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Carbon Footprint Based on Household Consumption: Case Study on Cocoa Farmer's Household in Polewali Mandar

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Abstract

Sustainable development has become an interesting issue in the 21st century. The main pillar of sustainable development is the economic sustainability, social, and environmental. Since the industrial revolution, there is a trade-off between economic growth and environment. The main environmental problem nowadays is a huge amount of carbon dioxide in the atmosphere. This study aims to analyze the determinant of carbon footprint formation through household consumption approach, with the case of cacao farmers in Polewali Mandar. This study employed OLS and quantile regression as the method. A combined GTAP-E data, I-O, and the calculation of carbon footprint survey used in this study. The result shows that fuel light consumption and transportation are the most carbon footprint formers. Furthermore, household income determines the most carbon footprint. The higher household income, the higher carbon footprint produced. The control variables that influence the carbon footprint are marriage status, poverty level and household size.

Keywords: carbon footprint, household consumption, OLS, quantile regression, sustainable development

1. Introduction

Sustainable development has been an interesting issue since 2015. Basically, economic development measured by economic growth, increasing prosperity and full employment (Bermejo, 2014). World Commission on Economic and Development (1987) in Brundtland's report as known as Our Common Future, explained that sustainable development is a development that fulfill the needs of nowadays generation without sacrificing the needs of the generation in the future (Brundtland, 1987).

Furthermore, development is not only about national income-oriented, but also in regards with other issues such as better education, better health and nutrition standard, better environmental condition, high employment-opportunities, individual freedom and the conservation of culture in life (World Development Report, 1991). Sustainable development has three main pillars, stable economic growth, continuous social structure with good income distribution, and continuous environmental with high awareness to the environment (Harris, 2000).

One of the most important issue in economic development is how to face the trade-off of fulfilling the needs of economic development with regards to keep the environmental sustainability as well. The benchmark to see the economic development is per capita income (Todaro & Smith, 2006). The condition of the environmental is represented by the level of pollutant emissions (Grossman & Krueger, 1991). The theory that connects per capita income and degradation of the environmental condition is known as Environmental Kuznets Curve (EKC). As a hypothesis from Kuznets (1955), when the income of a nation is low, the focus of the nation is how to increase the income by setting environmental issues aside. When the nation has achieved a high income, a turning point happened, the nation will try to decrease the level of emission by using eco-friendly technology (Mason & Swanson, 2002). Andreoni and Levinson (2001) said that in this stage, the citizen begin to decrease their consumption of high level carbon intensity as an awareness of the environmental.

Indonesia as a developing country still has issues as explained in Environmental Kuznets Curve (EKC), that the increase of per capita income is followed by the increase of per capita carbon dioxide emissions (Nuryartono & Rifai, 2017). Per capita GDP in Indonesia has positively grown up from 1960 to 2014 period. Indonesia per capita GDP has experienced 5.35 times of increased from 1960 to 2014 period. Nevertheless, the increase of per capita GDP is followed by the increase of carbon dioxide emission in Indonesia. The level of average emission in Indonesia is 1.14 metric ton per capita with 4.63 percent of average growth every year (World Development Index, 2018). The advancing of carbon dioxide emission becomes one of the indicators causing the global warming as a result of the increasing of a greenhouse effect.

Global warming is an environmental issue faces in the 21st century. The main cause of global warming is the greenhouse effect. The percentage of greenhouse effect concentration is approximately 90 percent comes from carbon dioxide emission, 9 percent from methane, and the other comes from nitrogen dioxide. While the carbon dioxide emission component is approximately 68 percent comes from the energy sector, 11 percent comes from the agricultural sector, 7 percent from the industry sector, and 14 percent comes from the other sectors (International Energy Agency, 2016). The carbon dioxide emission worsening the climate change, either in the short-term or long-term, and the climate change is certainly irreversible (Solomon et al., 2009).

The carbon dioxide emission level in Indonesia is high. In a few years, Indonesia is included as one of 20 countries that creates the most carbon dioxide in the world (United Nations, 2012). The carbon dioxide emission in Indonesia is caused by a lot of factors. Deforestation becomes the main problem that caused high carbon dioxide emission in Indonesia. However, in the past few years, household consumption has part of the increase of carbon dioxide emission in Indonesia (Jakob et al., 2014; Irfany& Klasen, 2017).

