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DETERMINANTS OF CARBON EMISSIONS AMONG HOUSEHOLDS IN EASTERN VISAYAS, PHILIPPINES

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Information and studies about carbon emissions are available on national level but it is very limited on regional level. Hence, we focus on Eastern Visayas and aim to investigate the influence of rising income and other socio-demographic characteristics on household's carbon emission level. The analyses reveal that income has a significant nonlinear relationship with carbon emission depicting a turning point. However, the turning point is very high implying that household carbon emissions in Eastern Visayas will increase given the current income range. In addition, other household characteristics such as age, educational attainment, civil status, floor area, access to electricity and urbanity significantly influence household carbon emissions. Basing from the results, income and other socio-demographic characteristics are significant determinants of household emissions. The strong and significant association of income and emissions indicates that we will be further expecting increase in emissions as households become richer. Implementation of policies regarding mitigating climate change should start at the household level since results show that households has a strong influence on the increasing carbon emission.

Keywords: income, socio-demographic characteristics, Environmental Kuznets Curve

1. INTRODUCTION

Global warming phenomenon has been largely attributed to the rising anthropogenic greenhouse gas (GHG) emissions particularly carbon dioxide (CO_2) emissions resulting from economic activities such as the burning of fossil fuels, industrial processes and other activities (Seriño and Klasen, 2015). The main

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contributing greenhouse gases to the climate change are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and CFCs or the chlorofluorocarbons. Carbon dioxide has the biggest share. According to the module 1-Introduction to Mitigation under the United Nations Framework Convention on Climate Change (UNFCCC), the contribution of carbon dioxide to total GHGs in the last one hundred (100) years accounted. The attention of both national and international climate change policy negotiations has increasingly focused on reducing the growth of anthropogenic greenhouse gas (GHG) emissions – most importantly of carbon dioxide (CO_2) (Bruckner *et al.*, 2010). Understanding the determinants of rising anthropogenic carbon emission would help in mitigating climate change. According to Girod and De Haan (2010), households exert a strong influence on the surging increase of greenhouse gas emissions. Seriño and Klasen (2015) found that household characteristics such as income, age and gender of household head, household size and marital status, rural-urban location, education, size of dwelling place and other relevant characteristics significantly matter in explaining carbon emissions. Buchs and Schnepf (2013) found that households with highly educated, 'middle aged', employed and male reference persons and those located in rural areas all have a high likelihood to have a higher carbon emission.

Most of the studies on determining households' carbon emissions focused on national level and mostly on developed countries. Information on household carbon emissions is relatively abundant for most of the developed countries (see for example Lenzen, 1998; Bin and Dowlatabadi, 2005; Druckman and Jackson, 2009; Kerkhof *et al.*, 2009) but information on household emissions from developing countries is mostly overlooked in the literature (Seriño and Klasen, 2015). In this regard, this study will add to the literature by investigating household carbon emissions at the regional level using socio-demographic characteristics as determinants of households' carbon emissions particularly in Eastern Visayas (Region 8). Eastern Visayas is of importance because it was hit by super typhoon Haiyan, locally known as super typhoon Yolanda. Extreme weather condition is considered as one of the adverse effect of climate change. Hence, investigating household carbon emissions will directly help policy makers in mitigating climate change by controlling household carbon emissions. Among the socio-demographic characteristics mentioned, what might be the significant determinants of carbon emissions among households in the Eastern Visayas Philippines? In this regard, what possible policies and feasible actions can be done in curbing household carbon emissions?

This study generally aims to examine the association between socio-demographic characteristics and carbon dioxide emissions among households in

Eastern Visayas, Philippines. It specifically aimed to (i.) investigate the influence of rising income and other socio-demographic characteristics on household carbon emissions in Eastern Visayas, and (ii.) draw potential policy implications and recommendations in mitigating climate change through controlling household carbon emissions.

2. METHODOLOGY

The study is based on the concept of Environmental Kuznets curve (EKC). It reflects the theorized relationship of income and environmental degradation. The EKC hypothesis proposes an inverted U-shaped relationship between per capita income and environmental degradation (Grossman and Krueger, 1995). Figure 1 shows the Environmental Kuznets curve (EKC) for household carbon emission and income reflecting nonlinear relationship.

Based on the available studies in the literature, there are broadly three major household characteristics that were hypothesized to influence the households' carbon emissions. This includes the social, economic and demographic characteristics. Figure 2 shows the relationship of socio-demographic characteristics of the household that may influence the carbon emission among households in Eastern Visayas, Philippines.

