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Income-carbon footprint relationships for urban and rural households of Iskandar Malaysia

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Abstract. Iskandar Malaysia has a vision to achieve sustainable development and a low carbon society status by decreasing the amount of CO_2 emission as much as 60% by 2025. As the case is in other parts of the world, households are suspected to be a major source of carbon emission in Iskandar Malaysia. At the global level, 72% of greenhouse gas emission is a consequence of household activities, which is influenced by lifestyle. Income is the most important indicator of lifestyle and consequently may influence the amount of households' carbon footprint. The main objective of this paper is to illustrate the carbon-income relationships in Iskandar Malaysia's urban and rural areas. Data were gathered through a questionnaire survey of 420 households. The households were classified into six categories based on their residential area status. Both direct and indirect carbon footprints of respondents were calculated using a carbon footprint model. Direct carbon footprint includes domestic energy use, personal travel, flight and public transportation while indirect carbon footprint is the total secondary carbon emission measurement such as housing operations, transportation operations, food, clothes, education, cultural and recreational services. Analysis of the results shows a wide range of carbon footprint values and a significance correlation between income and carbon footprint. The carbon footprints vary in urban and rural areas, and also across different urban areas. These identified carbon footprint values can help the authority target its carbon reduction programs.

1. Introduction

One of the most challenging environmental issues of the 21st century is global warming, which is directly changing the earth climate system mainly due to increasing emission of greenhouse gases (GHGs) produced by human activities. Increasing evidence suggests that human-induced GHGs released into the atmosphere might cause serious, potentially irreversible changes to the global climate within the next decades [1]. This is already being experienced in several parts of the world. There are several sources of GHGs but the most important of them is the use of fossil fuels. Reduction in CO_2 emission will require sustainable increase in the carbon efficiency of production process and change in the way we live and consume things [2]. Low Carbon Society (LCS) has been advocated for quiet sometime now, and widely used, as many low carbon projects have been done all around the world to reduce the emission of GHGs. A LCS is a society that consumes sustainable and relatively low carbon energy as compared with our present day practice so as to avoid adverse climate change [3]. The three basic principles of LCS are carbon minimization in all sectors, toward a simpler lifestyle that realize richer quality of life and co-existing with the nature. As stated before, GHGs are the main sources of

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global warming and climate change. A low carbon society in the ultimate sense would be a society that emits greenhouse gases only in an amount, which can be absorbed by the nature. In such society, consumers will choose the eco-friendly products, which have less emission of CO_2 to the atmosphere.

Carbon footprint has become a widely used term and concept in the public debate on responsibility and abatement action against the threat of global climate change [4].The common baseline is that the carbon footprint stands for a certain amount of gaseous emissions that are relevant to climate change and associated with human production or consumption activities. Carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that are directly and indirectly caused by an activity or is accumulated over the life stage of a product. These include activities of government, companies, individuals, organizations, processes, industrial sectors etc. In all the sectors, residential sector is significantly related with consumption.

Lifestyle research is a good instrument to focus on environmental impacts from the consumption perspective. As a consequence of climate change issue, increasing attentions are attracted to topics like energy consumption and carbon emissions. Micro-level CO_2 emissions, which are connected to household consumption and affected by lifestyle, are receiving more and more attention. "One's lifestyle is his way of living and influences; and is reflected by one's consumption behaviour" [5]. Research on households' carbon emission has become one of the most popular areas of climate change mitigation. It is also significant to sustainability study.

Within the component of consumer choices, household and individual activities (purchase and use) have direct or indirect impacts on energy use and related to CO_2 emissions. If a consumer's activity leads to energy consumption and CO_2 emissions while the product or service is in use, these are called direct (on-site) influences, where energy consumption and CO_2 emissions occur in the preparation (production and delivery) of a product or service and before its use, are called indirect (embodied) influences [2], Many studies have been done on households energy consumption and carbon emission in developed countries such as; Australia [6]; Denmark (CO_2 emissions) [7]; Japan (energy) [8]; Netherlands [9]; New Zealand [10]; Norway CO_2 emissions) [11; 12]; Spain CO_2 emissions [13] and the USA (energy and CO_2) [14;15]. But specific research on Malaysian households and their carbon emission is scanty.