In the past few years, enviromental issue becomes a global topic. Some researchers do an analytical study of greenhouse effect that comes from economic activity in the household level. These research conducted by calculating the carbon footprint through consumption and household income approach. Basically, there are a few studies that integrate household consumption data with the input-output analysis to calculate the intensity that is produced by the household. Methodologically, Lenzen (1998) used the intensity of carbon emission from the economic activity that comes from the input-output analysis.

Research about carbon footprint based on consumption is more likely done in developed countries rather than in developing countries due to data limitations in the developing countries. Previous studies related to carbon footprint in the developed countries: Australia (Lenzen, 1998), Irlandia (Kenny & Gray, 2009), Denmark (Wier et al., 2001), Netherlands, Sweden, United Kingdom, Norway (Kerkhof et al., 2009), United States (Bin & Dowlatabadi, 2005), United Kingdom (Baiocchi et al., 2010). However, studies about carbon footprint in the developing countries is limited. Those studies were done in India (Parikh et al., 1997; Grunewald et al., 2012), Philiphines (Serino & Klasen, 2015) and Indonesia (Irfany & Klasen, 2016; Irfany&Klasen 2017).

Lenzen (1998) analyzed the carbon footprint in Australia using the intensity of the carbon emission from economic activities with input-output analysis. The result of the study shows that the main factor that contributes to the carbon footprint is consumption of the industry sector. Kenny and Gray (2009) in their study found that the main indicator that affects the carbon footprint in households in Ireland comes from the consumption of energy and transportation. In the United States, more than 80 percent of energy used and carbon dioxide produced comes from consumption (Bin & Dowlatabadi, 2005). Meanwhile in the United Kingdom, household consumption contributes more than 70 percent of the total emission (Baiocchi et al., 2010). Carbon footprint analysis by Hertwich and Peters (2009) involved IO emission analysis with GTAP database to forecast the intensity of carbon dioxide emission by applying multi regional input-output to estimate carbon footprint. About 70 percent of the total greenhouse effect emission is produced by household spending to consume food and transportation.

One of the carbon footprint analysis in developing countries was done in India. This study was the first carbon footprint study in developing countries. Parikh et al. (1997) combined IO analysis distributed data on total household spending in India. This study calculated the emission intensity that comes from either direct or indirect product of household consumption. The result shows that direct goods and services consumption produces the most carbon footprint, while the rest caused by indirect goods and services consumption. The differences in income level leads to differences in carbon footprint of each household, high income household creates 15 times bigger carbon footprint than low income household.

Another study done by Grunewald et al. (2012) by integrating survey data in 2004 and 2007 in India, using regression method to analyze the income elasticity. The result shows that household income is a key determinant of carbon footprint, while the other is location, size of household, and level of education. Serino and Klasen (2015) investigated the carbon footprint in Philippines, using data from Philippines national survey in 2000 and

2006, also utilized the IO table and GTAP analysis. The result shows that the fuel of vehicle and transportation produces CO_2 the most. Furthermore, they found that household income becomes an important stimulus related to the emissions.

For some developing countries, the change of consumption pattern and income has an increase trend to the carbon footprint. Irfany and Klasen (2017) found that the carbon footprint in Indonesia determined by household expenditure. The IO table integrated with GTAP analysis shows that fuel, lights, and transportation become the indicators that produce emissions the most in Indonesia. The data from Indonesia National Socio-Economic Survey(SUSENAS) database utilized and the result shows that household income affects carbon footprint.

Indonesia is a country with high diversity in every territory. Irfany et al., (2015) chose Sulawesi and Jambi because every territory in Indonesia has its own production pattern and household consumption. Agriculture system in Jambi dominated by palm fruit plantation. In Sulawesi, cacao is the dominant one. The result shows that household income produces the carbon footprint the most. The household expenditure affects the carbon footprint the most comes from transportation and fuel light. The result of this study shows that the carbon footprint created in Jambi is bigger than the carbon footprint in Indonesia and Sulawesi.

The increase of the temperature level that caused by the increase of the carbon dioxide decreases the agriculture output (Cline, 2008). The extreme change of the climate and weather impacts to the productivity and the production of the agriculture sector (Salinger, 2005). The agriculture sector is an important sector for the economic growth in Indonesia. Plantation is a subsector of agriculture that contributes approximately 3.46 percent of the GDP Indonesia in 2016 (Bureau of Statistics Indonesia, 2017). One of the superior export commodity is cacao. Cacao becomes one of top 10 export commodity as declared by the Ministry of Trade of Indonesia for the period of 2011-2016. Moreover, cacao contributes 0.8 percent of the total of non-oil and gas export in 2016 (Bureau of Statistics Indonesia, 2017).