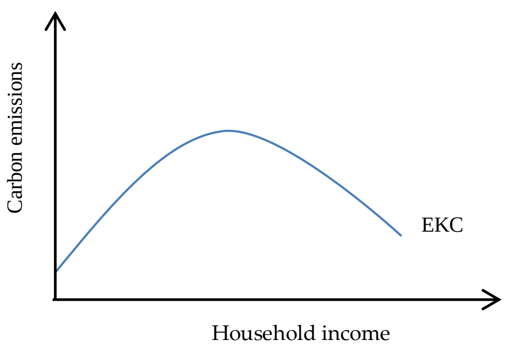

Figure 1. Environmental Kuznets curve for household carbon emissions and income (Source: adapted from the study of Seriño (2017))

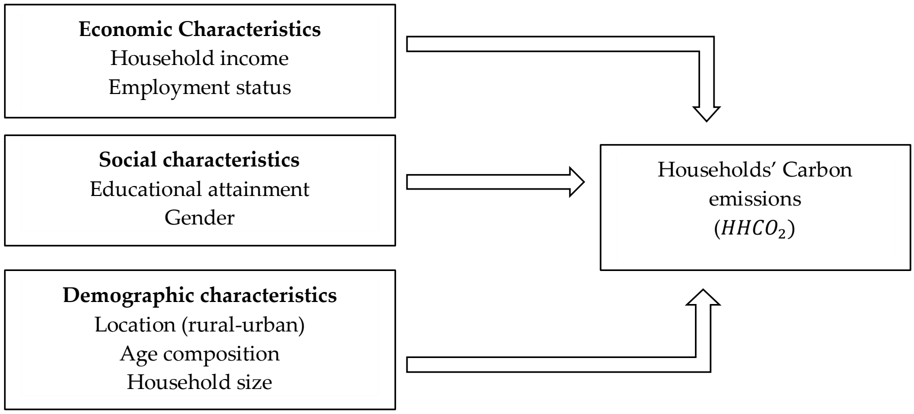

Figure 2. Schematic diagram showing relevant socio-demographic household characteristics influencing households' carbon emissions.

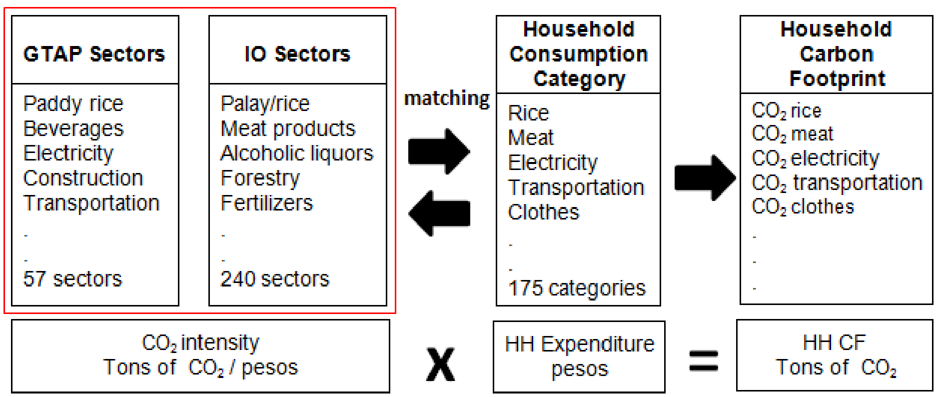

Figure 3. Process flow estimation and matching of IO sectors with household consumption (Source: Seriño and Klasen, 2015)

The study utilized the data and information from the study entitled "Do Philippine Households Lead a Carbon Intensive Lifestyle?" by Seriño (2014). Seriño (2014) used expenditure approach in estimating household carbon emission by using input-output analysis. Summing up all the carbon emissions of each consumption category yields the total household carbon emissions. To obtain the carbon emission of each category, mapping of the sectors was done for the consistent linking of the different data sources (Seriño, 2016). This was achieved through matching the Global Trade Analysis Project (GTAP) sectors and Philippine Input-Output (IO) sectors to the household consumption category. The data on household consumption used the Family Income and Expenditure Survey (FIES) of the National Statistics Office (NSO). Figure 3 provides the estimation procedure and the matching of IO sectors with household consumption. Through this method, we can estimate in detail the embedded carbon emissions of every household consumption item[1].

