

Materials Flow Analysis: Vietnam and Indonesia

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Abstract: This study performs an economy-wide material flow account (EW-MFA) on two Southeast Asian countries, Vietnam and Indonesia, in order to examine the interaction of their economy with the natural environment. Currently, literature presents limited research in this area, where studies mainly focus on small sectors of the country. Performing an MFA on this cluster allows for a comparison of trends to aid in policy planning for the environment. Data on material flows were obtained from government sources, global organizations, and journal articles. Results show that both countries are improving in terms of resource efficiency over time, but the peaks and troughs vary based on the historic and economic events of the individual country. There is also an increasing trend in material consumption but further analysis shows that both countries' domestic extraction cannot sustain the demand, thus leading them to become net importers of materials. A relative decoupling in terms of environmental pressures and consumption was also observed. Through these analyses, policy implications and recommendations were provided.

Key Words: material flow analysis; resource efficiency; decoupling; material consumption; IPAT

1. INTRODUCTION

With the increasing pace of industrialization, the use of materials has increased globally. Reportedly, materials that have been used as an input for the benefit of a country's economic system are often not disposed of properly (Krausmann et. al., 2017). This causes the increasing rate of emissions and waste disposals that harm the environment. To this, there is a need to properly understand the extraction of materials and its disposal. Materials Flow Analysis (MFA) is a broad method utilized in the 1990s by Japan and Austria, eventually leading to widespread use and scientific development to provide a proper framework for its methods (Hinterberger, Giljum, & Hammer, 2003). It is a method for the analysis of the utilization of resources and their effect on a country's economy and environmental status. The utilization of MFA provides policymakers hindsights for better national planning.

In the current studies, more attention is placed on the global and growing giants. Meanwhile, other developing countries receive less consideration for such analysis. With this, there is a need for a study that sets out and understands resource utilization of developing countries. As the East Asia-Pacific region illustrates the highest growth in material use, the setting of the study will be focused in that region. Particularly, the study will take into account both Vietnam and Indonesia.

Vietnam and Indonesia are rich in minerals and metal resources as well as the agricultural aspect related to the food industry (Vuong, 2014; Stocker et al., 2020; The World Bank, 2020). Vietnam is known as one of the world's largest exporters of the commodity (Kiprop, 2018; Mah, 2021). The food processing of Vietnam also contributes to around 40% of their export. This is in contrast to Indonesia which continues to import fruits and vegetables due to the high demand of the population. They are also known around the world for their mineral and rare metals deposits. On the other

hand, Indonesia is known for its coconut and rubber production. They have also ventured into the palm oil industry which received criticism due to illegal logging of the country's rainforests. Besides this, Indonesia is known for producing its own automobiles using local components, taking up 10% of the GDP (Ariansyach, 2017).

The study of the International Institute for Sustainable Development (1999) on Vietnam focused on the trade and sustainable development of the country, where the different import and export laws are defined alongside environmental issues and laws to lessen the negative impacts of trading activities. Another study by Tran et al. (2018) focused on performing the MFA to the electronic sector of the country, where they were able to estimate the number of obsolete televisions from households in the urban areas of the country, determine the material flows in the management system, and propose and implement improvements in the management system for waste disposal for the televisions. On the other hand, there is limited MFA analysis done on Indonesia, one of which focuses on the waste management of Bank Activities in Medan, Indonesia, and not the whole country. The study, however, uses the Material Flow Analysis method in order to analyze how to mitigate their increased waste generation. Their results lead to this small commercial sector in Indonesia still following a conventional and non-sustainable practice, that can be reflected in at least some of the other business practices in the rest of the country (Khair, Siregar, Rachman, & Matsumoto, 2019).

The existence of the MFA reports performed in Vietnam presents the availability of data resources and further expansions of the research not limited to China, Japan, and South Korea. As for Indonesia, it simply focused on specific regions which would not fully reflect the entire practice of the country, and how it affects its economy and environment. With both countries having a larger portion on construction, electronics, and manufacturing sectors, it is worth investigating their trends in material resource extraction and consumption. The current MFA reports performed on both Vietnam and Indonesia present a need to extend the past research through different cluster groups for country comparisons or the constant updating of MFA over the future years to deliver real-time and updated reports for the use of the country for further development to aid in its project planning and next plans of action. In addition, the MFA reports will be able to cover the whole country in terms of performance in inputs, outputs, imports, and exports, or the resource utilization and productivity for their economic growth.

