# Material Flow Analysis: Malaysia

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**Abstract:** Malaysia has transitioned from being a mining and agriculture economy to a manufacturing economy in the 1970s. This has accelerated the pace of industrialization in the country. It is relevant, however, to determine the interaction of these developments with the natural environment and the rest of the world. Current literature have only identified the relationship of this within certain urban cities. This study aims to fill the gap by performing an economy-wide material flow analysis (EW MFA). By analyzing the use of resources, environmental policies and initiatives may be developed. Data was gathered from various country reports and global organizations. Results show that Malaysia is efficient in its resource use. The country has also exhibited decoupling behavior in terms of the environmental pressures and domestic consumption.

**Key Words:** economy-wide; material flow accounting; domestic material consumption; decoupling

## 1. INTRODUCTION

Malaysia is considered as an upper middle-income country with a national income per capita close to $11,000. Less than 1% of households are living below the poverty line (ADB, 2021). It has transitioned from being a mining and agriculture economy to one that gives more focus on manufacturing in the 1970s. The Industrial Coordination Act of 1975 was developed to accelerate the pace of industrialization and achieve the objectives set by the New Economic Policy (Lim, 1987). From a 13.9% share of the GDP in 1970, the manufacturing sector grew to 30% in 1999. This replaced the agricultural and mining sector, which accounted for 42.7% of the GDP in 1970 to merely 9.3% and 7.3%, respectively in 1999. Because of this, the country has met the criteria for a Newly-Industrialized Country (NIC) status where 30% of exports should consist of manufactured goods (Tan, 1993). Major products of the country include electronic components, semiconductor devices, and appliances. Although the Asian Economic Crisis between 1997-1998 slowed down the growth of the country temporarily, the nine strategies presented in the Vision 2020 pushed the country forward as it aims to achieve a fully developed industrialized economy by the year 2020 (PMO Malaysia, n.d.)

To describe the interaction of the domestic economy with the natural environment and the rest of the world in relation to the flow of materials, an economy-wide material flow account (EW-MFA) is developed (Eurostat, 2013 ). The knowledge of these material flows would aid in the development of environmental policies such as decoupling policies and circular economy initiatives (Schenau, 2018).

The study of Shafie et al., (2016) used MFA with the aim of assessing the urban metabolism of three cities in Malaysia namely, Kuala Lumpur, Ampang Jaya and Selayang. Their results provided information on urban management in a city level that may be used to assist in decision making for future development and to provide informed assessment on

environmental performance of an urban area. Similarly, another article by similar authors expanded their study to the cities of Kajang, Sepang, and Putrajaya of Greater Kuala Lumpur, Malaysia, where it showed that even with the lowest population, Putrajaya consumers the highest amount of water (Shafie et al., 2018). Another study conducted by Shah et al., (2018) aimed to analyze the level of awareness among the public and retailers on MFA as well as their views on current e-waste management practices. Results showed that there is lacking awareness on MFA and environmental campaigns should be done to increase the general public's knowledge on the matter.

From the literature above, it can be identified that no study has been done on the material flow analysis for the whole of Malaysia. In fact, there needs to be more awareness on the said topic. This study aims to fill this gap by performing a thorough analysis of the material flows and its relationship with economic development and current policies.

## 2. METHODOLOGY

The use of materials have been increasing globally due to industrialization. While these materials are used for the benefit of the economy, they are often disposed of improperly. It is necessary, therefore, to understand the relationship of material use and extraction with its disposal. Materials flow analysis (MFA) is a method developed to describe the interaction of the economy with the environment and the world relative to the flow of materials (Eurostat, 2013).

To develop the material flow account of Malaysia and to calculate its indicators, the manual from United Nations Environment Programme (UNEP) was utilized as a basis. This document covers the current procedures of collecting material flow accounts based on Statistical Office of the European Union (EUROSTAT) and Organization for Economic Co-operation and Development (OECD) requirements.

The MFA indicators used in this study are shown in Figure 1 which gives a gives a general overview of the physical and socio-economic systems of the country. The solid area depicts the domestic border of the country under study.

