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Modelling Environmental Impact of Semarang Demak Sea Dike and Toll Road Based on Satellite Imagery Data

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Abstract

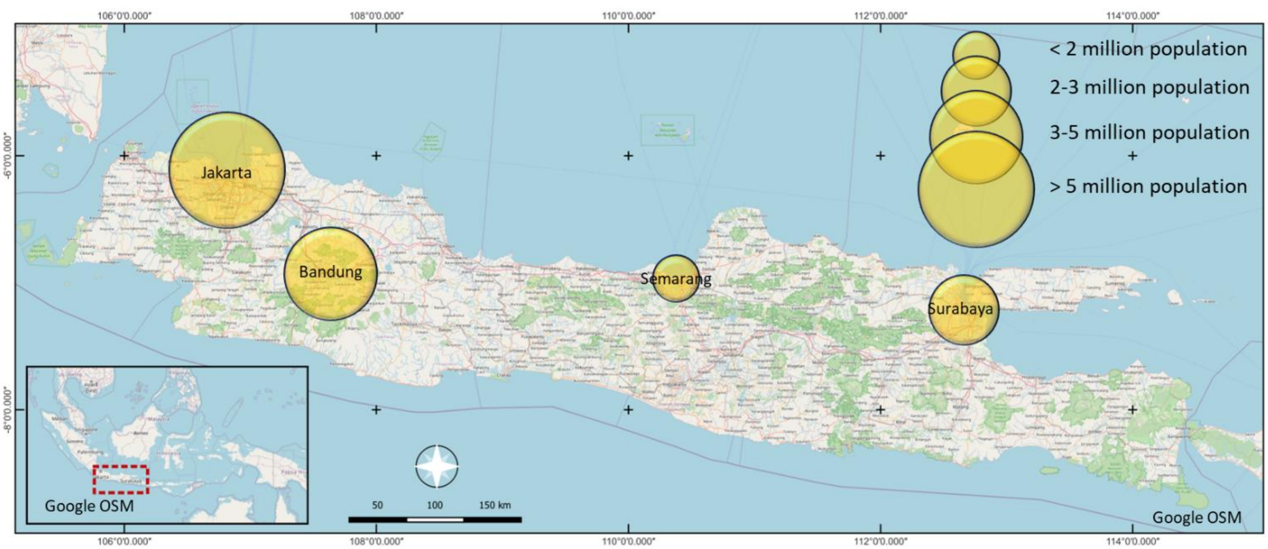
The construction of the sea dike and Semarang-Demak toll road has severed the mangrove ecosystem inside the dike, as well as increased greenhouse gas impacts due to transportation activities and the growth of built-up areas around the dike and toll road. The aim of this research is to formulate a regression model based on spatial data that can be used to measure the impact of transportation activities and building intensity on LST. The data used in this study are the number of motorized vehicles crossing the main roads in Semarang City and LST obtained from the Landsat 8 thermal infrared sensor band in 2013 and 2019. This research utilizes Geographic Information System, Remote Sensing, and statistical methods to model the environmental impact of the sea dike and toll road development. This model used to predict the environmental impact of the sea dike and Semarang-Demak Toll Road in the future. The result shows that the increase in the number of motorized vehicles and building intensity has a high contribution to LST. Every additional 1,000 passenger cars on a road will make LST increase from 0.015^{0}C to 0.038^{0}C, whereas every 10% increase in land intensity will make LST increase by 0.03^{0}C. In addition, there is an increase in the LST value of 30^{0}C from 26^{0}C previously. This model is expected to provide input for each stakeholder to mitigate the potential environmental impacts of the Semarang-Demak Sea dike and toll road in the future, and hope that the Semarang-Demak Sea dike.

1. Introduction

The north coast of Java faces very serious environmental problems, this is denoted by abrasion, tidal flooding, mangrove degradation, and land subsidence (Sidiq et al., 2021; Susilo et al., 2023). One area that has a high level of coastal degradation due to abrasion, tidal flooding, damage to mangrove ecosystems, and land subsidence is the coastal area of Semarang City and Demak Regency. Semarang City and Demak Regency have a national strategic role in the national urban system in Indonesia. Semarang City and Demak Regency are part of the Semarang metropolitan area which is located in the main economic corridor, and is the fourth largest city in Java Island in terms of population (see Figure 1).

Apart from having a strategic role in the Indonesian economy, the coastal areas of Semarang and Demak also have natural environmental problems that affect people living in coastal areas. Many researches that conducted over the last decade showed that environmental damage in the coastal areas of Semarang City and

Demak Regency had a very detrimental impact on the community such as the results of research by Lubis et al, Abidin et al, and Andreas et al which found community losses due to coastal disasters triggered by land subsidence and climate change (Abidin et al., 2013; Andreas et al., 2017; Lubis et al., 2011). In line with previous research, Prastika et al, Parwata et al, Yuwono et al, and Bott et al found that land subsidence on the Semarang-Demak coast caused significant losses for people living on the Semarang-Demak coast (Bott et al., 2021; Osorio-Cano et al., 2019; Parwata et al., 2019; Yastika et al., 2019; Yuwono et al., 2019). People lose their land assets due to abrasion, decreased property values, and experience mental stress, disease, and various non-material losses due to damage to coastal area due to tidal floods, abrasion, and land subsidence. Due to flooding and coastal erosion, the government must allocate more funds to sustain the functionality of basic infrastructure services in the coastal areas of Semarang City and Demak Regency (Hakim et al., 2023; Marfai & King, 2008; Utami et al., 2021). Even though Semarang coastal communities experience social and economic losses due to floods and tidal waves, they tend to remain in their current living locations, as research findings conducted by Buchori et al. Deep-rooted social ties are an important factor that encourages people to survive and make various adaptation efforts to environmental changes due to inundation on the coast of Semarang (Buchori & Tanjung, 2014; Buchori et al., 2018).



