

The Effect of the COVID-19 Pandemic on Waste Management in the Eastern Tourism Regions of Java and Bali Islands

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ABSTRACT

The tourism sector is one of the sectors that has been negatively affected by the COVID-19 pandemic. Increased waste generation is a significant problem that tourist areas must face during the COVID-19 pandemic. Therefore, to reduce the impact, research was carried out on waste management before and during the pandemic in regional tourism areas, especially in the eastern part of Java and Bali. This study aims to analyze the changes and composition of waste and during the COVID-19 pandemic in tourist areas in the Eastern Tourism Areas of Java and Bali. Collecting, processing data, and statistical analysis carry out the research method. Based on the study results, the waste generation generated in eight eastern regencies of Java and Bali experienced a change between -5.67% to 1.82%. Plastic waste increased by 27.61% during the pandemic, while mask waste increased by 1.23% in one area. Waste management also changed from -0.011% to 1.821%. The analysis results using ANOVA showed that the COVID-19 pandemic significantly affected the amount of waste generated by the eight tourist areas, with the main contribution caused by an increase in mask waste.

Keywords: waste management, tourism area, COVID-19.

INTRODUCTION

The COVID-19 pandemic is a new type of disease caused by a new variant of the SARS-CoV-2 virus. This pandemic started in Wuhan, China, and spread worldwide [Acter et al., 2020; Hu et al., 2021; Pan et al., 2020]. This virus attacks the respiratory system in humans and causes various symptoms such as cough, fever, shortness of breath, anosmia or loss of the sense of smell, and diarrhoea [Ahmed et al., 2020]. Since the end of 2019, the COVID-19 pandemic has become a

significant problem that is difficult to deal with worldwide. The high rate of transmission, the lack of health facilities, and the public's lack of discipline in complying with health protocols are the main factors for the increasing number of sufferers of the COVID-19 pandemic. As one of the most densely populated archipelagic countries, Indonesia occupies the 14th position with the highest number of COVID-19 cases globally. The high number of COVID-19 sufferers in Indonesia has made the government always strive to implement policies that can reduce the number of cases of

COVID-19 transmissions, such as using personal protective equipment, maintaining a safe distance, staying away from crowds, and washing hands with soap [Firmansyah et al., 2020]. It is estimated that masks waste generated in Indonesia can reach 159,214,791 pieces/day and produce medical waste of 420.03 tons/day [Sangkham, 2020]. As a result of these policies, the consumption of hygienic and health products has increased, causing various environmental problems.

The environmental problem that emerged during the COVID-19 pandemic was increased waste generation from plastic products [Benson et al., 2021]. This increase was due to the increasing consumption of plastic products such as disposable masks, gloves, drink bottles, sanitation tools and cleaning products [Cordova et al., 2021; Sari, Inoue, et al., 2022]. Waste management during the pandemic is also one of the main factors for the emergence of various environmental problems. During the COVID-19 pandemic, human interaction will be limited, and people will often carry out activities indoors, making waste management difficult [Sarkodie & Owusu, 2021]. As a result, waste cannot be managed properly and can cause various diseases and pollution in the surrounding environment.

The COVID-19 pandemic is a new type of disease caused by a new variant of the SARS-CoV-2 virus. This pandemic started in Wuhan, China and spread massively throughout the world. This virus attacks the respiratory system in humans and causes various symptoms such as cough, fever, shortness of breath, anosmia or loss of the sense of smell, and diarrhoea. Since the end of 2019, the COVID-19 pandemic has become a significant problem that is difficult to deal with worldwide. The high rate of transmission, the lack of health facilities, and the public's lack of discipline in complying with health protocols are the main factors for the increasing number of sufferers of the COVID-19 pandemic. As one of the most densely populated archipelagic countries, Indonesia occupies the 14th position with the highest number of COVID-19 cases globally. The high number of COVID-19 sufferers in Indonesia has made the government always strive to implement policies that can reduce the number of cases of COVID-19 transmissions, such as using personal protective equipment, maintaining a safe distance, staying away from crowds, and washing hands with soap. As a result of these policies, the consumption of hygienic and health products has increased, causing various environmental problems.

