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Article

A waste Kuznet curve: The negative shadows of tourism industry in West Nusa Tenggara, Indonesia using fully modified and dynamic ordinary least squares

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Abstract: This empirical study investigates the relationship between the tourism industry and municipal solid waste (MSW) creation in West Nusa Tenggara, Indonesia, to determine whether a Waste Kuznet Curve (WKC) exists. The study runs from 2014 to 2020, using data acquired from several government official websites in ten Regencies/Districts. Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) regression approaches were employed to analyze this relationship. This inquiry yielded three important discoveries. First, a significant and negative link is seen between the development of the tourism business and the increase in MSW output. This demonstrates that the booming tourism sector hurts environmental conditions, exacerbating environmental issues that require government intervention. This empirical study investigates the relationship between the tourism industry and MSW creation in West Nusa Tenggara, Indonesia, to determine whether a WKC exists.

Keywords: tourism performances; waste management; waste Kuznet curve; fully modified ordinary least squares; dynamic ordinary least squares

1. Introduction

In recent times, many countries, including Indonesia, have shifted focus from purely economic growth to sustainable development, aligned with the Sustainable Development Goals (SDGs). Indonesia has notably emphasized developing its tourism sector, but challenges persist. Rapid tourism-driven economic growth has led to negative consequences like environmental degradation and deforestation, posing significant challenges for future generations. However, tourism remains a crucial driver of economic growth, contributing nearly five % to Indonesia's GDP in 2020. Tourism expansion is linked to accelerated economic growth, reduced regional income disparities, job creation, and poverty alleviation (Ekeocha et al., 2021; Romão, 2020). However, rapid tourism-driven growth has also led to negative consequences such as environmental degradation, deforestation, overcrowding, increased crime rates, and a surge in MSW, posing significant challenges for future generations (Arbulu et al., 2017; Saarinen, 2003). Robust waste disposal systems are essential to mitigate these impacts (Mateu-Sbert et al., 2013).

The Environmental Kuznets curve (EKC) theory suggests that environmental quality initially worsens with economic activity but improves after reaching a certain income threshold (Miranda et al., 2020; Ozcan et al., 2020; Rastogi et al., 2023). Research on tourism's environmental impact varies: some studies indicate tourism enhances environmental quality in developed countries due to advanced technology

and environmental awareness (Katircioglu et al., 2014, 2018; Khan and Hou, 2021; Kongbuamai et al., 2020; Liu et al., 2022). Conversely, other research aligns with the EKC theory, showing tourism development can lead to environmental degradation (Fatai Adedoyin et al., 2021; Jaligot and Chenal, 2018; Koçak et al., 2020; Mikayilov et al., 2019; Zaman et al., 2016).The relationship between tourism and the environment is complex, influenced by economic development, technology, and environmental awareness (Mowforth and Munt, 1998).

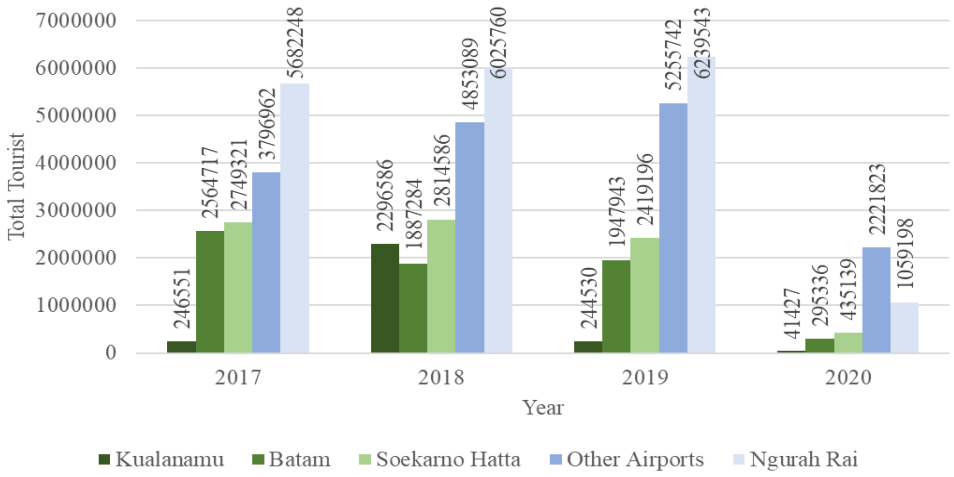

Figure 1. Total tourist based on the airport entrance.

