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Investigating the Decoupling Progress and Drivers of Resource Consumption in Cambodia, Laos, and Myanmar

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Abstract: This study examines the trends of material flow of three ASEAN countries in the same cluster (Cambodia, Laos, and Myanmar) by adopting the tool economy-wide material flow analysis. Using the data from global organizations, journal articles, and policy reports, this study organizes, calculates, and presents the significant material flow indicators. The results illustrate that all three countries have gradually shown improvement in terms of resource efficiency and have achieved relative decoupling. Further, IPAT analysis shows that there is a shift of consumption behavior for both Cambodia and Laos. The results of this study is intended to present an analysis of the current material flow trends of the countries to assist in policy formulations and sustainable resource management.

Key Words: material flow accounting; domestic material consumption; material footprint; decoupling; IPAT

1. INTRODUCTION

The increased global material extraction brought a multitude of environmental problems (Aoki-Suzuki et. al., 2012; Milner-Gulland, 2011). The market-oriented production of multiple economies also attempts to increase with the growth of population and improvement of economic conditions (Huong & Shah, 2021). Learning the uneven distribution and scarce resources of the environment, the overexploitation of several economies has been determined as a preeminent global issue. Although there are several drivers that influence the consumption of natural resources, the impact of economic development all things considered becomes more significant. Sustainable consumption and production entails the need for efficient resource utilization and waste management (UNEP, 2015). A method to formulate and control policies with regard to sustainable resource utilization is to understand the socio-economic metabolism of a country (Bringezu et. al., 2016). Among the methods to examine resource consumption, economic-wide material flow accounting (EW-MFA) has become a significant tool as it investigates the biophysical basis of an economy, allowing policy makers to examine significant indicators with economical and environmental interactions (Wiedenhofer et. al., 2019; Fischer-Kowalski et. al., 2011).

Currently, the East Asia-Pacific region experiences the most growth in material use. However, most attention of academia has been focused on the "Growing Giants" with only minor considerations on other developing countries. Recognizing that the other developing economies may also hold considerable impact on global environmental emissions, it is worthwhile to investigate the general material consumption pattern of these economies to augment economic development. This study aims to fill the gap by examining the decoupling progress and drivers of resource consumption of the emerging economies, particularly Cambodia, Laos, and Myanmar. While there exist studies examining the environmental Kuznets curve (EKC) hypothesis and urban footprint of Cambodia (Ozturk & Al-Mulali, 2015; Mialhe et. al., 2019), there has yet to be a study that investigates the material flow of Cambodia. Additionally, the existing studies in relation to material flow investigation of Laos and Myanmar are only constrained with the domestic and trade (Vilaysouk et. al., 2017; Maung et. al., 2013; Wutyi, 2019). This study further analyzes the EW-MFA

indicators with socio-economic drivers while performing comparisons of three ASEAN countries.

2. METHODOLOGY

EW-MFA is an analytical tool that enables policy makers to investigate the resource use trends and efficiency of a country at a macro level, utilizing the available data on consumption, production, trade, and environmental statistics. This study utilizes the methodological guide of UNEP (2021) in compilation of the data for material flow accounts. The materials taken into account are all in terms of mass flow in tonnes per year. The following MFA indicators are calculated in the study: domestic material consumption (DMC) and gross domestic product (GDP) ratio, material footprint (MF) per capita, domestic material input (DMI), and impact, population, affluence, and technology (IPAT) identity.

The data for the compilation of resource flows was taken from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) database. Only the four main material categories are considered in this study: biomass, fossil fuels, metal ores, and non-metallic minerals. The resource flows were primarily domestic extraction (DE), imports, exports, raw material equivalents (RME) of imports, and RME of exports. DMI is the sum of DE and imports. DMC is the difference between DMI and exports while MF is the difference between RME of imports and exports added to DE. On the other hand, the data for domestic processed outputs (DPO) was taken from various sources as there has yet to be a study that compiles the resource output data of various countries. The four primary DPOs are emission to air, dissipative use of products, waste disposal, and emission to water.

