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Potential improvement of Environmental Quality Index (EQI) based on district-level data case study in Bekasi Regency

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Abstract. *Bekasi Regency experiences an increase in population every year that significantly affects the Environmental Quality Index (EQI) in Bekasi Regency. The EQI is a value that can describe the quality of the environment in an area at a specified time. The Regency EQI is a composite of the Water Quality Index (WQI), Air Quality Index (AQI), and Land Quality Index (LQI). In this study, the calculation of the environmental quality index used existing data in the Bekasi Regency area. All Environmental Quality Indexes positively affect the fulfillment of basic needs. This study wants to show the potential for increasing the environmental quality index from the difference between the results of the calculation of the environmental quality index with existing data in Bekasi Regency and the results of the calculation of the environmental quality index by the Ministry of Environment and Forestry. The calculations in this research show the EQI Based on district level data in Bekasi Regency is 47,56. When using existing data in the Bekasi Regency region, there is the potential for an increase in the environmental quality index of 6,3.*

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INTRODUCTION

Bekasi Regency is one of the regencies in West Java Province, located East of Jakarta, the gateway for West Java from the state capital and one of the hinterlands for the state capital. Bekasi Regency is the largest industrial area in Southeast Asia. Bekasi Regency has ten areas, namely MM2100 Industrial Town, East Jakarta Industrial Park, Gobel Industrial Estate, Jababeka Industrial Estate, Indonesia-China Integrated Industrial Estate (KITIC), Lippo Cikarang, MM 2100 Industrial Estate, Greenland Int. Industrial Center and Marunda Center, as well as several zones. Bekasi Regency is one of the largest industrial centers in West Java, even in Southeast Asia. Most types and industrial activities in the Bekasi Regency area are the types of processing industries (Bekasi Regencial Environment Agency 2019).

A reasonably rapid population increase also follows the development of industrial activities in the Bekasi Regency. The recorded population in Bekasi Regency in 2018 was 3.631.000 people, with an average population density of 2.748 people per km^2 (BPS-Statistics Indonesia 2019). This condition can affect the Bekasi Regency's air quality, water quality, and land cover. This condition also leads to changes in the

Environmental Quality Index (EQI), making the success of environmental management performance in the Bekasi Regency less suitable. The Ministry of Environment has been adopting the EQI, which is a development of a concept developed by Virginia Commonwealth University (VCU) and the BPS-Statistics Indonesia using water quality, air quality, and land cover as indicators.

The EQI is an early indication to provide a quick conclusion of an environmental condition at a specific scope and period. It can be used as an instrument for the government's success in protecting and managing the environment (MoEF 2018). Suryani (2018) defines environmental quality as an environmental condition that can provide optimal carrying capacity for human survival in an area. The Regency's Environmental Quality Index calculation changes every year, with a new regulation issued, namely the Minister of Environment and Forestry Regulation Number 27 of 2021 concerning the Environmental Quality Index, so this calculation is urgently needed to follow the latest regulations. The Minister of Environment and Forestry Regulation Number 27 of 2021 regulated the calculation of The Environmental Quality Index. Based on the regulation, the Regency Environmental Quality Index consists of the Water Quality Index (WQI), Air Quality Index (AQI), and Land Quality Index (LQI).

Based on the regulation of the minister of environment and forestry number 27 of 2021, The calculation of the WQI in 2021 is different from 2020 because the parameter data for NH3-N (ammonia), Total Coliform, and TDS are no longer used due to Minister of Environment and Forestry Regulation Number 27 of 2021. The Ministry of Environment and Forestry has calculated the environmental quality index but does not use district-level data. In this study, the calculation of the environmental quality index used existing data in the Bekasi Regency area. This study wants to show the potential for increasing the environmental quality index from the difference between the results of the calculation of the environmental quality index with existing data in Bekasi Regency and the results of the calculation of the environmental quality index by the Ministry of Environment and Forestry. The benefit of this research is as a study substance for the Regional Government in determining the EQI by using district-level data.

RESEARCH METHODS

Study Area

The location of research was conducted in Bekasi Regency. Bekasi Regency is one of the regencies in West Java Province, located east of DKI Jakarta, and is one of the buffers for the state capital. Bekasi Regency is also the largest industrial area in Southeast Asia. The location of Bekasi Regency is at 6°10'-6°30' South Latitude 106°48'78"-107°27'29" East Longitude. Bekasi Regency is 127.388 Ha and Bekasi Regency has 23 Districts. Data collection for research, processing, and analysis was carried out in July – December 2021.