The sustainability of tourism development is crucial for its relationship with environmental conditions (Mowforth and Munt, 1998). Measuring environmental carrying capacity helps mitigate negative impacts like over-tourism and environmental degradation. In Indonesia, tourism significantly boosted foreign exchange reserves, notably increasing by nearly 25% in 2018 compared to 2017, according to data from the Statistics Indonesia, as shown in **Figure 1**. Ngurah Rai International Airport in Bali serves as a key gateway for tourists visiting West Nusa Tenggara. Despite being less renowned internationally, West Nusa Tenggara's tourism sector has grown since 2014, particularly due to the establishment of the Mandalika Special Economic Zones by Government Regulation No. 52/2004 (St, 2021), promoting tourism-related economic growth and increasing hotel occupancy rates in Nusa Tenggara Barat and central Lombok.

To investigate the relationship between tourism development and MSW creation in West Nusa Tenggara, this study utilizes panel data from 2014 to 2020 sourced from several government official websites across ten Regencies/Districts. The analysis employs FMOLS and DOLS regression approaches to assess this association and determine the presence of a WKC. Introducing a WKC perspective, the study focuses on the relationship between tourism growth and MSW generation in West Nusa Tenggara. It analyzes micro-level dynamics within the province's ten regencies/districts, providing insights into the localized environmental impact of tourism expansion. The identification of critical income thresholds adds sophistication to the analysis, offering policymakers precise benchmarks for decision-making. This paper proceeds as follows. Section 2 reviews relevant literature on tourism development, environmental impacts, and the Waste Kuznet Curve theory. Section 3

outlines the methodology, detailing data collection methods, variables, and statistical techniques used. Section 4 presents the empirical results and discusses their implications. Finally, Section 5 concludes with policy recommendations and avenues for future research.

2. Literature review

Waste management has emerged as a critical factor for sustainable tourism (Arbulú et al., 2015; Arbulu et al., 2017; Arbulú et al., 2021). Numerous studies have been dedicated to examining the intricate relationship between tourism and waste generation worldwide, e.g., the works by Arbulú et al. (2015). Waste, in this context, represents the negative externalities stemming from economic activities, particularly those associated with tourism development (Arbulú et al., 2015). International and domestic visitors contribute not only to increased CO_2 emissions and environmental degradation (Katircioglu et al., 2014; Koçak et al., 2020; Zaman and Bulut, 2018) but also to the accumulation of municipal waste in tourist destinations (Arbulú et al., 2021; Bashir and Goswami, 2016).

The general adverse impact of tourism on waste has been evident in previous research; however, the outcomes of these insightful studies have exhibited some degree of bias. Arbulú et al. (2015), for instance, found a negative relationship between tourism development and waste generation, a pattern consistent with the EKC. Furthermore, Arbulú et al. (2015), Diaz-Farina et al. (2020), Martins and Cró (2021), Mateu-Sbert et al. (2013) have underscored that tourism activities, particularly within the accommodation and food & beverage sectors, can significantly contribute to waste generation and environmental degradation, even when compared to other economic activities generating similar income for regional economies. Recent research conducted by Stefanica et al. (2021), employing Partial Least Squares (PLS) analysis, lends further support to this argument. The study's results convincingly affirm that tourism activities can indeed exacerbate environmental degradation, including adverse effects on water and air quality, as well as the introduction of noise pollution. These collective findings underscore the need for comprehensive waste management strategies within the tourism industry to mitigate its environmental impact and foster sustainable practices.

From a macroeconomic perspective, the impact of tourism on the environment has exhibited a consistent bias towards the deterioration of environmental quality. Numerous studies have endeavored to assess the influence of macroeconomic variables, with tourism being a prominent factor, on environmental quality in both developed and developing countries. A study centered on European countries has corroborated a robust relationship between trade, Foreign Direct Investment (FDI), and CO_2 emissions (Paramati et al., 2016). Similar findings have been replicated by Moutinho et al. (2020) and Liu et al. (2019) when examining data from OPEC countries. Notably, Moutinho et al. (2020) and Liu et al. (2019) have expanded their analyses to encompass a range of other macroeconomic variables, including energy consumption and oil prices, providing a more comprehensive understanding of the intricate interplay between economic activities, environmental quality, and sustainability.

