegetables	0.002660
10	Fruits	0.001850
11	Grains and other foodstuffs	0.000780
12	Rubber	0.007480
13	Cane	0.021460
14	Coconut	0.019640
15	Palm	0.025310
16	Fiber crops	0.000310
17	Tobacco	0.038470
18	Coffee	0.029880
19	Tea	0.029950
20	Clove	0.028100
21	Cocoa	0.025890
22	Cashew nuts	0.026000
23	Other plantation crops	0.033320
24	Other agricultural products	0.029300
25	Livestock and their products except fresh milk	0.005670
26	Fresh milk	0.023430
27	Poultry and their products	0.009140
28	Other animal products	0.003740
29	Timber	0.028400
30	Other forest products	0.028310
31	Marine fish and other marine products	0.046800
32	The inland fish and products	0.045190
33	Shrimp	0.046910
34	Agricultural services	0.032950
35	Coal	0.008320
36	Petroleum	0.008160
37	Natural gas and geothermal	0.081440
38	Tin ore	0.028600
39	Nickel ore	0.025250
40	Seeds of bauxite	0.043390
41	Copper seed	0.030620
42	Gold ore	0.031790
43	Silver ore	0.039280
44	Iron	0.027290
45	Other metallic minerals	0.024600
46	Nonmetallic mineral mining products	0.034900
47	Coarse salt	0.030480
48	Excavation of all types of goods	0.033690
49	Meat, offal and the like	0.006420
50	Processed and preserved meat	0.026770
51	Food and beverages made from milk	0.013140
52	Fruits and vegetables are processed and preserved	0.093870
53	Dried fish and salted fish	0.023870
54	Processed and preserved fish	0.025020
55	Copra	0.019600
56	Animal and vegetable oils	0.009260
57	Rice	0.004670
58	Wheat flour	0.010970
59	Other flours	0.012080
60	Bread, biscuits and the like	0.015100
61	Noodles, macaroni and the like	0.014640
62	Sugar	0.010110
63	Peeling grains	0.019800
64	Chocolate and sugar confectionery	0.012800
65	Ground and peeling coffee	0.015140

66	Processed tea	0.029010
67	Soybean processing results	0.013100
68	Other food	0.014480
69	Animal feed	0.018200
70	Alcoholic beverages	0.025000
71	Non alcoholic beverages	0.023500
72	Processed Tobacco	0.034640
73	Cigarette	0.020450
74	Cotton	0.076400
75	Thread	0.082420
76	Textiles	0.072660
77	Textiles products unless clothes	0.054530
78	Knitted goods	0.033800
79	Apparel	0.026400
80	Rugs, rope and other textiles	0.037070
81	Equate skin and processed	0.019420
82	Leather products	0.020030
83	Footwear	0.021260
84	Sawn and preserved timber	0.036540
85	Plywood etc	0.030980
86	Building materials of wood	0.030480
87	Furniture made of wood, bamboo and rattan	0.019920
88	Products of wood, cork, bamboo and rattan	0.022480
89	Webbing products unless plastic	0.013320
90	Pulp	0.053740
91	Paper and paperboard	0.066100
92	Processed goods from paper and paperboard	0.060060
93	Printed goods	0.071730
94	Basic chemicals except fertilizers	0.012060
95	Fertilizer	0.023240
96	Pesticide	0.031640
97	Synthetic resins, plastic materials and synthetic fibers	0.023960
98	Paints, varnishes and lacquers	0.037870
99	Drugs (medicals)	0.021070
100	Traditional herb	0.023610
101	Soap and cleaning agents	0.023290
102	Cosmetic goods	0.020070
103	Other chemical goods	0.019500
104	The products of oil refinery	0.110930
105	Liquefied natural gas (LNG)	0.128280
106	Crumb rubber and rubber fumes	0.011870
107	Tire	0.037650
108	Other items of rubber	0.027660
109	Plastic products	0.031330
110	Ceramics and items made of clay	0.368250
111	Glass and glass products	0.385420
112	Ceramics and building materials from clay	0.373310
113	Cement	0.446190
114	Other items of non-metallic materials	0.395520
115	Iron and steel basic	0.138910
116	Items of basic iron and steel	0.133080
117	Base metal (non-iron)	0.024030
118	Products of metal rather than iron	0.051320
119	Kitchen tools, woodworking and agriculture of the metal	0.052470
120	Household-office furniture from metal	0.054190
121	Construction materials from metal	0.068670
122	Other metal products	0.069270
123	First driving machine	0.020000
124	Machinery and equipment nec	0.006760
125	Generator and electric motors	0.015840
126	Electrical machinery and equipment	0.020130
127	Electronic goods, communications and equipment	0.020680
128	Electrical appliances for household	0.020910
129	Other electrical equipment	0.026940
130	Batteries and accumulators	0.020140
131	Shipbuilding and repair services	0.013680
132	Train and repair services	0.041400
133	Motor vehicles except motorcycles	0.013010
134	Motorcycle	0.016270

