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CO_2 EMISSIONS INDUCED BY HOUSEHOLDS LIFESTYLE IN MALAYSIA

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ABSTRACT

There is a growing concern of the impact of energy consumption on the environment in Malaysia as a result of the increased level of domestic energy consumption. Consequently, CO_2 emissions in the country are increasing at an alarming rate. Households from rural and urban areas are the major commercial energy consumers and they are the main consumers of energy in Malaysia. The objective of this study is to examine the impact of household consumption pattern on CO_2 emission by analyzing the following characteristics: stratum and expenditure classes per capita by applying hybrid input-output model. The findings show that urban households in Peninsular Malaysia with expenditure classes of RM1000-RM1999 has contributed more CO_2 emission through the 'Wholesale and retail trade' sector in 2005. It seems obvious that urban households contribute more CO_2 emissions compared to rural households. Urban household consumption has a great impact on CO_2 emission but it can be reduced through changes in consumer behavior by switching to less carbon-intensive products. Therefore, action should be taken to promote innovation, control the industrial structure and reduce emission intensity caused by household demand.

Keywords: Households; Expenditure Classes; Energy; CO_2 Emission; Consumption.

1. INTRODUCTION

Since Malaysia has experienced a remarkable change from an agriculture country to an industrialized country, its GDP has grown from RM100 billion in 1980 to RM528 billion in 2009. There is a strong relationship between income and expenditure because when

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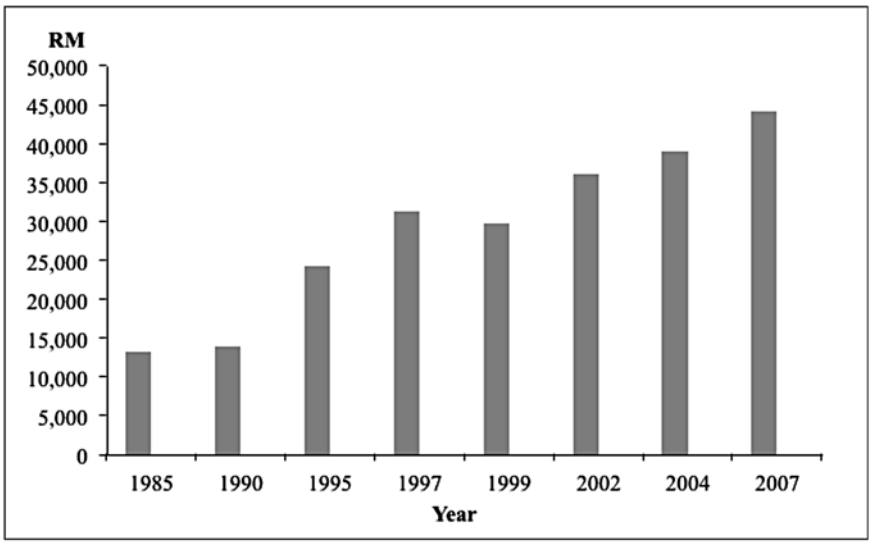
incomes increase, expenditure patterns tend to change (Sanne, 1998). However, expenditure or consumption plays an important role in generating GDP after export.

Figure 1 shows the Malaysian mean annual household incomes between 1985 and 2007. Households benefited from the continued increase in disposable income arising from high export earnings and positive economic growth which also generated full-employment and income-earning opportunities among Malaysians. Moreover, the competitive credit provided further support for more household spending. Malaysian economic growth and structural transformation have wide implications on employment growth and labour force distribution by sectors.

Figure 1: Malaysian mean annually gross household incomes, (RM),1985-2007



Source: Economic Planning Unit (EPU)

The increase in income level results in the monthly consumption per household to grow from RM731 in 1980 to RM1, 935 in 2005 (Department of Statistics, 1980-2005). Income grew at an average rate of 4% from 1997 to 2007. This suggests that the average household in Malaysia was relatively capable of managing its budget and avoid over-expenditure. In 1980/82, the average household expenditure was about RM732 monthly, compared with RM412 in 1973 (Household Expenditure Survey, 2005). The increase in household expenditure was not caused by the rise in price only but also by the increase in purchasing power when income rises due to positive economic growth.