Moreover, recent studies have further reinforced the notion of a complex relationship between tourism and environmental conditions. Ghosh (2020), for instance, has provided support for the existence of a quadratic relationship between long-term tourism and environmental conditions, even though the turning point is relatively high. This nuanced understanding suggests that the environmental impact of tourism may exhibit a U-shaped trajectory over extended periods. Papavasileiou and Tzouvanas (Papavasileiou and Tzouvanas, 2021) have similarly confirmed the U-shaped relationship between economic development and environmental degradation, underlining the intricate dynamics at play. Bashir and Goswami (Bashir and Goswami, 2016) have shed light on the pivotal role played by local governments and city resilience in managing the waste-related impacts resulting from the surge in tourists during peak seasons. Furthermore, Greco et al. (2018) have conducted a comprehensive investigation into the impact of tourism activities on waste management costs, specifically across various waste types such as paper and paperboard, multi-material, organic, and undifferentiated waste in Italy. Their research reveals a significant increase in the collection costs associated with each waste type due to the influx of tourists. The consequences of tourism activities extend beyond the mere generation of waste and disruption of natural landscapes; they also result in higher waste collection expenses. This elevation in costs can be attributed to the need for the collection of diverse waste types over larger geographical areas.

The hotel and hospitality sectors play a pivotal role in the development of tourism in various regions (Pham Phu et al., 2018). As these sectors provide essential infrastructure for the leisure industry, recent decades have witnessed a growing focus on understanding their impact. Limited research has confirmed that hotels and accommodations generate waste at levels exceeding those of the local population's activities, and this waste generation is statistically significant in negatively impacting the surrounding environment (e.g., Bashir and Goswami (2016); Chaabane et al. (2018); Dolnicar et al. (2020); Greco et al. (2018); Pham Phu et al. (2018); Sekito et al. (2019); Widyarsana et al. (2022); Xu et al. (2021)), it was revealed that, on average, tourism waste generated by hotels and hospitality establishments amounted to approximately 0.6 kg per room per day, 26.18 kg per day for a single restaurant, and 6.99 kg per 100 m of tourist streets per day. Similar findings were reported for Nusa Dua, Bali, Indonesia, where waste generation was estimated at around 11 tons, comprising 70% organic waste and 30% other waste materials (Widyarsana et al., 2022). Furthermore, studies conducted in neighboring areas, such as Gili Trawangan, which is a renowned destination among both international and domestic travelers in close proximity to Nusa Dua, Bali, have corroborated these findings. Sekito et al. (2019) highlighted that the hospitality sector contributed to more than 70% of MSW generation in such areas. These collective findings emphasize the significant environmental footprint associated with the hotel and hospitality sectors, underscoring the importance of sustainable waste management practices within these industries.

Furthermore, this research aims to discern the differential impacts and contributions of tourists and the local population to MSW generation. Several published studies have focused on estimating the influence of tourism development on MSW specifically in tourist areas or island destinations, including (Arbulu et al., 2017; Mance et al., 2020; Martins and Cró, 2021; Mateu-Sbert et al., 2013). Previous

research findings have revealed that a 1% increase in tourist arrivals can lead to a corresponding increase in MSW by approximately 0.282% (Mateu-Sbert et al., 2013) and 0.40 kg (Diaz-Farina et al., 2020). Additionally, these studies have compared the daily waste generation of tourists and the local population. For instance, Mateu-Sbert et al. (2013) reported that tourists generate approximately 1.31 kg of waste daily, while the local population produces approximately 1.48 kg daily. Diaz-Farina et al. (2020) also found that tourists produce 1.19 kg of waste daily in comparison to the local population. These comparative analyses shed light on the distinctive waste generation patterns between tourists and residents in tourist destinations, providing valuable insights into the dynamics of MSW management in such areas.