Source: Indonesian Statistical Bureau, 2023

Figure 1. Population of Main Cities on Java Island

Damage to coastal areas encourages stakeholders to pay serious attention to overcoming this problem. Efforts to overcome this damage are carried out through structural approaches and non-structural approaches. A structural approach was taken through the construction of coastal embankments to protect coastal areas from abrasion, and the construction of a polder system to overcome inundation due to tidal floods in North Semarang. Meanwhile, non-structural efforts are being made through reforestation of mangroves in several coastal locations in Semarang City and Demak Regency. Efforts to protect coastal areas in Semarang City and Demak Regency have not been fully effective. The construction of coastal embankments cannot last long and is very dependent on the reliability of the embankment construction. If the embankment structure is able to withstand the brunt of sea wave energy then the function of the dike will be effective in overcoming the abrasion problem, conversely if the dike structure is damaged then the function of preventing abrasion will be disrupted (Andreas et al., 2018; Hartati et al., 2016; Takagi et al., 2017).

Responding to the increasingly damage to beaches due to coastal erosion, and the increasingly widespread tidal floods in Genuk District (Semarang City) and Sayung District (Demak Regency), the government build a sea dike. This sea dike is expected to be effective and able to withstand the brunt of sea waves so that it can effectively overcome the problem of coastal erosion and flooding in coastal area of Semarang-Demak. The construction of sea dike in Semarang City and Demak Regency is integrated with the Semarang-Demak toll road. The integration of sea dike and toll roads aims to facilitate private sector participation in financing the development of sea dike and toll roads. The construction of sea dike is not only to protect coastal areas from abrasion and coastal flooding, but also to anticipate increased traffic in the northern coastal corridor.

On the other hand, the construction of the sea dike and the Semarang-Demak toll road has make the mangrove ecosystem on the south side of the dike deforested. The mangrove forest must be cut down for the construction of dike and retention ponds, and it leads a more complex environmental problem. One of the environmental problems that arise from the construction of sea dike and toll roads is an increase in surface temperature due to the growth of built-up areas and motorized vehicle traffic. Various studies show that increasing built-up area and transportation contribute to greenhouse gas emissions, and in turn trigger an increase in land surface temperatures (Franco et al., 2015; Khamchiangta & Dhakal, 2020; Louiza et al., 2015; Widjonarko & Maryono, 2021; Zhu et al., 2017).

The construction of sea dike and the Semarang-Demak toll road have an impact on environmental conditions, social and economic conditions of the people living in the surrounding areas. However most of the previous researches are focus on social impact due to the construction of Semarang-Demak Sea Dike and Toll Road (Hadi et al., 2020; Kamal & Gustaf, 2022), so it is important to study the environmental impact of the Semarang-Demak sea dike and toll road development. On the one hand, research on the impact of sea dike and toll road construction in the last three years is still limited. Most of the research that assess the environmental impact of road development are focus on land use change.

The previous researches by Setiawan in 2021, Salim et al in 2022 and Shofy et al in 2023 are use GIS method to measure the changes of land cover around the road (Salim & Faoziyah, 2022; Setiawan, 2021; Shofy & Wibowo, 2023). Those researches use GIS to describe the spatial changes around the toll road in Java, Indonesia. Another research by Khalid et al., in 2023 use GIS and remote sensing to measure the land transformation in Kuala Lumpur and Madrid (Mhana et al., 2023). The current research that explore the impact of Semarang-Demak sea dike development that conducted by Hadi et al using descriptive statistics to measure the impact of Semarang Demak Sea Dike development on mangrove ecosystem on its surrounding (Hadi et al., 2020). The research that use GIS to measure the environmental impacts of toll road construction that being constructed is still limited, so this study complements previous studies regarding the environmental impacts of infrastructure development, especially toll roads. This research uses GIS and remote sensing (Zaki et al., 2023), as well as statistical methods to assess the impact of infrastructure development, especially the construction of sea dike and the Semarang-Demak toll road which are currently under construction.

The use of remote sensing technology, geographic information systems, and statistical methods will make environmental impact assessments much faster. The use of GIS technology, remote sensing, and statistical methods has been carried out in various related studies in several countries. Remote sensing and geographic information systems can be used to assess land cover change, water quality, air quality, biodiversity, and soil quality (Cai et al., 2023; Kross et al., 2022; Sakti et al., 2023), while statistical methods can be used to predict the potential environmental impacts of infrastructure development, so using these methods is relevant for assess the environmental impacts of the construction of sea dike and the Semarang-Demak toll road. This study will contribute to formulating policies to minimized the environmental impact of the sea dike and the Semarang Demak toll road in the future.

2. Data and Methods

2.1. Study Area

This research is conducted in Coastal Area of Semarang-Demak which has the most impacted due to land subsidence, coastal erosion and coastal flooding (Bott et al., 2021; Damastuti et al., 2023; Sugiri et al., 2015). The study focuses on districts accrosed by the Semarang-Demak Sea Dike and Toll Road spreading from Genuk District until Demak District (see Figure 2).

