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Original Article

How Does the Circular Economy Impact the Sustainable Development Goal? An Investigation from an Asian Perspective

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Abstract: *This paper aims to examine the impact of the circular economy on the Sustainable Development Goals in the context of Japanese and Malaysian economies. Additionally, it also makes a comparative analysis in terms of the circular economy's implications on the Sustainable Development Goals in Japan and Malaysia. The empirical outcome reveals that municipal waste recycling negatively impacts the accessibility of drinking water in Japan, while it leads to positive impacts on drinking water accessibility in Malaysia. Moreover, the investigation shows that recycling does not exhibit a significant impact on sanitation accessibility in Japan, while it positively impacts that in Malaysia. These findings underline that recycling contributes meaningfully to advancing sustainability outcomes more in Malaysia than in Japan, where the effects appear weaker or negative.*

Keywords: *Circular Economy, Sustainable Development Goals (SDGs), Asia / Asian Perspective, Resource Efficiency, Waste Management & Recycling, Circular Business Models, Sustainable Consumption and Production.*

I. INTRODUCTION

The United Nations developed a set of 17 Sustainable Development Goals (SDGs) in 2015, representing a crucial initiative aimed at progressing towards a broader goal of sustainable development (SD) (Sorooshian, 2024). SD refers to economic development that meets the needs of the present without compromising the ability of future generations to do the same (Emas, 2015). However, progress towards achieving these objectives has been insufficient and requires further research on their attainment (Sorooshian, 2024). On 2 December 2015, the European Commission proposed a global transition to a circular economy (CE) as opposed to the traditional "take-make-dispose" model employed by the linear economy. A CE attempts to keep resources in use for as long as possible by recycling, reusing, and remanufacturing in order to minimize waste, increase resource efficiency, and maximize the value of resources (Toni, 2023). There is a clear positive correlation between CE and SD, with CEs being adopted globally to achieve multiple SDGs (Rodriguez et. al, 2019). In Asia, SD remains a priority, but conflicts with other pressing matters, such as countering financial instability and social unrest. With the shift towards a more regenerative economy, and with a rising population increasing demand for goods, Asian economies have transitioned to adopt CE to achieve both SD and economic growth. Economically, the adoption of CE brings about increased productivity and efficiency, increasing the attractiveness of investment for trading partners.

Additionally, it also stimulates innovation, boosts economic growth, and creates employment opportunities, as evidenced by the EU's projection of creating 700,000 jobs by 2030. Finally, circular processes also cause the economy to be less vulnerable to price fluctuations of raw materials (since they are now reused and recycled), flattening average cost curves and resulting in an efficient usage of resources in terms of value and volume (Sariatli, 2017). Besides being economically advantageous, CEs can also generate major environmental benefits by improving resource management and reducing emissions. Negative production externalities result from the use and flow of raw materials, such as increased carbon emissions and pollution. By reducing the level of raw materials subsumed in the production process, CEs can decrease the exposure of economies to such externalities. When combined with healthy economic growth, the conservation of natural resources and the environment can help economies achieve sustainable economic growth (Sariatli, 2017).

While the focus is usually placed on its environmental and economic benefits, CEs can also bring about positive social effects. CEs can reduce water waste, which can improve sanitation (Masruchiyah et. al, 2025). One example of wastewater recycling in Asia can be seen in Singapore's NEWater plant, where sewage water is recycled back into potable water through ultrafiltration and reverse osmosis. As a country that imports water from its neighbor, Malaysia, Singapore seeks to strengthen its water resilience and ensure a sustainable water supply for its growing population and economy. By producing such clean drinking water, the prevalence of waterborne diseases, such as cholera, can also be reduced, thereby improving public health and sanitation. In fact, this ties in with SDG 6 (Clean Water and Sanitation), and this paper seeks to analyze the relationship between CEs and sustainable development, specifically in relation to this goal. There is untapped potential in creating more CEs, as the global economy has been estimated to be only 9% circular. With increasing greenhouse gas emissions resulting in rising surface temperatures (https://ourworldindata.org/co2-and-greenhouse-gas-emissions), the implementation of CE would help reduce these emissions by more than half by 2050 in industries that are heavy users of plastics, steel, aluminum, and cement (Berg, 2018).