In the realm of waste generation and tourism, Arbulú et al. (2017) conducted a noteworthy study differentiating the impacts of tourist arrivals and tourist expenditure. Their research demonstrated that an increase in tourist arrivals resulted in a more substantial increase (1.25%) in waste disposal compared to the impact of tourist expenditure (0.51%). Furthermore, in Croatia, it was revealed that both international and domestic visitors could lead to an approximately 22% greater increase in MSW in tourist destinations when compared to the local population. Recent empirical research by Martins and Cró (2021) in Madeira presented findings that slightly deviate from previous studies. Their research showed that the impact of tourism activities could increase solid waste by 41.9% to 46.6% in Madeira, representing a higher magnitude compared to earlier studies. To bolster the argument that there exists a discernible disparity in waste generation contributions between tourism development and the local population, a cross-country study encompassing both developing and developed nations affirmed that the local population also contributes to MSW, albeit to a lesser extent. This contribution is largely attributed to factors such as population growth and urbanization (Zambrano-Monserrate et al., 2021). Additionally, research conducted in Tunisia by Chaabane et al. (2018) revealed that up to 36% of MSW in the country could be recycled, highlighting the potential for sustainable waste management practices.

As previously highlighted, the existing body of research often relies on time series data from small islands, regions, or countries, which may not adequately capture regional variations. To address this limitation, the present study aims to provide a more comprehensive regional analysis by focusing on each regency or city within the West Nusa Tenggara Province. This nuanced analysis will provide valuable insights for policymakers and stakeholders involved in waste disposal management in West Nusa Tenggara. By gaining a better understanding of the differing contributions to waste generation, policymakers will be better equipped to develop targeted strategies to address waste-related challenges in the region effectively.

3. Materials and methodology

3.1. Data sources

A panel data collected from 2014–2020 from several official website of Indonesia, including the West Nusa Tenggara Government Tourism Office, Statistics of West Nusa Tenggara Province, Ministry of Environment and Forestry, and The Forestry and Environment Office of the West Nusa Tenggara Provincial Government. To facilitate

the analysis, all data has been transformed using the natural logarithm (Log Natural). For a detailed breakdown of the panel data sources and their respective definitions, please refer to **Table 1** in the research. This information is crucial for understanding the research methodology and ensuring transparency in data utilization.

Table 1. Data sources and operational definitions of research variables.

Variable	Definition	Source
LnWaste (Municipal solid waste)	The West Nusa Tenggara Provincial Environmental Services defines Municipal waste with the amount of waste generated by each Regency/City in NTB is based on the development of the population each year.	The Forestry and Environment Office of the West Nusa Tenggara Provincial Government
LnHotel (Hotel Occupancy Ratio)	The hotel occupancy rate shows the % age number between the number of rooms or spaces used and the total space in the entire hotel building.	West Nusa Tenggara Government Tourism Office
LnSqHotel (Square of Hotel Occupancy ratio)	The hotel occupancy rate shows the % age number between the number of rooms or spaces used and the total space in the entire hotel building.	West Nusa Tenggara Government Tourism Office
LnPopulation (Local Population)	The population shows how many people inhabitant by each regency/city in West Nusa Tenggara.	Statistics of West Nusa Tenggara Province
LnPDRB (Regional Gross Domestic Product)	The Gross Regional Domestic Brutto shows how economic development in each region	Statistics of West Nusa Tenggara Province

As previously discussed, there is a burgeoning body of literature that delves into the impact of tourism on environmental waste and environmental degradation. However, it is noteworthy that only a subset of these studies has made distinctions between the contributions of the local population and tourists. The majority of these papers have employed different approaches to differentiate between these two variables. For instance, some have used population or population density as a proxy for the local population, while others have utilized tourist spending or hotel occupancy ratios as proxies for assessing tourism development. This diversity in methodologies reflects the complexity of the subject matter and the variety of factors that can influence waste generation and environmental impacts in different destinations. It underscores the importance of considering local context and using appropriate proxies when conducting research on the relationship between tourism and environmental conditions. In the empirical economic models, the heterogenous panel cointegration techniques are used namely Fully Modified Ordinary Least Squares and Dynamic Models Ordinary Least Square. The empirical model can be explained by the following equation.

$$Y_{it} = \beta_{0t} + \beta_{it}X_{1it} + \beta_{it}X_{1it} + \beta_{2it}X_{2it} + u_{it} \ldots \quad (1)$$

Table 2 in this research provides a descriptive statistical summary of the variables utilized in the study. This study draws inspiration from four research studies conducted in island-tourism destinations, namely (Arbulu et al., 2017; Mance et al., 2020; Martins and Cró, 2021; Mateu-Sbert et al., 2013),which have influenced its approach. For each category, this study employs a single proxy variable to represent the pertinent factors under investigation. This approach ensures clarity and consistency in the research design, allowing for meaningful comparisons with the existing literature and a better understanding of the specific dynamics at play in West Nusa Tenggara.