The environmental problem that emerged during the COVID-19 pandemic was increased waste generation from plastic products [Benson et al., 2021]. This increase was due to the increasing consumption of plastic products such as disposable masks, disposable gloves, drink bottles, sanitation tools and cleaning products [Canning-Clode et al., 2020]. Waste management during the pandemic is also one of the main factors for the emergence of various environmental problems. During the COVID-19 pandemic, human interaction will be limited, and people will often carry out activities indoors, making waste management difficult [Sari et al., 2023; Sarkodie & Owusu, 2021; Septiariva et al., 2022]. As a result, waste cannot be managed properly and can cause various diseases and pollution in the surrounding environment. The purpose of this study is analysis the changes and composition of waste during and during the COVID-19 pandemic in tourist areas in the Eastern Tourism Areas of Java and Bali.

METHODOLOGY

The waste generation data used for this study were taken from the national waste management information system [Kementerian Lingkungan Hidup dan Kehutanan, 2021]. The data used are waste generation and composition data in 2019 and 2020. The 2019 data is expected to describe the conditions before the pandemic, while 2020 data describes requirements during the pandemic. Waste generation data is used to show the amount of waste generated every day. At the same time, the waste generation rate is used to show the amount of waste generated for each resident. The waste generation rate is calculated using the total waste generated divided by the total population (Equation 1). Population data is obtained from each data centre statistical agency for each study location. The comparison of the amount of waste is calculated by comparing the difference between 2020 and 2019 divided by 2020. This figure shows whether there was an increase or decrease in waste generation during the pandemic [Tchobanoglous & Vigil, 1993].

$$\begin{aligned} \text{Waste generation rate (kg/day.cap)} &= \\ &= \frac{\text{Waste generation (kg/day)}}{\text{Total population (cap)}} \end{aligned} \quad (1)$$

The composition of plastic waste is obtained from the data centre of the national waste

management information system. Meanwhile, it is obtained from the generation of waste multiplied by the percentage composition to show the waste generation of plastic waste. The estimated generation of mask waste is obtained from calculations and assumptions. The data used is the average weight of the mask per sheet, which is 20 grams. In contrast, the population is used to predict the amount of mask waste generation where the assumption is that 25% of the population works outside the home. An analysis of the used waste through waste banks during the pandemic was also carried out to see the difference in processed waste. Waste managed in the waste bank is the total waste that is recovered every day for each region.

The results of data processing from this study are made in infographics. The analysis used percentage changes of total waste generation, plastic waste generation, mask waste generation, and waste management by waste banks. The data analysis technique used in this research is qualitative and quantitative. First, qualitative analysis was carried out using a literature review. Meanwhile, quantitative analysis was carried out using ANOVA and correlation statistics. The dependent variable used is the change in total waste generation. In contrast, the independent variable is the change in the waste generation of plastic waste, the difference in the waste generation of mask waste, and changes in a waste reduction made by the waste bank. This independent variable was chosen to see whether there is a correlation to the total waste generation.

RESULT AND DISCUSSION

Based on the observations, the amount of waste generated in the east of Java and Bali did not experience a significant change but experienced a slight decrease and increase. Table 1 shows the total waste generation before and during the COVID-19 pandemic in several districts in Java and Bali. Based on the data in Table 1, the decrease in waste generation occurred in Badung Regency (Bali), Banyuwangi Regency (East Java), Probolinggo Regency (East Java), and Bantul Regency (Yogyakarta). Meanwhile, the increase in the amount of waste generated occurred in four districts, namely Bangli Regency (Bali), Gianyar Regency (Bali), Malang Regency (East Java), and Lumajang Regency (East Java). Malang Regency experienced the most significant increase in the amount of waste generation among eight other regencies. In 2019 before the pandemic, the amount of waste generated in Malang Regency was 1042.48 tons per day, then increased to 1061.78 tons per day during the COVID-19 pandemic in 2020. This is contrary to the results of previous research at the beginning of the COVID-19 pandemic which stated that there was a decrease in waste generation during the COVID-19 pandemic in Bali Province [Suryawan et al., 2021], Surakarta [Sari, Septiariva, et al., 2022], and Riau Island [Sari et al., 2023].

