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ENVIRONMENTAL-ECONOMIC IMPACT ASSESSMENT IN URBAN PLANNING

RESUMEN

Las prácticas sostenibles requieren de un marco controlado en los sistemas urbanos donde su funcionalidad y eficacia puedan ser evaluadas. Este estudio tiene como objetivo revisar cómo la integración de la huella de carbono y el factor monetario pueden construir una dimensión de impacto en la salud ambiental para monitorizar los gastos de una nación, en general, o de un hogar o individuo, en particular, en relación al potencial de calentamiento global. El modelo de Input Output Económico de una nación o una región es una herramienta analítica fuerte que describe la estructura económica de una nación o región. La matriz inversa de Leontief deriva de la tabla input output económica. El resultado del modelo se expresa en potencial de calentamiento global, que describe su impacto total de calentamiento global relativo al dióxido de carbono a lo largo de un período de tiempo determinado. La estimación de la huella de carbono a partir de flujos monetarios en un entorno urbano es vital en el análisis de los impactos en la salud ambiental, donde la planificación urbana y la economía sostenible son complementarias

PALABRAS-CLAVE: ANÁLISIS DEL IMPACTO AMBIENTAL Y ECONÓMICO; METABOLISMO URBANO; HUELLA DE CARBONO; PLANIFICACIÓN URBANA

ABSTRACT

Sustainable practices require a controlled setting within an urban system where the practicality and efficacy could be assessed. This study aim to present a review by what means integrated carbon footprint and monetary factor may construct an environmental health impact dimension to oversee the expenditure of a nation in general or a household or an individual in particular in relation to global warming potential. Economic Input Output model of a nation or a region is a powerful analytical tool that describes the structure of one nation or region's economy. An inversed Leontief matrix is derived from the economic input output table. The outcome of the model is expressed in global warming potential which describes its total global warming impact relative to carbon dioxide over a set period of time. The estimation of carbon footprint from monetary fluxes within an urban setting is vital in the environmental health impact assessment where sustainable urban planning and sustainable economy are complimentary of each other.

KEYWORDS: ENVIRONMENTAL-ECONOMIC IMPACT ASSESSMENT, URBAN METABOLISM, CARBON FOOTPRINT, URBAN PLANNING

INTRODUCTION

There were 729 million of worldwide urban population back in 1950s and that takes up about 29% of the world total population. The number rise up to 3.63 billion in 2011 where it takes up 52% of the world total population. By 2050, the increase of the world urban population is expected to reach 6.3 billion citizens (United Nations Department of Economic and Social Affairs, 2011). Therefore, sustainability has become the key goal in every aspect of environmental health component especially in the diverse urban systems. The sustainability measure is constantly uphold in many planning principles because of the sentience that urbanization process may result in detrimental environmental impacts to the cities as the end result of increasing population, high demand of natural resources and production of environmental pollutants.

Natural greenhouse gases have been existing for nearly two hundred years. However, carbon dioxide emission has risen up by over 40% since industrial revolution begin in 1750 (Houghton, 2011). The enhancement of the emission of natural greenhouse effect associated with human activities that add in more intensity of greenhouse gases into the atmosphere will result in global warming (Wallington et al., 2004). The continued growth of global emissions gives various adverse effects towards environment especially on global warming (Azhar Khan et al., 2013). Compared to temperature in 1951-1980, the global surface temperature has risen 0.56°C in 2012 The global average temperature is expected to rise by between 2 and 6°C over the 21st century (Hansen et al., 2013).

CURRENT UNDERTAKING ON URBAN METABOLISM

The urban metabolism framework provides a rigorous tool for analyzing relevant energy pathways at different scales and can lead to the development of management systems that increase resource use efficiencies, recycling of wastes and conservation of energy. Urban metabolism analysis emerged from a growing understanding of the limited availability of fossil fuels and their impacts on the environment as well as ideas about efficiency of that use (Holmes & Pincetl, 2012).