2. METHODOLOGY

Both countries are applied with MFA taken from the manual by the United Nations Environment Programme (UNEP), where the manual serves as a basis for the material flow accounts and calculations of indicators. These are based on the guidelines of the Statistical Office of the European Union (Eurostat) and the Organization for Economic Co-operation and Development (OECD). The researchers gathered data on the country's extraction, consumption, inputs, and outputs from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) database where these are compiled and formed by collaborative efforts of established organizations and universities. This study focuses on Domestic Material Consumption (DMC), Domestic Material Input (DMI), and Material Footprint (MF) as indicators of material production, consumption, and input (domestic extraction and import), respectively. On the output side of MFA, the Domestic Processed Output (DPO) was derived from the calculation country's air emission, wastewater discharge, solid wastes, and dissipative use of products. These indicators were utilized to evaluate the resource intensity and resource efficiency of Indonesia and Vietnam.

The driver of material production (DMC) across different periods was also determine using the IPAT identity using the population, affluence (GDP/capita) and technology (DMC/GDP) as factors ($I=P \times A \times T$, Commoner 1972; Erlich and Holdren 1972). The percent changes of these factors from beginning to end period was approximated by log-transformation to the equation.

3. RESULTS AND DISCUSSION

This section exhibits the comparison of MFA data for both Vietnam and Indonesia, collected and organized from various sources.

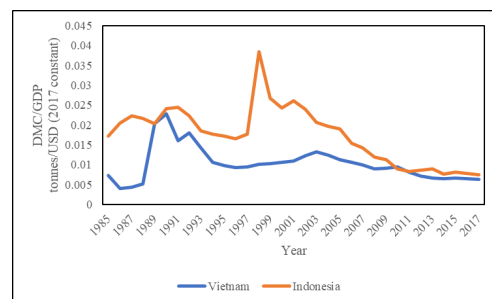


Fig. 1. Resource efficiency (DMC/GDP) of Vietnam and Indonesia

Based on Figure 1, it can be seen that both Vietnam and Indonesia exhibit a decreasing DMC/GDP ratio. This means that both countries are improving in terms of resource efficiency over time. However, it is also evident that the ascent and slump of the countries vary. This can be attributed to the impact of multiple forces. First, it is clear that there was a sudden spike in the DMC/GDP ratio of Vietnam from 1988 to 1990. This can be attributed to the several political unrests Vietnam has undergone. For instance, the battle of the Spratly Islands with the Chinese, armed conflict with Cambodians, the collapse of communist power in eastern Europe, and the dissolution of the Soviet Union, all of which directly and indirectly influenced the economic performance of Vietnam. Nevertheless, as the country experienced economic reform and a more stabilized leadership, the efficiency of material use gradually increased. While both Vietnam and Indonesia were affected by the 1997 to 1998 Asian Financial Crisis, the financial crisis impact was more visible in Indonesia. As observed, there is a sharp increase from 1997 to 1998 in the DMC/GDP ratio of Indonesia. The country was drastically hit by the said financial crisis which has led their government to ask for assistance from the International Monetary Fund (IMF). Although this approach aimed to assist their economy to get back on track, the local currency remained weak, leading to Suharto resigning from the presidency (Iriana & Sjöholm, 2002). Despite that, Indonesia continues to utilize its material consumption effectively as GDP increases gradually per material use.

Further analysis shows that both Vietnam and Indonesia exhibited the same efficiency improvement trend as both countries increased a considerable amount of infrastructure development projects. As of 2017, the material intensity (DMC/GDP) of Vietnam is 0.0012 lower than Indonesia. This signifies that Vietnam is more efficient in resource utilization than Indonesia. Nevertheless, more work should still be done to improve and maintain resource use over time.

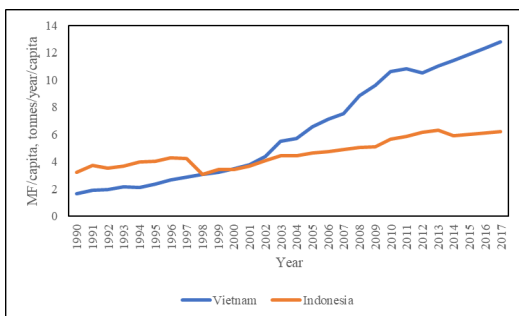
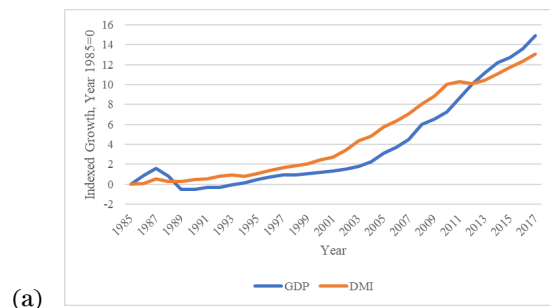