Table 2. Descriptive statistics.

Variables	Mean	Standard Deviation	Minimum	Maximum
MSW	11.7342	0.7238646	10.57194	12.87677
Hotel Occupancy Rate	6.627038	1.22044	4.025352	8.674368
Square of Hotel	45.38229	16.20806	16.20346	75.24466
Government Expenditure	22.66605	0.8580033	19.05838	23.98075
GDRB	9.160915	0.6626145	7.277939	10.15545
Population	12.93796	0.8154735	11.70493	16.24061

3.2. Methodologies FMOLS and DMOLS

Table 3 in this research presents the results obtained from the estimation of the FMOLS and DOLS equations for the proposed models. The authors have rigorously tested the panel unit root using various methods, such as those outlined by Breitung (2000); Harris and Tzavalis (1999); Im et al. (2003); Levin et al. (2002). The null hypothesis tested in the present research posits that all variables are non-stationary and contain a unit root. The findings presented in **Table 4** indicate that the majority of variables are non-stationary at the level of variables. However, these variables become stationary at the 1% level of significance when differenced once, highlighting the importance of considering first differences to achieve stationarity. This is a crucial step in time series analysis and econometric modeling, as non-stationary data can lead to spurious or misleading results.

Table 3. Panel unit root test.

Panel		Panel Unit Root Test			
		Pesaran	Breitung	Harris-Tzavalis	Levin-Lin-Chu
LnWaste (Municipal solid waste)	Level	0.000***	0.158	0.448	0.2234
	1st Diff	0.000***	0.000***	0.000***	0.000***
LnHotel (Hotel Occupancy Ratio)	Level	0.990	0.045**	0.162**	0.251
	1st Diff	0.000***	0.000***	0.000***	0.000***
LnSqHotel (Square of Hotel Occupancy ratio)	Level	0.999	0.161*	0.238	0.656
	1st Diff	0.000***	0.000***	0.000***	0.000***
Ln Gov	Level	0.0045***	0.002**	0.000***	0.000***
	1st Diff	0.000***	0.000***	0.000***	0.000***
LnPDRB (Regional Gross Domestic Product)	Level	0.000***	0.129	0.001***	0.0112***
	1st Diff	0.000	0.001***	0.000***	0.191**
LnPopulation (Local Population)	Level	0.000***	0.050**	0.001***	0.361
	1st Diff	0.000***	0.000***	0.000***	0.000***

Note: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 4 in this research serves to indicate the order of stationarity for the variables under investigation. Subsequently, the authors conducted panel cointegration tests, the results of which are presented in **Table 5**. Three different types of panels cointegration tests were employed in this study, namely the Kao Test, Pedroni, and Wsterlund (Kao and Chiang, 2000; Pedroni, 2004; Westerlund, 2007).

Table 4. Panel cointegration test.

Test	Parameter	*t*-stat	*P*-value
Kao test	Modified Dickey-Fuller t	2.93***	0.0017
	Dickey-Fuller t	2.16**	0.0153
	Augmented Dickey-Fuller t	3.78***	0.0001
	Unadjusted modified Dickey-Fuller t	−2.12	0.0172
	Unadjusted Dickey-Fuller t	−5.22***	0.0000
Pedroni test	Modified Phillips-Perron t	4.69***	0.0000
	Phillips-Perron t	−22.75***	0.0000
	Augmented Dickey-Fuller t	−23.68***	0.0000
Westerlund test	Variance ratio	78.01***	0.0000

* Significant at 10%, ** Significant at 5%, *** Significant at 1%.

The outcomes of these tests confirm the presence of cointegrated relationships among all variables at the 1% level of significance. This indicates that there is a long-run equilibrium relationship among the variables under examination, namely Waste, the tourism sector, government expenditure, GDP, and population. In other words, these variables move together in the long run. Having established the presence of cointegration, the authors then proceeded to estimate the model using the FMOLS and DOLS methodologies.