There are several methodologies and tools that are applicable in the urban metabolism and environmental assessment of a city. They are namely Material Flow Analysis (MFA), hybrid Input

Output Life Cycle Assessment (LCA), Economic Input – Output (I-O) analysis, substance flow analysis and ecological footprint (Lemos, 2011; Dias et al., 2014). A comparative study by Mat et. al. 2013, undertook three methods; Economic Input Output Analysis, Material Flow Analysis and Life Cycle Assessment and arrived with the advantages and disadvantages of each method. They concluded that I-O Analysis was found to be a very useful tool providing an accurate diagnosis of the area of study and are both time and resource efficient. MFA and LCA on the other hand, give a more in-depth view of resource consumption and associated life cycle impacts. However both methodology require high resources and also time intensive. LCA also requires a previous life cycle inventory, which can be unavailable or incomplete on current LCA database and the establishment of the life cycle can be time consuming. By means of the national or regional data, economic input-output table has strived to be one of the approaches that can be used to determine urban metabolism in a comprehensive yet practical manner (Lemos, 2011).

This environmentally extended input output analysis may become a baseline to the application of urban smart management by finding how cities can perform their activities by learning from natural ecosystems, for example using their materials, energy and water in a more balanced way by practicing control, efficiency and effectiveness thus minimizing the pollution, waste, noise and consumption of inputs.

Kennedy et. al. 2011 provides supports that urban metabolism study can be a tool in guiding sustainable green building design, planning ecologically sensitive design for a city and design new sustainable cities that will somehow benefits people in a long run. The evidences are discussed through urban sustainability indicators; inputs to urban greenhouse gas emissions calculation; mathematical models of urban metabolism for policy analysis, and also as a basis for sustainable urban design. For example, urban metabolism parameters essentially provide the required measures of activity levels for urban Greenhouse Gases (GHG). An extended approach to the conventional input-output takes the analysis farther to arrive with significant environmental indicators. The analysis investigates the input of material and natural resources to the output in the form of economic sectors.

ECONOMIC INPUT OUTPUT ANALYSIS

Input-output analysis (IOA) is an economics term that refers to the study of the effects that different sectors have on the economy as a whole, for a particular nation or region. This type of economic analysis was originally developed by Wassily Leontief (1905 – 1999), who later won the Nobel Memorial Prize in Economic Sciences for his work on this model. Input-output analysis allows the various relationships within an economic system to be analysed as a whole, rather than individual components. The main objective of the IO analysis is to provide a simplified overview of the environmental impacts caused by the residential and transport demands of the city in a country.

The analysis of city characterization is important as to get a broader picture of the environmental impacts of the city. The environmental impacts of the cities are increasing due to the escalating population, high demands for more natural resources and emission and production of environmental pollution. For examples; energy (at the final consumer), water, food and drinks were the input products considered while emissions, wastewater and solid waste were the outputs analysed. Thus, all the movement or flow of transaction within an urban system can be
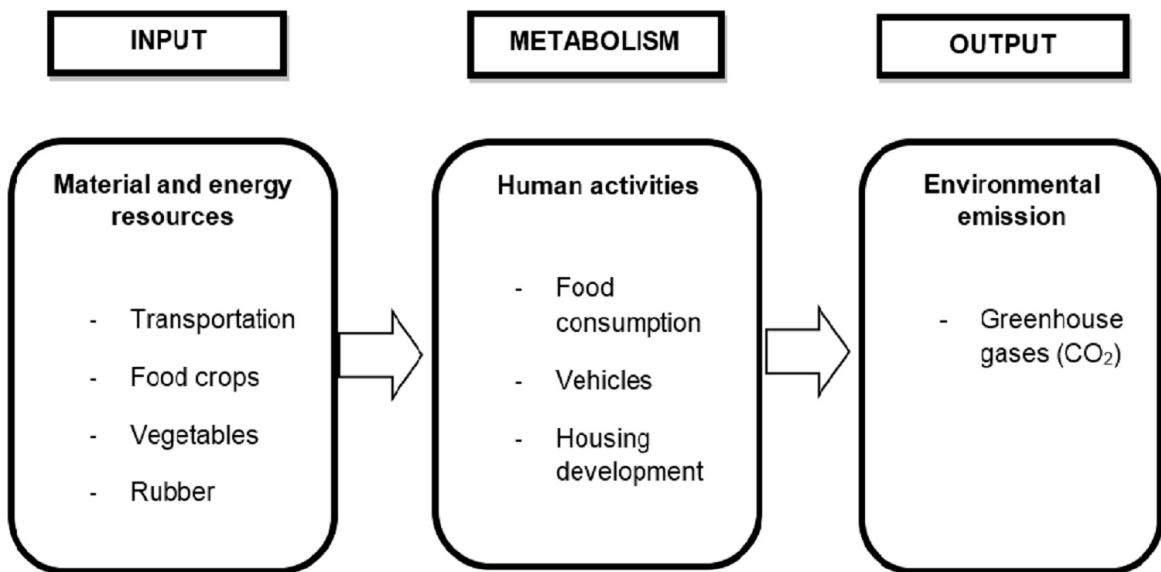