135	Other conveyance	0.028900
136	Aircraft repairs and services	0.008260
137	Measuring devices, photographic, optical and clocks	0.050580
138	Jewelry	0.097850
139	Musical instruments	0.108740
140	Sports tools	0.091770
141	Other industry products	0.100440
142	Electricity and gas	1.049620
143	Clean water	0.152200
144	Residential and non residential buildings	0.039490
145	Agricultural infrastructure	0.045890
146	Roads, bridges and ports	0.041360
147	Building and installations, electricity, gas and water supply and communication	0.030220
148	Other buildings	0.033460
149	Trade in services	0.028160
150	Restaurant services	0.015450
151	Hospitality services	0.013600
152	Railway services	0.171560
153	Road transport services	0.111490
154	Marine transportation services	0.163380
155	River and lake transport services	0.161530
156	Air transport services	0.204210
157	Transport support services	0.107950
158	Communication services	0.015180
159	Bank	0.014460
160	Other financial institutions	0.014820
161	Insurance and pension funds	0.012100
162	Building and land rent	0.005080
163	Corporate services	0.020050
164	General government services	0.025900
165	Government educational services	0.023290
166	Government health services	0.016340
167	Other government services (entertainment, recreation and culture)	0.018760
168	Private education services	0.019120
169	Private health services	0.015720
170	Other community services	0.016430
171	Film and distribution services of private	0.006330
172	Entertainment services, recreation and culture of private	0.020130
173	Overhaul services	0.023410
174	Personal and household services	0.018980
175	Goods and services not included elsewhere	0.039860

Source: Irfany, 2014 based on GTAP-E and IO 2005.

Appendix 2.a GTAP sectors

No.	***Code***	***Description***
1	pdr	Paddy rice
2	wht	Wheat
3	gro	Cereal grains nec
4	v_f	Vegetables, fruits, nuts
5	osd	Oilseeds
6	c_b	Sugar cane, sugar beet
7	pfb	Plant-based fibers
8	ocr	Crops nec
9	ctl	Bovine cattle, sheep and goats, horses
10	oap	Animal products nec
11	rmk	Raw milk
12	wol	Wool, silk-worm cocoons
19	cmt	Bovine cattle, sheep and goat, horse meat products
20	omt	Meat products nec
21	vol	Vegetable oils and fats
22	mil	Dairy products
23	pcr	Processed rice
24	sgr	Sugar
25	ofd	Food products nec
26	b_t	Beverages and tobacco products
15	col	Coal
16	oil	Oil
17	gas	Gas
32	p_c	Petroleum, coal products
43	ely	Electricity
44	gdt	Gas manufacture, distribution
13	for	Forestry
14	fsh	Fishing
18	omn	Minerals nec
27	tex	Textiles
28	wap	Wearing apparel
29	lea	Leather products
30	lum	Wood products
31	ppp	Paper products, publishing
33	crp	Chemical, rubber, plastic products
34	nmm	Mineral products nec
35	i_s	Ferrous metals
36	nfm	Metals nec
37	fmp	Metal products
38	mvh	Motor vehicles and parts
39	otn	Transport equipment nec
40	ele	Electronic equipment
41	ome	Machinery and equipment nec
42	omf	Manufactures nec
45	wtr	Water
46	cns	Construction
47	trd	Trade
48	otp	Transport nec
49	wtp	Water transport
50	atp	Air transport
51	cmn	Communication
52	ofi	Financial services nec
53	isr	Insurance
54	obs	Business services nec
55	ros	Recreational and other services
56	osg	Public administration and defense, education, health
57	dwe	Dwellings