Methods of Collecting Data

The first step before carrying out data processing and analysis is collecting data. The data collection method used is the secondary data collection method. The collection of secondary data on water and air quality in the Bekasi Regency was obtained from the Bekasi Regency Environmental Service. In contrast, this research took the land cover data from Image Spot 6, then processed it using Arc GIS to obtain the land cover area. Other supporting data is obtained through literature studies from relevant agencies or various other sources, such as the publication of statistical information by the Public Housing, Settlement, and Land Areas of Bekasi Regency, the Environment Agency, and the Bekasi Regency Regional Development Planning Agency. The types and sources of data used in this study are based on regional data as follows: Results of water quality monitoring in 18 rivers in Bekasi Regency; Results of air quality monitoring in Bekasi Regency; and Data on the land cover area in Bekasi Regency.

Data Analysis Method

This research uses quantitative methods. This research's quantitative data analysis method is a data processing approach through mathematical methods collected from secondary data. The advantage of this method is a more measurable and comprehensive conclusion. The EQI is a composite of the WQI, AQI, and LQI. The explanation of the analysis method for the Environmental Quality Index is as follows:

Water Quality Index (WQI)

The following is the method to calculate the Bekasi Regency WQI Based on the regulation of the minister of environment and forestry number 27 of 2021, as used in this study:

1. Calculating the water quality status at all monitoring locations for river water bodies for eight parameters, namely pH, DO, BOD, COD, TSS, Nitrate, Total Phosphate TP, and Fecal Coliform, using the Pollution Index (PI) according to the Decree of the State Minister of the Environment Number 115 of 2003 concerning Guidelines for Determining the Status of Water Quality.
2. The water class used is class 2 of the National Water Quality Standard according to Attachment VI of PP RI No. 22 of 2021 concerning the Implementation of Environmental Protection and Management.
3. Using the Pollution Index against time-series data, calculate the average of the pollution index values for each time.
4. Determine the quality status of each location with the provisions of 0 IPj 1.0: Good (meets quality standards); 1.0 IPj 5.0: lightly polluted; 5.0 IPj 10.0: moderately polluted; IPj > 10.0: heavily polluted.
5. Count the number of each quality status (good, lightly polluted, moderately polluted, and heavily polluted) for all locations.
6. Calculate the percentage of the number of each quality status with the total amount.
7. The weight of the index value is multiplied by the fraction of the transformation of compliance with quality requirements to convert the IP value into the WQI/IKA (*Indeks Kualitas Air*). The percentage of samples meeting quality requirements is calculated by adding the number of sample points that meet quality standards to the total number of samples.
8. The weight of the national index has a limitation namely, it meets the quality standard: 70; Lightly polluted: 50; Moderately polluted: 30; and Heavily polluted: 10.
9. Calculate the WQI value for the Bekasi Regency, which is the average of the WQI for all water bodies in its administrative area.

Air Quality Index (AQI)

Based on the regulation of the minister of environment and forestry number 27 of 2021, The following is the method of calculating the AQI of Bekasi Regency used in this study:

1. Calculate the average of each NO_2 and SO_2 parameter for each location at each stage (one year consists of 2 stages)
2. Calculate the annual average concentration of NO_2 and SO_2 parameters by calculating the average SO_2 and NO_2 parameters at the four sampling locations (transportation, industry, settlements/housing, and offices)
3. Calculate the district's annual average concentration of SO_2 and NO_2 parameters by calculating the district's average annual concentration

Calculating the EU model air index (IEU) is converted to the AQI index using the following formula:

$$\text{AQI} = 100 - [\frac{50}{0,9} \times (\text{IEU} - 0,1)]$$

Note: IEU is the average monitored SO_2 concentration divided by the ambient air quality standard SO_2 Ref EU, and NO_2 monitored by the ambient air quality standard NO_2 Ref EU. The Ref EU ambient air quality standard for SO_2 is 20 g/m^3, and NO_2 is 40 g/m^3.