Set to be a strong and sustainable metropolis of international standing, Iskandar Malaysia (formerly Iskandar Development Region and South Johor Economic Region) located at the southernmost tip of Peninsular Malaysia has a part to play in the global campaign of carbon reduction. This is suggested because of its strategic position at the heart of the Asia region and cross-roads of East and West trade route of fast growing countries of China and India. Iskandar Malaysia, as a new and one of the fastest growing metropolises in Malaysia has a vision to achieve sustainable development and implement low carbon society. Many research has been done regarding to this vision, different researchers have studied different aspects of low carbon society. But still there seems to be lack of commitment and participation from local communities. Hence studies need to be done to better understand the behaviour of the people, their lifestyle and how best to approach the implementation of low carbon society initiative in Iskandar Malaysia [12]. Current annual GHGs emissions of Iskandar Malaysia are approximately 12.6 million t-CO_2 [10]. Under this scenario, without mitigation measures the greenhouse gases emission will increase to 45.5 million t-CO_2 in 2025, (36 times higher than 2005). By adopting mitigation options available at 2025 the emission can decrease approximately by 60% and suppressed to 19.6 million t- CO_2. Current per capita emission for Iskandar Malaysia is 9.3 t- CO_2, which is bigger than national average of Malaysia (5.0 t-CO_2). In 2025 without mitigation options it will increase to 15.1 t-CO_2, while by adopting mitigation measures it would be 6.5 t-CO_2. The main objectives of this study therefore are, to measure the carbon footprint of six different residential areas

of Iskandar Malaysia, to compare carbon footprint of different categories and to find out if income as a key factor of lifestyle has a relationship with the carbon footprint of Iskandar Malaysian households

2. Methodology

In this research a geo-demographic segmentation has been applied to create six categories of residences from villages to high cost urban areas which includes; Kampung Ulu Pulai (villages); Kampung Skudai Kiri (squatters); Bandar Seri Alam(non market housing); Taman Pulai Perdana (affordable housing); Melana and Melawis apartments (medium cost housing); and Taman University Semi Detached and Banglows (high-cost housing). A set of questionnaire was prepared to gather data from the study areas. The data includes their domestic energy use, personal travel, public transportation usage and secondary carbon footprint. To choose the respondents first of all, a stratified random sampling was applied. Then within each stratum samples were randomly selected. The total number of respondents in this research was 420. Data were analysed using *carbon footprint ltd*. Both direct and indirect carbon footprint of respondents were used as model to measure the carbon footprint of each household. Direct carbon footprint includes; domestic energy use, personal travel (car and motorbike) and Public transportation (flights, bus and taxi). While indirect carbon footprint refers to as secondary carbon emission, includes housing operations, transportation operations, food, clothes, education, cultural and recreational services. Analysis of households' carbon footprint was done using Statistical Package for Social Sciences (SPSS) software to determine the impact of individual household's income on the total carbon emission.

3. Results and Discussion

The result of this study indicates that within the whole Iskandar Malaysia region there is a significant correlation between income and carbon footprint. In other words generally by increasing the household's income, their total carbon footprint also increases. Figure 1 below shows the box plots of income versus carbon footprint. It can be seen how increase in income would generate higher carbon footprint. The effects are evident for income below RM6000 and start to taper off as income rises beyond RM9000.