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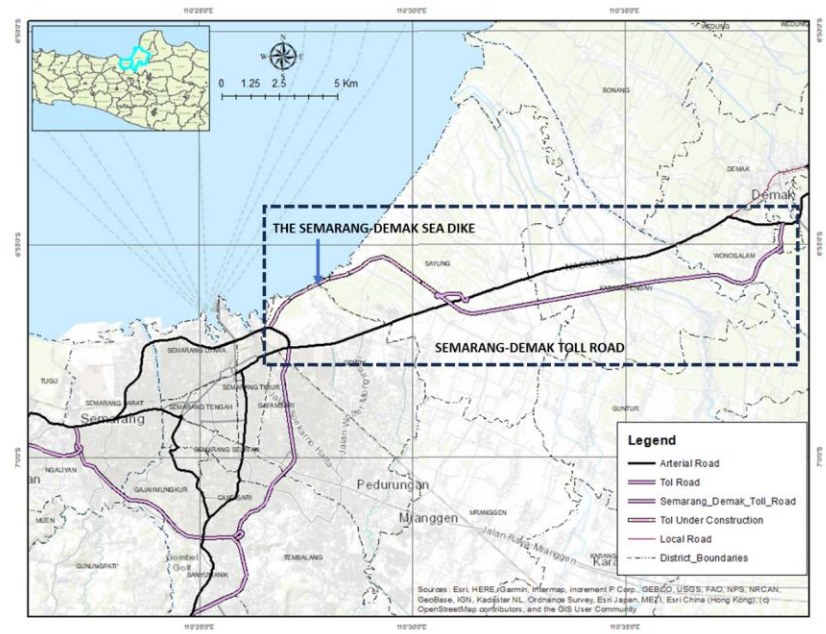


Source: The Ministry of Public Work, 2023

Figure 2 The Location of Sea Dike and the Semarang-Demak Toll Road

2.2. Data

The data used in this research include annual average daily traffic data (AADT) on the main road network of Semarang City and Demak Regency, as well as Landsat 8 Thermal Infrared Sensor (TIRS) Satellite Image Data. AADT data is obtained from Inter Road Management System (IRMS) data produced by the Directorate General of Highways. Satellite image data (Landsat 8) was obtained from the USGS website. Satellite image data will be used to identify land cover patterns and air temperature around embankment and toll road locations. The AADT and satellite image data used are temporal data with a time range between 2010 and 2020. The use of this data range is intended to provide more complete information before and during the construction of sea dike and Semarang-Demak toll roads. Details of the data that used in this research can be followed in Table 1.

Table 1. Data Use for the Research

No	Data Types	Variables	Parameter	sources	Data Usage
1	Traffic	Number of traffic	Passenger car unit (per) day	The Ministry of Public Work and Public Housing	Correlation and Regression analysis between built up area, and AADT to Land Surface Temperature
2	Landsat 8 Imagery	Bands number 4, 5, 6, 7, and 8	Wave length of each band	USGS	Build up area identification
3	Landsat 8 Imagery	Bands number 10 (TIRS)	Temperature in Kelvin	USGS	Land surface temperature identification

2.3. Methods

This research use GIS and remote sensing and statistical analysis to reveal the environmental impact of Semarang-Demak Sea Dike and Toll Road. The first step in data processing is to create a combination of Landsat imagery bands using bands number 7, 6, 4 on the satellite image to produce information on the built-up area and building intensity, while simultaneously processing the thermal infrared sensor (TIRS) on the Landsat imagery. Landsat 8 produces land surface temperature (LST) in Kelvin units, then converted to degrees Celsius. The second data processing is to model the influence of building intensity and AADT on LST using the regression method. This step will produce a regression model that represents the contribution of building intensity and AADT to LST. The use of regression models as an instrument to reveal the influence of transportation and land use has been widely used in previous studies (Domhnaill et al., 2023; Guo et al., 2022; Huang et al., 2020). The final step is to carry out a regression model simulation to predict LST around toll roads. A brief workflow of the study can be seen on Figure 3.

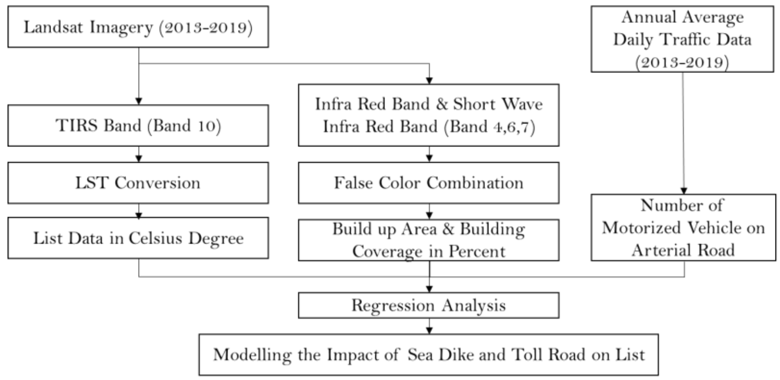
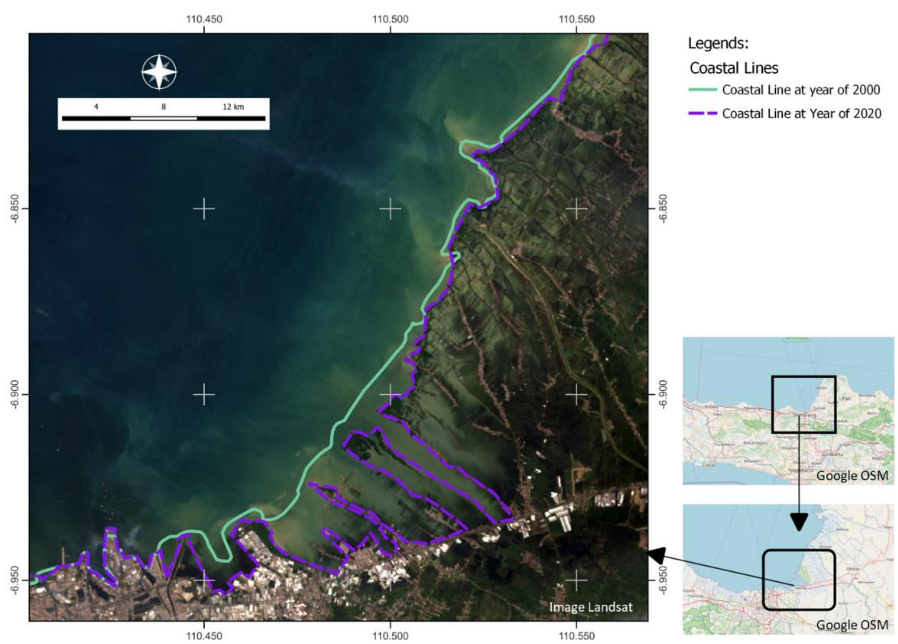