Additionally, as the world experiences rapid population growth, more wastewater is discharged by both residential and industrial sources. CEs can treat this wastewater effectively, power alternative energy sources, and provide clean drinking water for millions of people globall. This research paper seeks to provide a deeper understanding of how SDG 6 (Clean Water and Sanitation) can be achieved through the implementation of CEs in Japan and Malaysia. By analyzing municipal waste recycling, drinking water access, and sanitation access, this paper aims to establish the relationship between CE and achieving sustainable development, focusing specifically on SDG 6.

II. LITERATURE REVIEW

Piao et al. (2023) examine how a CE can embrace social inclusion through both quantitative and qualitative analyses of 118 papers, with a special focus on workers. The paper finds that the analysis of CEs in developed countries is more systematic, taking into consideration distinct stakeholders, such as the community, society, and workers. The paper concludes that there is a lack of clarity on how a non-inclusive CE could displace workers and increase structural unemployment. It also suggests that future research should explore the importance of entrepreneurship and innovation to embrace social inclusion, especially in developing countries. Rodriguez et al. (2019) aim to determine the relationship between CE and SD, as well as the homogeneity of countries in achieving SD. The paper finds a clear correlation between CE and SD, and that countries with similar characteristics exhibit homogeneity in their achievement of SDGs. The paper hence recommends that developed countries should aid developing economies in achieving these SDGs through the implementation of similar CEs. Ortiz-de-Montellano et. al (2023) analyse the effects of 27 CEs on each SDG. The paper finds that while CEs can contribute to all the SDGs, they are most effective in contributing to SDGs 8, 12, and 13. Nevertheless, the paper suggests that for this to happen, CEs must follow one of the 7 pathways identified. However, the paper also finds that the focus of CEs (products and materials) differs from that of SDGs (people and environment). Hence, SDGs must consider the social, economic, and environmental roles of products, and the CE must deepen its understanding of its involved actors and their socioeconomic and demographic circumstances. Roleders et. al (2022) explore how the CE serves as a model for achieving SD. The paper finds that, unlike the traditional linear model of economic development, CE conserves resources, as it is based on both efficient waste disposal and global environmental principles, such as recycling. The paper also finds that this is dependent on population size and level of economic development. A larger population and a more economically robust country generate more waste, due to the nature of the 'take-make-waste' linear model. Toni (2023) examines the degree of awareness of CE and analyzes how it may affect the adoption of CE in business practices. He then evaluates the impact of this in the context of SDG 9 (Industry, Innovation, and Infrastructure) and 12 (Responsible Consumption and Production). The paper uses a structured questionnaire as a primary data collection method and concludes that there is an average degree of awareness of CE, and consequently a low level of adoption of CE in businesses. The paper also finds that financial limitations, supply chain restrictions, and a lack of knowledge and understanding are the primary obstacles to CE's adoption. Schoggl et al. (2020) employ a mixed-methods approach to analyze the evolution and state of CE research over the past two decades and examine the relationship between CE and sustainable development (SD). The paper finds that the CE body of literature can be divided into management and technically oriented studies, and recycling has been the most referred-to R-strategy within it. Additionally, there is a subset relationship between CE and SD, and only a limited number of environmental aspects are centrally addressed. In contrast, other environmental and social aspects form the periphery of CE research. Haput & Hellweg (2019) propose a new environment-based indicator to better assess a CE's sustainability. By using retained economic value (REV) over mass-based indicators, they extend the focus from end-of-life to the entire life cycle and include substitution of primary materials. The REV indicator provides a quantitative marker that can be used to quantify the net impact, inclusive of environmental, social, and economic effects. For increased efficiency, the paper suggests using it to complement mass-based indicators in assessing the environmental sustainability of cross-material substitutions, i.e., materials replacing other materials in open-loop applications. Arauzo-Carod et. al (2022) analyse the importance and implications for policies supporting CE in light of a growing population and hence growing demand for natural resources. They conclude that public policies supporting the CE should be designed at the lowest levels of public administrations, so that regional governments can effectively monitor these policies. Since CEs tend to have strong industrial and regional dimensions and involve intermediate spatial consumption, local and regional governments play a key role in designing such policies. Sariatli (2017) compares the impacts of CE versus the linear economy on optimising the sustainability of an economy, in light of our natural environment being close to irreversibly losing its self-sustaining ability. It also uses SWOT analysis to evaluate the effectiveness of a CE and lend support to its superiority compared to the linear model. The take-make-dispose nature of the linear economy cannot sustain the increasing demands of our growing population. Khajuria et. al (2022) summarize key insights from the 16th International Conference on Waste Management and Technology on accelerating CE solutions in rapidly developing economies to achieve