Meanwhile, Bantul Regency experienced the most significant decrease in waste generation among other districts, which is 555.92 tons per day in 2019 and 526.09 tons per day in 2020.

Table 1. Total waste generation before and during the COVID-19 pandemic

Location	Year	Total waste generation (ton/day)	Total population ¹	Rate waste generation (kg/cap·day)	Waste generation difference (%)
Bali, Bangli Regency	2020	108.98	178071	0.612	0.87
	2019	108.03		0.607	
Bali, Gianyar Regency	2020	438.86	516300	0.850	0.80
	2019	435.37		0.843	
Bali, Badung Regency	2020	281.24	683200	0.412	-0.78
	2019	283.42		0.415	
Jawa Timur, Malang Regency	2020	1,061.78	2619975	0.405	1.82
	2019	1,042.48		0.398	
Jawa Timur, Lumajang Regency	2020	501.46	1044700	0.480	0.22
	2019	500.35		0.479	
Jawa Timur, Banyuwangi Regency	2020	1221.97	1617814	0.755	-2.00
	2019	1246.41		0.770	
Jawa Timur, Probolinggo Regency	2020	461.0	239649	1.924	-1.11
	2019	466.1		1.945	
Yogyakarta, Bantul Regency	2020	526.09	954706	0.551	-5.67
	2019	555.92		0.582	

Meanwhile, the most considerable waste generation rate is owned by Probolinggo Regency, which is 1.945 kg/capita.day in 2019 and decreased to 1.924 kg/capita.day capita.days in 2020. The high increase in the amount of waste generated during the COVID-19 pandemic in Malang Regency was caused by the high number of confirmed COVID-19 cases in the region, which was 14,327 positive cases compared to Lumajang, Banyuwangi, and Probolinggo Regencies [Pemerintah Jawa Timur, 2021]. The high number of positive cases of COVID-19 has led to increased consumption of medical equipment and personal protective equipment, resulting in high waste generation. Meanwhile, Bantul Regency experienced a decrease in the amount of waste generated due to the declining public interest in tourism in the area. Interest in tourism during the pandemic has decreased significantly [Agapa et al., 2021]. This has an impact on reducing the amount of waste generated in the tourism area, including the Bantul Regency (Figure 1).

The COVID-19 pandemic has not only caused a decrease or increase in the amount of waste generated in tourist areas but has also changed the types of waste produced by the community. The COVID-19 pandemic has an impact on human health and has an impact on the environment.

During the pandemic, the consumption of single-use tools such as masks and medical equipment experienced a significant increase. Based on the data in Table 2, it is shown that, in general, during the COVID-19 pandemic, the amount of plastic waste experienced a significant increase. In contrast, the mask waste that was not originally there became available during the pandemic.

The data shows that during the COVID-19 pandemic, Badung Regency (Bali) experienced the most significant increase in plastic waste generated compared to other districts. In 2019 it was noted that Badung Regency (Bali) did not have the generation of plastic waste, then in 2020, the generation of plastic waste increased significantly by 27.61%. The districts with the second and third largest amounts of plastic waste are Bantul (Yogyakarta) and Bangli (Bali) districts with an 18.13% and 10.50% increase in plastic waste, respectively.

Meanwhile, Malang Regency (East Java) is the only regency that experienced a decrease in plastic waste generation. In 2019, the generation of plastic waste in Malang Regency (East Java) was 15.16%, then in 2020, it decreased to 14.82% (Figure 2). As for the generation of mask waste, it is known that Malang Regency (East Java) experienced the most significant increase compared to other districts, namely 1.23%. The