Figure 3. Research Flow Chart

3. Results and Discussion

The coastal areas of Semarang City and Demak Regency are threatened by abrasion and tidal flooding. Abrasion and tidal floods have caused enormous losses to residents living in coastal areas. The threat of disaster hazard on the coast of Semarang City and Demak Regency is triggered by various factors, including global warming which triggers sea level rise, land subsidence due to uncontrolled use of deep groundwater, and loss of mangrove ecosystems as natural coastal protectors (Bott et al., 2021; Damastuti et al., 2023). The coastal erosion that occurred on the coastal area of Semarang City and Demak Regency caused a shift in the coastline and the loss of existing settlements. Satellite imagery data for 2000 and 2020 show a shift in the coastline more than 2.7 km from the coastline in 2000 (see Figure 4). In order to minimize the impact of coastal erosion and tidal flooding, the government builds a sea dike in the coastal areas of Genuk and Sayung sub-districts which have the most severe level of damage. The sea dike will also be used as a toll road at the top of the dike which is connected to the Semarang Toll Section C. This toll road will connect Semarang to Demak and make logistics movements on the North Coast of Java more effective.



Source: Modified from Google Earth, accessed, 2023

Figure 4. The Shift of Coastal Line Between 2000 and 2020

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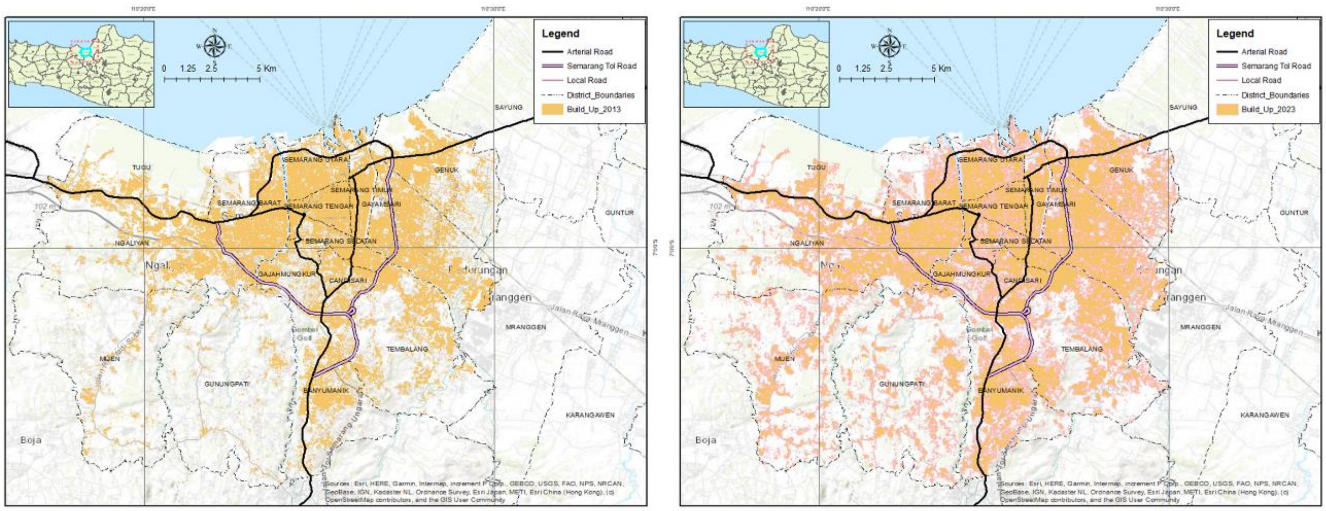
However, the construction of sea dike in order to protect coastal areas from coastal erosion and tidal floods has raised concerns among environmental activists. The construction of a sea dike requires to cut down the mangrove forests. Apart from that, the existence of sea dike which also function as toll roads has an impact that will degrade environmental quality in the future. The mobility of vehicles on toll roads has the potential to increase carbon emissions from motorized vehicles, as well as create a greenhouse gas effect that makes the surrounding environment warmer. This indication is based on various previous studies which have proved the impact of fossil-fuel vehicle transportation which cause a decrease in urban air quality (Domhnaill et al., 2023; Guo et al., 2022; Huang et al., 2020; Sakti et al., 2023; Widjonarko & Maryono, 2021). The potential for environmental quality degradation will increase if area at the south side of the dike changes into built-up area. The more extent of built-up land will contribute to an increase in carbon emissions due to energy use in each land-use activity.