4. Result and discussion

4.1. Empirical findings

The primary objective of this research is to investigate the non-linear relationship between the development of the tourism sector and waste generation. The empirical findings confirm a robust and significant relationship among the variables studied. This aligns with previous research that has also validated a strong positive relationship between tourism development and waste generation, as demonstrated by studies such as those conducted by Bayar et al. (2021); Gui et al. (2019); Nyland et al. (2021a); Paramati et al. (2016); Tian et al. (2021). The statistical significance of the relationship is evident from the p-values obtained through both the FMOLS and DOLS methodologies, which are significant at the 1% and 5% levels, respectively. In essence, the results indicate that an increase in hotel capacity or the development of the tourism sector can have a negative impact on environmental conditions, particularly with regard to MSW generation. **Table 5** reveals that a 1% increase in international or domestic tourists can lead to an additional generation of 3.6 kg of waste per tourist per day. It is worth noting that the total volume of waste generated from the tourism sector in this study is notably higher compared to previous research findings. For instance, Diaz-Farina et al. (2020) reported that tourists generate approximately 0.40 kg of MSW, while Mateu-Sbert et al. (2013) Click or tap here to enter text. estimated it to be around 1.31 kg.

Table 5. Test FMOLS and DOLS estimation result.

LnWaste	FMOLS		DOLS	
	***t*-stat**	***P*-value**	***t*-stat**	***P*-value**
Ln Hotel	133,647.5**	0.045	88,089.71***	0.000
Ln Sq Hotel	−9353.736**	0.062	−5952.5***	0.000
Ln Population	111,855.6***	0.000	147,130.9***	0.000
Ln GDRP	7238.022	0.587	−26,416.68***	0.000
Cons_	−1,831,268***	0.000	−1,831,332***	0.000
Turning Point	7.1440716		7.3993868	
R-Squared	0.0873746		0.9068674	
Long Run S. E	0.1294857		0.1213436	

* Significant at 10%, ** Significant at 5%, *** Significant at 1%.

The EKC theory primarily emphasizes the turning point of the curve (Gui et al., 2019). In this context, the variable "Ln Sq Hotel" represents the Environmental Kuznet Curve, which serves as a key focus of the present research. The statistical significance of this variable is evident, with significance levels of 10% and 5%, respectively, in the FMOLS and DOLS estimations. Additionally, the variable representing population is also statistically significant at the 1% significance level in both the FMOLS and DOLS estimations. This underscores the importance of population as a factor in understanding the relationship between tourism development and waste generation in the context of the study.

4.2. The relationship between tourism development and municipal solid waste

A substantial body of literature currently delves into the impact of tourism growth on environmental degradation. This argument can be summarized in two main facets. First, in mature tourism industries, tourism growth often has a positive impact on environmental conditions. On the other hand, in the context of expanding tourism sectors, the pursuit of tourism development sometimes comes at the cost of environmental quality, leading to complex challenges for governmental authorities. West Nusa Tenggara has emerged as a focal point of Indonesia's governmental policies in recent years, as evidenced by the numerous regulations aimed at developing the tourism sector, with the Mandalika resort area at its core. It is noteworthy that the substantial challenges posed by the tourism industry in West Nusa Tenggara have yet to be thoroughly examined by researchers within the province.

Table 5 unequivocally confirms the hypothesis positing a strong and positive relationship between the expansion of tourism and environmental degradation in West Nusa Tenggara. These findings provide robust support for prior research endeavors. It is noteworthy that, in line with the research by Filimonau and De Coteau (2020), hospitality food waste emerges as the leading contributor to MSW within the tourism industry. Furthermore, it is important to acknowledge that the Government of Indonesia has issued regulations pertaining to Special Economic Zones in West Nusa Tenggara, leading to a noticeable increase in the number of hotels and accommodations in the region. This regulatory shift has likely played a significant role

in shaping the observed trends in waste generation and environmental impact associated with the burgeoning tourism sector in West Nusa Tenggara.

The hospitality sector, comprising both star and non-star establishments in West Nusa Tenggara, offers a range of services that can significantly contribute to the generation of MSW, with hotel buffets being a notable example (Dolnicar et al., 2020). As the hotel industry continues to expand within the tourism sector, the associated increase in the number of hotels is expected to result in a greater contribution of MSW to the environment, potentially leading to environmental depletion. Another contributing factor is the inclination of tourists to sample a wide variety of local foods in West Nusa Tenggara, which can lead to overconsumption and, consequently, a higher volume of MSW. It is also worth noting that in West Nusa Tenggara, the use of food delivery services via mobile apps is prevalent, making it easier for individuals to order food. Unfortunately, the majority of small and medium-sized enterprises (SMEs) and restaurants in tourism areas rely on non-degradable packaging materials such as Styrofoam and plastic, further exacerbating the waste generation issue.

