Surface Temperature Changes as the Impact of Industrial Development Along the Northern-Coastal Road (*Pantura*) of Semarang City

Muharar Ramadhan[1], Imam Buchori[2]
{muhararramadhan@gmail.com[1], i.buchori@undip.ac.id[2]}

[1]Master of Urban and Regional Development, University of Diponegoro, Indonesia
[2]Lecturer Master of Urban and Regional Development, University of Diponegoro, Indonesia

Abstract. The rapid industrial development in Semarang City often impact on the environment, especially surface temperature changes. The Industrial development and built up area have been increasing surface temperature. This article aims to study surface temperature changes as the Impact industrial development along the Northern-Coastal Road of Semarang city. This research used monochromatic satellite imaginary data and google earth imaginary data to see industrial and build up development from 1999 to 2018. Furthermore, to see surface temperature changes, this research used satellite imaginary of Landsat TM 5 with thermal infra-Red sensors band 6 (1999) and satellite imaginary of Landsat 8 OLI with thermal infra-Red sensors Band 10 (2018). The results analysis from 1999-2018 show that the area of industrial increased 8.4 km^2 and build up area increased 7.88 km^2. Surface temperature result show area with temperature more than 30^{o}C increased 75,8 Km^2 from 1999-2018. The number of urban villages which has area temperature >30^{o}C more than 50% also increased from 14 to 44. The increasing surface temperature indicates global warming along the Northern-Coastal Road of Semarang City. Therefore, monitoring surface temperature changes is needed to control and reduce global warming in Semarang City.

Keywords: Surface Temperature, Industrial Development.

1. Introduction

In 2018, more people choose live in urban area then rural area, it about 55% of The world's Population and projected increase to 68% by 2050 [1]. Semarang city is the one of urban area which has experianced population growth each year [2]. Incresing population has significant impact on incresing surface temperature. Many scientist indicates incresing surface temperature caused by green house emission and carbon dioksida emission [3]. Urbanization and industrialization increase CO_2 emission [4]. It indicates that urbanization and industrialization can increase surface temperatures.

Semarang city is part of the Kedungsepur National Activity Center (Kendal, Demak, Ungaran, Semarang, Salatiga and Purwodadi) which is a strategic national economic growth zone. Industrialization is a long-term prospect of improving the regional economy and providing employment opportunities to the population. Now, industrial development is carried out to increase economic growth in Semarang city. Industrial development tends to develop along northern-coastal road of Semarang city. the strategic location and proximity to the port are the main reasons for the fast growth industrial estate in this area.

ICESI 2019, July 18-19, Semarang, Indonesia

DOI 10.4108/eai.18-7-2019.2290354

Increasing industrial activities along northern-coastal road also increase surface temperature in this area. Several recent studies have indicetes surface temperature increase in northern Semarang city which have industries area[5]. this research is a follow-up study from previous studies that are used to detail the impact of industrialization on changes in surface temperature. The aims of research is to study surface temperature changes as the Impact industrial development along the Northern-Coastal Road of Semarang city.

2. Study Area and Method

2.1 Study Area

The study area is along the Northern-Coastal Road (*Pantura*) of Semarang City. Most industrial development growth along the Northern-Coastal Road because it provides easy access to go to Tanjung Emas Port. Study area in this research includes 68 urban villages which divided on three regencies; Semarang City (58), Kendal Regency (4) and Demak Regency (6) see **Figure.1**.

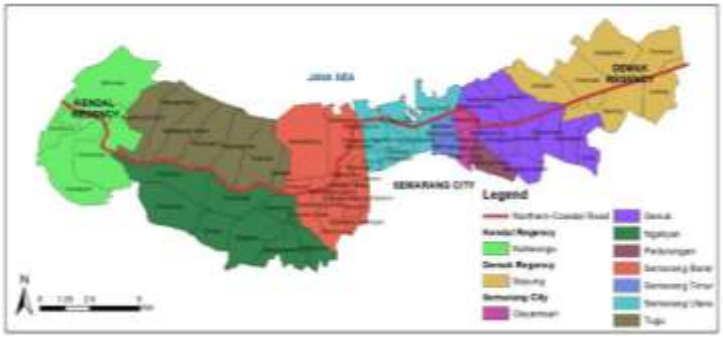

Fig. 1 The Northern-Coastal Road of Semarang City Map

2.2 Land use Analysis

Land use analysis in this research used 8 key satellite images interpretation there are hue or colors, shapes, sizes, textures, patterns, shadows and sites [6]. Land use recognition digitized using quantum GIS with 4 classification (Industrial, build up, non-build up, and transportation). Data analysis used Monochromatic Image Satellite for identification in 1999 and google earth image satellite in 2018 (**Figure. 2**). The detail object recognition is 1.5 – 2 meters.