Figure 1- Conceptual Framework of Input-Output Analysis (IOA)

accounted systematically as expressed in Figure 1. This environmental-economic model could assess the planning interventions on a national or a smaller urban development level based on environmental and socio-economic objectives and indicators.

The idea works on a notion that when another consumption vector smaller than the national one (y) is multiplied by the "inverse Leontief" matrix, the result will be a vector of gross output (x) needed to supply this smaller demand. Therefore, the consumption for a region or household could be determined. For new urban development assessment, model results and field measurements provided scientific and objective data whereby subjective values are also integrated through significance weighting.

METHODOLOGY

Economic Input Output Analysis can be conducted on a national, regional, city or household level. For example, a National Input Output Table for a country which normally contains monetary fluxes within the economic sectors is obtained from the regulatory body or statistical provider of the country. Then, the most significant step is to generate an inverse Leontief matrix by using I-O equation as following:

$$X - AX = Y \qquad (1)$$
$$(I - A)X = Y \qquad (2)$$
$$X = (I - A)^{-1} Y \qquad (3)$$

With

X = column vector of industrial gross output

Y = column vector of final demand

A = matrix of coefficients that indicate the amount of one economic sector product needed to produce one unit of another economic sector product.

I = Identity matrix (matrix with "1" in the diagonal, "0" in all other fields)

$$(I-A)^{-1} = \text{"Leontief Inverse (Matrix)"}$$

The total final of each economic sector is divided by the country's total population as to determine the average individual consumption. The "inverse Leontief" matrix is multiplied by the final consumption vector (Y) to obtain the gross output (X). Greenhouse gases emission for each economic sector is obtained from the national department of environment or a regulatory body that is responsible for the reporting of the national greenhouse gases. Finally, the intensity of each considered economic sector is calculated by dividing the greenhouse gases emission with the calculated gross output. Re-grouping of several economic activities as an economic sector may be considered necessary as this modification is to optimise the economic data to available greenhouse gases inventory.

The final result of an economic input output analysis is an intensity factor in the form of carbon dioxide (CO_2) equivalent/currency. The idea is to express the impact of each different greenhouse gases in terms of the amount of carbon dioxide. With this intensity factor, environmental impacts from different regions or cities can be compared and ranked accordingly. Generally, higher environmental performance would result in lower carbon dioxide intensity. A concerted effort in establishing this EIO database for Southern Europe has been initiated by the EcoTech Sudoe group. Similar studies using the same approach have been conducted and improved for three different cities; Aveiro in Portugal, Marseilles in France and Barcelona in Spain (Mat et. al. 2012, Shafie et al, 2013, Dias 2014). The same approach is also being currently undertaken in a developing country; Malaysia via this research networking.

ANALYSIS AND INTERPRETATION

Economic input output analysis takes into account the monetary fluxes it generates in the total national economy and the average environmental impact of each economic sector in carbon dioxide (CO_2) emissions per currency i.e Euros, Ringgit Malaysia etc. Comprehensiveness of economic input output data collection and the extensiveness of the economic data are the basis of the difference a national and a smaller region. Some economic input output data come along with export and import data where certain consideration shall be made to which value to be used. Simplified economic view and value added services comprising conversion and ordinary used matrices are also among other economic data that can be of use.

For instance, for in the city of Barcelona case study, economic input output analysis was conducted to evaluate the environmental impact in the term of the Global Warming Potential (GWP) and indirectly it was very practical to determine the control measures when the potential contribution of environmental impacts were determined (Shafie et al., 2013). Therefore, current policies and undertaking of a city performing with lower emission can be adapted into future city planning.