Source: Huff, McDougall, Walmsley (2000) in Irfany, 2014

Appendix 2.b GTAP sectors: detailed description

No.	***Code***	***Code***	***Description***
1	pdr	113	Rice, not husked
		114	Husked rice
2	wht	111	Wheat and meslin
3	gro	112	Maize (corn)
		115	Barley
		116	Rye, oats
		119	Other cereals
4	v_f	12	Vegetables
		13	Fruit and nuts
5	osd	14	Oil seeds and oleaginous fruit
6	c_b	18	Plants used for sugar manufacturing
7	pfb	192	Raw vegetable materials used in textiles
8	ocr	15	Live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds
		16	Beverage and spice crops
		17	Unmanufactured tobacco
		191	Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets
		193	Plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes
		194	Sugar beet seed and seeds of forage plants
		199	Other raw vegetable materials
9	ctl	211	Bovine cattle, sheep and goats, horses, asses, mules, and hinnies, live
		299	Bovine semen
10	oap	212	Swine, poultry and other animals, live
		292	Eggs, in shell, fresh, preserved or cooked
		293	Natural honey
		294	Snails, live, fresh, chilled, frozen, dried,
			salted or in brine, except sea snails; frogs'
			legs, fresh, chilled or frozen
		295	Edible products of animal origin n.e.c.
		297	Hides, skins and furskins, raw
		298	Insect waxes and spermaceti, whether or not refined or coloured
11	rmk	291	Raw milk
12	wol	296	Raw animal materials used in textile
13	for	3	Forestry, logging and related service activities
19	cmt	21111	Meat of bovine animals, fresh or chilled
		21112	Meat of bovine animals, frozen
		21115	Meat of sheep, fresh or chilled
		21116	Meat of sheep, frozen
		21117	Meat of goats, fresh, chilled or frozen
		21118	Meat of horses, asses, mules or hinnies, fresh, chilled or frozen
		21119	Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, chilled or frozen
		2161	Fats of bovine animals, sheep, goats, pigs and poultry, raw or rendered; wool grease
20	omt	21113	Meat of swine, fresh or chilled
		21114	Meat of swine, frozen
		2112	Meat and edible offal, fresh, chilled or frozen, n.e.c.
		2113	Preserves and preparations of meat, meat offal or blood
		2114	Flours, meals and pellets of meat or meat offal, inedible; greaves
		2162	Animal oils and fats, crude and refined, except fats of bovine animals, sheep, goats, pigs and poultry
21	vol	2163	Soya-bean, ground-nut, olive, sunflower-seed, safflower, cotton-seed rape, colza and mustard oil, crude
		2164	Palm, coconut, palm kernel, babassu and linseed oil, crude
		2165	Soya-bean, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and mustard oil and their fractions, refined but not chemically modified; other oils obtained solely from olives and sesame oil, and their fractions, whether or not refined, but not chemically modified
		2166	Maize (corn) oil and its fractions, not chemically modified
		2167	Palm, coconut, palm kernel, babassu and linseed oil and their fractions, refined but not chemically modified; castor, tung and jojoba oil and fixed vegetable fats and oils (except maize oil) and their fractions n.e.c., whether or not refined, but not chemically modified
		2168	Margarine and similar preparations
		2169	Animal or vegetable fats and oils and their fractions, partly or wholly hydrogenated, inter-

			esterified, re-esterified or elaidinised, whether or not refined, but not further prepared
		217	Cotton linters
		218	Oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues resulting from the treatment of fatty substances or animal or vegetable waxes
22	mil	22	Dairy products
23	pcr	2316	Rice, semi- or wholly milled
24	sgr	235	Sugar
25	ofd	212	Prepared and preserved fish
		213	Prepared and preserved vegetables
		214	Fruit juices and vegetable juices
		215	Prepared and preserved fruit and nuts
		2311	Wheat or meslin flour
		2312	Cereal flours other than of wheat or meslin
		2313	Groats, meal and pellets of wheat
		2314	Cereal groats, meal and pellets n.e.c.
		2315	Other cereal grain products (including corn flakes)
		2317	Other vegetable flours and meals
19		2318	Mixes and doughs for the preparation of bakers' wares
		232	Starches and starch products; sugars and syrups n.e.c.
		233	Preparations used in animal feeding
		234	Bakery products
		236	Cocoa, chocolate and sugar confectionery
		237	Macaroni, noodles, couscous and similar farinaceous products
		239	Food products n.e.c.
26	b_t	24	Beverages
		25	Tobacco products
14	fsh	15	Hunting, trapping and game propagation including related service activities
		5	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing
15	col	101	Mining and agglomeration of hard coal
		102	Mining and agglomeration of lignite
		103	Mining and agglomeration of peat
16	oil	111	Extraction of crude petroleum and natural gas
		112	Service activities incidental to oil and gas extraction excluding surveying (part)
17	gas	111	Extraction of crude petroleum and natural gas
		112	Service activities incidental to oil and gas extraction excluding surveying (part)
18	omn	12	Mining of uranium and thorium ores
		13	Mining of metal ores
		14	Other mining and quarrying
27	tex	17	Manufacture of textiles
		243	Manufacture of man-made fibres
28	wap	18	Manufacture of wearing apparel; dressing and dyeing of fur
29	lea	19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
30	lum	20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
31	ppp	21	Manufacture of paper and paper products
		22	Publishing, printing and reproduction of record media
32	p_c	231	Manufacture of coke oven products
		232	Manufacture of refined petroleum products
		233	Processing of nuclear fuel
33	crp	241	Manufacture of basic chemicals
		242	Manufacture of other chemical products
		25	Manufacture of rubber and plastics products
34	nmm	26	Manufacture of other non-metallic mineral products
35	i_s	271	Manufacture of basic iron and steel
		2731	Casting of iron and steel
36	nfm	272	Manufacture of basic precious and non-ferrous metals
		2732	Casting of non-ferrous metals
37	fmp	28	Manufacture of fabricated metal products, except machinery and equipment
38	mvh	34	Manufacture of motor vehicles, trailers and semi- trailers
39	otn	35	Manufacture of other transport equipment
40	ele	30	Manufacture of office, accounting and computing machinery
		32	Manufacture of radio, television and communication equipment and apparatus
41	ome	29	Manufacture of machinery and equipment n.e.c.
		31	Manufacture of electrical machinery and apparatus n.e.c.
		33	Manufacture of medical, precision and optical instruments, watches and clocks