Land Quality Index (LQI)

The method of calculating the LQI of Bekasi Regency based on the regulation of the minister of environment and forestry number 27 of 2021, which will be used in this study, is:

1. They were interpreting image data to find out the land cover area in the Bekasi Regency
2. Calculate the area of land cover in the Bekasi Regency
3. Calculate Land Cover Area (LCA) with the formula

$$LCA = (FCA) + ((SA + SAapl + Agos) \times 0,6) + (FRA \times 0,6)$$

Information:
LCA : Land Cover Area
FCA : Forest Cover Area
SA : Scrub Area in Forest Area
SAapl: Scrub Area in APL
Agos : Area Of Green Open Space
FRA : Forest Rehabilitation Area

4. LQI calculation with the following formula

$$LQI = 100 - ((84,3 - ((\frac{LCA}{RA} - ICF) \times 100)) \times \frac{50}{54,3})$$

Information:
LCA : Land Cover Area
RA : Regency Area
ICF : The Impact of Canals and fires on The Unity of The Peat Ecosystem

Environmental Quality Index (EQI)

The following is the method of calculating the EQI of Bekasi Regency Based on the regulation of the minister of environment and forestry number 27 of 2021, which was used in this study:

$$EQI\ (Regency / City) = (0,376 \times WQI) + (0,405 \times AQI) + (0,219 \times LQI)$$

Information:
EQI : Environmental Quality Index
WQI : Water Quality Index
AQI : Air Quality Index
LQI : Land Quality Index

RESULTS AND DISCUSSION

Water Quality Index (WQI) in Bekasi Regency

The calculation of the Water Quality Index in 2021 is different from 2020 because it no longer uses parameter data for NH3-N (ammonia), Total Coliform, and TDS. Monitoring river water quality results strongly affects the Water Quality Index (WQI) in Bekasi Regency. The river water quality standard used in calculating the WQI in Bekasi Regency is Attachment VII PP No. 22 of 2021. The Bekasi Regency Environmental Agency carried out river water sampling in May, July, and October. The results of monitoring river water quality in May are called the first period. The results of monitoring river water quality in July are called the second period.

The results of monitoring river water quality in October are called the third period. Based on monitoring at several monitoring locations, it can be seen that a lot of waste from household activities is directly channeled into drainage channels or directly into rivers (Bekasi Regencial Environment Agency 2020). The increased

discharge of domestic wastewater generated can lead to an increase in the burden of domestic wastewater pollution. Domestic wastewater pollution can cause physical, chemical, and biological parameters in river water to increase so that it exceeds the quality standard limit. The results of the calculation of water quality status at each location in monitoring river water quality for periods 1, 2, and 3 in 2021 are based on regional data as shown in Table 1.

Table 1 Results of calculation of river quality status periods 1, 2, and 3 in Bekasi Regency