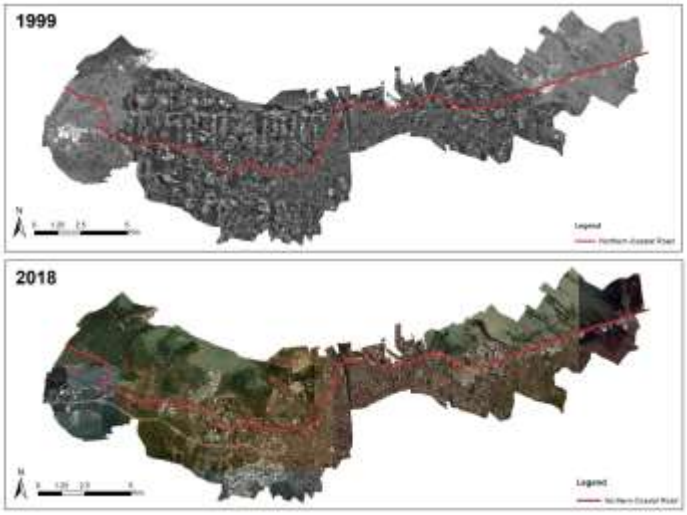

Fig. 2 Satellite Imaginary Monochromatic (1999) and Google Earth (2018)

2.3 Surface Temperature Change Analysis

Remote sensing is the art and science of acquiring information about objects, regions or phenomena by analyzing data acquired using instruments without direct contact with the object, region or phenomenon studied[6]. The trend of surface temperature changes in this research was performed with remote sensing by comparing the two satellite imaginaries there are satellite imaginary of Landsat TM 5 with thermal infra-Red sensors band 6 (1999) and satellite imaginary of Landsat 8 OLI with thermal infra-Red sensors Band 10 (2018). Furthermore, Information of Landsat Images satellites on table 1 is using as constants of formula[7]. For generate surface temperature there are 2 steps. First, conversion of digital number to TOA radiance with formula (1):

$$L\lambda = MLQcal + AL \quad (1)$$

where:

Lλ = TOA spectral radiance (Watts / (m2 * srad * μm))
ML = a Band-specific multiplicative reSCAMCling factor from the metadata (RADIANCE_MULT_BAND (**RMB**)_x, where x is the band number)
AL = a band-specific additive reSCA-MCling factor from the metadata (RADIANCE_ADD_BAND_(**RAB**)x, where x is the band number)
Qcal = Quantised and calibrated standard product pixel values (DN)

Second, Generate surface temperature with formula (2):

Commented [a1]: this section is an improvement about How about the temperature trend? This paper only uses two cross-sectional cases (1999-09-06 and 2018-08-25)

$$T = \frac{K2}{\ln(\frac{K1}{L\lambda}+1)} - 273{,}15 \quad (2)$$

where:

T = the top of the atmosphere brightness temperature (C)
Lλ = TOA spectral radiance (Watts/ (m2*srad*μm))
K1 = band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number)
K2 = band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number)

Tabel 1 Information of Landsat Images Satellites for Surface Temperature Analysis

No	Year	Type	Data Acquired	Band	RMB	RAB	K1	K2
1	1999	Landsat 5 TM	1999-09-06	6	0.055375	1.18243	607.76	1260.56
2	2018	Landsat 8 OLI	2018-08-25	10	0.0003342	0.1	774.8853	1321.0789