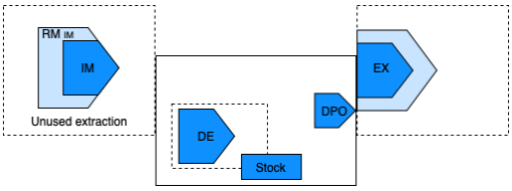


Fig. 1. Overview of Material Flow Analysis in the socio-economic system (UNEP 2021)

Domestic material consumption (DMC) accounts for the total quantity of inputs (domestic material input or DMI) less the materials for exports. The inputs include imports and domestic extraction (DE) which are the materials taken from the local environment for the utilization of the socio-economic system. Besides exports, another output of the economy are the domestic processed output (DPO) which are the by-products generated during manufacturing, consumption, and disposal of materials. These indicators are summarized in Table 1. The disruption to the natural environment that may happen due to the extraction and conversion process of materials makes DE and DMC the proxy for local environment pressures (Martinico-Perez, 2016).

Table 1. Computations for material flow indicators

| Indicator | Calculation |
|---|---|
| DE | Biomass + Non-Metallic Minerals + Metal Ores + Fossil Fuels |
| DMI | DE + Imports |
| DMC | DMI – Exports |
| DPO | Emission to air + Emission to water + Discharge to soil + Dissipative use of products |

Data on the country's import, export, domestic extraction (DE), domestic material consumption (DMC), and material footprint (MF) were gathered from the database provided by the Commonwealth Scientific and Industrial Research Organization (CSIRO), which includes information for 150 countries dating back from 1970 to 2017 which are measured in tonnes per year. For the material output, which include emissions to air and water, discharge to soil, and dissipative use of products, data was collected from various sources. For emissions to air, the study made use of emissions of carbon dioxide (CO2), methane (CH4), and Nitrous Oxides (NOx) in the country where the data was obtained from the World Bank from the year 1970 to 2018. The dissipative use of products covers fertilizers and pesticides which was gathered from the database of the World Bank and Food and Agriculture

Organization of the United Nations (FAO) respectively. Data for the waste disposal from 2001 to 2018 was obtained from the Department of Statistics Malaysia (2013;2015; 2017; 2018; 2020) and Environment Quality Report (2006; 2009). Meanwhile, the emissions to water pertains to the biological oxygen demand (BOD) only due to limitations of available data. The data for 1978 to 1982, 2000 to 2006, 2009, and 2016 to 2018 were obtained from the Environment Quality Report (1980; 1998, 2004; 2006; 2009; 2016 ; 2017; 2018), data for 2011 and 2012 were from the technical paper of Huang et al. (2015), data for 2008 was from the technical paper of Afroz et al. (2014), and the data for 1986 to 1989 is from the study of Chua and Garces (1992). Socio-economic data such as population, gross domestic product, and total land area was derived from the data of the World Bank. Straight-line method using the year's population as explanatory variable was used to fill in the gaps of the other years between 1970-2017.

# 3. RESULTS AND DISCUSSION

## *3.1 Resource Efficiency*

The DMC of Malaysia steadily increased over the years mainly due to the Nation Development Policy. The aim of this plan is to sustain the growth momentum and to manage it successfully (International Monetary Fund, 1998).

The DMC of a country is obtained by subtracting the exports to the domestic extraction and imports. The largest contributor to domestic extraction of Malaysia is biomass, which includes timber, oil palm waste, coconut trunk fibers, and rice husks (Ozturk, 2017). In 2012, Malaysia was considered the world's largest exporter of palm oil and its second largest producer (May , 2012). This creates large quantities of biomass from the extraction of palm oil from palm fruits. Malaysia is also one of the leading producers of natural rubber along with Thailand (Kawano , 2018). The industrialization and urbanization of Southeast Asia in the 1990s expanded the demand for rubber for tire manufacturing and other industrial goods.

Moreover, a steady growth in the construction sector contributes to the increased production of non-metallic minerals. This sector increased from 7.79% in 1970, to 33.03% in 2017. These include the increased construction of road, rail, port, and airport projects from the expansion programs from the National Development Policy.

Similarly, the import of materials in Malaysia have seen a growth of 833% from 1970 to 2017. Import of fossil fuels takes up the largest share at 52.32% because of the country's dependence on fossil fuels such as coal and oil as energy sources, which they mainly import from Indonesia and Australia (Oh et al., 2010).