In this study, the emission to air includes carbon dioxide (CO_2), methane (CH_4), and nitrous oxides (NO_x). The data of these were organized from the database of the World Bank. The dissipative use of products consists of fertilizer and pesticides. The data of fertilizer was obtained from the World Bank while the data of pesticides was collected from the Food and Agriculture Organization (FAO). The data of waste disposal and emission to water was collected and organized from various sources (e.g. action plans, journal articles, regional reports, etc.) as not all the government offices of the countries have systematic databases. The waste disposal data of Cambodia was obtained from Phnom Penh Capital Administration et. al. (2018) and Seng et. al. (2010). Meanwhile, the waste disposal data of Laos and Myanmar was obtained from UNEP (2017) and UNEP Climate and Clean Air Coalition (2015) respectively. The emission to water data of Cambodia was obtained from the Water and Sanitation Program (2012), Hutton et. al. (2017), and the Mekong River Commission (2017). As there lacks efficient and accurate wastewater monitoring studies for Laos, the emission to water indicator of Cambodia was used instead. Specifically, the data of Cambodia was converted into emission to water per capita and multiplied by the population of Laos. Finally, the emission to water data of Myanmar was obtained from Yangon City Development Committee et. al. (2019). As data gaps are present and inevitable, statistical straight-line was used to fill-in the gaps using population as explanatory variable.

3. RESULTS AND DISCUSSION

3.1 Material Intensity

The DMC/GDP ratio illustrates the intensity of material use. This ratio signals the efficiency of a country in utilizing its resources to increase each unit of value. Higher ratio implies inefficient use of resources as it requires more resources for every unit of GDP. Figure 1 shows the trend of material intensity for every unit of value of the three countries from 1970 to 2017.

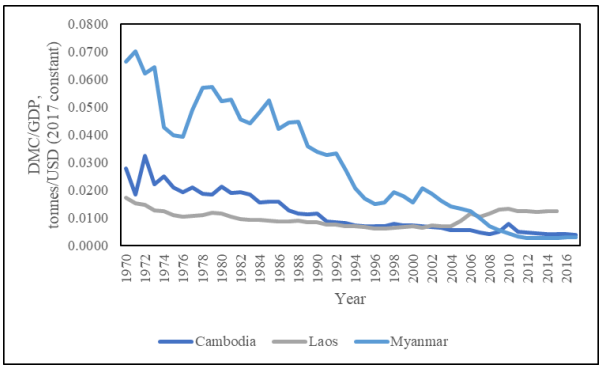

Fig. 1. DMC/GDP trend of three countries from 1970 to 2017.

It is evident that the material intensity of both Cambodia and Myanmar has reduced over the past decades. The DMC/GDP ratio of Cambodia has reduced from 0.0278 in 1970 to 0.0038 in 2017, while the ratio of Myanmar has reduced from 0.0665 in 1970 to 0.0031 in 2017. These can be attributed to the increase of attention on infrastructure development. With the piling backlogs and increasing demand for the infrastructure development (roads, bridges, dams, etc.) both countries have imported a considerable amount of non-metallic minerals. The improvement of infrastructure paved the way for increase in efficiency for production activities. In addition, there is a shift in agricultural production

methods of Cambodia as it adopted more recent and efficient agricultural machinery. Contrary to the evident downward trend of Cambodia and Myanmar, Laos exhibited an increase of material intensity in the latter years of the study period. Originally, Laos exhibited a decrease of material intensity from 0.0173 in 1970 to 0.0061 in 1997. The material use efficiency was lost due to economic reforms, increased production for exports, and technological developments, resulting in an increase of material intensity. Nonetheless, Laos, with its multiple efforts for development, has graduated from being the least developed country. Comparing the three countries, it is apparent that Myanmar has exhibited the most significant improvement in resource use efficiency.

3.2 Per-Capita Metabolic Rates

Another indicator for MFA analysis is the MF, which provides supplementary information on the usage of resources while including the raw material trade balance (RTB). RTB is essentially the difference between RME of imports and exports which incorporate the resource demand of the country in analysis. Figure 2 shows the trend of MF per capita of the three countries from 1970 to 2017. It can be observed that both Cambodia and Laos exhibited an increase of MF per capita over the period. This may initially seem to contradict the result of previous discussion on material intensity. The DMC/GDP ratio expresses the material used for production, meanwhile, the MF/capita indicates the materials used for satisfying the demand of the economy (Martinico-Perez et. al., 2018). Hence, both indicators actually express two different but close subjects.