Polewali Mandar is the center of cacao production in West Sulawesi with the productivity of 0.45 ton/ha in 2015. In the year of 2011 up to 2015, the productivity of cacao in Polewali Mandar experienced a decrease (Ministry of Agriculture Indonesia, 2017). Aggregately, the trend of the cacao production and productivity in Indonesia decreases, either in the national or in the regional level. This will affect the share income of cacao farmers towards the total income of the farmer. This research aims to explain the general description about carbon footprint based on cacao farmers' household consumption and analyze indicators that affect the carbon footprint in Polewali Mandar.

2. Data and Methodology

To estimate and calculate the carbon footprint in Indonesian, this study utilizes Input Output (IO) table. the Global Trade Analysis Project- Environmental Account (GTAP-E) consists of CO2 emission from fossil fuels burning and cement output, but does not include emissions from land use change which is also important in Indonesia (PEACE, 2007). and the Polewali Mandar household expenditure survey in 2017.

Polewali Mandar household expenditure survey collected used case study method through interview to farmer household by using questioner. The respondents were selected using systematic random sampling and purposive sampling technique. *Systematic random sampling* is done by using sample frame that has been owned, while *purposive sampling techniques* taken intentionally. Purposive sampling procedure choose the sample based on the characteristics needed to answer the research. In percentage, 31% of respondents (36 household) were selected based on *systematic random sampling*, while 69% of respondents (74 household) selected by *purposive sampling technique*. From total of 116 respondents, 57 respondents were located in sub district Anreapi, and 59 respondents in sub district Mapili. The primary data for this study were taken from July-August 2017 through a survey questionnaire with structured and semi-structured questions.

2.1 Measuring Emission Intensities and Deriving the Household Carbon Footprint

To calculate household carbon footprint in Indonesia, this study used an approach adopted by Lanzen (1988). Carbon dioxide emissions resulting from household end-consumption either directly or indirectly using IO analysis (Input Output). According to Kok et al. (2006), there are 3 calculation approaches to analyze input-output energy to the gas emissions of greenhouse effect generated by household activities. The approaches were taken to calculate emissions intensity are basic approach, expenditure approach, and process approach. This study employed household consumption expenditure approach by combining the IO tables. The expenditure approach also used in several household expenditure surveys conducted by Irfany et al,. (2015) in Sulawesi, Jambi and Indonesia. How to measuring emission intensities and deriving the household carbon footprint can explain from picture below:

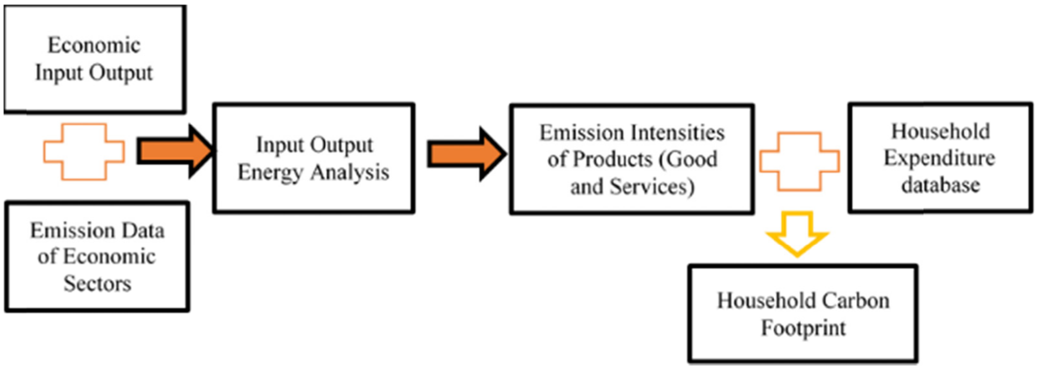

Figure 1.Calculate the carbon footprint by expenditure approach

Source: Kok et al. (2006) Modified by Irfany and Klasen (2017)

Figure 1 illustrates how to measure the carbon footprint produced by households. The first thing to do is to calculate the IO of energy by combining IO tables with emissions data of economic sector. From the calculation of IO energy produces the emission intensity of the product, both services and goods. After that it combines a household expenditure survey database with emissions intensity to produce a household carbon footprint.

2.2 Carbon Footprint Calculation based on Household Consumption

The next step is the intensity of carbon emissions from each sector is categorized into household expenditure in the database. To match these sectors, questionnaires from the study were used together with sector categories, so expenditure consumption items could be duplicated to obtain carbon emission intensity. Then in the end the carbon footprint will be obtained as the following summary.