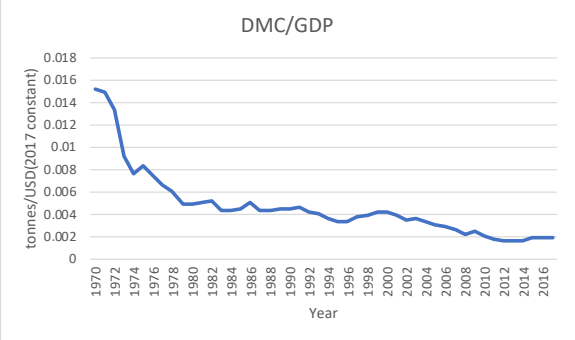


Fig. 2. Resource efficiency (DMC/GDP) of Malaysia

Even with the increase in DMC, there is an evident decline in material intensity (DMC/GDP) from 1970 to 2017 as seen in Figure 2. This shows that over time, the increase of GDP is greater than the DMC, meaning that there is lesser demand for materials to achieve the same GDP.

In other words, the resource efficiency of Malaysia has improved over the years due to several factors such as development of technology and less material intensive industries. Malaysia also set the Third National Agricultural Policy (NAP3) (1998-2010) which includes increasing productivity by using fully mechanized and automated product system and processes.

## *3.2 Per-Capita Metabolic Rates*

From the definition of the United Nations, material footprint pertains to the total amount of raw materials used to cater to the final consumption demands. It is the sum of the material footprint of biomass, fossil fuels, metal ores, and non-metallic minerals, which serve as an indicator for the

pressures on the environment in order to support economic development (UN, n.d.).

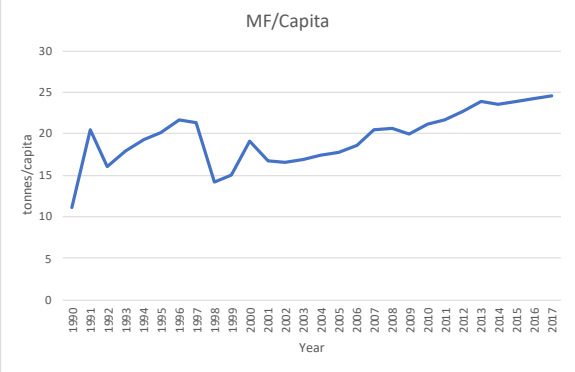


Fig. 3. Material Footprint per Capita of Malaysia

Figure 3 shows the increasing trend on the material footprint per capita of Malaysia from 1990 to 2017. The Sixth Malaysia Plan, which is the first phase of the implementation of the Second Outline Perspective Plan (OPP2) that embodies the Nation Development Policy, began in 1991. This explains why there is a spike of material footprint in the figure. It then showed a dip during the 1998 Asian Financial Crisis where there was a drop in domestic demand and investment that led to lower consumption. To counter this, the government promoted liberal trade and investment regime that led to an increase the following years.

### *3.3. Decoupling and Economic Growth*

To give a broader view of Malaysia's economy, the figures below show the trend of DMI, DPO, CO2, and GDP with a base year for indexing on 1970.

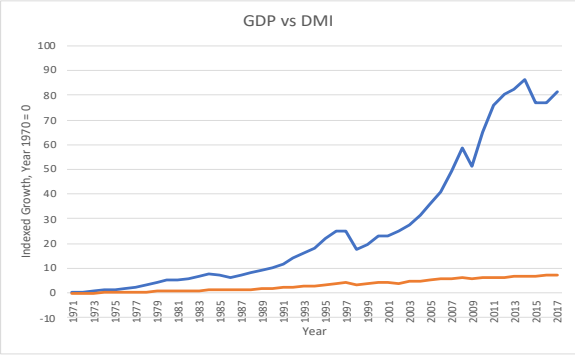


Fig. 4. GDP vs. DMI

DMI pertains to the materials that have economic value and are directly used in production and consumption of the country. This adds the domestic extraction and the imports. It can be observed from Figure 4 that GDP has surpassed DMI which means that it has increased economic gain while minimizing the use of materials. This suggests decoupling. This finding can also be related to the discussion of resource efficiency above wherein the domestic material consumption is being utilized efficiently.