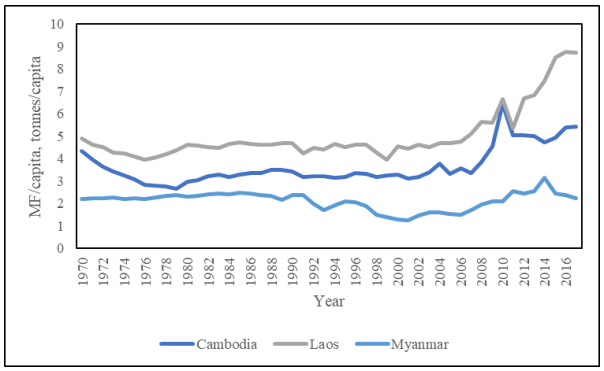

Fig. 2. MF/capita trend of three countries from 1970 to 2017

From 4.3326 in 1970, the MF per capita of Cambodia decreased to 2.6500 in 1979 and gradually increased to 5.4191 in 2017. Likewise, Laos experienced a downward trend of MF per capita in the early years. From 1970 to 1976, its MF per capita decreased from 4.8834 to 3.9605. The MF per capita then increased to 8.7219 in 2017. Meanwhile, the material usage of Myanmar to satisfy its demands per capita seems to merely fluctuate around 2.1045. From 2.1956 in 1970, it moderately increased to 2.397 in 2017. Comparing the trends of the three countries, it is evident that Laos is the least efficient among all. This analysis further adds insights to the previous findings as it appears Myanmar was able to sustain its material footprint while increasing its economic value. This essentially shows that Myanmar has been performing well and improving over the decades.

3.3 Decoupling and Economic Growth

To further learn the performance of the countries under environmental pressures, decoupling charts were constructed. Fundamentally, decoupling is the reduction of resource use while generating economic growth. Therefore, decoupling charts show the trends of economic value and environmental pressures which allows comprehension of the performance of a country.

Figure 3 shows the decoupling charts of the three countries. Figure 3a demonstrates the economic and environmental trend of Cambodia. It can be observed that there are less material inputs needed to generate higher economic growth for Cambodia as its DMI is much lower than its GDP. To be precise, its GDP in 2017 has reached 22.1772 billion USD while its DMI was at 85.9659 million tonnes. This indicates that Cambodia has significantly developed its resource utilization efficiency over the decades. In 2017, the DPO of Cambodia totalled 19.2631 million tonnes, showing that Cambodia has achieved relative decoupling as its GDP has far surpassed its environmental emissions. Figure 3b shows the decoupling trend of Laos. It can be observed that Laos is also gradually improving its efficiency in terms of material use as its GDP reached 6.6240 billion USD in 2017 with 98.8235 million tonnes of DMI. Like Cambodia, Laos also achieved relative decoupling as its DPO came to 41.9521 million tonnes which is lower than its GDP. However, its relative decoupling is only limited to resource decoupling as its CO_2 emission far exceeds the GDP as seen in Figure 3b. This means that Laos still has yet to achieve impact decoupling in terms of CO_2 emission. Figure 3c illustrates the decoupling chart of Myanmar. It is evident from this figure that Myanmar is performing efficiently as well. Its GDP in 2017 has reached 61.4494 billion USD with 332.2720 million tonnes of material inputs. Like other two countries, Myanmar has achieved relative

decoupling as its DPO in 2017 yielded 120.1057 million tonnes. Although there is a significant gap between economic value and environmental pressures, more improvements can still be made to improve the management of wastes for all three countries. As a matter of fact, despite having policies regarding air emission, solid waste, and wastewater management, all three countries still illustrate rather high levels of DPO.