3. Result and Discussion

3.1 Land Use Change Analysis and Industrial Development

The result of land use change analysis shows that in 1999-2018 there was a change in non-buildup area into industrial areas, buildup areas and transportation areas. The Industrial development dominates in northern-Coastal road until 8.4 km^2 or 95.38% (**Table 2**). The northern-Coastal road provides easy access to industrial activities for distribute logistic, product and labor. Moreover, land subsidence in the Genuk sub-district [8] and abrasion in Tugu sub-district [9] encouraged the Semarang city government to plan along the Northern Coast road as an industrial area. In 1999-2018, Industrial development lead to west side of semarang city rather than east side semarang city. It caused east side semarang city especially Genuk Sub-district frequent tidal flood[10]. The most Industrial development in west side there are Bambankerep and Ngaliyan urban villages (Ngaliyan Sub-district) it called Candi Industrial Estates 261,54 Ha, Randugarut villages (Tugu Sub-district) it called Wijayakusuma Industrial Estates 89,06 Ha. The most Industrial development in east side there are Trimulyo Villages (Genuk Sub-district) it called Terboyo Industrial Estates 85,85 Ha (**Table 3**). The industrial development followed by buildup development around it. In 1999-2018, buildup development reach 7.88 km^2 or 24,8 %. The most buildup development there are Bangetayu Kulon (Genuk Subdistrict) 60,29 Ha, Bringin (Ngaliyan Sub-distrcit) 60,05 Ha, Kalipancur (Ngaliyan Subdistrict) 55,34 Ha (See **Figure 3**).

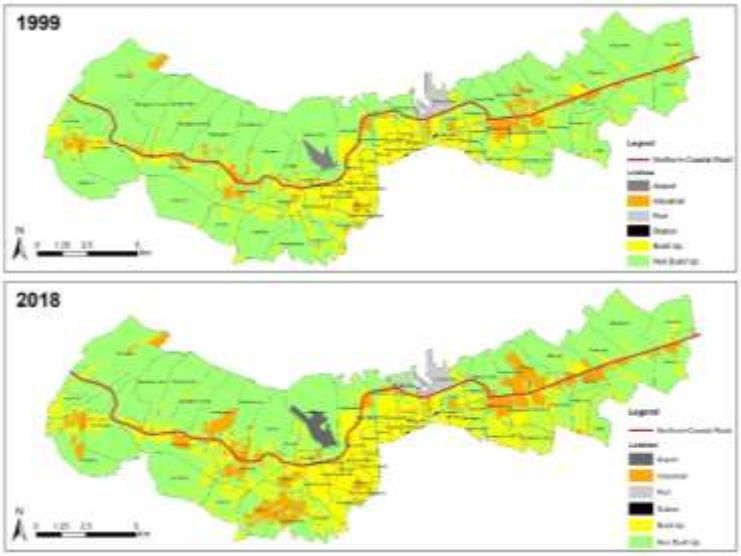

Fig. 3 Land use along the Northern-Coastal Road of Semarang City

Tabel 2 Land use Changes Analysis

Landuse	1999		2018		Δ 1999-2018	
	(Km^2)	%	(Km^2)	%	(Km^2)	%
Trasportation	3.07	1.68%	4.39	2.41%	1.32	42.91%
Industrial	8.80	4.83%	17.20	9.44%	8.40	95.38%
Buildup	31.77	17.43%	39.65	21.76%	7.88	24.80%
Non-Build up	138.59	76.05%	121.00	66.39%	-17.60	-12.70%
Total	182.24	100.00%	182.24	100.00%		

Tabel 3 Industrial Development in 1999-2018

Sub-District	Urban Village	1999 (Ha)	2018 (Ha)	Sub-District	Urban Village	1999 (Ha)	2018 (Ha)
Gayamsari	Kaligawe	5.38	10.83		Bambankerep	2.22	91.90
	Sawah Besar	-	0.26	**Ngaliyan**	Kalipancur	6.73	2.22
	Tambakrejo	-	7.45		Ngaliyan	20.58	177.38