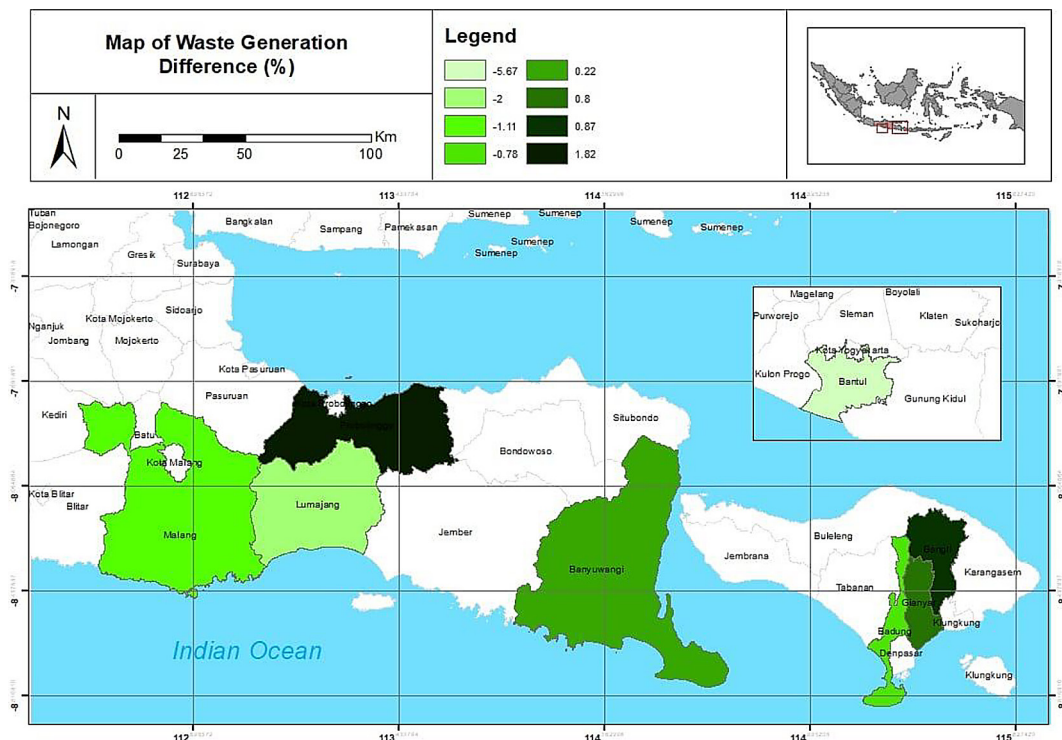


Figure 1. Changes in Waste Generation During the COVID-19 Pandemic in the Eastern Tourism Regions of Java and Bali Islands

Table 2. Generation and composition of plastic waste and masks before and during the COVID-19 pandemic

Location	Year	% Plastic waste	Total plastic waste generation (ton/day)	% Mask waste	Total mask waste generation (ton/day)	% Other waste	Total other waste generation (ton/day)	% Plastic waste generation difference	% Mask waste increase
Bali, Bangli Regency	2020	14.5	15.80	0.82	0.89	84.7	92.3	10.50	0.82
	2019	4	4.32	0	0	96.0	103.7		
Bali, Gianyar Regency	2020	17.08	74.96	0.59	2.58	82.3	361.3	0.07	0.59
	2019	17.01	74.06	0	0	83.0	361.3		
Bali, Badung Regency	2020	27.61	77.65	1.21	3.42	71.2	200.2	27.61	1.21
	2019	0	0.00	0	0	100.0	283.4		
Jawa Timur, Malang Regency	2020	14.82	157.36	1.23	13.10	83.9	891.3	-0.34	1.23
	2019	15.16	158.04	0	0	84.8	884.4		
Jawa Timur, Lumajang Regency	2020	18.2	91.27	1.04	5.22	80.8	405.0	0.40	1.04
	2019	17.8	89.06	0	0.00	82.2	411.3		
Jawa Timur, Banyuwangi Regency	2020	21.76	265.90	0.01	8.09	78.2	948.0	0.00	0.01
	2019	21.76	271.22	0	0	78.2	975.2		
Jawa Timur, Probolinggo Regency	2020	16.9	77.91	0.003	1.20	83.1	381.9	0.00	0.003
	2019	16.9	78.77	0	0	83.1	387.3		
Yogyakarta, Bantul Regency	2020	24.33	128.00	0.65	4.77	75.0	393.3	18.13	0.65
	2019	6.2	34.47	0	0	93.8	521.5		