This approach assumes that domestic energy and the level of production technology of goods and services are the same as those abroad, the direct and indirect carbon emissions from the demand for the industrial sector can be calculated. Now, the direct and indirect emissions intensity of the final demand can be illustrated by the equation below.

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

c', E^{fd}, and y represents the reverse of the coefficient of emission vector, the energy using the matrix, and the final demand vector.

Indirect emissions (CO_2^{ind}) can be classified as 3 sources: 1) domestic product of final demand, 2) intermediate goods from abroad, 3) imported products from domestic end of demand (not for calculating export products). Through the multiplication of each y end demand sector, the emission coefficient being transposed, c', The matrix of energy use industry, E^{ind} , and with domestic Leontief inverse $(I - A)^{-1}$, estimation of sectoral carbon emission intensity can be obtained through the equation below:

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

Where: $A_{tot} = A + A_{imp}$, and $Y_{tot} = Y + Y_{imp}$

$y_{\neq exp}$ and I represent the final domestic demand and matrix identity, where A represents the technical coefficient matrix as the contribution of intermediate goods to one final output unit.

Then the intensity of direct and indirect carbon emissions can be calculated through the equation below:

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

$$CO_2 = c'\{E^{fd}y + E^{ind}\begin{bmatrix}(I - A)^{-1}y_{\neq exp} + (I - A_{tot})^{-1} - \\ (I - A)^{-1}y_{\neq exp} + (I - A_{tot})^{-1}y_{imp\neq exp}\end{bmatrix}\} \quad (4)$$

And last step, household consumption from cocoa farmer in Polewali Mandar Regency (in Rp) is doubled with carbon intensity from each sector (kg / Rp). The carbon intensity of each sector has a one-to-one classification with the database and therefore all goods and services of these categories can be summarized for each household. For every household, carbon footprint CO_2^{hh} can be calculated by:

$$CO_2^{hh}{}_i = \sum_i^j (CO_{2j} * Exp_{ij}) \quad (5)$$

i and j successively represent a household item and expenditure. In this study, the data of carbon dioxide intensity of each sector (kg CO_2/Rp) is obtained from calculations performed by Irfany and Klasen (2017). So to get the value of carbon footprint (Kg CO_2) multiplied by Polewali Mandar household expenditure survey data for each sector (Rp).

2.3 Factors Affecting Carbon Footprint

To analyze the factors affecting the carbon footprint of our cocoa farmers, this study employed the OLS *(Ordinary Least Square)* method. The OLS model used in this research are:

$$LnCO_2^{hh}i = \alpha + \beta_1 LnINC_i + \beta_2 X_i + \varepsilon_i \quad (6)$$

Where $LnCO_2^{hh}$ represents the natural logarithm of CO2 emissions generated by household consumption, $LnINC_i$is the natural logarithm of household income of farmers, $X_i$are control variables such as number of families, sex, age of each family head, education level of head of household, and $\varepsilon_i$is *error terms* .

Alternatives in analyzing factors that affect carbon footprint using *quantile regression*. Quantile regression is an approach in regression analysis introduced by Koenker and Bassett (1978). Quantile regression can be used to overcome the limitations of linear regression in analyzing unmet assumptions in the classical regression, no normal distributed error, susceptible to evangelism and unconstant variance error (heteroscedasticity). Quantile regression equation in this research can be seen in equation below:

$$LnCO_2^{hh}i = \alpha + \beta_q \sum_{q=1}^{5} Q_{qi} + \varepsilon_i \quad (7)$$

And

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

Where ε_i is the residual of the regression in equation 7.

3. Results and Discussion

This research was conducted in PolewaliMandarRegency, using primary data by conducting a consumption share survey of total expenditure on 116 cocoa farmer households. The results of the consumption share survey of total household expenditure of cocoa farmers can be seen in Figure 1.