Data Analysis

Pooled ordinary least squares regression analysis was used in this study. In testing the presence of Environmental Kuznets Curve (EKC) the square of the income variable was included in the model. The square of the income will capture the hypothesized quadratic relationship of income and carbon emissions.

The regression model used in this study was subjected to some post-estimation procedures like test for multicollinearity to check for any serious linear relationship that exists among predictor variables included in the model and Breusch-pagan test for detecting presence of heteroskedasticity.

Empirical Model

To capture the influence of household characteristics on household carbon emissions and to incorporate the arguments postulated by EKC, the square term of income were included in the model. To evaluate also the non-linear relationship between age, household size and carbon emissions the squared term of the said variables were included and the regression model was postulated as follow:

$$lnCO_2hh = \beta_0 + \beta_1 lninc + \beta_2 lninc^2 + \beta_3 ln\_age + \beta_4 ln\_age^2 + \beta_5 ln\_hsize + \beta_6 ln\_hsize^2 + \beta_7 ln\_farea + \beta_8 hh\_gen + \beta_9 hh\_educ + \beta_{10} hh\_mstat + \beta_{11} hh\_empstat + \beta_{12} floor\_area + \beta_{13} elect + \beta_{14} location + \beta_{15} year + \varepsilon \quad (1)$$

where:

$lnCO_2hh$ = log of household carbon dioxide emission,
lninc = log of summation of all income of the household,
$lninc^2$ = log of the income squared,
ln_age = log of age of the household head (year),
ln_age^2 = log of the age squared,

[1] For more discussion on the estimation procedure please refer to the study entitled "Do Philippine Households Lead a Carbon Intensive Lifestyle?" by Seriño (2014).

ln_hsize = log of household size (member of the household),
ln_hsize^2 = log of household squared.
ln_farea = log of floor area (size of the dwelling place),
hh_gen = dummy of the variable gender of the household head: 1if male and 0 if female,
hh_educ = dummy of the variable educational attainment of the household head, measured using: 0 if no formal education, 1 if elementary undergraduate, 2 if elementary graduate, 3 if high school undergraduate, 4 if high school graduate, 5 if college level, 6 if college graduate, 7 if post grad,
hh_mstat = dummy of the variable marital status of the household head:1 if single, 2 if married 3 if live-in 4 if separated 5 if widowed,
hh_empstat = dummy of the variable employment status, 1 if employed and 0 otherwise,
elect = dummy of the variable access to electricity, 1 if they have access and 0 otherwise,
location = dummy of the variable location whether from urban or rural, 1 if from urban and 0 if from rural
Y_{2006}= dummy for year 2006 and,
Ɛ = for the remaining error term.

3. RESULTS AND DISCUSSION

Socio-demographic characteristics

Table 1 shows the summary statistics of the socio-demographics being analyzed. Household income is the summation of all income of the household in year 2000 and year 2006. It can be observed that there was an increase in households' average income, from PhP99, 903.14 in 2000 to PhP122, 781.8 in 2006.

Larger dwelling place are assumed to be positively associated with household emission. Results show that the floor area which is measured through square meters shows that households have decreasing floor area across years. Sample households are mostly headed by male with an average age close to 51 years and were married. Age like income is also hypothesized of having a nonlinear effect on carbon emissions depicting an inverted U-shape kind of relationship.

Table 1. Presents the descriptive statistics of the variables used in the study.

	2000				2006			
Variables	Mean	Stdev	Min	Max	Mean	Stdev	Min	Max
HH income	99903.14	126928.4	4273	1762522	122781.8	148332	9885	1342764
Floor area	543.271	429.857	20	2880	57.095	64.631	2	1200
Male	.810	.392	0	1	.834	.372	0	1
Age	51.437	14.498	16	95	50.639	14.468	19	99
Married	.785	.411	0	1	.790	.407	0	1
Widowed	.165	.372	0	1	.158	.364	0	1
Separated	.0162	.126	0	1	.022	.146	0	1
Elem undergrad	.314	.464	0	1	.290	.454	0	1
Elem graduate	.221	.415	0	1	.147	.354	0	1
HS Undergrad	.121	.326	0	1	.100	.300	0	1
HS Graduate	.102	.303	0	1	.094	.292	0	1
College Undergrad	.102	.303	0	1	.055	.228	0	1
College Graduate	.090	.286	0	1	.270	.444	0	1
Post Graduate	.006	.074	0	1	.012	.111	0	1
With Job/Business	.875	.330	0	1	.874	.332	0	1
Urban	.508	.500	0	1	.210	.407	0	1
HH Size	5.100	2.348	1	15	5.061	2.325	1	19
With Electricity	.620	.486	0	1	.743	.437	0	1