The significant increase in waste generation by tourists, reaching 3.6 kg per tourist per day, can be attributed, in large part, to inadequate waste management practices in several cities in West Nusa Tenggara (Septarini et al., 2021; Wahyudin et al., 2017). As highlighted by Septarini et al. (2021), poor waste management, coupled with a lack of high-quality waste facilities in public areas, especially in key tourism destinations, is a common issue in West Nusa Tenggara. Despite efforts by regional governments to promote the importance of waste reduction, reuse, and recycling, the results have been less than promising. Additionally, the low level of awareness among the local population exacerbates the waste management challenge (Septarini et al., 2021; Septyanun et al., 2022). On a positive note, since 2017, large companies have been actively involved in Corporate Social Responsibility (CSR) initiatives aimed at preserving the environmental condition in West Nusa Tenggara, although the impact of these efforts may not yet be deemed significant (Septyanun et al., 2022). This highlights the complex interplay of factors contributing to waste management challenges in the region.

In the context of the general EKC, the underlying assumption is the presence of a non-linear, inverted U-shaped relationship between economic growth and environmental degradation over the long term. Remarkably, the present research successfully substantiates the existence of a Waste Kuznet Curve, exemplifying a U-shaped relationship between the tourism industry and MSW. This finding is vividly illustrated in **Figure 2** and corroborated by the statistical significance of the probability of the ln Sq Hotel variable in both FMOLS and DOLS estimations, with significance levels of 5% and 10%, respectively. Furthermore, **Figure 2** provides a clear visual representation of the inverted U-shaped relationship between these two examined variables, aligning closely with the findings of prior studies by Arbulú et al. (2015); Ercolano et al. (2018); Gui et al. (2019); Madden et al. (2019); Mazzanti and Zoboli (2009); Trujillo Lora et al. (2013); Yılmaz (2020). These collective results collectively underscore the presence of a U-shaped relationship between tourism industry growth and MSW generation, further contributing to the body of knowledge on this subject.

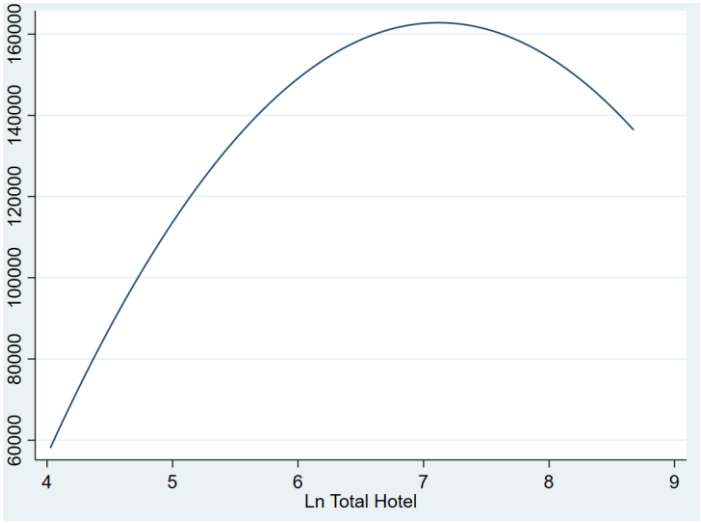

Figure 2. Waste Kuznet curve.

In the case of West Nusa Tenggara, the predicted turning points stand at $12.66 (FMOLS) and $16.34 (DOLS). Notably, these coefficients are relatively lower compared to those found in other WKC studies. For instance, Arbulú et al. (2015) estimated turning points ranging from approximately 44.836 Euro to 52.262 Euro in their research. However, it's worth mentioning that the predicted turning points in this study are slightly below those estimated by Yılmaz (2020) for developing countries, which amounted to around $12.548. These variations in turning points underscore the nuanced nature of the relationship between tourism industry growth and waste generation, with regional and contextual factors contributing to the differences observed in these studies.