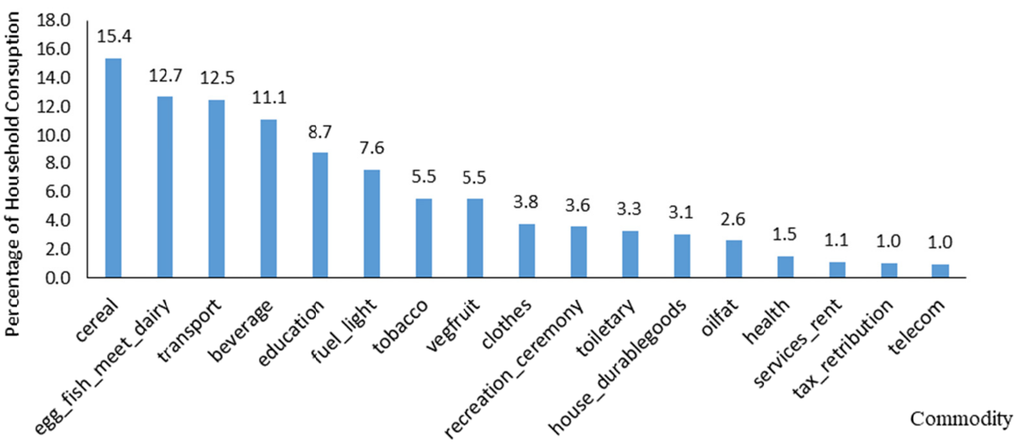

Figure 2. Share of Cocoa Farmer's Houshold Expenditure

Source: Primary data (2017, Calculated)

Figure 2 shows that the highest household expenditure of cocoa farmers, which is 15.4 percent, used for cereal consumption. While the lowest expenditure is used for tax and telecommunication sectors, each represents 1 percent of total household expenditure of cocoa farmers. This shows that the expenditure of cocoa farmers' households in Polewali Mandar Regency is still dominated to meet the needs of food and other basic needs. The survey results also show that the cocoa farmer community in Polewali Mandar Regency is classified into rural type.

3.1 Carbon Intensity by Economic Sector

This research uses Input Output table (table IO) economic and carbon emission data based on economic sector to calculate carbon emission intensity. Table IO used is table IO in 2005, while the carbon emission data of economic sector comes from GTAP E 2005. In previous research, Irfany and Klasen (2017) calculated the intensity of carbon emission in Indonesia, concluded that the sector that produces the largest emission electricity and gas sectors. While *fibber corps* is the sector that produces the smallest emission intensity.

Table 1. The intensity of CO 2 emissions by economic sector: the 10 largest and lowest

No	Sector	gram CO2/Rp
	Top 10	
1	Electricity and gas	1.0496
2	Cement	0.4462
3	Other items of non-metallic materials	0.3955
4	Glass and glass products	0.3854
5	Ceramics and building materials from clay	0.3733
6	Ceramics and items made of clay	0.3683
7	Air transport services	0.2042
8	Railway services	0.1716
9	Marine transportation services	0.1634
10	River and lake transport services	0.1615
	Bottom 10	
10	Other nuts	0.00379
9	Other animal products	0.00374
8	Soybean	0.00286
7	Cassava	0.00280
6	Vegetables	0.00266
5	Bean	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 and Klasen, 2017 based on IO table 2005 and GTAP-E 2005

3.2 Carbon Footprint Generated by Expenditure Category

The calculation of carbon emission level generated by cocoa farmer household in Polewali Mandar Regency is done by multiplying the intensity of carbon emission per sector of economy ($C0_2$/Rp) with the result of consumption share survey to total household expenditure of cocoa farmer (Rp) in Polewali Mandar Regency.

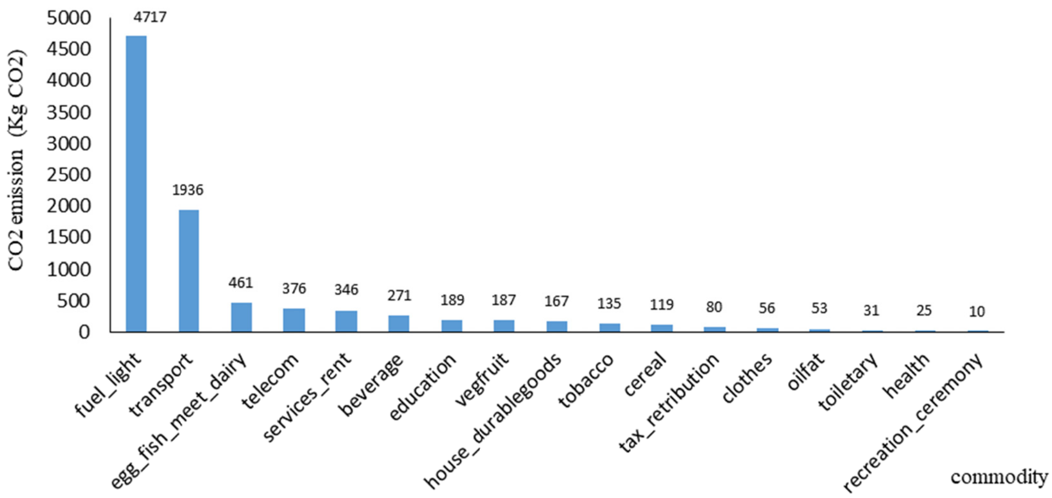

Figure 3. Carbon Footprint Generated by Expenditure Category

Source: Primary data (2017, Calculated)