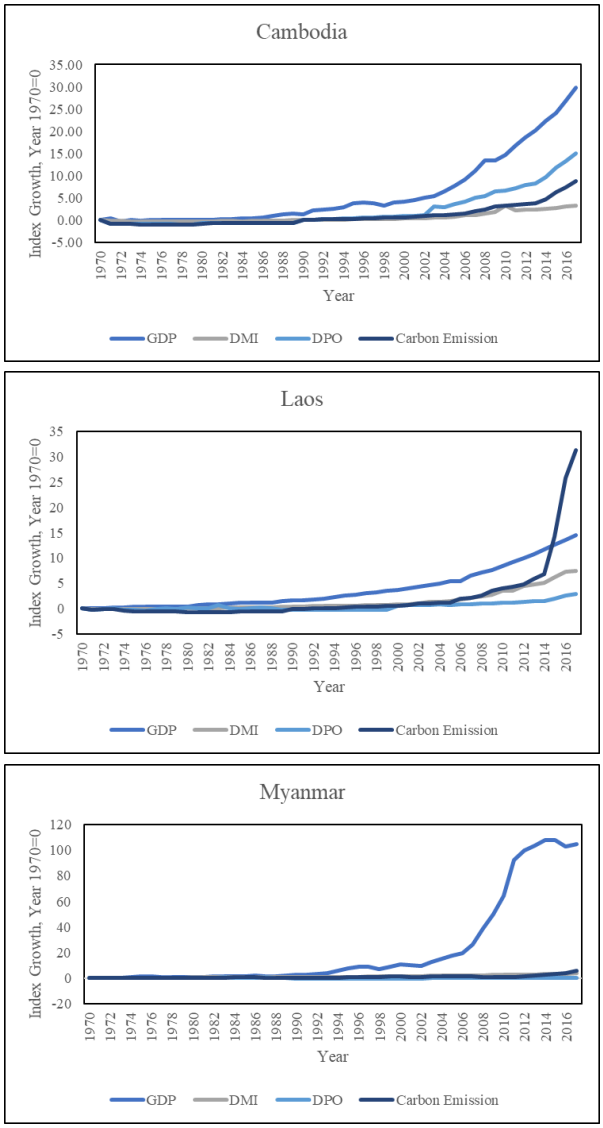

Fig. 3. Decoupling chart from 1970 to 2017 of (a) Cambodia (b) Laos (c) Myanmar

Further investigation shows that the emission to air contributes the highest proportion to the DPO of all countries. CO_2 emission was recorded as the highest emission for Cambodia, whereas CH_4 and NO_x emissions contributed more in Laos and Myanmar. The high emissions of CH_4 and NO_x of Laos can be attributed to the increased mining and garment production activities of the country as these induced considerable economic growth. Although CO_2 emission is much less than CH_4 and NO_x emissions, proper monitoring and management should still be placed as it exhibited a considerable growth from 2015 onwards. Meanwhile, the high emissions of CH_4 and NO_x of Myanmar can be attributed to its considerable activities in the agricultural sector as it occupies 68.0755% of the DMC. From this, Laos can adopt more efficient machinery for less emission and implement stricter emission monitoring. On the other hand, Myanmar can adopt the method of Cambodia wherein they shifted from the reliance on fertilizers and pesticides to agricultural machinery, significantly reducing the dissipative use of products and respective air emissions.

3.4 Drivers of Material Consumption

For analyzing the drivers of material consumption, the IPAT identity from Martinico-Perez et. al. (2016) was adopted. Impact (i) was formulated as DMC, affluence as GDP/capita, and technology as DMC/GDP. Figure 4 shows the percent changes of each factor formulating the IPAT identity of three countries. Among the three countries, only Myanmar exhibited a positive change in domestic consumption for the first time period with the affluence as the significant factor influencing the consumption. Meanwhile, both Cambodia and Laos exhibited a negative change in domestic consumption with technology as the main driver of change. For the succeeding time periods, the domestic consumption of all countries increased. Based on Figure 4, it can be deduced that there is a significant shift of consumption behavior of the population as affluence became the most influential factor for the domestic consumption of all countries. Indeed, there is a considerable change in the economy and development plans for the three countries. For instance, the economic reforms of both Cambodia and Laos which shifted their economies towards market-oriented. Meanwhile, Myanmar engaged with other countries in economic cooperation after the stabilization of coups. Further, the sharp increase in the third time period for all countries can be attributed to the infrastructure developments. Although biomass resources still constitute a considerable proportion of extraction and consumption, all countries have invested in non-metallic minerals to support their economic development activities. Cambodia and Myanmar primarily focused on the

infrastructure backlogs and road pavements while Laos focused on their energy development to shift from fossil fuel dependence to reliance on hydropower. Although Cambodia and Laos lost their material efficiency for the third time period, the three countries still exhibited exceptional performance in enhancing their efficiency in material usage, especially in the last time period.