SDGs. The paper finds that public-private partnerships on the 3Rs (reduce, reuse, and recycle) optimise natural resource management, and should be integrated with green chemistry principles of designing less hazardous chemicals. Berg et. al (2018) explore whether the promotion of CE would benefit from a tailored international process or whether the goals set by, e.g., the SDGs are sufficient. The paper finds that implementing the CE and SDGs at large must work together but may result in trade-offs between environmental and social objectives. The paper also concludes that ultimately, the next course of action should be to experiment with both business cases and policy instruments and make constant improvements to CE. On the other hand, Bouattour et. al (2025) combine green technological innovation, renewable energy sources, and CE into a single green growth model. They then investigate the relationship between green growth and green technological innovation. The paper finds that green technological innovation facilitates circularity, showing that CE's desired effects on green growth depend on increased green technological innovation. Hence, the paper also recommends that EU policymakers focus on creating incentives and regulations to encourage green technological innovation to advance SD. Avdiushchenko et. al (2025) explore how CE could accelerate SD in urban cities by interviewing 17 NYC stakeholders. The paper finds that NYC's cultural diversity requires tailored circularity measures that ensure benefits for multiple groups of people. The paper recommends that local authorities establish neighborhood-level circularity centers in partnership with local community organizations. These centers could focus on selected aspects of circularity, such as collection, repair, reuse, sharing, and education. Xiao et. al (2025) explore the extent to which new energy storage technologies are working to make the world more sustainable. The paper finds that natural resource utilization and oil use intensity hinder SD, while innovations in energy storage and CE present global possibilities for a more sustainable and environmentally friendly future. Ultimately, the paper recommends that while a low-carbon economy can be achieved rapidly with the help of CE, energy storage is essential for balancing the energy supply. Policymakers should invest in R&D on nuclear energy to enhance waste management and lessen reliance on fossil fuels. In collaboration with CE, the paper suggests that a more sustainable energy system can be achieved. Chrispim et. al (2025) analysed company reports and interviewed Swedish companies to investigate how CEs are currently employed and how they could be improved upon. The paper finds that these companies have only just begun their transition into circular business practices, and the main practice adopted has been resource recovery. Additionally, the paper suggests that the low adoption of CE is due to endogenous barriers such as a lack of knowledge and a shortage of resources, as well as a lack of collaboration between other stakeholders (e.g., governments). Hence, the paper proposes that more collaboration would allow companies to reap increasing returns to knowledge and increase CE implementation. Masruchiyah et. al (2025) explore how the integration of CE, green human capital (GHC), and green technology adoption could strengthen urban water sustainability in Indonesia. The paper finds that while CE practices enhance sustainability through water waste reduction and by reusing resources, it does not necessarily sufficiently alter urban water system dynamics unless reinforced by robust implementation mechanisms and sustained behavioral change. Yosthongngam et. al (2025) investigate the key Environmental, Economic, Social, and Governance (EESG) drivers influencing Waste-to-Energy (WtE) production across nine EU countries from 2000 to 2020. The paper finds that, in the long term, recycling efficiency, energy self-sufficiency, recycling innovation, and WtE consumption significantly enhance CE performance. There is also a bidirectional relationship between CE and both recycling efficiency and energy self-sufficiency, suggesting that as CE advances, it improves recycling systems and energy resilience, which in turn accelerates progress toward circular outcomes. Ultimately, the paper reinforces the need for targeted, system-level policies that balance environmental integrity, energy autonomy, and technological capability to enhance WtE's contribution to CE transitions in the EU. Bandeira et. al (2025) developed a CE maturity framework for SMEs that considers SMEs' often-limited resources, in order to help practitioners evaluate and manage CE and allows organizations to assess the current level of CE maturity in SMEs. They propose the Circular Economy Maturity Framework (CEMAF), composed of five dimensions: take, make, distribute, use, and recover. The paper finds that the CEMAF model allows SMEs to prioritize their efforts and resources, resulting in benefits like reduced carbon footprint and increased resource efficiency. The paper also recommends that SMEs use CEMAF to benchmark their sustainability performance against market peers to identify opportunities for collaboration.