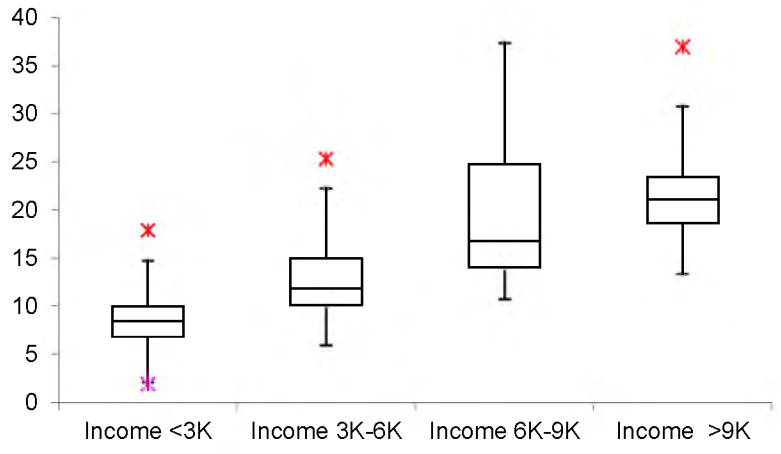

Figure 1: Relationship between income and carbon footprint

The average total carbon footprint of Iskandar Malaysia's households was 11.76 t-CO_2 while 7.02 t-CO_2 was for primary carbon emission, secondary carbon footprint was 4.73 t-CO_2. The average income range for Iskandar Malaysia is between RM4001 to RM5000. The total carbon footprint for each household of Kampong Ulu Pulai was 9.58 t-CO_2 where primary carbon footprint was almost two times higher than secondary carbon footprint by 5.84 t-CO_2 and 3.73 t- CO_2 respectively. The avarge monthly income for Kampung Ulu Pulai is RM3001-RM4000. The most important source of pollution

in Kampung Ulu Pulai is personal cars with the mean of 3.24 t-Co2, followed by domestic energy use. The overall carbon footprint of this village is generally same as low-income urban categories. Kampung Skudai Kiri is the settlement of squatters in this study. The total carbon footprint of this category was 10.18 t-Co2 per household. In This category primary carbon footprint was slightly higher than secondary one, where the average primary carbon footprint was 5.71 t-CO_2 and secondary 4.50 t-CO_2. In Kampong Skudai Kiri secondary carbon emission was the most important source of pollution, which was followed by domestic energy use and cars. The average income range in this category is RM2001-RM3000. Bandar Seri Alam is host for non-market Housings (PPRT) in this study. Non-market housing is kind of flats that government provides for those who cannot afford buying a house. The average carbon footprint of this category was 9.76 t-CO_2, which was the third lowest carbon footprint in this study. Bandar Seri Alam is the only category in which secondary carbon footprint (CF) was very closed to primary CF. The residents of this category have the lowest average income range within all categories (RM1001-RM2000). Affordable housings for the study were Taman Pulai Perdana. The average carbon footprint of residents of this area was 9.39 t-CO_2, where primary CF was 5.18 t-CO_2 and secondary CF was 4.15 t-CO_2. Like other categories in this area also carbon footprint increases with increase in income. Melana apartment is a category for medium cost housings in Iskandar Malaysia, where average of total carbon footprint was recorded as 11.51 t-CO_2. Cars were the main reason of pollution in this area, followed by secondary CF and electricity (domestic energy use). The lowest belongs to public transportation (bus and taxi) with 0.11 t-CO_2. Residents of Melana apartments have an average monthly income of RM4001-RM5000. The highest carbon footprint in study belongs to high cost housings in Taman University. The average of total carbon footprint recorded in this category show some rapid increase of 20.14 t-CO_2. The average income of these respondents is RM7001-RM8000. Primary CF is almost two times higher than secondary CF (13.19 t-CO_2 and 6.96 t- CO_2) respectively.

Table 2. Descriptive Statistics; Income and Carbon footprint.