No.	River	First Period		Second Period		Third Period	
		PI	Water Quality Status	PI	Water Quality Status	PI	Water Quality Status
1	Upstream Jaeran River	3,653	Light	3,641	Light	1,555	Light
2	Sungai Jaeran Hilir Downstream Jaeran River	4,082	Light	2,289	Light	6,157	Moderate
3	Upstream Sasak Jarang River	3,664	Light	3,227	Light	4,063	Light
4	Downstream Sasak Jarang River	3,172	Light	6,032	Moderate	0,769	Good
5	Upstream Jambe River	7,002	Moderate	7,685	Moderate	7,700	Moderate
6	Downstream Jambe River	6,944	Moderate	7,263	Moderate	6,874	Moderate
7	Upstream Babakan River	1,230	Light	7,378	Moderate	1,848	Light
8	Downstream Babakan River	3,546	Light	3,747	Moderate	3,725	Light
9	Upstream Pisangan River	2,656	Light	1,569	Light	3,391	Light
10	Downstream Pisangan River	3,371	Light	1,208	Light	5,600	Moderate
11	Upstream CBL River	2,648	Light	7,302	Moderate	1,553	Light
12	Downstream CBL River	3,875	Light	4,038	Light	4,026	Light
13	Upstream Bekasi River	2,065	Light	1,659	Light	4,078	Light
14	Downstream Bekasi River	1,813	Light	1,155	Light	0,510	Good
15	Upstream Cipamingkis River	6,064	Moderate	2,264	Light	6,115	Moderate
16	Downstream Cipamingkis River	5,753	Moderate	2,278	Light	6,457	Moderate
17	Upstream Cikadu River	3,665	Light	3,676	Light	5,728	Moderate
18	Downstream Cikadu River	2,094	Light	3,502	Light	5,869	Moderate
19	Upstream Cibeet River	5,612	Moderate	0,731	Good	4,383	Light
20	Downstream Cibeet River	6,954	Moderate	3,267	Light	6,050	Moderate
21	Upstream Cilemahabang River	2,842	Light	3,236	Light	4,485	Light
22	Downstream Cilemahabang River	2,490	Light	2,669	Light	4,369	Light
23	Upstream Ciherang River	1,248	Light	2,947	Light	4,788	Light
24	Downstream Ciherang River	1,255	Light	1,533	Light	2,288	Light
25	Upstream Ulu River	1,211	Light	2,928	Light	2,108	Light
26	Downstream Ulu River	1,235	Light	4,292	Light	2,140	Light
27	Upstream Cikarang River	6,170	Moderate	1,523	Light	4,585	Light
28	Downstream Cikarang River	2,451	Light	2,448	Light	0,730	Good
29	Upstream Cikedokan River	1,887	Light	4,521	Light	3,864	Light
30	Downstream Cikedokan River	2,057	Light	2,644	Light	0,761	Good
31	Upstream Sadang River	1,821	Light	3,942	Light	6,062	Moderate
32	Downstream Sadang River	2,058	Light	3,441	Light	3,875	Light
33	Upstream Blencong River	3,905	Light	3,420	Light	4,978	Light
34	Downstream Blencong River	2,078	Light	4,284	Light	4,745	Light
35	Upstream Cibeurum River	3,469	Light	4,207	Light	4,145	Light
36	Donwstream Cibeurum River	3,052	Light	2,917	Light	2,485	Light

From the results of monitoring the quality of river water in Table 1, it can be seen that the most dominant parameters in pollution in Bekasi Regency are BOD and DO. BOD or also called Biochemical Oxygen Demand, is a property or characteristic that indicates the amount of dissolved oxygen required by microorganisms (bacteria) to decompose or decompose organic matter in aerobic conditions. The BOD value

does not indicate the actual amount of organic matter but only measures the relative amount of oxygen needed to oxidize the waste material (Rachmawati 2017). A high BOD content will have an impact on decreasing the dissolved oxygen (DO) content of the waste (Nuraini *et al.* 2019). DO is needed by all living organisms for respiration, metabolic processes, or the exchange of substances, which then produces energy for growth and reproduction. In addition, oxygen is also needed for the oxidation of organic and inorganic materials in aerobic processes. The main source of oxygen in waters comes from a diffusion process from free air and the results of the photosynthesis of organisms that live in these waters (Salmin 2000).

DO in water is an important factor in ensuring the growth of healthy aquatic products because stress hypoxia is known to limit aquatic growth. Accurate monitoring and prediction of dissolved oxygen is the key to properly regulating and controlling pond culture water quality (Cao *et al.* 2020). Oxygen acts as an oxidizing agent and reduces toxic chemicals into simpler and less toxic compounds. In addition, oxygen is also needed by microorganisms for respiration. Based on research Ali *et al.* (2013) states that polluted water has a very low oxygen content (Roboredo *et al.* 2016), The more organic waste in the water, the less oxygen content dissolved in the water. The decrease in DO levels was caused by the large number of organic substances produced from the tofu factory liquid waste which was directly discharged into the waters. The low value of dissolved oxygen in the water will have a negative impact on the life of the biota in the waters (Sepriani *et al.* 2016). Based on District Level Data, The value of the water quality index, as shown in Table 2, is according to the calculation of river water quality in periods 1, 2, and 3.

Table 2 Water Quality Index (WQI) in Bekasi Regency

Status	Amount	Percent (%)	Coefficient	Score
Good	5	5	70	3,241
Light	81	75	50	37,5
Moderate	22	20	30	6,111
Heavy	0	0	10	0
Total	108			
Water Quality Index				46,852

It can be seen in Table 2 that there are 81 points with mild quality status, 22 points with moderate quality status, and 5 points with good quality status in 1 year. Thus, it can produce a WQI/IKA value of 46,852. The Bekasi Regency WQI value category is less than the index value. Based on the results of the calculation of the WQI carried out by the MoEF in 2021, the Bekasi Regency WQI is 30. A difference between the index value produced by MoEF with the index value obtained and generated from the data in the regency area. So, this can be a potential increase in the EQI.