The CE is often viewed as a pathway to sustainability, yet research on this relationship remains limited, especially in Malaysia and Japan. Only a few studies have explored CE within the East Asian context, while most existing work has focused on Western and other advanced economies. Since Asian economies differ greatly from Western ones in terms of structure and outlook, the findings from those studies cannot be directly applied to Asia. Furthermore, existing evidence on the role of CE in achieving sustainable development is mixed and inconclusive. To address this gap, the present study offers new insights using a unique methodological approach. It contributes in three main ways. First, it examines multiple indicators of CE to understand their impact on sustainability—an approach rarely applied in Asian research. Second, it makes use of a large dataset covering the period 2000–2022, which strengthens the reliability of the findings. Third, it conducts a comparative analysis of Malaysia and Japan, allowing for a more comprehensive and nuanced interpretation of results.

The paper is organized as follows: Section 1 introduces the study, followed by a literature review in Section 2. Section 3 explains the data and methodology, Section 4 presents the analysis and discussion, and Section 5 highlights the conclusions and key implications.

III. DATA AND METHODOLOGY

A) Data

As previously stated, this research strives to examine the impact of CEs on the Sustainable Development goal in the context of Japan and Malaysia. To accomplish this, this analysis considers municipal waste recycled (in million tonnes) as a proxy of the circular economy model, as mentioned in several studies in this context. On the other hand, to gauge the Sustainable Development Goal, this paper considers SDG 6: Clean Water and Sanitation. This paper considers the %age of people having access to clean drinking water and sanitation. The data on clean drinking water and sanitation have been collected from the Our World in Data website, which can be accessed freely at https://ourworldindata.org/water-access. On the other hand, data related to municipal waste recycling (in million tonnes) has been accumulated from the United Nations Environment Programme database, which is freely available at the Our World in Data website, which can be found here: https://ourworldindata.org/waste-management. All the data chosen is from 2000 to 2022 and has been selected based on the availability of the data set.