Sub-District	Urban Village	1999 (Ha)	2018 (Ha)	Sub-District	Urban Village	1999 (Ha)	2018 (Ha)
Semarang Barat	Bongsari	18.20	18.20		Purwoyoso	67.74	49.38
	Gisikdrono	1.17	1.17		Tambakaji	37.42	97.56
	Krapyak	14.90	20.06		Wonosari	-	73.46
	Manyaran	17.93	12.71		Bangetayu Kulon	1.99	7.24
	Ngemplak Simongan	7.72	8.21		Banjardowo	15.18	33.42
	Tawangmas	28.09	28.09		Gebangsari	33.35	41.40
	Tawangsari	2.12	6.43		Genuksari	39.79	43.25
Semarang Timur	Kemijen	17.63	17.63	**Genuk**	Karangroto	3.88	8.09
	Mlatibaru	1.68	1.68		Muktiharjo Lor	92.75	100.56
	Rejomulyo	3.28	3.28		Terboyo Kulon	13.84	29.53
Semarang Utara	Bandarharjo	16.89	25.97		Terboyo Wetan	47.47	73.69
	Dadapsari	1.41	1.41		Trimulyo	53.60	139.46
	Kuningan	1.31	1.31	**Kaliwungu**	Kutoharjo	0.33	0.33
	Panggung Lor		7.22		Mororejo	47.41	58.52
	Tanjung Emas	9.36	9.36		Nolokerto	57.64	98.54
Tugu	Jerakah	6.87	1.21		Sumberejo	23.66	30.60
	Karanganyar	32.28	55.93	**Sayung**	Gemulak	0.00	0.00
	Mangkang Kulon	7.70	10.08		Loireng	23.46	37.45
	Mangkang Wetan	0.57	0.99		Purwosari	5.13	34.18
	Mangunharjo	2.78	2.78		Sayung	23.29	62.35
	Randugarut	29.53	118.59		Sriwulan	17.63	21.51
	Tugurejo	18.55	37.40				

3.2 Surface Temperature Analysis

The result of surface temperature analysis shows that in 1999-2018 there was Increasing temperature along northern-coastal road until 5 degrees Celsius. The area development with temperature more than 30 ^{0}C increase until 75.8 Km^2 or 439.17 % (**Table 4**). Increasing temperature area more than 30^{0}C reach 51.06% of study area. Semarang Utara Sub-district and Semarang barat Sub-district become the hottest sub-district along northern-coastal-road (See

Figure 4). It caused proportion of land use in this sub-district majority is build up area. Moreover, Tanjung Mas Port activities and Candi industrial estates near of it.

Tabel 4 Surface Temperature Analysis

No	Temperature (Celcius)	1999		2018		Δ 1999-2018	
		(Km2)	%	(Km2)	%	(Km2)	%
1	< 25 C	46.58	25.56%	32.27	17.72%	-14.31	-30.72%
2	25-30 C	118.40	64.97%	56.91	31.25%	-61.49	-51.93%
3	> 30 C	17.25	9.47%	92.93	51.03%	75.68	438.72%
	Total	182.23	100%	182.11	100%		

In 1999 the the number urban village which impact increasing surface temperature until >30^{0}C just 60 urban villages. In 2018 all of study area which is 68 urban villages has surface temperature>30^{0}C. The number of urban villages which has temperature area >30^{0}C more than 50% also increased from 14 to 44 (see **Table 5**). Urban villages which has industrial area or located near industrial area must experience increasing surface temperature until >30^{0}C.

Tabel 5 Urban Villages with Temperature area >30^{0}C

No	Sub-District	Urban Village	Urban Village Area (Ha)	1999		2018	
				(Ha)	%	(Ha)	%
1	Gayamsari	Kaligawe	83.48	10.28	12.31%	68.65	82.24%
2	Gayamsari	Sawah Besar	61.92	4.17	6.74%	48.50	78.33%
3	Gayamsari	Tambakrejo	101.97	8.59	8.43%	55.27	54.20%
4	Genuk	Bangetayu Kulon	198.67	-	0.00%	93.06	46.84%
5	Genuk	Banjardowo	255.07	-	0.00%	143.99	56.45%
6	Genuk	Gebangsari	125.78	25.43	20.22%	94.45	75.09%
7	Genuk	Genuksari	226.06	9.90	4.38%	104.39	46.18%
8	Genuk	Karangroto	217.08	0.36	0.17%	117.72	54.23%
9	Genuk	Kudu	201.91	-	0.00%	84.40	41.80%
10	Genuk	Muktiharjo Lor	138.93	50.24	36.16%	97.24	70.00%
11	Genuk	Terboyo Kulon	274.68	-	0.00%	49.24	17.93%
12	Genuk	Terboyo Wetan	194.66	3.10	1.59%	44.17	22.69%
13	Genuk	Trimulyo	333.43	3.91	1.17%	91.87	27.55%
14	Ngaliyan	Bambankerep	322.33	38.77	12.03%	300.90	93.35%
15	Ngaliyan	Bringin	296.08	20.21	6.83%	227.85	76.96%
16	Ngaliyan	Gondoriyo	548.04	41.63	7.60%	268.88	49.06%
17	Ngaliyan	Kalipancur	227.47	57.26	25.17%	215.27	94.64%
18	Ngaliyan	Ngaliyan	541.03	50.33	9.30%	449.97	83.17%
19	Ngaliyan	Purwoyoso	210.87	31.07	14.73%	208.44	98.85%