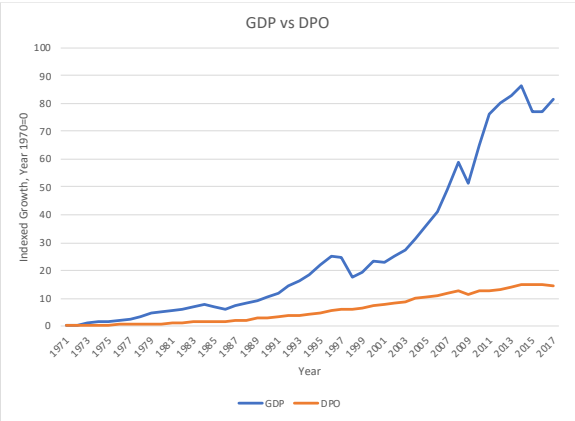


Fig. 5. GDP vs DPO

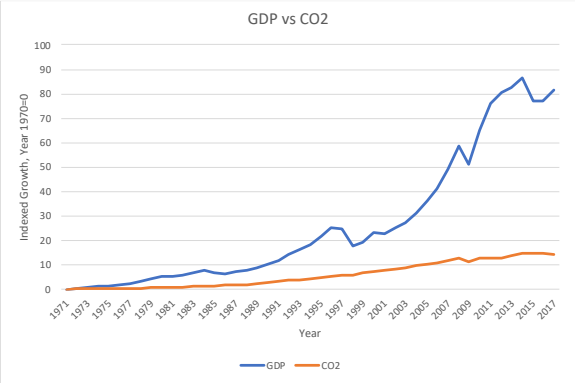


Fig. 6. GDP vs Carbon Emission

In terms of the environmental pressures of economic development, it can be observed from Figure 5 and Figure 6 that Malaysia is able to attain development without creating as much damage to the environment. The two figures are similar since emissions to air has the largest contribution to the DPO. This is attributed to the country's large

consumption of fossil fuels, large number of piggeries, and palm oil factories.

Policies such as the National Policy on Climate Change was implemented, which aims to mainstream climate change by managing resources wisely and to strengthen institutional and implementation capacity (Yahaya et al., 2015). Specifically, they have a national green technology policy that ensures sustainable real gross domestic product and increase energy consumption while reducing carbon dioxide emissions in the atmosphere. Furthermore, they implemented the Low Carbon Mobility Blueprint and Action Plan (LCMB) which would encourage the people to use public transport due to clean energy vehicles and improvement of vehicle technologies.

Malaysia has also set the Third National Agricultural Policy (NAP3) (1998-2010) which provided new approaches and policies that would enhance food security and increase productivity. Some of these approaches include less labor input by using fully mechanized and automated produced system and processes. This allows an increase in productivity while reducing the cost of production. With the use of machinery and equipment, processes are optimized which leads to a low contribution of dissipative use of products to the DPO.

To address the emissions to water which is part of the DPO of a country, the Environment Quality Act of 1974 was created, which sets a standard of effluent discharge to be followed by various sectors. According to the Veterinary Services Department of Malaysia, there are approximately 717 standing pig population per farm, which generates large of waste. Some farms discharge their effluents directly into estuaries without any pretreatment (Lim, 1992). Besides livestock, mills operation for palm oil production also impacts the amount of BOD generated in Malaysia. The extremely dense population in urban centers also contribute to the pollution of rivers, basically converting them to open servers (Borhan & Ahmed, 2010). The Environment Quality Act of 1974 is the primary legislative instrument that governs the improvement and maintenance of water quality in Malaysia. These regulations include the Environmental Quality (Sewage) Regulations 2009 and Environmental Quality (Industrial Effluent) Regulations 2009.

## 4. CONCLUSIONS

Malaysia has shifted its economy from agricultural and mining, to a manufacturing economy in the 1970s. This was done to accelerate the pace of industrialization and to achieve the goal of eliminating poverty as stipulated in the New Economic Policy. With this vision, Malaysia was able to attain rapid economic growth, with the manufacturing sector taking up 30% of the GDP in 1999. This changes the status of the country to a Newly-Industrialized Country (NIC). In terms of direct materials productivity, it was identified that Malaysia is more efficient in its resource use where materials are maximized for economic gain. An increase in domestic resources used for consumption is also evident. Although the country is more efficient in its resources, the amount of waste it releases to the environment is also continuously increasing. Better policies should be implemented for greener consumption of resources and production of goods. In terms of DPO, focus should be given to the emissions on air as current efforts have not seen a decrease in these outputs.

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