Badung Regency (Bali) and Lumajang Regency (East Java) followed with 1.21% and 1.04%, respectively. Based on these data, it was concluded that during the COVID-19 pandemic, the number of masks and plastic used increased. This is because, during the pandemic, people needed to

use personal protective equipment in the form of masks and needed more hygienic products with single-use plastic packaging such as processed products, food and health products [Ammendolia et al., 2021; de Sousa, 2020; Septiariva et al., 2022; Sharma et al., 2020].

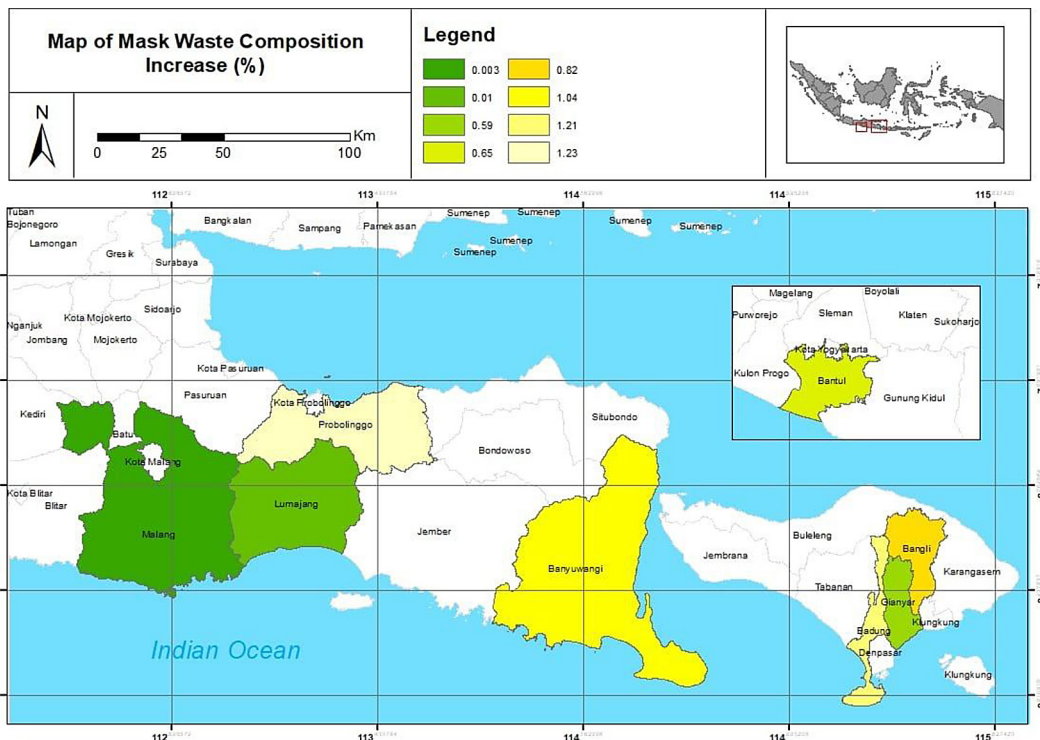


Figure 2. Changes in mask waste composition during the COVID-19 Pandemic in the eastern tourism regions of Java and Bali Islands

During the COVID-19 pandemic, changes occurred in the types of waste, the amount of waste generated, and the percentage of waste management in each related district. Based on Table 3, during the COVID-19 pandemic, four districts experienced a decline in waste management, namely Bangli Regency (Bali), Lumajang Regency (East Java), Banyuwangi Regency (East Java), Probolinggo Regency (East Java). Meanwhile, other districts experienced an increase in waste management. Bangli Regency (Bali) experienced the most decline in waste management than other regencies, -0.011%. In 2019, Bangli Regency (Bali) was able to process 155.23 kg of waste in the Waste Bank per day, then decreased when the pandemic took place in 2020 to 144.45 kg per day.