Air Quality Index (AQI) in Bekasi Regency

We divide the location of air quality monitoring in Bekasi Regency into several uses: transportation, industry, offices, and settlements. Each designation is given ten monitoring points and is carried out twice in 1 year. The calculation of AQI sourced from the air quality monitoring results in Bekasi Regency is calculated by the average of each designation, shown in Table 3. SO_2 can cause bronchitis, emphysemia, and others, as well as sufferers of respiratory tract diseases, to become more severe (Wijiarti *et al.* 2016). The mechanism of SO_2 suction by activated carbon was investigated in a fixed-bed reactor.

First, SO_2 was sucked in by activated carbon and then catalytically oxidized to H_2SO_4 in the presence of O_2 and H_2O. The initial SO_2 suction rate increases with increasing SO_2 concentration but decreases with increasing temperature (Li and Ma 2018). NO_2 can damage the respiratory tract, irritate the lungs and eyes, and also contribute to heart damage (Mirzaei *et al.* 2018), lungs, liver, and kidneys. The use of fuel that continues to increase has a negative impact on the environment, namely the high level of pollution in the air

due to emissions from the burning process of fossil fuels. Emissions in the form of particulates (dust, lead) and gases (CO, NO, SO, H_2S) can cause health problems and damage to the environment (Riviwanto and Sani 2017).

Table 3 Calculation results of average air quality in Bekasi Regency

	SO_2					NO_2				
	First Period	First Period Average	Second Period	Second Period Average	Average	First Period	First Period Average	Second Period	Second Period Average	Average
Transportation	266,6	26,66	257,43	25,74	26,2	144,21	14,42	284,99	28,5	21,46
Industry	230,3	23,03	226,53	25,17	24,1	153,22	15,32	229	25,44	20,38
Housing	147,7	14,77	194,66	19,47	17,12	87,49	8,75	177,83	17,78	13,27
Office	215,8	21,58	210,15	21,02	21,3	167,5	16,75	230,56	23,06	19,9
Average					22,18					18,75

As shown in Table 3, the average annual concentration of SO_2 and the average yearly quality of NO_2 for transportation purposes is still high, so more handling is needed. The average yearly rate of SO_2 in the Bekasi Regency can be reduced. Based on District Level Data, The AQI of Bekasi Regency is 61,73. The AQI results make Bekasi Regency fall into the category of medium index values. Based on the results of the calculation of the AQI conducted by the MoEF in 2021, the Bekasi Regency AQI is 61,89.

Land Quality Index (LQI) in Bekasi Regency

The conversion of forest land in the northern part of the Bekasi Regency affects the LQI. The protected forests and production forest changes into fish/shrimp ponds. Based on District Level Data, Figure 1 shows the results of image Interpretation. This study conducted the interpretation by using land cover classifications of the MoEF with the results of the area, as shown in Table 4.