Household consumption and income are related to living standard. Higher living standard is a reflection of higher income and purchasing power. Information on consumption pattern is

particularly useful for policy-makers to assist the lower income groups in improving their living standard. During the 1990s, as incomes grow due to the vibrant Malaysian economic growth, the share of household spending on goods and services highly increased. Increasing demand for energy resources also affects the Malaysian standard of living through urbanization and industrialization. With increased energy consumption the environment is bound to be strongly affected, especially the use of fossil fuels which gives rise to CO_2 emissions. According to World Bank Report, 2010 Malaysia's per capita CO_2 emissions is around 7 metric tons in 2005 but then increased to 7.6 metric tons in 2008 compared to China's 5.3 metric ton per capita in 2008.

There is growing concern in Malaysia on the impact of energy consumption on the environment as a result of the increased level of domestic consumption. Households are the major energy consumers and they are the major consumers of the total energy directly and indirectly in Malaysia. For example, consumption of electricity and petroleum products by households can be classified as direct energy consumption by household, while indirect energy is required to produce goods (physical products) such as food, beverages and tobacco, clothing and footwear, household equipment and transportation. Similarly, all the goods consumed are also related to energy consumption (Reinders et al., 2003). The items in the services sector seem not to require energy (such as communication, recreational, healthcare, education, entertainment, restaurant and hotel, and miscellaneous goods and services) but if we analyse deeply, these activities require energy.

According to IPCC (2001), changing the consumption patterns is a possible approach to reduce the climate change effects. Most developed countries have implemented policies in order to reduce the environmental impacts from household activities. This study focuses on Malaysian rural and urban households and households indifferent expenditure classes because household activities are among the major contributors directly or indirectly to the generation of CO_2 emissions through the use of electricity from electrical appliances as well as gas and oil for cooking at home which have resulted in harmful materials and pollutants being emitted into the air. In 2005, Malaysian households spent about 31% of their monthly expenditure on food whether in restaurants or in the home, followed by housing and transportation at about 18 and 17% respectively. Another household activity contributing directly to the generation of CO_2 is the burning of fossil fuels by private motor vehicles. In recent years, the number of private motor vehicles on Malaysian roads has steadily increased thereby increasing the consumption of fossil fuels. This study is very helpful as a guide on consumer behavior toward the development of a low-carbon economy because Malaysia is striving to be a high-income country.

This paper is organized as follows. Section 2 presents a literature review of energy consumption and CO_2 emission. Section 3 describes an overview of the model employed in this study. Section 4 presents results and findings. Conclusions and Policy implications of the results are discussed in Section 5.

2. LITERATURE REVIEW

In general, changes in consumer behavior are considered as an option to reduce energy consumption and GHG emissions both in terms of composition and quantity of goods and services (UNEP, 1995). These changes can affect both direct household energy consumption and indirect energy requirements (Reinders et al., 2003). Therefore, it is important to analyze consumption patterns in reducing the development of carbon by reducing the energy consumption. Previous studies clarifying on energy and CO_2 emissions of household consumption have been done by a numbers of researchers for the Netherlands, Denmark, the United Kingdom, Korea and China, (Vinger and Blok, 1995; Munskgaards et al., 2000; Reinders and Vinger, 2003; Jackson and Papathanasopolou, 2008; Park and Heo, 2007; Feng and Zou, 2011 and Dai et al., 2011) and they suggest that income rise is one of the most important factors of total energy consumption increase.

Increase in energy consumption is influenced by household lifestyle and technology advancement. Most energy researchers started to focus on the impact of consumer's lifestyle on energy consumption since late 1980s. Schipper et al. (1989) concluded that about 45–55% of total energy use is influenced by consumers' activities for transportation, services, and housing. Bender et al. (2006) used a simple method to estimate changes in consumption that were assessed during the period of survey by suggesting to the households the way to use energy efficiently. They described a decrease in demand of energy of about 8%. However, this survey did not allow for the evaluation of consumption changes. The study done by Vringer and Blok (1995) found energy requirement reduced by about 9%, assuming the households had chosen energy-saving products at higher prices, and changed their consumption towards lower energy-intensity products. Pachauri and Spreng (2002) analyzed the direct and indirect energy demand of Indian households using input–output tables. Reinders et al. (2003) evaluated the average energy requirement of households in 11 European Union member countries, based on household data of expenditure.