No	Sub-District	Urban Village	Urban Village Area (Ha)	1999 (Ha)	%	2018 (Ha)	%
20	Ngaliyan	Tambakaji	436.29	20.29	4.65%	384.99	88.24%
21	Ngaliyan	Wonosari	549.32	77.59	14.12%	457.81	83.34%
22	Pedurungan	Muktiharjo Kidul	213.56	12.52	5.86%	175.65	82.25%
23	Semarang Barat	Bojong Salaman	60.45	36.03	59.59%	57.65	95.36%
24	Semarang Barat	Bongsari	85.62	36.19	42.26%	85.62	100.00%
25	Semarang Barat	Cabean	22.37	18.04	80.64%	22.03	98.46%
26	Semarang Barat	Gisikdrono	131.97	60.95	46.18%	131.97	100.00%
27	Semarang Barat	Kalibanteng Kidul	44.38	18.69	42.12%	44.38	100.00%
28	Semarang Barat	Kalibanteng Kulon	97.91	23.35	23.85%	97.79	99.88%
29	Semarang Barat	Karang Ayu	53.78	34.19	63.57%	53.78	100.00%
30	Semarang Barat	Kembang Arum	188.76	10.73	5.68%	188.49	99.86%
31	Semarang Barat	Krapyak	92.36	48.56	52.57%	77.86	84.30%
32	Semarang Barat	Krobokan	87.04	43.56	50.04%	83.06	95.43%
33	Semarang Barat	Manyaran	176.38	35.95	20.38%	175.92	99.74%
34	Semarang Barat	Ngemplak Simongan	83.45	23.61	28.30%	82.33	98.66%
35	Semarang Barat	Salaman Mloyo	46.94	38.49	82.00%	46.94	100.00%
36	Semarang Barat	Tambakharjo	806.92	21.67	2.69%	458.97	56.88%
37	Semarang Barat	Tawangmas	137.79	22.88	16.60%	126.25	91.63%
38	Semarang Barat	Tawangsari	382.83	37.18	9.71%	331.72	86.65%
39	Semarang Timur	Kemijen	122.43	14.10	11.52%	69.49	56.76%
40	Semarang Timur	Mlatibaru	52.19	33.19	63.59%	50.28	96.34%
41	Semarang Timur	Mlatiharjo	46.53	21.99	47.26%	46.50	99.94%
42	Semarang	Rejomulyo	37.74	21.96	58.18%	35.22	93.31%

No	Sub-District	Urban Village	Urban Village Area (Ha)	1999 (Ha)	%	2018 (Ha)	%
	Timur						
43	Semarang Utara	Bandarharjo	222.84	54.49	24.45%	193.17	86.69%
44	Semarang Utara	Bulu Lor	67.61	47.72	70.59%	61.34	90.73%
45	Semarang Utara	Dadapsari	39.64	34.82	87.85%	39.46	99.55%
46	Semarang Utara	Kuningan	85.06	58.40	68.66%	85.06	100.00%
47	Semarang Utara	Panggung Kidul	44.80	31.64	70.63%	41.07	91.67%
48	Semarang Utara	Panggung Lor	240.82	89.32	37.09%	178.17	73.99%
49	Semarang Utara	Plombokan	57.14	32.48	56.85%	56.85	99.50%
50	Semarang Utara	Purwosari	48.08	36.44	75.80%	48.01	99.86%
51	Semarang Utara	Tanjung Emas	394.42	99.34	25.19%	280.85	71.20%
52	Tugu	Jerakah	118.98	11.20	9.41%	111.83	93.99%
53	Tugu	Karanganyar	445.53	11.36	2.55%	131.80	29.58%
54	Tugu	Mangkang Kulon	432.96	1.20	0.28%	67.57	15.61%
55	Tugu	Mangkang Wetan	395.28	0.70	0.18%	43.59	11.03%
56	Tugu	Mangunharjo	465.87	-	0.00%	50.44	10.83%
57	Tugu	Randugarut	499.99	40.93	8.19%	164.62	32.92%
58	Tugu	Tugurejo	542.94	17.06	3.14%	137.13	25.26%
59	Kaliwungu	Kutoharjo	220.87	8.96	4.06%	90.38	40.92%
60	Kaliwungu	Mororejo	1,065.73	11.90	1.12%	105.54	9.90%
61	Kaliwungu	Nolokerto	726.67	46.53	6.40%	508.99	70.04%
62	Kaliwungu	Sumberejo	789.89	18.54	2.35%	485.28	61.44%
63	Sayung	Gemulak	405.79	-	0.00%	2.17	0.53%
64	Sayung	Loireng	388.98	-	0.00%	95.78	24.62%
65	Sayung	Purwosari	431.44	-	0.00%	33.68	7.81%
66	Sayung	Sayung	484.76	2.26	0.47%	173.96	35.89%
67	Sayung	Sidogemah	660.75	-	0.00%	4.48	0.68%
68	Sayung	Sriwulan	430.86	2.37	0.55%	53.76	12.48%
Total			**18.,224.14**	**1,724.65**		**9,293.91**	