(2A) Built Up Area in 2013 (2B) Built Up Area in 2013

Source: USGS, 2013-2023, and Analysis, 2024

Figure 5. Increase in Built-up Area in Semarang City in 2013 and 2023

The city of Semarang has experienced significant growth in the last ten years which can be seen from the increase in built-up land area. In 2013 the built-up land area was 17,147 Ha (45% of the total area), and became 19,708 Ha (around 53% of the total area) in 2023 (see Figure 5). The increase in built-up land area in the 2013-2023 period was 2560 Ha, or an increase of 12 .9%, with an average increase in built-up area of 1.29% per year. The growth of Semarang City is also marked by the increasing number of vehicles crossing the main road. In 2010 the number of vehicles was around 0.49 million units of passenger cars, and in 2020 the number of vehicles was 0.71 million units of passenger cars. Changes in land cover in the last ten years can be seen in Figure 4. Increasing the number of built-up area and increasing number of vehicles will have an impact on urban heat temperatures which is in line with previous research in the Bangkok Metropolitan Area (Khamchiangta & Dhakal, 2020), in Hong kong (Zhu et al., 2017), in Hyderabad (India) (Franco et al., 2015), and in Baghdad City (Mhana et al., 2024) which provides empirical facts regarding the influence of changes land cover and transportation on air temperature in urban areas.

Empirically, the relationship between transportation activity and built-up land on environmental quality in the city of Semarang can be proven through satellite imagery data. TIRS on Landsat 8 shows the highest LST value in Semarang City at 35.6^{0}C. in 2013. Meanwhile, in 2019 the highest LST value was in Semarang City at 36.13^{0}C. In 2020, due to the Covid-19 pandemic and restrictions on urban activities, LST decreased to 35.3^{0}C, while in 2023 after the pandemic, LST began to increase to 36.1^{0}C. The LST trends in Semarang City in 2013-2023 (see Figure 6).

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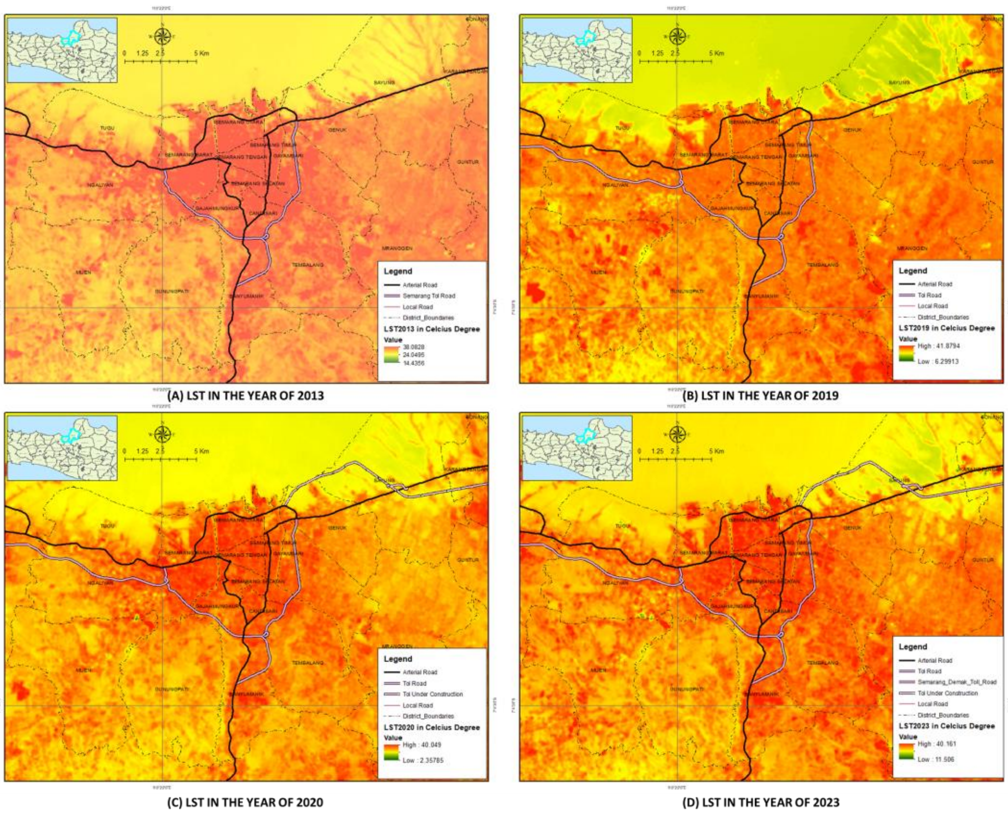

Source: USGS, 2013-2023, and Analysis,2023

Figure 6. Land Surface Temperature in Semarang City in 2013-2019

Based LST data that represent on Figure 5, it can be seen that road sections that have more motor vehicle traffic and denser building intensity (BC) tend to have higher air temperatures than road sections that have less traffic and lower building intensity. In order to explore the relationship patterns between LST, BC, and AADT, samples were taken at 17 locations around the main roads in the cities of Semarang and Demak (see Figure 7).

Figure 7. Spatial Distribution of Sample Locations

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The sample data is presented in graphical form (see Figure 7) in order to see the relationship pattern between LST to AADT, and LST to BC. The samples were carried out temporally, namely in 2013 and 2019. The positive relationship pattern can be seen from the graphical representation of LST, BC and AADT at 17 sample locations in Semarang and Demak. Roads that has a high AADT values tend to be followed by high LST values, similarly roads with high BC values tend to be followed by high LST values. This means that there is a positive relationship between AADT to LST and BC to LST. This condition provides at least one empirical fact that is in line with previous studies which explain the effect of the movement of motorized vehicles on ambient air temperature (Chen et al., 2020; Guo et al., 2022; Li et al., 2024; Louiza et al., 2015; Nugroho et al., 2022; Van-Bijsterveldt et al., 2020; Widjonarko & Maryono, 2021). Based on this relationship pattern, the process of regression analysis to see the relationship and influence of AADT and BC on LST can be carried out.