Most environment degradation can be traced regarding consumer behavior and activities directly or indirectly, Rees (1995), Daly (1996) and Duchin (1998). Alfredsson (2004) concluded that applying "green" consumption patterns without reduced consumption level will undesirably much similar. A green consumption pattern is known as a reduction in energy requirements of less than 8% and CO_2 emissions of less than 13% using a model of micro-simulation for households in Sweden with eight main categories of consumption and derived GHG reductions. Bin and Dowlatabadi (2005) studied the relationship between consumer activities and energy use and the related CO_2 emission using the Consumer Lifestyle Approach (CLA). The study done by Girod and de Haan (2009) looked at the pattern of households that will produce low GHG emissions within the survey of consumption, since some people can argue that small groups of today's households already exhibit green consumption behavior.

Brand and Boardman (2008) found that about 43% of the total GHG emission is caused by personal travels by 10% of households in the UK. This study has contributed to the empirical studies by presenting a framework of innovative estimation and instrument of evaluation for emissions of cross-modal travel outlined at the personal and household levels, and improved

understanding of the degree to which individual and household travel activity patterns, choice of type of transport, socio-economic, geographical location, and other factors impact on GHG emissions.

Carlsson-Kanyama et al. (2005) found a potential for the reduction of today's expenditure levels in the order of 10–20% in Stockholm. This study found that a medium expenditure range reduced about 30% of CO_2 emissions by assuming a given lifestyle changed adequately with the support of the Dutch energy analysis programme (EAP). There have been more findings on the study of households lifestyle can have an important and significant impact on energy use and the related CO_2 emission in China, (Yi et al., 2007; Feng et al., 2010). Vringer and Blok (1995) analyzed the variance in total energy consumption and found that households consuming 22% in the lowest decile of energy consumed 25% more energy than households in the upper decile.

Since total energy consumption is strongly interrelated with expenditure, controlling for constant expenditure in analyses is important (Kok et al., 2006; Lenzen et al., 2006). Lenzen (1998) analyzed the impact of consumers' activities on energy consumption and greenhouse gases emissions in Australia using the input–output model. This study also applies an Input-Output model in order to identify the CO_2 emissions induced by Malaysian households according to their region (Peninsular Malaysia, Sabah and Sarawak), Strata (Rural and Urban) and range of expenditure (expenditure classes) based on statistic data of Household Expenditure Survey (HES). Wier et al (2001) used Input-output model to calculate the embodied energy and CO_2 emissions in consumer goods by different types of Danish households. Duarte et al (2010) studied links between income levels, patterns of consumption and CO_2 emission for Spanish households.

3. METHODOLOGY

This study converts the monetary unit from the traditional input–output tables into energy input–output tables (in physical unit) with the help of energy prices (Miller and Blair, 2009). In order to estimate the average energy prices, information on energy use and expenditure by input-output energy was used. Average energy prices are the ratios of energy use (inputs) to the total output (intermediate plus final demand) by type of fuel, expressed in toe/RM, the same as energy intensities as shown in equation (1). The energy intensities are more normally used prices expressed in toe/RM. Thus, higher toe/RM values or higher energy intensities mean lower energy prices. Energy intensities can be expressed by following equation:

$$P_i = E_i / X_i - m_i \ (\text{ktoe} / \text{RM}) \qquad (1)$$

where P_1 is the energy price for sector 1, e.g. price of petroleum products, is used to quantify 40 intermediate inputs of petroleum product to produce goods of 40 sectors, E_i is energy use, X_i is the production of sector 1, e.g. petroleum product, m_i is the imports of sector 1. Industries (40 sectors) will pay much lower prices than households (final expenditure) for the same energy. Within the intermediate demand for fuels, price differentials exist. (see Lenzen (1998a;b) for more discussion). It is easy to estimate direct energy intensities of individual

sectors if intermediate energy inputs (energy input–output tables) are computed by using equation (2).

$$Z_{1,j} \text{ x } P_1 = ZE_{1\,j} \quad (2)$$

where $Z_{1,j}$ are the intermediate outputs of sector 1 to be used for the production of goods of sectors 1 to 40. Once intermediate energy inputs (energy input–output tables) are computed as in Equation 2, it is easy to estimate direct energy intensities of individual sectors. Direct energy intensities of individual sectors are the ratios of direct energy expenditure converted in physical energy term to total inputs (intermediate inputs and value-added inputs), also expressed in toe/RM, i.e.

$$d_1 = E_{i,1} / X_i \ (\text{toe} / \text{RM}) \quad (3)$$

Where $\mathbf{d}_1$ (direct) is the direct energy intensity of sector 1. Total energy intensities can be computed by multiplying them with the Leontief inverse $(1\text{-}A)^{-1*}$ of the corresponding hybrid input-output table as expressed in

$$r = d_1 . (1\text{-}A)^{-1*} \quad (4)$$

wherer is the total energy intensity.