The calculation results show that the largest carbon emission rate is generated by fuel light sector4717.15 Kg carbon dioxide emission (51.5 percent) and transportation sector 1935.58 Kg carbon dioxide emission (21.1 percent). In other words, although the largest expenditure of cocoa farmers is allocated to cereals and other staple foods, but the largest carbon emissions are generated by the fuel light and transportation commodity. This indicates a tendency to use high fossil fuel energy by households in Indonesia, especially in cocoa farmers' households in Polewali Mandar Regency. These results are in line with several other studies in some developing countries such as the Filipino (Serino and Klasen 2015), Indonesia (Irfany and Klasen, 2017; Irfany et al., 2015; India (Grunewald et al., 2012), that fuel light are contributor to emissions largest on total carbon emissions produced by households.

3.3 Carbon Footprint Generated by Income Level

Previous research has shown that different income levels will result in different carbon footprints depends on the characteristics of the household. This research divides cocoa farmer households by their opinion level into 5 income groups, from the lowest to the highest.

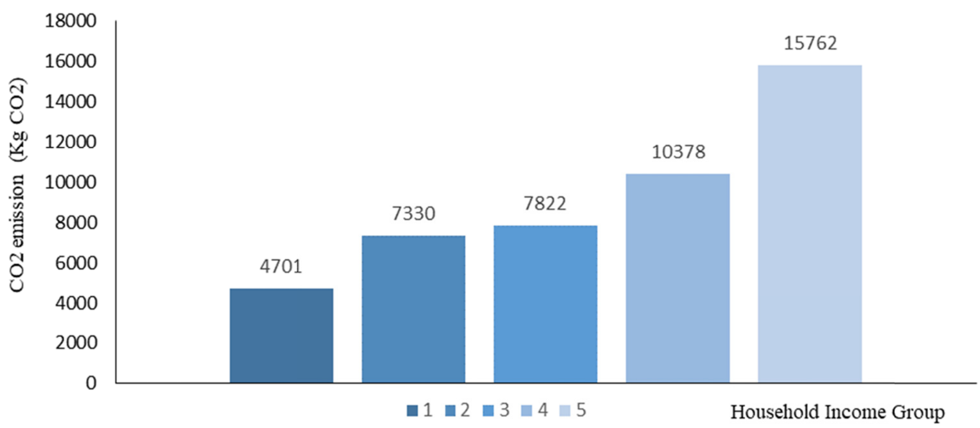

Figure 4. Carbon Footprint Generated by Household Income Group

Source: Primary data (2017, Calculated)

The results showed that farmers' households belonging to the lowest income group generated the least carbon emissions of 4701 kg CO2. Meanwhile, farm households belonging to the group with the highest income generated carbon emissions of 15762 kg CO2 and became the most household group contributing to total carbon emissions. The results of this study are in line with previous studies. The results of research conducted by Irfany and Klasen (2017) suggested that the higher the level of household income, the higher the carbon footprint generated.

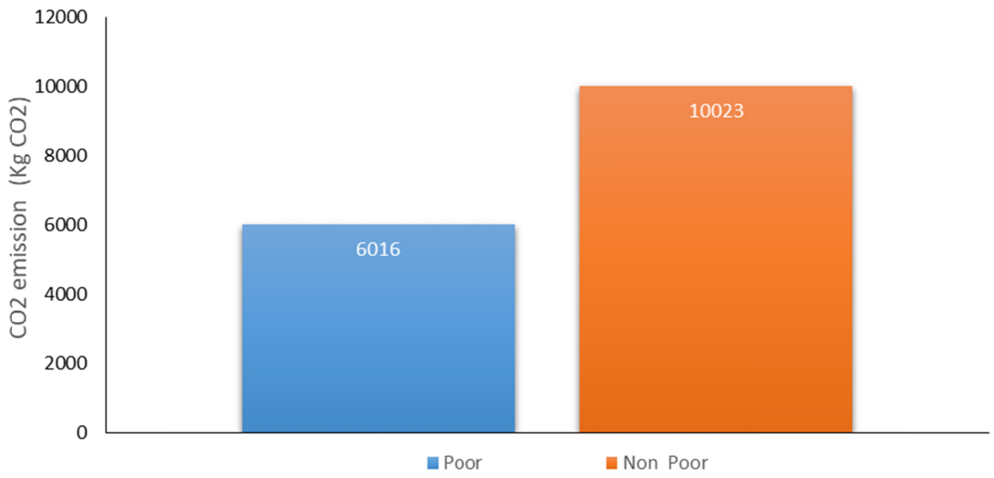

Figure 5. Carbon Footprint Generated by Revenue Rate

Source: Primary data (2017, Calculated)