The regression model used is a multiple regression model, where LST is the dependent variable, while the independent variables include the amount of traffic on the main road (AADT) and the intensity of buildings (BC) on the side of the main road. Regression modeling was carried out in two time periods, namely 2013 and 2019. The aim of modeling in two different time dimensions was to see the dynamics of the influence of AADT and BC on LST values. Based on 2013 data, the regression model shows that there is a significant contribution between AADT and BC to LST, with a determination value of 54%. The AADT has a positive influence on LST, every 1,000 motorized vehicles will increase the LST value by 0.015^{0}C. Meanwhile, building intensity will increase the LST value by 0.03^{0}C for every 10% increase in building intensity (see Figure 8). A brief explanation of the regression modeling between LST, AADT and BC for the 2013 period can be seen in Table 2.

These two modeling results provide clear evidence that the movement of motorized vehicles and the increasing of building intensity make a major contribution to the surrounding microclimate, especially in relation to ambient air temperature. The resulting regression model is in line with previous studies in several cities in the world which show the impact of motorized vehicle movement and building intensity to an increase in air temperature (Chen et al., 2020; Guo et al., 2022; Kellner, 2016; Li et al., 2024; Widjonarko & Maryono, 2021). The increasing growth of motorized vehicles will worsen environmental quality if it is not matched by efforts to increase road service capacity. If more and more vehicles pass, on the one hand there is no increase in road capacity, this will cause congestion. Congestion contributes to increased carbon emissions, and causes greenhouse gas effects (Bharadwaj et al., 2017; Kellner, 2016).

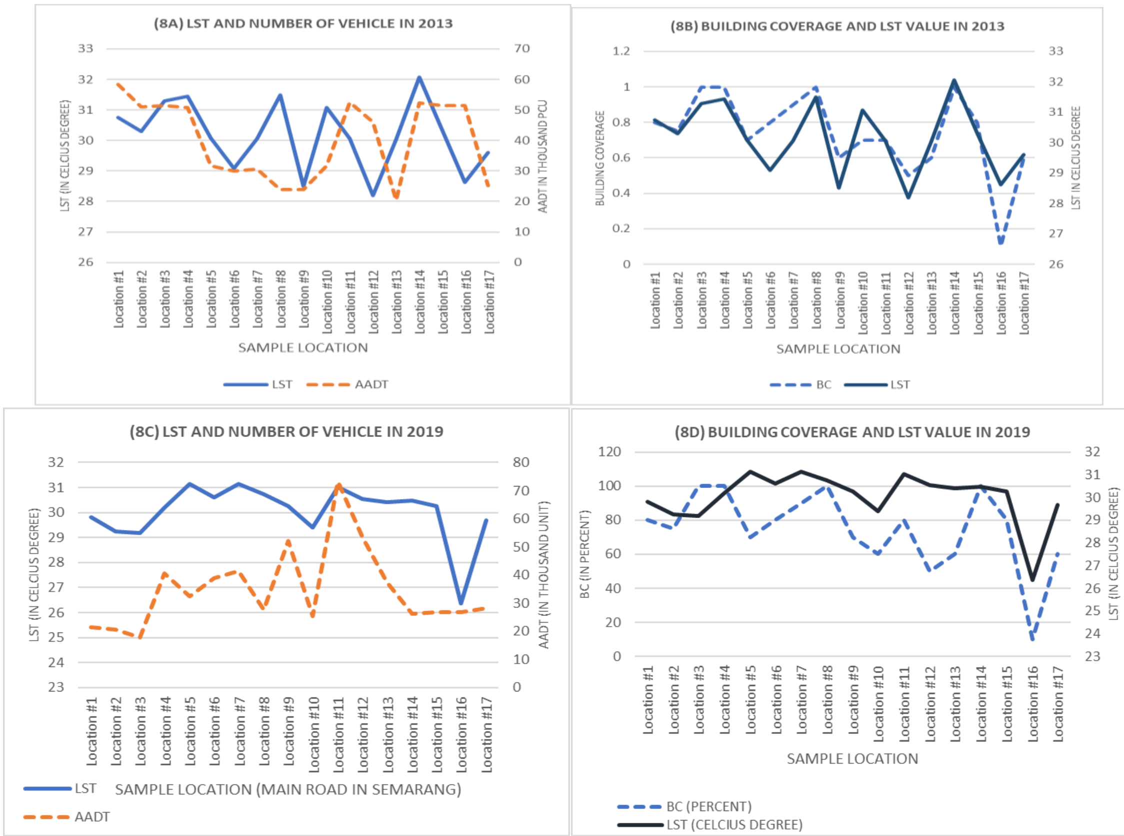
Table 2 Summary of 2013 Regression Model Output

Regression Statistics						
Multiple R						0.7332903
R Square						0.5377146
Adjusted R Square						0.4716739
Standard Error						0.8146268
Observations						17
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2	10.806552	5.403276	8.1421618	0.004512	
Residual	14	9.2906363	0.6636169			
Total	16	20.097188				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	27.014562	0.9002536	30.007725	4.16E-14	25.08371	28.94541
AADT	0.0153866	0.0155888	0.9870244	0.340383	-0.0180482	0.048821
BC	0.0341456	0.0089154	3.8299593	0.0018388	0.015024	0.053267