In order to calculate CO_2 emission by the household, the CO_2 intensity or multiplier in equation (5) was used by using the extended input-output model first introduced by Leontief and Ford (1972) and later extended by others, for example Munskgaardet al. 2000; Wier et al (2001), Cruz (2002), Kim (2002) and Chung et al. (2009). The basic environmental I-O model can be represented using the equation as follows:

$$v=f.(m\#r).(I\text{-}A)^{-1} \quad (5)$$

where v denotes the CO_2 emission intensity or multiplier, # denotes element by element multiplication (cell by cell), f is an 1x11 vector of CO_2 emissions per unit of energy consumption of each of the 11 energy types or considered as CO_2 emission factor; **m** is a 40x11 matrix of energy mix or energy consumption in the production sectors, i.e. demand for 11 energy types per unit of total demand for energy for all production sectors[1]; **r** is a 40x1 vector of total energy intensity (direct plus indirect energy intensity), i.e. total energy consumption per unit of production in all 40 sectors; $(I\text{-}A)^{-1}$ is the 40 x 40 Leontief inverse matrix, and in order to calculate the CO_2 emissions produced by household is:

$$K=v.\ Cc_I \quad (6)$$

Where K denotes total CO_2 emissions by households, C is a 40 x 10 matrix of the composition of consumption commodity aggregates, i.e. 10 private consumption expenditure classes

[1] Fuel mix or energy consumption in the production side is provided by the National Energy Center according to the production sector.

aggregates apportioned by production sectors; c_1 is the 10 x 1 vector of aggregate expenditure classes in private consumption, i.e. demand for 10 expenditure classes per unit of total consumption as shown in equation (6).

3.1. Data sources

This study utilized two kinds of data:

The first set of data was based on Malaysian input-output tables for the years 2005 from the Department of Statistics (DOS). The input-output tables are aggregated into 40 x 40 dimensions of production sectors and four categories of final demand.

The second set of data regarding the energy consumption for the years 1991-2008 were taken from the National Energy Centre (PTM) which contained data on energy consumption for the 40 production sectors as well as for the three categories of household energy consumption. Energy demand was reported for eleven types of energy in monetary and physical unit. The *CO_2 emission factors* for the 11 primary fuels were calculated on the basis of the carbon contents of the fuels (as shown in the IPCC revised 1996-Module 1- Tier 1).

4. RESULTS AND FINDINGS

4.1. Energy consumption and CO_2 emissions by Malaysian household

The energy use by households (direct and indirect) had increased dramatically for the last few years and contributed to the CO_2 emission. Evidence from private consumption (Input-output table 2005) shows that consumption by services sector, an important sector in the economy since 2000 is the largest contributor to CO_2 emission. The services sector contributes about 58% of the gross domestic product (GDP) in 2010 particularly 'Wholesale and retail trade' which remained the largest subsector accounting for 13% of GDP in 2010 as shown in Table 1 (Productivity Report 2010/2011).

Table 1: Contribution of Services Sector to GDP (%)

Services subsector	**2006**	**2007**	**2008**	**2009**	**2010**
Wholesale and retail trade	11.22	12.02	12.63	12.95	13.06
Transportation	3.56	3.68	3.74	3.68	3.68
Communication	3.64	3.65	3.75	4.03	4.09
Real estate	4.64	5.21	5.09	5.28	5.31
Other services	5.57	5.52	5.56	5.89	5.72
Services Sector (All services subsector)	**54.18**	**56.01**	**57.05**	**57.78**	**58.31**