At this stage, the level of household wealth of cocoa farmers is grouped into non-poor and poor is based on the poverty line issued by Bureau of Statistics Indonesia. The results showed that cocoa farmers belonging to the non-poor cocoa farmer group produced a carbon footprint of 10,023 kg of CO2, or about 1.66 times greater than the carbon emissions produced by cocoa farmers belonging to poor households.

3.4 Comparison of Expenditure Share with Carbon Share by Category of Income

This time analysis uses to see how much share of household expenditure generating carbon emissions. The analysis shows that the cocoa farmer household belonging to the income level group of one to four shows that the contribution of carbon footprint is greater than the share of expenditure. Meanwhile, for the group of farm households belonging to the fifth group tends to produce a lower carbon footprint compared to the share of household expenditure. It shows that energy use that produces a large carbon footprint is dominated by households with income groups of one to four. While in the household belonging to the group of five, tend to have awareness to use low intensity carbon goods, resulting in a lower carbon footprint compared to the share.

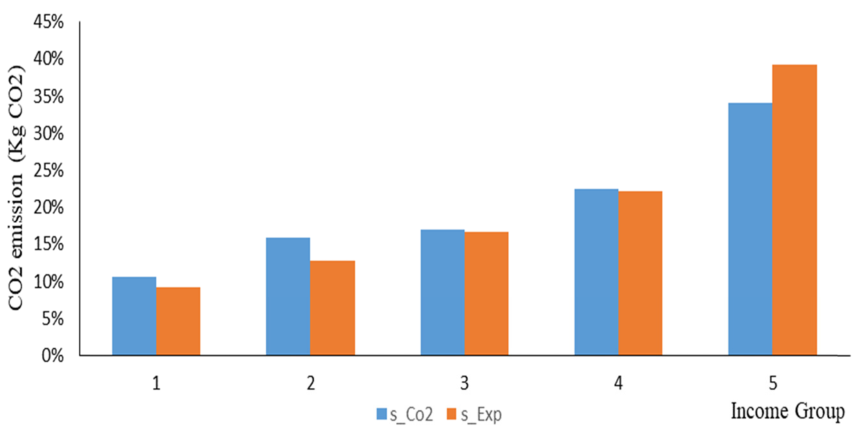

Figure 6. Comparison of Expenditure Share and Carbon Footprint Share by Income Group of income

Source: Primary data (2017, Calculated)

3.5 Factor Affecting Carbon Footprint

Analysis of factors affecting carbon footprint by cocoa farmer household in Polewali Mandar Regency was done by simple regression technique using several alternative models. The first model is carried out by including all independent variables, which include farmers' income and other control variables. The first model shows that the significant factors affecting the carbon footprint are the income of farmers and marital status of household head. Regression results show that the income of cocoa farmers and the resulting carbon footprint has a positive relationship, meaning that the higher the farmer's income, the higher the carbon footprint, and vice versa.

The second model uses quadratic regression techniques to analyze whether there is a turning point in the relationship between income and carbon dioxide emissions. The results show that there is no turning point in the quadratic equation. Which means that in Polewali Mandar district, the increase income will increase carbon dioxide emissions.

The third model is done by not including the income as an independent variable. All regressions are control variables which become independent variable. The results showed that poor *dummy* variables affect the amount of carbon footprint produced. This indicates that the more affluent household earn more carbon footprint than the poor farmer households. Other results show that the larger the size of the household carbon footprint generated greater.

The fourth model tests the carbon footprint generated by the income category. based on the regression results showed that the value of cocoa farmers' income categories is significant to the carbon footprint. Regression results show that each income group has a different coefficient value and rises continuously by income group.