Source: Analysis, 2024

The mathematical representation of the regression model based on 2019 data can be expressed as follows (Equation 1):

$$LST = 27.01 + 0.038AADT + 0.032BC \ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation 1)}$$



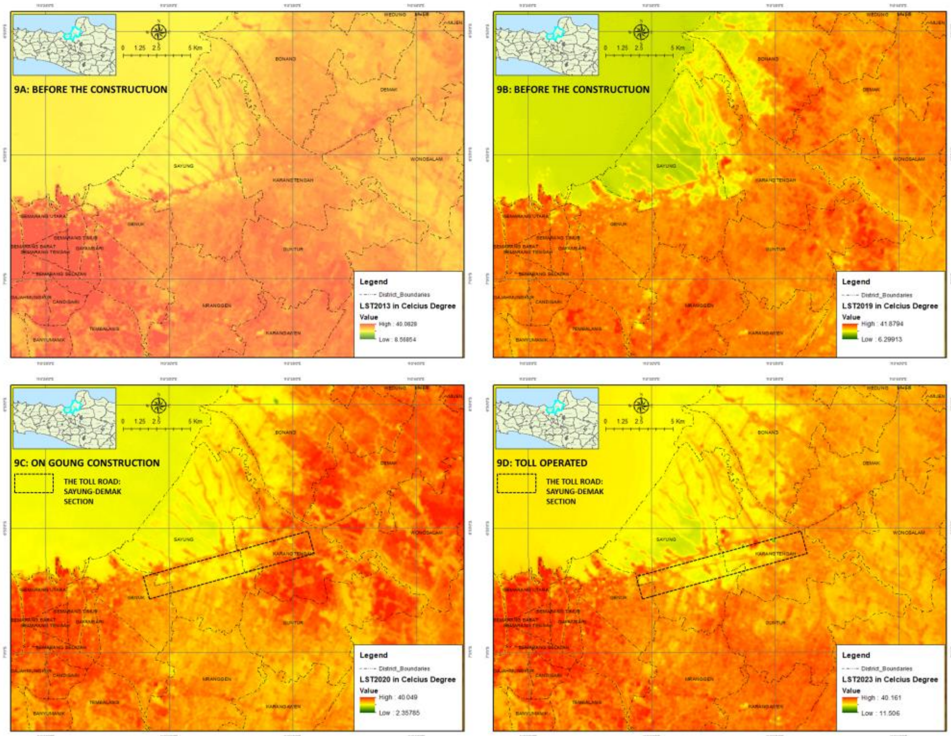
Source: Analysis, 2023

Figure 8. Relationship Between LST to BC, and LST to AADT in 2013 and 2019

It is feared that the construction of sea dike and the Semarang-Demak toll road, which aims to overcome coastal damage in Semarang City and Demak Regency, will contribute to environmental degradation. The existence of sea dike will potentially accelerate sedimentation in the area on the south side of the embankment, sedimentation will trigger an area that was originally inundated land to turn into land, similarly the existence of the Semarang Demak toll road, will certainly trigger changes in land cover around it, given its very strategic location. The location of the sea dike and the toll road is very close to the Port of Tanjung Emas and close to the economic corridors on the island of Java. If the Semarang-Demak toll road operates, the movement of motor vehicles on the Semarang-Demak toll road will have an impact on environmental degradation. The development of built-up area and the movement of motor vehicle will certainly have an impact on the quality of the environment.

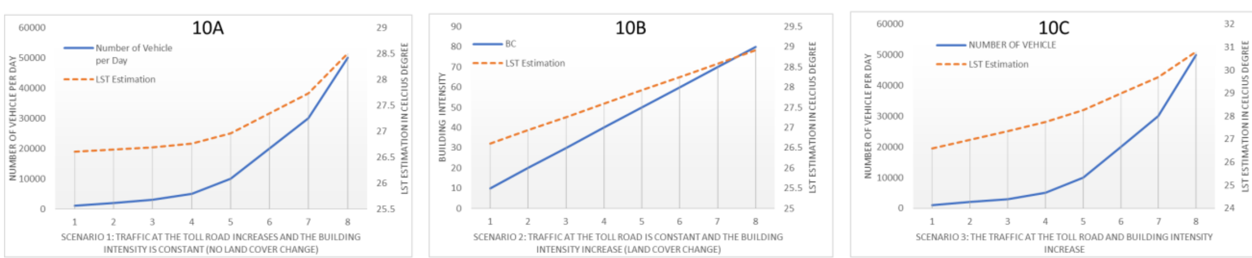
The initial evidence of the environmental impact due to the sea dike and the Semarang-Demak toll road can be seen empirically from the trend of increasing land surface temperatures around the Sayung-Demak toll road. The average land surface temperature in the 2013-2019 period around the Sayung-Demak toll road was 26.4^{0}C- 26.7^{0}C. An interesting phenomenon was happened in 2020, there is an increase of land surface temperature on Sayung Demak toll road sections that are under construction due to the use of heavy equipment in toll road construction. Meanwhile, in 2023, when the Semarang-Demak toll road section from the Sayung interchange to the Demak interchange is operational, the land surface temperature increase ranging from 26,52^{0}C to 27,16^{0}C. The development of land surface temperature around the proposed sea embankment and the

Semarang Demak Toll Road before construction activities (2013-2019), during construction in 2020-2023 and during the operation of the Sayung-Demak Toll Road section can be seen in Figure 9.