Fig. 2. MF/capita of Vietnam and Indonesia

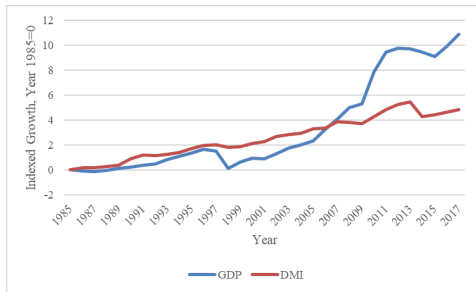
To further investigate the material flow of both countries, the material consumption for satisfying the final demands was analyzed. As shown in Figure 2, both Vietnam and Indonesia exhibited an increasing trend in MF per capita from 1990 to 2017. Comparing the GDP of both countries, the economic performance of Indonesia far exceeds that of Vietnam. However, the MF/capita of Indonesia is far lower than that of Vietnam. This indicates that Indonesia is using far fewer resources to satisfy its final material demands than Vietnam. The increasing MF/capita trend may seem to contradict the previous discussion in Figure 1. On one hand, the result on DMC in Figure 1 fundamentally shows the material used for production. On the other hand, the result on MF of Figure 2 essentially shows the material used to satisfy the needs of the country by taking into account the source of materials (domestic and import). Hence, the result is still not contradictory.

In 1990, a larger share of MF/capita in Vietnam was attributed to biomass at 59.33%, followed by non-metallic minerals at 34.86%. From 1998 onwards, however, non-metallic minerals are taking up the majority of the MF/capita, reaching 76.64% in 2016. This is mainly due to the industrialization and urbanization efforts of Vietnam, which require an increasing amount of construction materials. Likewise, biomass occupied the largest share (55.26%) of MF/capita in Indonesia in 1990. The difference between the two countries is that biomass stayed the largest category of material consumed in Indonesia throughout the study period. Nonetheless, there is a slow decline in regard to the proportion of biomass as the consumption of non-metallic minerals in Indonesia increased from 19.45% in 1990 to 26.27% in 2017.

Further analysis shows that the extraction of materials from domestic resources can no longer support the increasing population of both Vietnam and Indonesia, leading both to become net importers of materials.



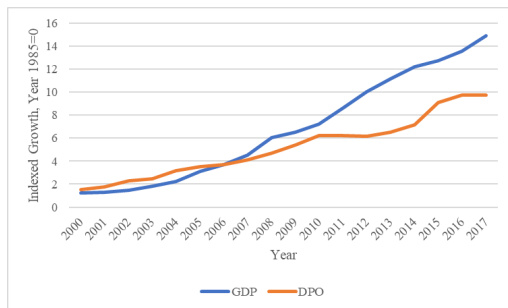
(a)



(b)

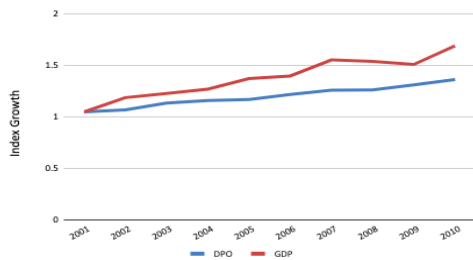
Fig. 3. GDP vs DMI Decoupling of (a) Vietnam and (b) Indonesia

Figure 3 shows decoupling rather than a ratio over time. This will relate to the index growth of both, whether to see that when GDP is higher and decoupling against DMI, indicates that materials are efficiently used. There is relative decoupling, as GDP is rapidly increasing, with DMI trailing too far behind to catch up. There are recessions, however, there were significant moments in Indonesia's history with the 1997 Asian Financial Crisis and the change of presidency in 2015 has changed policies into the easing of regulations with foreign investors to lift Indonesia's economy at that time. With its trend, however, we can see that GDP and DMI's index growth would continue to remain decoupled, despite the recent COVID-19 pandemic in 2020, with long-term planning and regarding the country's economic future.



(a)

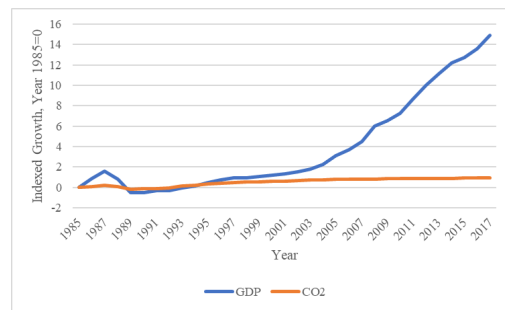
GDP vs DPO Decoupling



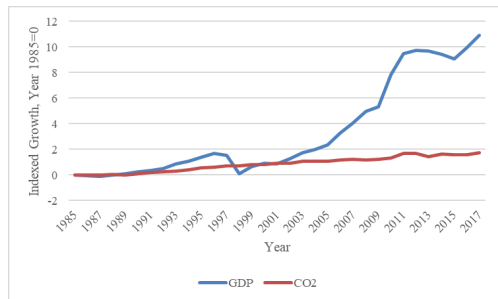
(b)