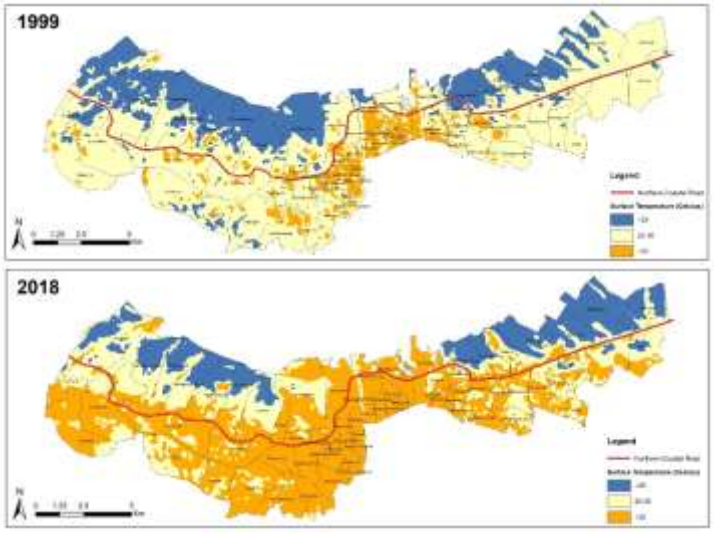

Fig. 4 Surface Temperature along the Northern-Coastal Road of Semarang City

3.3 Surface temperature changes as the impact Industrial Development

In 1999-2018 surface temperature increase along northern-coastal road. Increasing industrial development also increase surface temperature in this area. The result of analysis show that industrial development until 95.58% generate increasing surface temperature area >30^{0}C until 438.72%. The impact of the existence of industrial estates is seen that the increase in surface temperature does not only occur in the built-up area and industrial area but also in non-built areas as well (see **Figure 6**). increasing surface temperature follows the direction of industrial development that leads to the west side. Increasing surface temperature also tends to be in densely buildup area such as in Semarang Barat Subdistrict and Semarang Utara Subdistrict. (see **Figure 5**).