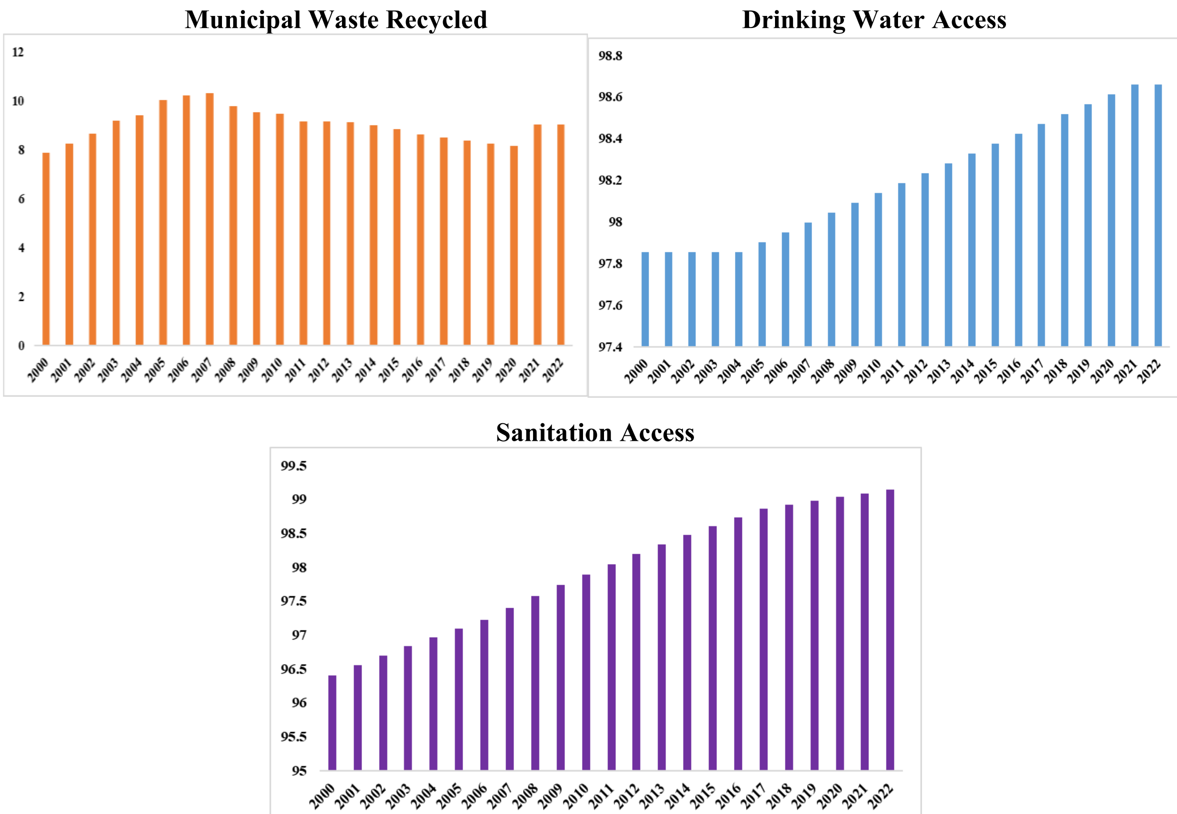
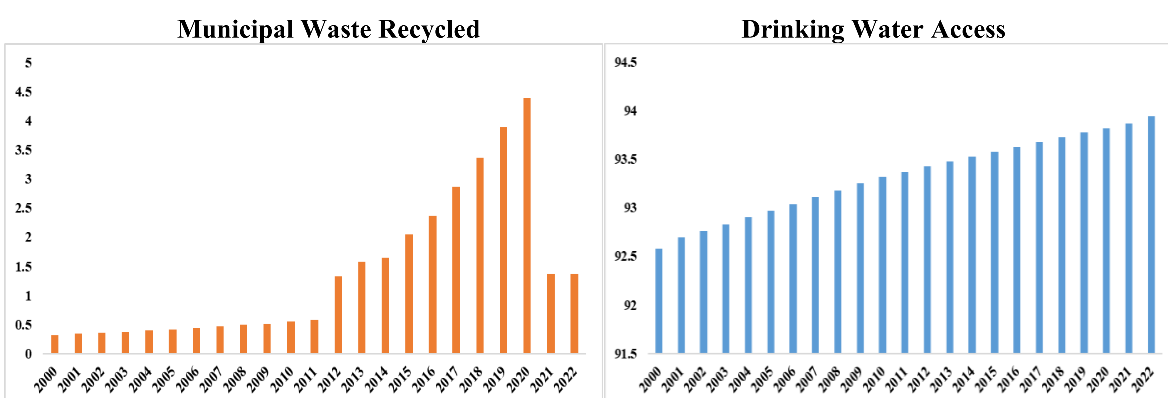


Fig 1: Municipal waste recycled, drinking water access, and sanitation access in Japan.



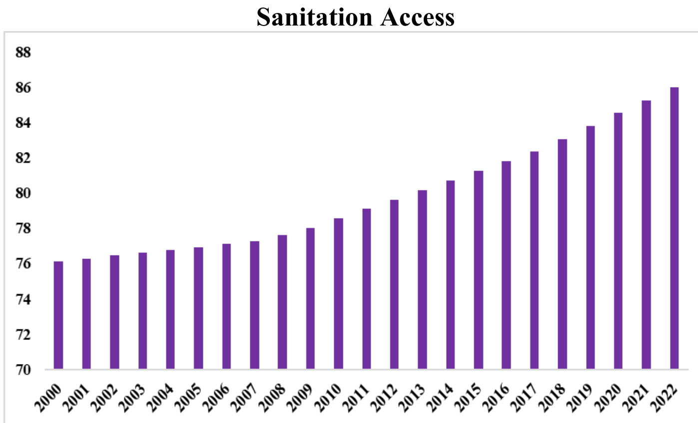


Figure 2: Municipal waste recycled, drinking water access, and sanitation access in Malaysia.