Fig. 4. GDP vs DPO Decoupling of (a) Vietnam and (b) Indonesia

DPO is a collection of different data from, emissions to water, waste disposal, emissions to water, and dissipative use of products. The DPO gives a general overview of pollution generated by the country. Emissions to water are based on carbon dioxide emissions as this usually constitutes most of the air emissions, while waste disposal is the total solid waste generated, emissions to water are based on Biological Oxygen Demand (BOD), and dissipative use of products are based on nitrates and nitrites (NOx). For Indonesia's data on DPO, most of their pollution comes from the emissions to air followed by their emissions to water. Eventually, both waste disposal and dissipative use of products show a total of almost 20% of their DPO. The trend also continuously increases over time, as data is based on a per capita basis for waste disposal and emissions to water, while emissions to air and dissipative use of products are gathered from data from the World Bank. More data should be gathered regarding the DPO of Indonesia, as a decade may still be insufficient to signify the entirety of its trend, whether it may be increasing or decreasing over time. If data is to be compared to other ASEAN countries also sharing the same economic values as Indonesia, it is best to compare it to the same decade from 2000 to 2010, or research more data that can cover a wider time. However, we can see for Vietnam that since 1985, they continue to struggle to decouple like Indonesia, however, an optimistic trend can be seen as of 2007, they have relatively decoupled and continue to do so in 2017.



(a)



(b)
Fig. 5. GDP vs CO2 Decoupling of (a) Vietnam and (b) Indonesia

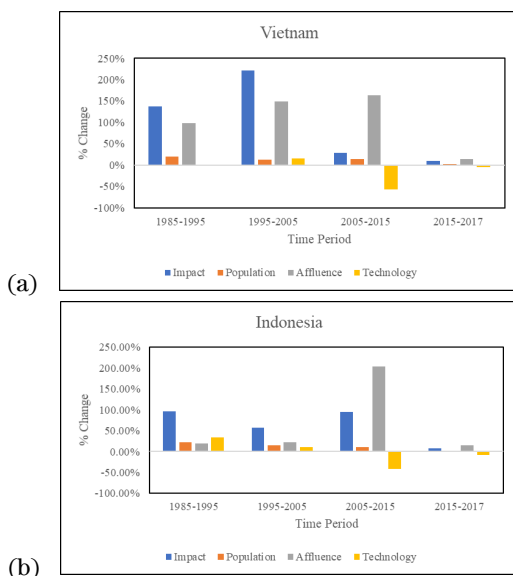
There is relative decoupling, as GDP is rapidly increasing, with carbon emissions almost consistent all throughout. However, with only the analysis of carbon emissions, it can be seen here that there seems to be only relative decoupling starting from 1980 to 2017. With the current trend, however, we may still see that GDP and Carbon emissions index growth will still remain decoupled in the following years if the government continues to provide policies that they utilize their raw materials more sustainably and with their legislation regarding carbon emissions reduction. Indonesia still faces tremendous pressure and trouble regarding its carbon emissions despite being a member of the Kyoto Protocol with multiple climate treaty negotiations and policies and issues on information dissemination (Murdiyaso, 2004).

Finally, the drivers of domestic material consumption were also investigated. Based on Figures 9a and 9b, the population, affluence, and technology of both countries follow the same trend over the period. The influence of both population and technology on the DMC gradually decreased over the period. On the other hand, the influence of affluence increased considerably. It can also be observed that population was the dominant driver in the first period for both countries. Nevertheless, this shifted to affluence for the latter two time periods. This signifies that the actual consumption of both countries is primarily driven by their economic development activities.

4. CONCLUSIONS

Both countries are performing well in terms of the growth of their GDP, however, they should be open to improvements to attain a more sustainable future. Vietnam has undergone a shift from a centrally planned economy focusing on agriculture to a more open market economy that focuses on industrialization and urbanization. The shift to urbanization has increased the waste products of the country, which has continuously faced challenges due to a lack of resources and facilities. The government should put more emphasis on this issue and build more capacity for sanitary landfills as the leachate from both burying and open landfills may damage the surrounding environment. The adoption of a waste reduction policy (3R) should also be looked into.

Similarly, Indonesia must be sustainable in its practices, especially on palm oil plantations where the environment is highly affected. Policies on agricultural safety and sustainable technologies and knowledge should improve this. Continuously expanding agreements among other countries would help them continue to grow their GDP while utilizing domestic materials which will help reduce internal costs rather than importing them, and provide jobs for their constituents. Indonesia should find ways to provide policies on self-sufficiency, as its agricultural sector cannot sustain its population.



(b)
Fig. 6. Drivers of domestic material consumption (DMC) of (a) Vietnam and (b) Indonesia using the IPAT identity

5. ACKNOWLEDGMENTS

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