Global Warming Potentials (GWPs) are relative measure of the amount heat of a greenhouse gas traps in the air. It relates the effect of outflows of a gas to that of outflow of a comparable mass of carbon dioxide. It is characterized as the total of radioactive forcing – both immediate and circuitous impacts incorporated over a time from the discharge of a unit mass of gas in respect to some reference gas (UNEP, 1996). Carbon dioxide (CO_2) was chosen by the IPCC as this reference gas and its GWP is situated equivalent. There are

three key factors that determine the GWP value of a GHG which are:

1. The gases absorption of infrared radiation,
2. Where along the electromagnetic spectrum (i.e., wavelengths) the gas absorbs radiation
3. The atmospheric lifetime of the gas

Since the GWP of a greenhouse gas depends straightforwardly on its infrared range, the consumption of infrared spectroscopy to study the gasses is midway essential in the exertion to comprehend the effect of human activities on worldwide environmental change. Some GWP values may also account for indirect as well as direct effects. Some GWP qualities might additionally represent circuitous and immediate impacts. Circuitous radioactive compelling happens when chemical changes including the first gas create a gas (es) that is/are greenhouse gas, or when a gas impacts other radioactively critical methods, for example, the environmental lifetimes of different gasses.

Under the Ecotech Sudoe group projects, three contemporary cities in Europe namely Aveiro in Portugal, Marseilles in France and Barcelona in Spain has taken on this GWP output approach. The total emission for the city of Aveiro, Marseilles and Barcelona is 13.74, 25.8 and 24.4 kg CO2eq./cap/day respectively. Objective value of the environmental indicator allows extensive comparison with other cities and methodology.

A more extensive methodology has been developed from the basic economic input output analysis is the Economic Input-Output Life Cycle Assessment (EIO-LCA) method. The advancement has been taken up by the Green Design Institute of Carnegie Mellon University to guide on the relative impacts of different types of products, materials, services, or industries with respect to resource use and emissions throughout the supply chain. It estimates the required materials and energy resources and the environmental impact generated throughout the human activities in the economy and its consequences towards the environment (Finnveden et. al., 2009).

APPLICATION TO LOCAL AUTHORITY

The national or regional economic input output outcome may further be used to determine even smaller local area by the using a downscaling method. Firstly, a weightage or a factor needs to be assigned to each local authority under consideration. For example, a downscaling approach used for local authorities in the Klang Valley in Malaysia managed to rank the local councils in comparison with the national indicator. The first method is by using the assessment tax as a factor to determine the greenhouse gases emission in four local authorities namely Shah Alam City Council, Klang Municipal Council, Kajang Municipal Council and Putrajaya Corporation. The assessment tax indicates property assessment gathered by the neighbourhood powers for the procurement of the administrations to the occupants. It is also a part of income or input for the local authority when they provide the services to the public. The services include maintenance of infrastructures such as waste collection, drainage, roads, lighting and others. Besides that, the rate of the taxes imposed to the public are different from one local government to another. Thus, taxes can determine approximately the total expenses or income for the local authority.

Another method is to assign the respective factor to the local authority according to their annual budget. Each local authority receives their budget on two main sections; management budget and development budget allocated yearly by the state government. Management budget is mainly the amount of money for the council to provide services to public such as logistic supply and city maintenance while development budget is for more permanent infrastructure such as setting up a bus interchange station. This monetary value can also be used to determine the factor to each of the local authority. These two considerations have ranked the local councils with their factors from the highest to the lowest starting with Shah Alam City Council (3.4), Klang Municipal Council (2.8), Kajang Municipal Council (1.6) and Putrajaya Corporation (0.4).

Finally, the total of GHG emission in those local authorities were measured by multiplying the factors that have been assigned with total greenhouse gases emission by the national average economic sectors in Malaysia. The cities in the Klang Valley are in the most developed region of Malaysia compared to other cities in other states in Malaysia. Putrajaya on the other hand is the new and still expanding federal government administrative area. Therefore, the greenhouse gases in the cities except Putrajaya are expected to be higher than the national average.

CONCLUSION

Upon the application of this environmental-economic impact assessment in several cities, the output of the analysis is able to deliver an objective environmental indicators which essentially allows comparison with other cities to be made. Uniform and consistent reporting of economic input-output table and greenhouse gases for a country or a smaller region are vital to this analysis. The basic understanding in the impact assessment is the more detailed and explanatory the economic sectors are, the more precise the determination of the highest source of greenhouse gases become. Acknowledging the most substantial economic sector results in a more concise plan of action in the city environmental management.

ACKNOWLEDGEMENT

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