42	omf	36	Manufacturing n.e.c.
		37	Recycling
43	ely	401	Production, collection and distribution of electricity
44	gdt	402	Manufacture of gas; distribution of gaseous fuels through mains
		403	Steam and hot water supply
45	wtr	41	Collection, purification and distribution of water
46	cns	45	Construction
47	trd	50	Sales, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
		51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
		521	Non-specialized retail trade in stores
		522	Retail sale of food, beverages and tobacco in specialized stores
		523	Other retail trade of new goods in specialized stores
		524	Retail sale of second-hand goods in stores
		525	Retail trade not in stores
		526	Repair of personal and household goods
		55	Hotels and restaurants
48	otp	60	Land transport; transport via pipelines
		63	Suupporting and auxiliary transport activities;
49	wtp	61	Water transport
50	atp	62	Air transport
51	cmn	64	Post and telecommunications
52	ofi	65	Financial intermediation, except insurance and pension funding
		67	Activities auxiliary to financial intermediation
53	isr	66	Insurance and pension funding, except compulsory social security
54	obs		Real estate, renting and business activities
55	ros	92	Recreational, cultural and sporting activities
		93	Other service activities
		95	Private households with employed persons
56	osg	75	Public administration and defense; compulsory social security
		80	Education
		85	Health and social work
		90	Sewage and refuse disposal, sanitation and similar activities
		91	Activities of membership organizations n.e.c.
		99	Extra-territorial organizations and bodies
57	dwe	n.a.	n.a.

Source: Huff, McDougall, Walmsley (2000), in Irfany, 2014
Note: GTAP A5GSC2 sectors defined by reference to the ISIC.

Appendix 3. Expenditure category: description

Expenditure Category	***Description***
Cereal	Rice, grains, and cereals
Vegetable and fruit	Vegetable and fruit
Oil and fat	Oil and fat ingredients
Beverage	Drink material, season, noodles, chips, alcohol drink
Egg, fish, meat, and dairy	Egg, fish, meat, dairy products
Tobacco	Tobacco
Fuel and light	Electricity bill, fuel
Telecommunication	Telephone bill, other telecommunication
Transportation	Transportation cost
Health	Health costs, health insurance
Education	Education costs
Toiletry	Soap, cosmetic, etc
Clothes	Clothes
House and durable goods	House and durable goods
Services and rent	Services
Taxes	Taxes, retribution, other taxes
Recreation, entertainment, ceremony	Recreation, entertainment, ceremony

Source: Irfany, 2014

Appendix 4. Descriptive Analysis: C02 emission of Sulawesi, Jambi and National 2013 Survey