4.3. The relationship between local population and municipal solid waste

The third objective of this research is to distinguish between the contributions of local residents and tourists to MSW generation. While a substantial body of literature emphasizes the significant impact of tourism activities on environmental degradation, only a small fraction of research studies have delved into the differentiation between the roles of local communities and tourists in this context (Arbulú et al., 2015). As discussed earlier, the study confirms that tourist activities, particularly those related to hotels, indeed contribute to the generation of MSW. However, it is equally crucial to incorporate the local population into this research because local residents also play a role in MSW generation. Although the relationship between population and environmental depletion remains a contentious topic, many researchers have utilized population density and the level of urbanization as proxies for local population. Nevertheless, it is imperative to acknowledge that each individual within the local population makes their unique contribution to local MSW generation.

The previous research examining the impact of population and urban density on environmental conditions has considered both the long run and short run effects. As noted by Nyland et al. (2021b), the permanent population tends to contribute more significantly to MSW generation due to their daily activities, which encompass a wide range of sectors including agriculture, education, transportation, and others. This finding is corroborated by other research studies such as those by Andriansyah et al.

(2019); Bayar et al. (2021); Liu et al. (2022); Mance et al. (2020); Mateu-Sbert et al. (2013); Shamshiry et al. (2011). The implication drawn from this body of research is that an increase in population or urbanization levels can lead to higher MSW generation if not managed effectively (Pham Phu et al., 2018; Sekito et al., 2019). According to Septarini et al. (2021), in the case of West Nusa Tenggara, a significant increase in MSW generated by the local population has been observed over the past decade. Additionally, Shamshiry et al. (2011) suggest that population growth and urbanization can intensify waste production among the population, driven by changing consumption patterns and an increased prevalence of plastic waste.

5. Conclusion

The primary objective of this research is to investigate the existence of the Waste Kuznet Curve in the context of tourism development in West Nusa Tenggara. The findings can be summarized in three key points. Firstly, the empirical results confirm the presence of a long-term relationship between tourism development and environmental degradation. It can be concluded that the expansion of the tourism sector in West Nusa Tenggara comes at the cost of environmental quality. Secondly, it is noteworthy that the decline in environmental quality in West Nusa Tenggara can also be attributed to the growth in the local population, as affirmed by both FMOLS and DMOLS analyses. Lastly, the predicted turning points in the case of West Nusa Tenggara are estimated to be $12.66 (FMOLS) and $16.34 (DOLS). Given the established long-term relationship among the variables, it is imperative for the government to prioritize the development of the tourism industry while simultaneously implementing effective waste management strategies to mitigate environmental degradation. Additionally, this research emphasizes the concept of environmental carrying capacity, crucial for understanding the sustainable limits of tourism activities without compromising environmental health. It highlights the necessity for robust waste management systems and sustainable practices to uphold this capacity and ensure the long-term sustainability of tourism in West Nusa Tenggara.

Future research in this area could be enhanced by incorporating the government budget allocated for waste management in West Nusa Tenggara. The authors recognize that government policies and funding can play a significant role in improving environmental quality, including reducing MSW in the region. Additionally, it would be valuable for future studies to delve deeper into the individual and household characteristics that influence waste generation and management. Consumption patterns among tourists and local populations can vary significantly, leading to different waste management needs. Examining waste generation at the individual or household level could provide further insights. Furthermore, as the concept of the Environmental Kuznet Curve has evolved into a more complex "N-shaped" curve, future research endeavors should aim to accommodate this nuanced curve and apply it to the context of West Nusa Tenggara. This would contribute to a more comprehensive understanding of the relationship between economic development, tourism, and environmental quality in the region.

Based on the findings, several policy recommendations can be made to address the environmental impacts of tourism in West Nusa Tenggara. It is crucial for the

government to develop and enforce strict waste management regulations to control the amount of municipal solid waste generated by both tourists and the local population. Investing in waste management infrastructure and promoting recycling and waste reduction programs are essential steps. Additionally, policies should encourage sustainable tourism practices among local businesses and tourists, such as promoting eco-friendly accommodations and activities. Public awareness campaigns on the importance of environmental conservation and waste management should be intensified to foster a sense of responsibility among tourists and locals alike. Collaborative efforts between government agencies, local communities, and the private sector are necessary to create and implement effective solutions for sustainable tourism development in West Nusa Tenggara.

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