Table 2. Factor affecting carbon footprint on Polewali Mandar Regency

Variabel Independent	Dependent Variable			
	LnCo2			
	I	II	III	IV
Lnincome	**0.873*** **	**0.209*** **		
Lnincomesq		**0.0018*** **		
Poor	0.06		**-0.626*** **	
Expenditure quantile				
2				**0.449*** **
3				**0.502*** **
4				**0.799*** **
5				**1.137*** **
Hhsize	-0.014	0.011	**0.119*** **	
HHsizesq		-00092		
Age	0.002	-0.00159	-0.002	
Agesq		0.00003		
Hheduc				
elementary	-0.214		-0.004	
Secondary	-0.319		-0.273	
High school	-0.263		-0.203	
At least college	-0.354		0.288	
HH.married	**0.315*** **		0.163	
HH.female	0.142	-0.101	-0.226	
asset index	-0.011	0.00086	0.031	
Cons	**-6.064**		**8.439**	**8.377**
R-Squared	0.681	0.676	0.333	0.466

Source: Estimation of the writer

Noted: *significant at α = 10%, ** significant at α = 5%, *** significant at α = 1%.

The next analysis is to use a quantile regression technique. The purpose of quantile regression is to avoid the classical assumption of melodies when using OLS. Quantile regression is used when in using a simple regression of error that spread is not normal. Quantile regression results show that farmers' income is the most influential factor on carbon footprint (Table 3).

Table 3. Calculation of quantile regression estimation

Variabel independent	Variabel Dependent LnCO2					
	OLS	q1	q2	q3	q4	q5
Lnincome	**0.87**	**0.91**	**0.89**	**0.87**	**0.94**	**0.86**
Poor	0.06	0.06	-0.01	0.09	0.17	0.22
Hhsize	-0.01	0.01	-0.01	0.03	-0.05	-0.06
Age	0.00	0.00	0.00	0.00	0.00	0.01
Assetindex	-0.01	-0.02	-0.01	0.01	0.00	-0.03
d_married	0.32	0.03	0.18	0.35	0.22	0.40
d_female	0.14	0.22	0.23	0.28	-0.09	-0.38
d_noschool	0.35	0.08	-0.04	0.52	0.61	0.27
d_elementary	0.14	0.01	-0.05	0.13	0.21	-0.04
d_juniorhs	0.03	-0.08	-0.16	0.08	0.14	-0.21
d_seniorhs	0.09	0.05	-0.12	0.23	-0.02	-0.17
_cons	**-6.42**	**-7.01**	**-6.40**	**-6.73**	**-7.16**	**-5.61**
Pseudo R-Square	0.62	0.49	0.45	0.40	0.38	0.43

Source: Estimation of the writer

Noted: Bold significant at α = 5 percent.

4. Conclusions and Recommendation

This research aims to know the general description of carbon footprint generated by cocoa farmer household and to analyze the influencing factors of carbon footprint in Polewali Mandar Regency with cocoa farmer household consumption approach. This study used primary data with interview and survey techniques on the household ladder of cocoa farmers in Polewali Mandar Regency.

In summary the results of this study addressed that cocoa farmer's expenditure spent on household consumption of cereals (including rice and grains) and the consumption of eggs, and the most consumption on fish and meat. Meanwhile, the household expenditure of cocoa farmers used for telecommunication and taxes are the least. Based on the results of carbon footprint calculations produced by cocoa farmers, the fuel light consumption and transportation contributed the most carbon footprint. This is similar to research conducted by Irfany and Klasen (2017); Irfany et al. (2015); Serino and Klasen (2015).

The level of household expenditure of cocoa farmers is divided into 5 income groups from the rich to the poor. The results show that the higher the cocoa farmer's income (quartile) group, the higher the carbon footprint generated. In this case the quintile produces a carbon footprint of 15,762 metric tons while the 1st quartile group produces a carbon footprint of 4,701 metric tons. In addition, households with rich incomes generated greater carbon footprint than poor households. rich households produce carbon footprints 1.66 times larger than poor households.

Based on the simple regression results indicate that the income level has a positive effect on the carbon footprint, means that the increase in farmer's income will increase the carbon footprint. Quadratic regression show that there is no turning point between income and carbon dioxide emissions. In additional the influential control variables are poor dummy, marital status of household head and household size. The result of regression where the independent variable is the income group of the farmer shows the greater the income generated by the higher coefficient group. This indicates that the higher income group, then the higher carbon footprint generated. The quantile regression results show that the income level of farmers for each income level affects the carbon footprint the most.

Based on the results of the study, found that income has an important role to the carbon footprint generated. Fuel light and transportation are the highest carbon footprint producers. Therefore, this study suggests that households need to reduce the consumption of goods or services with high emission intensity. The government should also take part, to encourage the citizen about energy efficiency with policies that support it by creating more ecofriendly renewable energy, and also low-emission public transportation to achieve the sustainable development.

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