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SPATIAL - TEMPORAL ANALYSIS OF URBAN HEAT ISLAND IN TANGERANG CITY

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ABSTRACT

Urban Heat Island (UHI) is a phenomenon which is affected by human activities. Land use change by human activities, expressed by urbanization that means rural or suburban areas changed to urban areas. This study is intended to identify the UHI phenomena in Tangerang city. To answer the aim of this research,temperature data is collected (direct and indirect data). Direct collection for air surface temperature conducted by surveying some location collect in 24 hour period (April 2012) and another location by rapid 10 – 15 minute in day time (April, July, August and September 2012). This technique employed mobile temperature and humidity tools. Secondary air surface temperature data (24 hour period) during 2009-2012 also use in this study. Indirect data employed Landsat TM only two year data 2001 and 2012 for land surface temperature. Satellite data employed to identify land cover change to get information about land use change. The result shown that the temperature condition, both air surface and land surface temperature, were changed. UHI phenomenon in Tangerang City indicated by temperature higher than 30^{0}C. Based on land surface temperature, UHI phenomenon in 2001 already occurred at small area. UHI phenomenon in 2012 almost covered the Tangerang City area. UHI Index in 2009 is 3.6^{0}C, in 2011 is 1.5^{0}C and then 2012 become 1.2^{0}C. This study concludes that UHI phenomena found since 2001 and trend of UHI Index AST since 2009 with average UHI Index AST of 2^{0}C. UHI Index LST in 2001 is 9.78^{0}C and 2012 is 13.96^{0}C

Key words: urban heatisland phenomena, land cover changes.

ABSTRAK

Urban Heat Island adlaah sebuah fenomena yang disebabkan oleh aktifias manusia. Perubahan penggunaan tanah akibat dari aktifitas manusia digambarkan dengan urbanisasi, yang berarti pedesaan atau daerah peralihan desa kota menjadi perkotaan. Penelitian ini bertujuan untuk identifikasi fenomena UHI di Kota Tangerang. Untuk menjawab tujuan penelitian ini digunakan pengumpulan data suhu (pengumpulan data secara langsung dan tidak langsung). Pengumpulan data langsung untuk suhu udara permukaan dengan survey, beberapa lokasi diambil selama 24 jam (April 2012) dan beberapa lokasi lainnya dengan pengambilan data cepat selama 10-15 menit pada siang hari (April, Juli, Agustus dan September 2012). Teknik ini mengunakan alat pengukuran suhu dan kelembaban. Data sekunder suhu udara (24 jam) selama 2009-2011 juga digunakan. Pengumpulan data tidak langsung menggunakan data Landsat TM yang terdiri dari dua tahun, yakni 2001 dan 2012 untuk menghasilkan suhu permukaan tanah. Data satelit digunakan untuk identifikasi perubahan data tutupan lahan sebagai indikasi perubahan penggunan tanah. Hasil penelitian menunjukkan keadaan temperatur, baik temperatur suhu udara dan suhu permukaan tanah terjadi perubahan. Fenomena UHI di Kota Tangerang terindikasi dengan temperatur lebih dari 30^{0}C. Berdasarkan suhu permukaan tanah, fenomena UHI pada tahun 2001 telah terjadi pada area yang tidak luas. Fenomena UHI tahun 2012 terjadi hampir menutupi seluruh Kota Tangerang. UHI Index di tahun 2009 adalah 3.6^{0}C, pada tahun 2011 adalah 1.5^{0}C dan kemudian pada tahun 2012 menjadi 1.2^{0}C. Kesimpulan dari penelitian iniadalah fenomena UHI sudah terdapat sejak tahunn 2001 dan tren UHI Index Suhu Udara Permukaan sejak tahun 2009 dengan UHI Index rata-rata 2^{0}C tiap tahun. Sedagkan UHI Index Suhu Permukaan Tanah pada tahun 2001 adalah 9.78^{0}C dan pada tahun 2012 adalah 13.96^{0}C.

Kata kunci : fenomena urban eeat island (*UHI*), perbahan tutupan tanah.