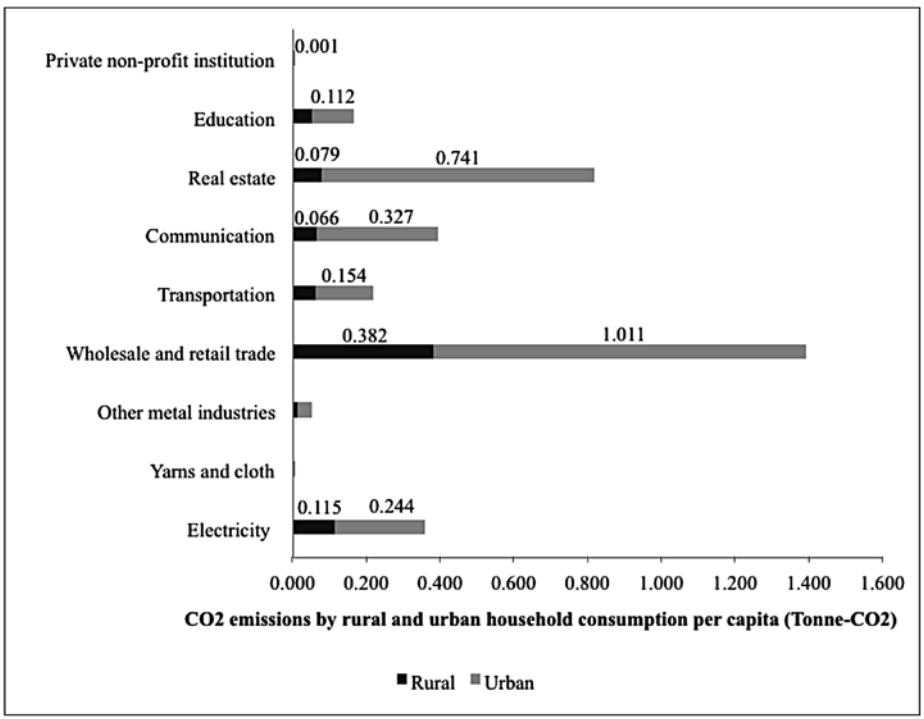
Sources: Productivity Report 2010/2011, Malaysian Productivity Corporation.

In terms of energy and CO_2 emissions intensity, services sector such as Wholesale and retail trade, Real estate, Communication, Education and Private non-profit institution are below average value (64.5 ktoe/M-MyR) and (0.278 tonnes/M-MyR), respectively as shown in figure 2. According to Input-output table 2005, Wholesale and retail trade is the largest contributor in the private consumption in 2005 about 15% of total final demand (Input-output table 2005). Up to 2010 contribution of Wholesale and retail trade to GDP increase by 13.06%. Therefore, wholesale and retail trade sector is the highest contributor of CO_2 emissions since demand from that sector is also high compared to other sectors.

4.2. CO_2 emission induced by households consumption groups in Malaysia

The results from this study show that there are obvious differences in the two types of stratum (rural and urban) according to household expenditure classes. Increased emissions of CO_2 emissions are mainly induced by increase in income and consumption from year to year. CO_2 emissions from rural and urban households in 2005 are presented in figure 4. CO_2 emissions from households obviously come from the Wholesale and retail trade at 1.011 tonnes-CO2, followed by Real estate at 0.741 tonnes-CO_2. Rising CO_2 emissions in urban households is due to increase in population, urbanization and most commercial activities play an important role in urban areas.