Source: USGS, 2013-2023, and Analysis,2023

Figure 9. Land Surface Temperature in Surrounding Sea Dike and Semarang Demak Toll Road 2013-2023



Source: Analysis, 2023

Figure 10. Estimated LST Value Due to Traffic Growth and Built-up Areas Around the Semarang-Demak Toll Road

The increase in land surface temperature values will be even higher if there is a change in current land cover to built-up areas in the future. Changes in land cover around toll roads have a high probability, referring to previous research on the Cipularang toll road and the Trans Java toll road (Salim & Faoziyah, 2022; Shofy & Wibowo, 2023). Based on the existing phenomenon, that the existence of a toll road changes the surrounding land cover, it can be assumed that the same condition will also occur in the area around the Semarang-Demak toll road and this will have an impact on environmental degradation, unless the government issues regulations to control development the area around the Semarang Demak Toll Road. The impact of the sea dike and the Semarang Demak Toll Road on the surrounding environment can be estimated using the LST regression model. If it is assumed that vehicle flow reaches 50 thousand vehicles per day, and the built-up area does not change, then it is estimated that the highest LST value is 28.5^{o}C (Figure 7a), if traffic does not change, and if there is an increase in built-up area up to 80%, then the LST value will reach 28.9^{o}C (Figure 10b). If traffic on toll roads and built-up areas increases simultaneously, the LST value will reach 30.8^{o}C (Figure 10c). This simulation is in line with research in China that the development of a highway contribute to increase the traffic flow and triggering the green house gas emission (Kazancoglu et al., 2021) that make the temperature on its surrounding road warmer (Xu et al., 2022; Zhang & Qian, 2023).

Based on predicted LST values around the sea dike and the Semarang-Demak toll road, comprehensive steps are needed to reduce potential environmental impacts. Instead of reducing tidal inundation and coastal erosion, the existence of sea dike and the Semarang-Demak Toll Road reduces environmental quality. Increasing the LST value not only reduces the comfort of people living nearby, but also has wider impacts such as increased evaporation, especially during the dry season, according to research results in Australia, Poland, tropical countries in America, the Mediterranean countries, and Southeast China (Helfer et al., 2012; Okoniewska & Szumińska, 2020; Zhou et al., 2021). Higher evaporation will make the amount of condensed water vapor in the clouds increase, and will cause the rain intensity go up, of course this still requires more in-depth study later. If the increasing intensity of rain is not anticipated with good stormwater management, it will cause flooding. Therefore, it is important to take comprehensive action to reduce the potential environmental impact of the construction of sea dike and toll roads by issuing regulations to control the growth of built-up areas around the Semarang-Demak Toll Road, and maintain efficient traffic flow to minimize carbon emissions and greenhouse gas effects. A study by Magazzino et al on greenhouse gas emissions across European road networks highlights that smooth traffic flow helps mitigate greenhouse gas impacts (Magazzino et al., 2025).

Based on predicted LST values around the sea dike and the Semarang-Demak toll road, comprehensive steps are needed to reduce potential environmental impacts. Instead of reducing tidal inundation and coastal erosion, the existence of sea dike and the Semarang-Demak Toll Road reduces environmental quality. Increasing the LST value not only reduces the comfort of people living nearby, but also has wider impacts such as increased evaporation, especially during the dry season, according to research results in Australia, Poland, tropical countries in America, the Mediterranean countries, and Southeast China (Helfer et al., 2012; Okoniewska & Szumińska, 2020; Zhou et al., 2021). Higher evaporation will make the amount of condensed water vapor in the clouds increase, and will cause the rain intensity go up, of course this still requires more in-depth study later. If the increasing intensity of rain is not anticipated with good stormwater management, it will cause flooding. Therefore, it is important to take comprehensive action to reduce the potential environmental impact of the construction of sea dike and toll roads by issuing regulations to control the growth of built-up areas around the Semarang-Demak Toll Road, and maintain efficient traffic flow to minimize carbon emissions and greenhouse gas effects. A study by Magazzino et al on greenhouse gas emissions across European road networks highlights that smooth traffic flow helps mitigate greenhouse gas impacts (Magazzino et al., 2025).

4. Conclusion

The construction of the sea dike and the Semarang-Demak toll road contributes to reducing the environmental quality of its surrounding due to land cover change and the motorized traffic flow. The environmental degradation can be characterized by an increase in land surface temperature due to the movement of motorized vehicles, as well as the growth of built-up area around toll roads and sea dike. Potential environmental quality degradation around the toll road can be proven empirically by an increase in land surface temperature during the construction of the Sayung-Demak section, as well as after the operation of the Semarang-Demak toll road in the future. The land surface temperature around the Sayung-Demak section in 2013 was 25.52^{o}C, and increased 27.16^{o}C in 2023 or an increase of land surface temperature around 0.64^{o}C after the construction of the toll road.

The land surface temperature will be higher and higher if the movement of motorized vehicle traffic on the road, and the built-up land go up. The predicted LST value using the regression model has a small deviation with the factual LST conditions in 2023. The deviation is around 0.07^{o}C. This model provides an initial information about the environmental impact of the Semarang Demak toll road and sea dike in the future. Hope it can become a consideration to manage the potential impact of Semarang-Demak toll road and sea dike, and controlling the growth of built-up area in the surrounding toll in order to minimize environmental degradation in the future.

This research still does not fully provide comprehensive results regarding the impact of the construction of sea dike and the Semarang-Demak Sea toll road, but it strengthens the results of previous research. There is a limitation in this research, and it is possible to conduct further research which can provide a more comprehensive results about the impact of the construction of the sea dike and the Semarang-Demak toll road on environmental quality. It is important to explore the impact of Semarang Demak toll road and sea dike on evaporation and hydrometeorological disaster in a larger area of study, for instance in Babon, Jragung, and Tuntang watershed area.

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