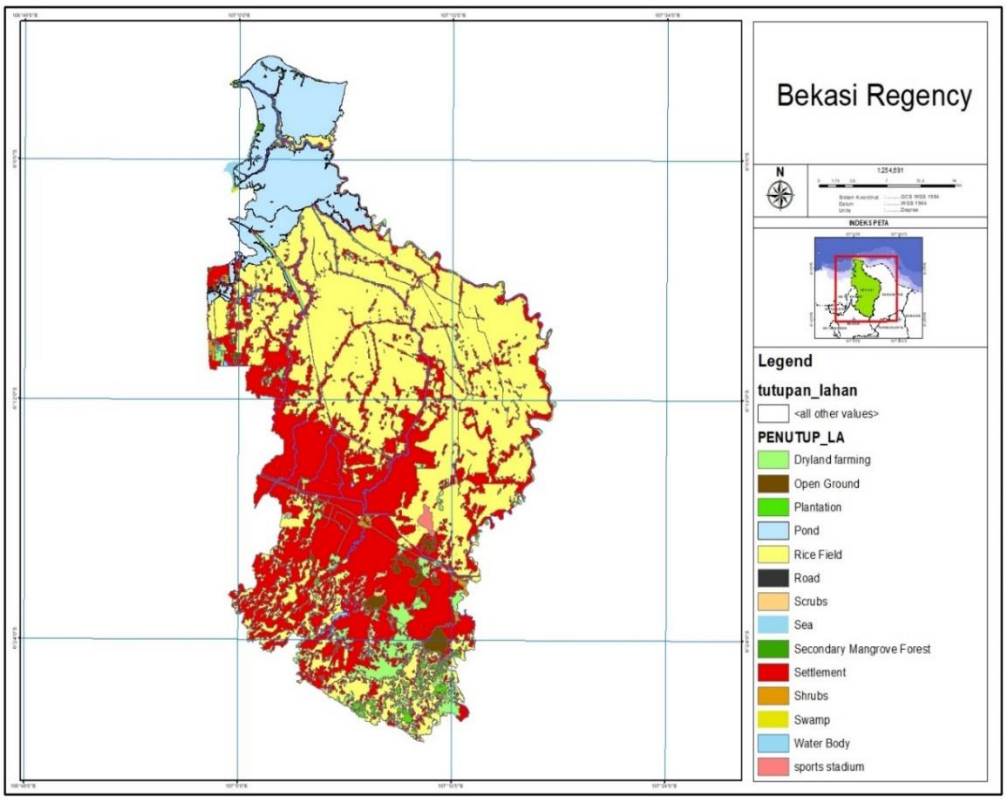

Figure 1 Image interpretation results in Bekasi Regency

Table 4 Land cover area in Bekasi Regency

No	Land cover	Areal extent (Ha)
1	Settlement	45.176,64
2	Water Body	1.518,87
3	Open Field	1.529,64
4	Secondary Mangrove Forest	260,17
5	Plantation	1.270,98
6	Dryland farming	4.465,71
7	Sea Waters	170,73
8	Ricefield	57.059,58
9	Bush	602,87
10	Shrubs	621,52
11	pond	1.4034,57

Table 4 shows that the northern part of Bekasi has transformed into a pond, with a current area of 14.034,57 hectares. Still, there is a secondary mangrove forest with 260,17 ha, but there is no data on Green Open Space (GOS) in Bekasi Regency. Therefore information is needed. According to the Department of Bekasi Regency's Department of Public Housing, Settlement Areas, and Land The amount of GOS in Bekasi Regency is 153.429,4 m^2 or 15,343 ha of public housing, settlement areas, and land. The Land Quality Index can then be determined using the image interpretation results and the area of green open space. Based on District Level Data, The LQI of Bekasi Regency is 22,57. According to the LQI, Bekasi Regency falls into the low category. The LQI of Bekasi Regency is 22,45, according to the results of the LQI calculation done by the MoEF in 2021. The index value calculated by the MoEF differs from the index value calculated using regional data. As a result of the GOS and secondary mangrove forests data, the EQI may rise.

Environmental Quality Index (EQI) in Bekasi Regency

The WQI, AQI and LQI all have a significant impact on the EQI in Bekasi Regency. The following is the EQI for Bekasi Regency. Based on the regulation of the minister of environment and forestry number 27 of 2021. Based on District Level Data, The EQI of Bekasi Regency is 47,56. According to the EQI results in Bekasi Regency, the region descends into the low category. The Bekasi Regency EQI is 41,26, with details of the WQI, AQI, and LQI are 30; 61,89; and 22,45, respectively, according to the results of the EQI calculation conducted by the MoEF in 2021. The benefit of using current regional data is that index yields are higher. This benefit is evident in comparing the environmental quality index derived from regional data with the findings produced by the MoEF for Bekasi Regency. So, When using existing data in the Bekasi Regency region, there is the potential for an increase in the EQI of 6,3. A more considerable discrepancy in values for the WQI and the LQI could indicate a potential for raising the EQI if used existing data in the Bekasi Regency area.

CONCLUSION

Based on District Level Data, The 2021 EQI in Bekasi Regency is 47,56, with details of the WQI, AQI, and LQI being 46,852; 61,73; and 22,569. There is a difference between the results of the EQI calculation with the existing database in the regions and the results of the Index calculations carried out by the MoEF in 2021. When using existing data in the Bekasi Regency region, there is the potential for an increase in the environmental quality index of 6,3. Some of the efforts made by the local government in improving the EQI in Bekasi Regency are clean-up activities, Increasing community participation in environmental management, training that aims to provide information and training to the community in Bekasi Regency, and increasing the supervision of the Bekasi Regency Government to industry and households.

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