Meanwhile, the most significant increase in waste management was found in Bantul Regency (Yogyakarta), which was 1.821%. In 2019, the district of Bantul (Yogyakarta) processed 6005.89 kg of waste per day than during the COVID-19 pandemic, and the waste was processed into 15309.44 kg/day (Figure 3). The difference in the amount of waste managed before and during the COVID-19 pandemic. The difference was caused by various factors, such as the increasing number of COVID-19 sufferers in the district. Therefore, it is difficult for waste management officers to carry out their activities; the high increase in waste during the pandemic and differences in policies in each district are related to waste management at the Waste Bank.

Turnover is estimated to have decreased by around 70% due to the Covid-19 pandemic. Currently, many plastic seeds are stored (not sold) to wait for prices to stabilize. The process of supplying raw materials is taken from used goods stalls. Plastic does not receive it directly from scavengers. It aims to keep the chain of social entrepreneurship from breaking. This means that the owner of the used goods stall can still exist [Saragih & Elisabeth, 2020]. In addition, the waste bank was not active during the Covid-19 Pandemic, so that garbage piled up on the customer's side. There was a lack of literacy about waste, and most customers did not understand the impact caused by waste and how to manage waste banks. [Antin et al., 2020]. The effect of the COVID-19 pandemic on the sustainability of waste bank operations has had economic implications that customers collected from waste banks decreased by up to 84% due to the pandemic [Anastasya et al., 2021].

In this study, statistical analysis was carried out using ANOVA (Analysis of Variance) analysis to determine the relationship between the dependent variable and changes in total waste generation. The independent variables are changes in plastic waste generation, changes in mask waste generation, and changes in waste reduction by the waste bank. Based on the results of the ANOVA test in Table 4, the calculated F value is 9.604 with a significance of 0.027. A significance value of less than 0.05 identifies

Table 3. Differences in managed waste in waste banks before and during the COVID-19 pandemic

Location	Year	Managed waste in the waste bank (kg/day)	Total waste reduction (%)	Difference during and before pandemic (%)
Bali, Bangli Regency	2020	144.45	0.13	-0.011
	2019	155.23	0.14	
Bali, Gianyar Regency	2020	2058.75	0.47	0.114
	2019	1547.51	0.36	
Bali, Badung Regency	2020	3668.25	1.30	0.103
	2019	3403.56	1.20	
Jawa Timur, Malang Regency	2020	5806.39	0.55	0.139
	2019	4249.64	0.41	
Jawa Timur, Lumajang Regency	2020	698.63	0.14	-0.004
	2019	714.74	0.14	
Jawa Timur, Banyuwangi Regency	2020	21.32	0.002	-0.001
	2019	36.52	0.003	
Jawa Timur, Probolinggo Regency	2020	182.40	0.04	-0.005
	2019	207.46	0.04	
Yogyakarta, Bantul Regency	2020	15309.44	2.91	1.821
	2019	6055.89	1.09	