We include gender since men and women have different consumption preferences, it is interesting to see how gender affects carbon emissions. Households' marital status may influence carbon emissions because married couples have different lifestyle as compared to other marital status. In terms of educational attainment in year 2000 and 2006 most of the household heads have an elementary undergraduate level of education. Higher education increases awareness on environmental issues so we expect that emission and education be negatively correlated. However, it is also plausible that education is positively correlated with emission if gaining higher education is associated with a lifestyle that is carbon intensive. It was included in the model to test its impact on the level of carbon emission in Eastern Visayas, Philippines. Employment status looks at whether household head has or does not have a job/business. In both year 2000 and 2006 majority were employed comprising of 87.53% and 87.43%, respectively. It is included in the model to determine the impact of the working household head on the level of household carbon emissions.

In terms of location on whether the household is situated in rural or urban area, about 50.83% of the total household sampled in year 2000 are situated in urban areas, but in 2006 it decreased to 20.95%. This huge change according to Seriño (2014) was mainly due to the change in the definition of urban areas. The location whether from urban or rural was included in the model to determine if there is a difference between coming from rural or urban on emission level. The average household size is five (5) which is considered as a medium sized family composing only of three (3) children. Household size was included in the model to determine if household CO_2 emissions are associated with household size. It is hypothesized of having a nonlinear effect on carbon emissions depicting an inverse U-shape kind of relationship. Access to electricity is also captured by categorizing households as having access to electricity and no access to electricity. In year 2000, 61.95% have access to electricity and has improvement in year 2006 since it increased to 74.25%. Access to electricity is assumed to be positively associated with household carbon emission.

Household Carbon Emissions and Income

The logarithmic transformation was used to address the situations where a non-linear relationship exists between the independent and dependent variables. In Table 2, the result indicates a significant positive coefficient (1.831, $p<0.01$). This implies that income has a positive relationship with households' carbon emissions. Income is a well-known determinant of carbon emissions, the more income you have the more likely you are to spend. The income squared which is used to capture the presence of EKC (Environmental Kuznets Curve) shows a significant negative coefficient (-0.0419, $p<0.01$) depicting an inverted U-shaped. This means that emissions rise together with income and then reach a turning point. After reaching the turning point, further increases in income are associated with a decline in household emissions. This may imply that after reaching the turning point, household consumption behaviour shifted to a more environment friendly (e.g. ozone friendly appliances and more efficient cars and other gadgets). Figure 5 shows the scatter plot of income with fitted values to carbon emissions.

Table 2. Factors affecting household CO_2 emissions with log of CO_2 a dependent variable

VARIABLES	Regression model lnco2hh	
Income	1.831***	(0.169)
Income squared	-0.0419***	(0.00722)
Age	0.900*	(0.492)
Age squared	-0.116*	(0.0648)
Household size	0.0748	(0.0508)
Household size squared	-0.0143	(0.0170)
Floor area	0.0375***	(0.0092)
Male	0.0188	(0.0250)
Married	0.0156	(0.0413)
Widowed	0.0363	(0.0435)
Separated	0.0244	(0.0589)
Elem undergraduate	0.0843**	(0.0336)
Elem Graduate	0.132***	(0.0347)
HS Undergraduate	0.196***	(0.0373)
HS Graduate	0.188***	(0.0386)
College undergraduate	0.255***	(0.0409)
College graduate	0.199***	(0.0377)
Post graduate	0.169**	(0.0679)
With job/business	-0.0442**	(0.0222)
With electricity	0.388***	(0.0163)
Urban	0.0971***	(0.0140)
Year 2006	0.196***	(0.0273)
Constant	-18.25***	(1.283)
Observations	4,100	
R-squared	0.846	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5 depicts the presence of EKC as manifested by its non-linear relationship. The turning point of income can be determined through the use of the first derivative of household carbon emission with respect to income. Based on the computation, it is expected that emission will start to decline when income is at PhP 3,084,458,662.00. Further increase of income from this point is associated with lesser carbon emission. The turning point can be explained by the relative capacity of high income household to buy less carbon intensive goods and adopt certain technologies that offer energy saving or eco-friendly devices for which low income cannot afford. However, the turning point is unattainable given the economic condition of Eastern Visayas region. In the Philippines, a greater proportion of the population has an income below the poverty threshold. The PhP 3B threshold is quite difficult to achieve given the average annual income of the Filipino family. As of 2012, on average Filipino families had an annual income of 235 thousand pesos, Philippine Statistics Authority (PSA), 2013. This means that we will be expecting more emission as households become richer.