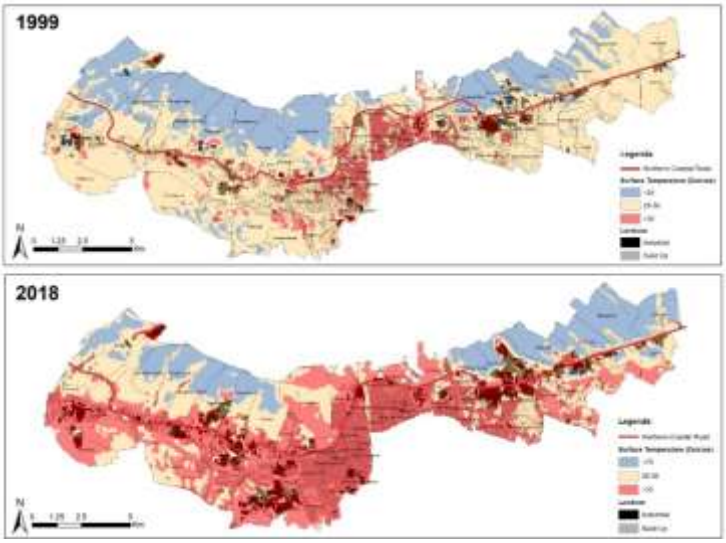

Fig. 5 Distribution Industrial and Build up Development to Surface Temperature

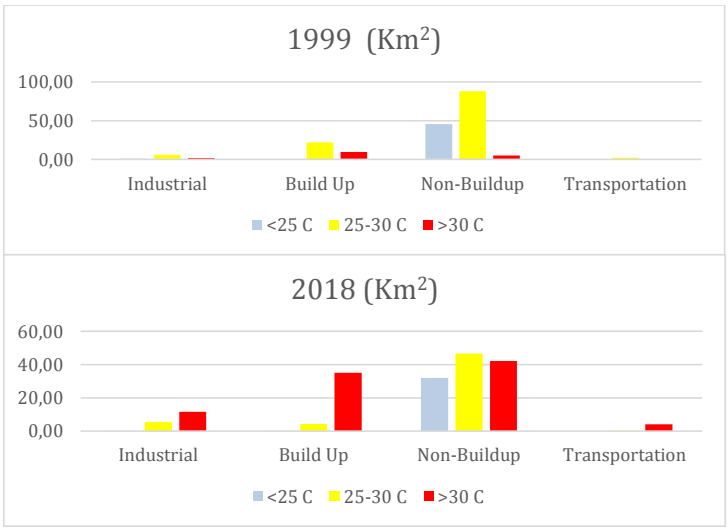

Fig. 6 Increasing Surface Temperature in Land use area

4. Conclusion

The existence of the *Kedungsepur* National Activity Center encourages the development of industrialization along the Northern-Coastal road in Semarang. Industrial development was followed by buildup area development and increase surface temperatures along the Northern-Coastal road in Semarang. Urban villages that are affected by surface temperatures of more than 30^0C tend to increase from 1999-2018. Increasing surface temperature follows industrial development lead to west side of study area. Increasing surface temperature is a sign of global warming in this region. Prolonged global warming can cause other effects on health and the environment. this study successfully demonstrated the form of surface temperature monitoring in industrial estates. Therefore, this research is expected to be a capital in controlling and reducing the occurrence of global warming in the city of Semarang.

References

[1] U. Nations, "2018-revision-of-world-urbanization-prospects @ www.un.org." .

[2] A. W. Sejati, I. Buchori, and I. Rudiarto, "The impact of urbanization to forest degradation in Metropolitan Semarang: A preliminary study," in *IOP Conference Series: Earth and Environmental Science*, 2018, vol. 123, no. 1, p. 12011.

[3] S. Zhang, X. Liu, and J. Bae, "Does trade openness affect CO 2 emissions : evidence from ten newly industrialized countries ?," 2017.

[4] X. Liu and J. Bae, "Urbanization and industrialization impact of CO2 emissions in China," *J. Clean. Prod.*, vol. 172, pp. 178–186, 2018.

[5] A. W. Sejati, I. Buchori, and I. Rudiarto, "The Spatio-Temporal Trends of Urban Growth and Surface Urban Heat Islands over Two Decades in the Semarang Metropolitan Region," *Sustain. Cities Soc.*, p. 101432, 2019.

[6] T. M. Lillesand *et al.*, *Penginderaan Jauh dan Interpretasi Citra*. Gadjah Mada University, 1993.

[7] N. Landsat, "Science Data Users Handbook," *2011-03-11]. http://landsathandbook. gsfc. nasa. gov/inst_cal/prog_sectS_2. html*. 7AD.

[8] N. Rahmawati, J.-F. Vuillaume, and I. L. S. Purnama, "Salt intrusion in Coastal and Lowland areas of Semarang City," *J. Hydrol.*, vol. 494, pp. 146–159, 2013.

[9] B. Citra and S. Landsat, "Analisis Pola Perubahan Garis Pantai Pesisir Semarang dan Sekitarnya Analisis Pola Perubahan Garis Pantai Pesisir Semarang dan Sekitarnya Berdasarkan Citra Satelit Landsat Mulitemporal," no. December, 2018.

[10] I. Buchori, A. Sugiri, M. Mussadun, D. Wadley, and Y. Liu, "International Journal of Disaster Risk Reduction A predictive model to assess spatial planning in addressing hydro- meteorological hazards : A case study of Semarang City , Indonesia," *Int. J. Disaster Risk Reduct.*, no. October, pp. 0–1, 2017.