B) Regression Model

$$Drinking\ Water = \alpha + \beta(Waste\ Recycled) + \epsilon \quad \textbf{(1)}$$

$$Sanitation = \delta + \varphi(Waste\ Recycled) + \varepsilon \quad \textbf{(2)}$$

The above regression model has been used to gauge the impact of waste recycling on the drinking water and sanitation (indicators of SDG 6). In equation 1, drinking water is the dependent variable, while the amount of waste recycled is the independent variable. Similarly, in equation 2, sanitation is the explained variable while waste recycling is the explanatory variable. In the current model, consumption is our dependent variable. Moreover, the terms α and δ represent the intercept term, while β and φ are the coefficients of waste recycling, revealing its impact on the dependent variables such as drinking water and sanitation. Moreover, ϵ and ε are the stochastic error terms. We apply the method of ordinary least squares (OLS) to estimate the coefficients of the above regression model, which is a robust estimation technique in this context. Additionally, the student's t-test is applied to examine the significance of estimated coefficients and is appropriate to apply when we are not above the population standard deviation.

The null and alternative hypotheses under the Student's t-test can be displayed below.

$$\boldsymbol{H_0: Coefficient\ value = 0}$$

$$\boldsymbol{H_a: Coefficient\ value \neq 0}$$

The null hypothesis states that the coefficient value is equivalent to zero, while the alternative hypothesis assumes that the coefficient significantly differs from zero. A larger t value shows that the coefficients are significant and have a substantial impact on explanatory variables on the explained variables, which is consumption in the present context.

IV. RESULT ANALYSIS

A) Descriptive Analysis

Table 1: Outcome Descriptive Analysis

	Japan			Malaysia		
	MUR	**DW**	**SAN**	**MUR**	**DW**	**SAN**
Mean	9.03	98.20	97.95	1.37	93.32	79.79
Standard Error	0.13	0.06	0.19	0.26	0.08	0.66
Median	9.03	98.19	98.04	0.57	93.37	79.09
Standard Deviation	0.66	0.29	0.91	1.24	-	-
Coefficient of Variation	7.32	0.29	0.93	90.60	0.40	3.15
Kurtosis	-0.48	-1.40	-1.37	0.47	0.43	3.95
Skewness	0.25	0.20	-0.24	1.21	-1.09	-0.97
Range	2.44	0.80	2.74	4.07	-0.25	0.58
Minimum	7.86	97.85	96.40	0.32	1.36	9.86
Maximum	10.3	98.66	99.14	4.39	92.58	76.11

Source: *Author calculations*

Current analysis begins with the presentation of descriptive statistical outcomes of all the variables under consideration, which include digital payment systems such as municipal waste recycling, drinking water access, and sanitation in Japan and Malaysia (see Table 1). The pertinent outcome of descriptive statistics reveals that in Japan, the average amount of municipal waste recycled from 2000 to 2022 was 9.03 million tonnes, while average drinking water accessibility is 98.20%. Moreover, on average, 97.95% people have access to sanitation in Japan during this period. In addition, the results of the coefficient of variation reveal that municipal waste recycling shows a higher level of variation compared to other variables in Japan. Moreover, the results of skewness exhibit that municipal waste recycling and accessibility of drinking water are positively skewed, while sanitation accessibility seems to be negatively skewed. On the other hand, the descriptive statistics of Malaysia exhibit that, on average, the amount of municipal waste recycled from 2000 to 2022 was 1.37 million tons, while average drinking water accessibility was 93.32%. Moreover, on average, 79.79% people have access to sanitation in Malaysia from 2000 to 2022. Like Japan, the results of the coefficient of variation reveal that municipal waste recycling shows greater variation in comparison to other variables in Malaysia. Moreover, the results of skewness exhibit that sanitation accessibility and accessibility of drinking water are negatively skewed, while the accessibility of municipal waste recycling is positively skewed. After exploring the descriptive statistics of the data set, the current analysis also reveals the result of the correlation analysis, which is shown below in Table 2.

B) Correlation Analysis

Table 2: Correlation Analysis Results

	Japan				**Malaysia**		
	MUR	**DW**	**SAN**		**MUR**	**DW**	**SAN**
MUR	1.00			**MUR**	1.00		
DW	-0.37	1.00		**DW**	0.76	1.00	
SAN	-0.25	0.98	1.00	**SAN**	0.78	0.95	1.00

Source: *Author calculations*
Note: **** is significant at 1% and ** at 5%*

The outcome correlation analysis shows the negative relationship between municipal waste recycling and drinking water accessibility in Japan. On the other hand, it also shows that accessibility of sanitation and municipal waste recycling are negatively correlated in Japan. Moreover, based on the correlation analysis outcome of Malaysia, it can be derived that municipal waste recycling and drinking water accessibility are positively correlated. Finally, it can be concluded that accessibility of sanitation and municipal waste recycling has a positive relationship in Malaysia. After using correlation analysis, this research also applies the regression analysis to exhibit the impact of municipal waste recycling on drinking water and sanitation accessibility.