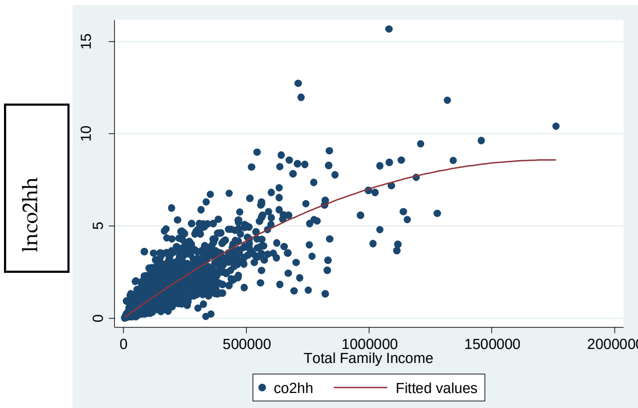

Figure 5. Graphical presentation of the relationship between households' carbon emission and total family income.

Household Carbon Emissions and Age of the Household Head

The variable age shows that it is significantly associated with emission. The square of age indicates that it has a non-linear relationship with household carbon emissions. Having a significant negative coefficient of -0.116 ($p<0.1$) depicting an inverse U-shaped implies that carbon emissions increase with age until they reach a maximum at a certain age level and after which they start to decline. This can be explained by the fact that younger individual consumes more carbon intensive goods or services since most of them lead a more active lifestyle and those older household heads are more meticulous on what they consume mostly because of health reasons. This conforms to the study of Seriño (2014) and Seriño and Klasen (2015) that younger households are just starting to raise their family, build houses and accumulate durable goods and this is associated with increasing carbon emissions. As household heads get older, kids grow up and the demand for goods and services also increases, thereby driving carbon emissions even higher. Then later on carbon emissions decline as households reach old age due to changes in preferences and consumption patterns. Older households are more inclined to consume service related goods that are less carbon intensive. The turning point of age based on the computation is that household carbon emissions will decrease when the household head reaches the age of 48.

Household Carbon Emission and Floor Area or the Size of the Dwelling Place

Larger dwelling place is assumed to be positively associated with household emissions. The study of Seriño (2014) also reported a positive relationship between large dwelling sizes and total emissions which means larger dwelling places are associated with higher emissions. The regression result shows a significant positive coefficient which means that with bigger living space the households are more likely to put more appliances (carbon intensive) and thereby associated with bigger cost in maintenance and repair.

Household Carbon Emissions and Marital Status

Households' marital status may influence carbon emissions because married couples have different lifestyles as compared to singles, widowed and with separated household head. Regression result is not significant. The possible reason is that their consumption patterns are not statistically different among the group. Since the coefficients are positive, this means that their carbon emissions are probably greater than the reference status which is single. On one hand, single household head emits lesser since most single individual normally defer their consumptions in favor of saving for future. Married households, on the other hand, emit highest since having a family means joint consumption of goods and services. Widowed household head and separated household heads emits higher than the singles.

Household Carbon Emissions and Gender

Gender can be a factor that can explain the level of household carbon emission. It is interesting to know how gender affects carbon emissions since men and women have different consumption preferences. For example, female headed households have significantly higher home energy emissions than male household head. Meanwhile, male headed households have higher carbon emission on transport emissions than female. Based on the regression result in Eastern Visayas, Philippines, Filipino males tend to have a little higher carbon emission than women. Contradicting to the study of Seriño (2014) who found out that on national level in Philippines, male tend to emit less carbon than women. The regression result indicates that the variable has a positive coefficient of 0.0188 however their difference is not significant.

Household Carbon Emission and Educational Attainment

Household heads' educational attainment were classified into (0) no formal education, (1) elementary undergraduate, (2) elementary graduate, (3) high school undergraduate, (4) high school graduate, (5) college undergraduate, (6) college graduate, and (7) post graduate. High education makes a greater difference to consumption and travel patterns. Regression results show significant positive coefficients which means better educated household heads have higher carbon emission levels than households headed by someone who has no formal education. This contradict to some studies (Lenzen et al., 2006, Baiocchi et al., 2010) that educational attainment has a negative relationship with carbon emission since attaining higher education means gaining more knowledge with regards to the adverse effects of carbon emission/climate change/global warming. The result to this study conforms to the study of Seriño (2014) and Seriño and Klasen (2015) that better educated household heads have higher carbon emission levels than households headed by someone who has no formal education. This indicates that awareness of the negative effects of carbon emission is not a reason for a person to change consumption. Also if one is educated he has more opportunities to work in a high paying job that enables him to acquire goods that contributes to carbon emissions. Higher educational attainment is associated with higher carbon emissions.