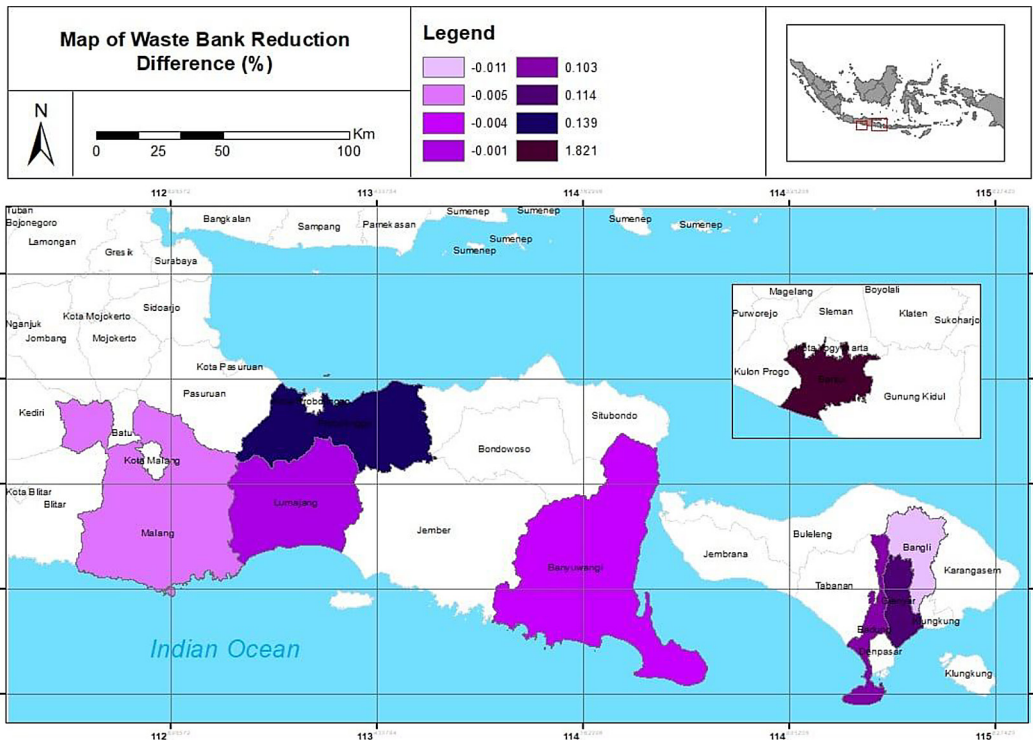


Figure 3. Changes in Waste Bank reduction during the COVID-19 Pandemic in the eastern tourism regions of Java and Bali Islands

the hypothesis H0 is rejected, and H1 is accepted [Larson, 2008]. This indicates that the independent variable affects the dependent variable. It can be interpreted that various factors influence the total waste generation in a district.

Meanwhile, the correlation between independent variables on differences in waste generation is shown in Table 5. Based on the results of the ANOVA analysis in Table 5, it is shown that a significance value <0.05 was obtained in the change in mask waste variable and the difference in waste generation variables

during and before the pandemic, namely each, respectively 0.061 and 0.02. While the significance value > 0.05 was obtained from the plastic waste difference variable of 0.291. Meanwhile, the regression analysis showed that the dependent variable negatively affected the independent variable (-1.259). Therefore, from the ANOVA analysis, it can be concluded that the change in waste generation in eight tourist areas in the eastern part of Java and Bali was caused by an increase in mask waste due to the COVID-19 pandemic.

Table 4. ANOVA test results between independent variables on waste generation difference (%)

Parameters	Sum of squares	Df	Mean square	F	Sig.
Regression	33.78	3	11.26	9.604	0.027
Residual	4.69	4	1.172		
Total	38.469	7			

Table 5. Correlation between independent variables on waste generation difference (%)

Variable	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. error	Beta		
(Constant)	-1.259	0.719		-1.751	0.155
% Plastic waste generation difference	-0.014	0.012	-0.258	-1.216	0.291
% Mask waste increase	2.429	0.939	0.503	2.586	0.061
Differences during and before the pandemic waste bank management (%)	-2.703	0.72	-0.726	-3.752	0.02

CONCLUSIONS

Based on the study results, waste generation in eight regional tourist areas in the eastern part of Java and Bali experienced an increase of no more than 2% and a decrease of no more than 6% during the pandemic. Changes in the composition of waste generation also occurred during the COVID-19 pandemic in the eight districts. The amount of plastic waste and masks, on average, has increased. Badung Regency experienced the highest increase in plastic waste generation by 27.61%, while Malang Regency experienced the most significant increase in mask waste generation by 1.23%. Meanwhile, the increase in waste management during the pandemic occurred in four districts, namely Bangli, Lumajang, Banyuwangi and Probolinggo districts, while the rest experienced a decrease of up to 0.011%. The research and ANOVA analysis results concluded that the COVID-19 pandemic impacted the amount of waste generated in the regional tourist areas of the eastern part of Java and Bali. The significant difference in the generation was due to an increase in mask waste due to the COVID-19 pandemic.

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