C) Regression Analysis Outcome

Table 3: Outcome Regression Analysis of Japan

Drinking Water (DW)		
	Coefficients	**P-value**
Intercept	99.64	0.002
Municipal Waste Recycled (MWR)	-0.159	0.080
R^2	0.37	
DW Statistics	1.76	
Sanitation (SAN)		
	Coefficients	**P-value**
Intercept	99.55	0.002
Municipal Waste Recycled (MWR)	-0.33	0.25
R^2	0.25	
DW Statistics	1.45	

Source: *Author calculations*
Note: ****, **, * are significant at 1, 5, and 10%, respectively.*

Table 3 reveals the results of regression analysis, which show the impact of municipal waste recycling on drinking water and sanitation accessibility in Japan. It can be inferred that municipal waste recycling negatively impacts drinking water accessibility in Japan at a 10% level of significance. The results also show that, for a 1 million-tonne increase in the amount of municipal waste recycled, there is a 0.15% fall in accessibility of drinking water. On the other hand, the coefficient of determination shows that we can explain 37% variability of the dependent variable in the given equation. Meanwhile, it can be posited that municipal waste recycling negatively impacts the accessibility of sanitation in Japan. However, the coefficient of municipal waste recycled is not significant at both the 5% and 10% level of significance. Hence, this research concludes that municipal waste recycling does not have any significant impact on accessibility of sanitation in Japan. On the other hand, the coefficient of determination shows that we can explain 25% variability of the dependent variable with the given equation.

Table 4: Outcome Regression Analysis of Malaysia

Drinking Water (DW)		
	Coefficients	**P-value**
Intercept	92.98***	0.000
Municipal Waste Recycled (MWR)	0.24***	0.000
R^2	0.75	
DW Statistics	1.86	
Sanitation (SAN)		
	Coefficients	**P-value**
Intercept	77.02***	0.000
Municipal Waste Recycled (MWR)	1.99**	0.000
R^2	0.78	
DW Statistics	1.83	

Table 4 reveals the results of the regression analysis of Malaysia. It can be inferred that municipal waste recycling positively impacts drinking water accessibility in Malaysia. The results show that for an increase of 1 million tonnes in the amount of municipal waste recycled, there is a 0.24% increase in drinking water accessibility at a 1% level of significance. On the other hand, the coefficient of determination shows that we can explain 75% variability of accessibility of drinking water with the given regression. On the other hand, it can be realized that municipal waste recycling leads to the advancement of sanitation accessibility in Malaysia. Moreover, it can be posited that the coefficient of municipal waste is significant at 1% level of significance. Hence, the 1-million-ton increase in municipal waste recycled increases sanitation access by 1.99 % in Malaysia. Finally, the coefficient of determination shows that we can explain 78% variability of sanitation accessibility with the given regression model.

V. CONCLUSION

The regression outcomes reveal clear differences in how municipal waste recycling affects sustainability in Japan and Malaysia. In the case of Japan, recycling shows a weak and adverse association with drinking water accessibility, significant only at the 10% level of significance. A one-million-ton increase in municipal waste recycling is linked to a 0.15% decline in drinking water accessibility. For sanitation, the effect of recycling is statistically insignificant, with the models explaining only 25–37% of the variation. This shows that municipal waste recycling in Japan does not play a decisive role in shaping water or sanitation access, and other structural or environmental factors may be more influential.

In contrast, Malaysia presents a markedly different picture. Recycling is strongly and positively associated with improvements in both drinking water and sanitation accessibility. The results show that a one-million-ton increase in recycling raises drinking water access by 0.24% and sanitation access by 1.99%, both significant at the 1% level. The explanatory power of the Malaysian models is also much stronger, accounting for 75–78% of variability. These findings suggest that municipal waste recycling contributes substantially to sustainability in Malaysia, while its influence in Japan appears limited and, in some cases, counterproductive.

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