Households headed by someone with at least college or university level of education posted higher carbon emissions. Possible explanations are related to the prestige effect of attaining higher education. Gaining higher education in the Philippines is associated with an elevated social status, and the consumption pattern of such status is carbon intensive. Hence, households headed by someone with a higher education are more likely to consume energy intensive goods. In this case, the argument that better educated households are more aware of the environmental issues is less apparent.

Household Carbon Emission and Employment Status

The employment status is categorized into a dummy variable, (0) means no job or no business (reference of comparison) and (1) if with job or with business. The study of Fahmy et. al (2011) stated that mean total emissions are highest amongst households where the household reference person (HRP) is in employment and substantially lower amongst households where the HRP is economically inactive or unemployed. The regression result of this study shows a significant negative coefficient (-0.0457) significant at 0.05 level of significance. This means that household headed with no job/business has higher carbon emission than those with job/business. It contradicts to the study of Fahmy et. al (2011). The possible reason why households with no job/business emits more carbon emission is that maybe the household heads with no job/business were engaged into more carbon intensive activities than those with job/business for example staying at home and consuming more electricity by watching television, cooking, and perhaps by indulging into vices such as smoking and other carbon intensive activities.

Household Carbon Emission and Access to Electricity

Regression result shows that household heads with access to electricity are emitting more carbon than those who don't have access to electricity. Households with access to electricity produce more than double carbon emissions than those without access as expected. It is understandable that those who don't have electricity tend to emit only little carbon because they are not using any electricity powered devices/ appliances.

Household Carbon Emission and Location (Rural/ Urban)

Urban-rural setting affects household emissions differently, several studies in developed country showed that households situated in rural areas emits more carbon than those situated in rural areas mainly because on transportation. Regression result conforms to the findings of Seriño (2014) that households situated in urban areas emits higher carbon emissions. The result can be explained through the lifestyle of those situated in urban areas and rural areas. It can be observed that in Eastern Visayas (Region 8) those living in urban areas are way much more dependent on transportation services than in rural areas. Numbers of transportation services are higher in urban areas plus the presence of many establishments that are using facilities, electricity and more carbon emission. Electrification is common on urban areas while there are many households located in rural areas with no access to electricity.

Household Carbon Emission as Affected by Length of Time

Results show a significant positive coefficient (0.196) which means that the year dummy consistently has a higher emission. This implies that holding other factors constant, with time household consumption are moving towards a carbon intensive lifestyle. This indicates that with time there's a development in technology. As we can observe as time passes carbon intensive goods are becoming more affordable. For example, cell phones, motorcycles, televisions can be found in every household these days. Technologies that lower production cost results in lower priced gadgets increasing their supply as well as demands.

Post-estimation Tests

The regression model used in this study was subjected to some post-estimation procedures like test for multicollinearity to check for any serious linear relationship that exists among predictor variables included in the model using variance inflation factors (VIF) and Breusch-pagan test to test for heteroskedasticity. By convention, VIF values greater than 10 are problematic, using VIF the result of the test shows that the model didn't suffer with multicollinearity with a mean VIF of 3.25. Hence, multicollinearity may not be an issue in this case. In dealing with heteroscedasticity, the result shows that the regression model suffers from heteroscedasticity. To address the problem, robust standard error were applied.

4. CONCLUSION

This study was conducted to examine the association between socio-demographic characteristics and carbon dioxide emissions among households in Eastern Visayas, Philippines. Regression analysis was carried out. Results show that in Eastern Visayas income has a positive relationship with household's carbon emission. The analyses also reveal that income has a significant nonlinear relationship with carbon emission depicting a turning point. Other households' socio-demographic characteristics such as age of the household head, household size, floor area, educational attainment, employment status, access to electricity and location have a significant relationship with carbon emissions. Implementation of policies regarding mitigating climate change should start on household level since findings of this study showed that households has a huge influence on carbon emissions. Research should be directed at developing household technologies that emits relatively lesser carbon. Further studies using more recent data from FIES with the same study can strengthen the results.

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