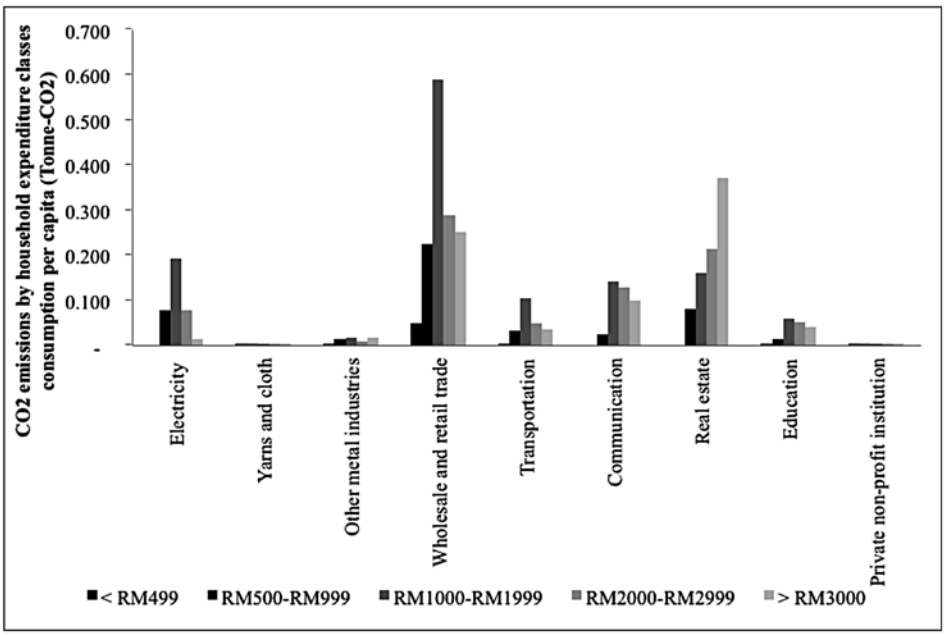
Figure 2: CO_2 emissions from rural and urban household, 2005



Source: Equation 6

The way households spend their money is very important to take into consideration because household spending is also sometimes associated with standard of living. The higher the standard of living of a nation, the higher is the purchasing power of its people. Information on expenditure patterns is particularly useful for government programmes to assist the lower income group. The consumption increased by 45 percent from 2000 to 2005 due to enhanced consumer confidence affecting consumer behaviour. The higher household spending was accompanied by increase in income as well as increase in the bundle of goods bought by households, not just because of higher prices. Therefore, this study considers household expenditure classes and this is divided into five classes as shown in figure 3.

Figure 3: CO_2 emissions from household expenditure classes, 2005



Source: Equation 6

Households in the expenditure classes (RM1000-RM1999) have the most CO_2 emissions for Electricity, Wholesale and retail trade, Transportation, Communication and Education sectors. The households with expenditure above RM3000, contributes the highest CO_2 emissions through their consumption on Real estate.

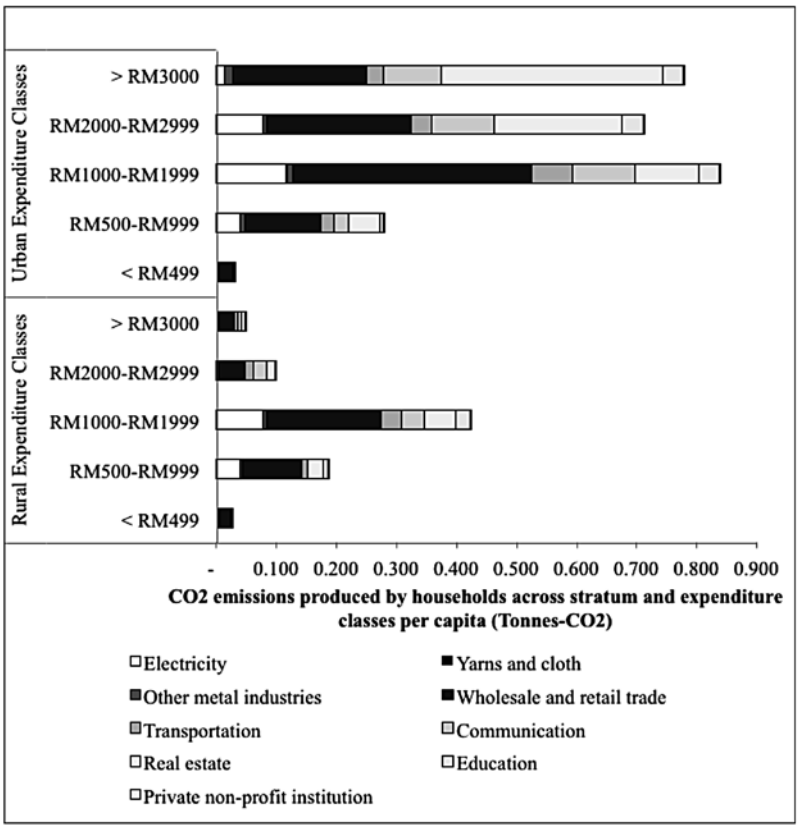
For details, figure 4 shows the trend of total CO_2 emission by households expenditure across urban and expenditure classes for 2005 for the sectors that lie in quadrant (High-High) such as Electricity, Wholesale and retail trade, Real estate, Yarns and cloth, Transportation, Education, Other metal industries, Communication and Private non-profit institution. In general, urban households contributed the highest CO_2 emissions for every expenditure classes compared with rural expenditure classes. Household with (RM1000-RM1999) expenditure classes from rural area contribute the largest CO_2 emissions through 'Wholesale and retail trade' about 0.19