	Secondary CF	**Primary CF**	**Total CF**
Mean	4.7355	7.0266	11.7650
Median	4.6500	5.8650	10.5150
Std. Deviation	1.84283	4.53361	5.88096

4. Conclusion

The study revealed that, the highest carbon footprint in this study belongs to those who are living in the most expensive residential areas. The total carbon footprint of Iskandar Malaysia is higher than the country's average, which is 7 t-CO_2. One of the most important reasons of high carbon footprint in Iskandar Malaysia is the usage of personal vehicles, which shows the lack infrastructure in terms of public transportation. The other important source of pollution is usage of electricity, mostly because of using air conditioners and appliances at home. Income is a key factor to households' lifestyle, as income increases, people try to improve their living standards by buying better appliances, more clothes, new cars which in Malaysia's case is usually more than one car per household. People will eat more meat and dairy in their diet. They will buy new houses and are less interested in using public transportation. They will buy new houses and have more entertainments and produce more carbon by their daily activities. Also, people at different income levels have different lifestyles; therefore, different patterns of consumption are related to CO_2 emissions.

Interestingly, most of the respondents in the study indicated willingness to change their lifestyle so as to achieve a low carbon society in Iskandar Malaysia. This is an indication that, with good efforts from the government there is a potential from peoples' part to help government reach a low carbon society. We therefore conclude that, to achieve low carbon society, serious efforts should be taken by government, citizens and industries to change their wrong energy usage behaviours. The government should improve on infrastructure provisions that enhance renewable energy use. And engaged in public campaign or awareness by encourage people to use renewable energy facilities, public transportation among others. On the other hand, the society should adopt into a low carbon life style which prefer to use renewable energies, less dependence on fossil fuels and practice 3Rs (Reduce, Reuse, Recycle)

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6. References

[1] IPCC. 2007b. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp

[2] Baiocchi, G., Minx, J., &Hubacek, K. (2010). The Impact of Social Factors and Consumer Behavior on Carbon Dioxide Emissions in the United Kingdom.*Journal of Industrial Ecology, 14*(1), 50-72.

[3] Siong, H. C. (2006). *Low Carbon Society Scenarios Towards 2050-2006 Aim Training Workshop, Case Study Malaysia*: UniversitiTeknologi Malaysia

[4] Wiedmann, T., & Minx, J. (2008). A Definition of 'Carbon Footprint'. In: C. C. Pertsova, Ecological Economics Research Trends (pp. pp. 1-11). Hauppauge NY, USA.: Nova Science Publishers.

[5] Bin, S., Dowlatabadi H. (2005) Consumer lifestyle approach to U.S. energy use and the related co2 emissions, *Energy Policy*, 33, pp. 197-208

[6] Lenzen, M. (1998).Energy and greenhouse cost of living for Australia during 1993/94, *Energy*, 23 (6), pp. 497-516.

[7] Munksgaard et al. (2000). Impact of household consumption on CO2 emissions, *Energy Economics*, 22 (4), pp. 423-440.

[8] Lenzen, Manfred et al. (2006). A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan, Energy, 31, pp. 181-207.

[9] Vringer, K. and Blok, K. (1995). The direct and indirect energy requirements of households in the Netherlands, Energy Policy, 23 (10), pp. 893-910.

[10] Peet, N.J. et al. (1985). Energy in the New Zealand household, 1974-1980, Energy, 10 (11), pp. 1197-1208.

[11] Herendeen, R. et al. (1981). Energy cost of living, 1972-1973, *Energy*, 6, pp. 1433-1450.

[12] Peters, G.P. et al. (2006). Environmental impacts and household characteristics, an econometric analysis of Norway, 1999-2001, In: Tukker, A. (Ed.) Sustainable Consumption Research Exchange Launch Conference, Wuppertal, DE, pp. 292-307.

[13] Roca, Jordi and Mònica Serrano (2007). Income growth and atmospheric pollution in Spain: an input-output approach, Ecological Economics, 63, pp. 230-242.

[14] Herendeen, R. and Tanaka J. (1976). Energy cost of living, *Energy*, 1, pp. 165-178.

[15] Ngah, I., &Tsong, T. B. (2011). *Low Carbon Lifestyle: A Key in Moving Iskandar Malaysia Towards Low Carbon Region* Paper presented at the ISSM 2011, Malaysia Conference