Variable	*Sulawesi 2013*		*Jambi 2013*		*National 2013*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
HHCO2 cereal	**111.7612**	**73.62308**	**121.5191**	**159.4434**	**83.5547**	**50.89924**
HHCO2 vegetable & fruit	**131.5513**	**114.9804**	**542.3238**	**347.9399**	**306.9308**	**227.4745**
HHCO2 oilfat	**37.64763**	**40.0668**	**64.31804**	**49.71962**	**43.48686**	**29.13329**
HHCO2 beverage	**206.8912**	**155.8832**	**364.3545**	**434.8049**	**548.2607**	**1042.143**
HHCO2 egg, fish, meat & dairy	**210.1239**	**1008.699**	**497.3163**	**431.9577**	**390.7365**	**558.0579**
HHCO2 tobacco	**154.0506**	**179.2982**	**254.9024**	**246.9553**	**136.5291**	**206.8849**
HHCO2 fuel & light	**1906.13**	**5130.861**	**4174.405**	**18942.7**	**1480.34**	**1764.669**
HHCO2 transportation	**737.3247**	**1648.665**	**1259.725**	**3644.973**	**1038.54**	**2585.237**
HHCO2 health	**68.41313**	**734.0008**	**2.500176**	**57.1272**	**157.2524**	**1546.808**
HHCO2 education	**94.61633**	**296.387**	**55.56453**	**168.5152**	**99.77821**	**336.6432**
HHCO2 toiletary	**49.99057**	**46.99602**	**82.07207**	**416.3139**	**55.64317**	**64.18389**
HHCO2 clothes	**86.03296**	**194.5066**	**115.3199**	**119.1287**	**336.3757**	**634.0334**
HHCO2 house durable goods	**103.1066**	**427.2681**	**587.5377**	**1903.596**	**762.1031**	**8680.517**
HHCO2 services & rent	**58.32375**	**468.1595**	**193.0625**	**900.1311**	**76.64272**	**778.7012**
HHCO2 tax & retribution	**3.779958**	**16.79681**	**22.33307**	**55.33881**	**94.61824**	**388.3925**
HHCO2 recreation & ceremony	**96.66014**	**893.6408**	**630.5849**	**1829.429**	**2298.813**	**38660.87**
HHCO2 Food	***852.0258***	***1103.119***	***1844.734***	***1038.728***	***1509.499***	***1444.369***
HHCO2 Nonfood	***3204.379***	***5829.694***	***7123.105***	***19940.58***	***6400.106***	***40238.44***
HHCO2 Total	***4056.404***	***6041.263***	***8967.839***	***20075.76***	***7909.605***	***40444.73***

Source: Author’s computation, based on GTAP-E, Indonesian Input Output and Susenas (based on Irfani. 2014)

Appendix 5. Average per capita CO2 emissions by income quintiles (Ton), Sulawesi, Jambi and National Susenas 2013

	Sulawesi	***Jambi***	***National***
	Year 2013	***Year 2013***	***Year 2013***
Per capita income quintiles	**Per capita CO2 (in tons)**	**Per capita CO2 (in tons)**	**Per capita CO2 (in tons)**
Q1 (poorest)	**0.3031**	**0.7052**	**0.4593**
Q2	**0.4676**	**1.2682**	**0.7550**
Q3	**0.6546**	**1.8725**	**1.1179**
Q4	**1.0995**	**2.4781**	**1.7228**
Q5 (richest)	**2.7970**	**6.1458**	**6.7585**
Average	**0.9400**	**2.3148**	**2.1627**

Source: Author's computation, based on GTAP-E, Indonesian Input Output and Susenas2013 (based on Irfany, 2014).

Appendix 6. Average per capita CO2 emissions by income quintiles (Ton), Sulawesi, Jambi and National Susenas 2005, 2009, 2013

	National	***National***	***National***	***Sulawesi***	***Jambi***
	Year 2005	***Year 2009***	***Year 2013***	***Year 2013***	***Year 2013***
Per capita income quintiles	Per capita CO2 (in tons)	Per capita CO2 (in tons)	Per capita CO2 (in tons)	Per capita CO2 (in tons)	Per capita CO2 (in tons)
Q1 (poorest)	0.2542	0.3170	0.4593	0.3031	0.7052
Q2	0.4097	0.5440	0.7550	0.4676	1.2682
Q3	0.5679	0.7810	1.1179	0.6546	1.8725
Q4	0.8212	1.1450	1.7228	1.0995	2.4781
Q5 (richest)	1.7715	2.4760	6.7585	2.7970	6.1458
Average	**0.6979**	**0.8980**	**2.1627**	**0.9400**	**2.3148**
Note: quantile classification is based on household per-capita expenditure distribution.					

Source: Author's computation, based on GTAP-E, Indonesian Input Output and Susenas 2013 (based on Irfany, 2014), computation on Susenas 2005 and 2009 based on Irfany, 2014