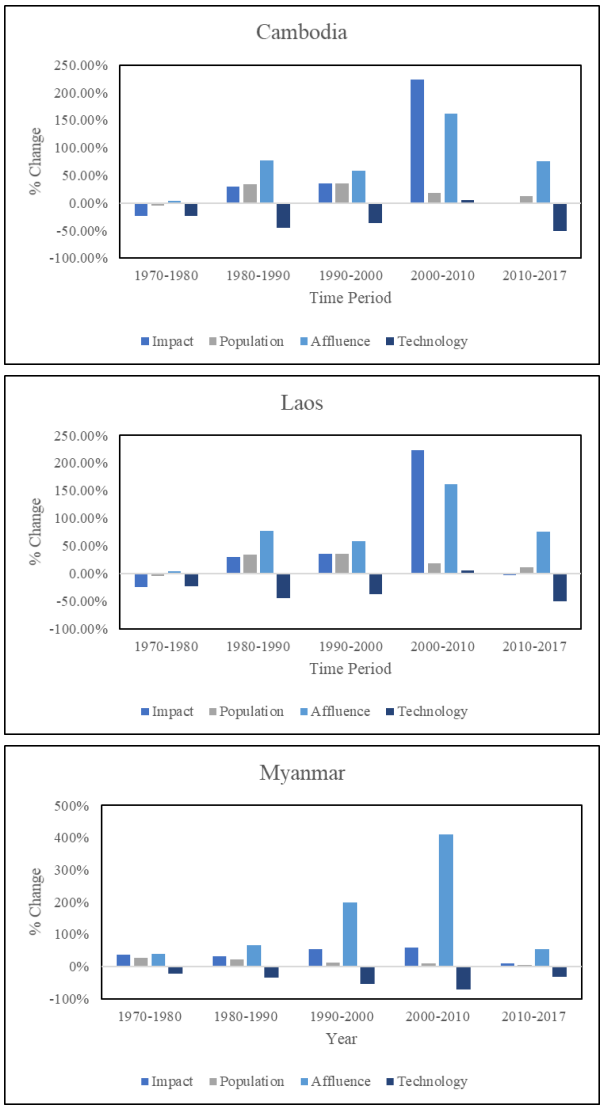

Fig. 4. IPAT from 1970 to 2017 of (a) Cambodia (b) Laos (c) Myanmar

4. CONCLUSIONS

This study employs an approach that utilizes the accounts of material flows to investigate the progress of three ASEAN countries in decoupling economic growth from the environmental pressures. This study filled the gap in the literature by providing the first material intensity analysis and domestic consumption driver analysis for the three countries in ASEAN. Hence, this study enables a more in-depth look at the trends and implications to the policies of the different countries. The results illustrate that Cambodia, Laos, and Myanmar have gradually improved their efficiency in material utilization. They have succeeded in increasing their economic value while minimizing their material consumption. However, Laos still needs to do more to deliver a declining DMC/GDP trend. As the population grows, the needs of the countries also increase which induces the increasing material footprint per year. Therefore, further studies can investigate methods to reduce the material use while satisfying the final demands of a country. The results also indicate that all three countries have achieved relative decoupling, with Myanmar performing the best and Laos performing the least among the cluster. Nonetheless, all three countries must continue to put more emphasis on the reduction of emissions. Particularly, more policies must focus on the emissions to air as it contributes greatest to the DPO. Lastly, the results indicate that there is a shift in the consumption patterns of the three countries, with technology as the most influential factor for the domestic consumption in the first time period and affluence as the main driver in latter periods. Further studies can also investigate the DMI in a bottom-up approach to further describe in detail the shifts in material consumption.

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