tonnes-CO_2 and 'Real estate' about 0.05 tonnes-CO_2. Most rural household contribute small CO_2 emissions which is less than 0.04 tonnes-CO_2.

Urban household expenditure trend is different from rural trend for every expenditure class range particularly on 'Wholesale and retail trade' which also contributed the largest amount of CO_2 emission for every expenditure classes. The exception is urban household above RM3000 expenditure class which contributes the highest CO_2 emission through consumption on Real estate about 0.370 tonnes-CO2. This is followed by 'Wholesale and retail trade' about 0.223 tonnes-CO_2 and 'Communication' about 0.095 tonnes-CO_2. Spending on Real estate is the main expenditure by Malaysian households who spend more than RM3000 of their income on this activity. Spending on Real estate is influenced by the income of the household the prices of goods and also the standard of living. Income levels may influence wealthier households to renovate to big house or buy more houses.

After contribute the highest CO_2 emissions through 'Wholesale and retail trade', urban household with expenditure classes (RM2000-RM2999) contribute the second highest CO_2

Figure 4: CO_2 emission produced by consumption across Stratum and expenditure classes, 2005



Source: Equation 6

emissions through 'Real estate' about 0.212 tonnes-CO_2. This is followed by 'Communication' which contributes about 0.104 tonnes-CO_2. In Urban household with expenditure classes (RM1000-RM1999), 'Wholesale and retail trade' contributes the highest CO2 emissions, the second highest is from 'Electricity' about 0.115 tonnes-CO_2, followed by 'Real estate' about 0.106 tonnes-CO_2.

Most people whether from rural or urban areas spend their income on 'Wholesale and retail trade' particularly household with expenditure classes (RM1000-RM1999) because shopping habit in the Malaysian households has been growing and changing due to rising affluence and education levels. Besides that, some Malaysian households are becoming more educated, particularly those living in big cities. They are attracted to foreign brands since the emergence of the foreign-owned hypermarkets in Malaysia such as Aeon, Tesco, Giant and Carrefour. Households in urban areas have adapted to shopping for groceries at hypermarkets and supermarkets, particularly the high-income and middle-income households. Meanwhile rural people or low-income households continue to purchase from traditional grocers and mini markets.

5. CONCLUSION AND POLICY IMPLICATION

In conclusion the increase in income and consumption has resulted in increased CO_2 emissions, especially those who live in urban areas because households in urban areas are equipped with modern facilities along with availability of higher education facilities and good career opportunities. Households in urban areas lead an economically more stable and high class lifestyle. The increasing attraction of the people towards the urban areas has resulted in crowded cities causing an inequality in the density of human population. Large scale industrialization has provoked environmental problems like pollution. From this study, it seems obvious that urban households in expenditure class of RM1000-RM1999 have generated more CO_2 emissions because they are not really concerned about environment.

In future, Malaysia will face a big challenge to control pollution particularly CO_2 emissions due to increase in demand for communication, transportation, energy, housing, shopping mall, shop lots etc in the urban areas. Therefore, action should be taken such as promoting innovation, controlling the industrial structure and reducing emission intensity caused by households demand. In addition, households should be given awareness about the importance of combating environmental problems through the introduction of low-carbon economy lifestyle.

As clearly shown, the relationship between energy consumption and CO_2 emissions is extremely significant and will influence economic growth. This study proposes the policy to be taken based on the results. In order to reduce CO_2 emissions, households in urban and rural areas have to consume green-tech products to achieve the sustainable consumption as well as sustainable development. This awareness is very important to the environment because without such awareness manufacturers will continue to produce non-green tech products more and more as the demand for non-green tech products is still increasing. For example the demand for motor vehicles, real estate and wholesale and retail trade has led to a large increase in CO_2 emissions particularly in urban areas.

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