INTRODUCTION

The Intergovernmental Panel on Climate Change (*IPCC*) Fourth Assessment Report (*AR4*) has reported that global temperatures have risen about 0.74 ^{0}C since the beginning of the 20th century [*Malaysian Meteorological Department*, 2009]. This report also gives an indication of the impact of increasing global temperature to urban area conditions, especially urban heat island. Even though studies related to urban heat Island already conducted by so many researchers in the past-since Howard in 1818 [*Parham and Haghighat*, 2010], cases of urban heat island (*UHI*) are increasing as a consequence of urbanization and raising global temperature [*Oke*, 1981 in *Parham and Haghighat*, 2010]. UHI is a phenomenon where air temperatures in densely built-up areas inside a city are higher than the suburban rural areas [*Wong and Yu*, 2005]. It also known as a phenomenon of rising temperature in urban settings and urban area [*Ichinose et al*., 2008; *Kim and Baik*, 2005]. *UHI* is a mutual response of many environmental and manmade factors and has not been fully explored [*Memon et. al.,* 2009].

Cases of *UHI* in Indonesia, as representation of tropical cities, has been studied by Tursilawati in 2008 as researcher from Indonesian National Aerospace (*LAPAN*). The study conducted especially in major Indonesian cities, namely Bandung, Surabaya, Semarang and Jakarta by employing Landsat (Land Satellite) data. Result shown that there is growing urban area in Bandung-which annually-of about 1,029 ha (0.36%), Semarang 1,200 ha (0.83%) and Surabaya 531.28 ha (1.69%). Urban Heat Island (high temperature 30-35^{0}C) spreading is located in the downtown area, about 12,606 ha or 4.47%, Semarang 12,174 ha or 8.4%, Surabaya 1,512 ha or 4.8% in annual basis. *UHI* in Jakarta also conducted using Landsat estimation, in which UHI spatially found to be centralized in downtown areas and spreading to the surrounding area. In both 1989 and 2002, distribution of *UHI* that indicated by high surface temperature (upper than 30 °C) is identified at the central area of the city where buildings, roads, parking areas, and other non-vegetation surface types are dominant. The *UHI* area at the time of satellite passed in 1989 is around 8,453 ha, but in 2002 expanded to about 56,834. On the other hand, lower temperatures are found over vegetated areas (suburban) and water body areas. Comparison of Ts (temperature estimation) distribution between 1989 and 2002 shows that the urban development during those 13 years has caused significant increase in the surface temperature. The increase is not limited to the central part of the city, which has flat topography, but spreading to the southern-hilly part as well [*Tursilawati et. al.,* 2012].

THE METHODS

To answer the aim of this research, temperature data obtained from direct and indirect data collections are used. The research data is including direct air surface temperature and indirect data for land use and temperature change. Data which are collected in this research mainly consist of field survey data, maps, tabular data, and satellite imageries from the study area.

Direct collections of air surface temperature data were conducted by field survey from various location at the study area.. Some location collected in 24 hour period (April 2012) and other location colected by rapid 10 – 15 minute in day time (April, July, August and September 2012). The air temperatures measured based on interval and stored in device internal memory, which then were manually acquired from the mobile temperature and humidity tool, according to *Suzuki* [2008]. Mobile temperature and humidity tools were utilized as rapid measurement technique for air temperature data collection [*Wong, and Yu*, 2005].

Secondary data air surface temperature during 2009-2012 from Environmental Bureau of Tangerang City used for collecting 24 hour data (data collected for one week within a month, covering 50 air quality samples location). Sampling of temperature conducted based on several categories, including residential areas, central business or administration areas, bus stations, and industrial areas. Sample locations are selected based on *Suzuki* [2008], who measured *UHI* in Japan. The sampling sites were located in 2.5 km grids in the central part of Tokyo and 5 km grids in the surrounding area. The grid sizes were determined by the spatial representative of land cover/land use. Air surface temperature data measured using Hioki 3641 device, with specification consists of two channels. Range of temperature measurement is about -20.0^{0}C to 70.0^0 C. The range of internal temperature sensor and humidity measurement is about 0.0% - 100% for relative humidity (rh) sensor. The device temperature accuracy is $\pm$ 0.5^{0}C (at 0.0 to 35.0^{0}C) and humidity accuracy is = $\pm$ 5% (at 25^{0}C).

Indirect data obtained from Landsat ETM+ P122R064 (imageries captured at 15/07/2001 and 26/06/2012). Both two year data in 2001 and 2012 used for land cover/land use change and land surface temperature identification [*Hernina et al.,* 2008; *Tursilawati*, 2008; *Mallick et. al.,* 2008; *Mallick et. al.,* 2012; *Tursilawati et al.,* 2012]. Supervised method for land cover identification conducted based on land use data in 2005. Land Use data in 2005 is used according to *Shidiq* [2009]. equation from *Tursilawati et. al.,* [2012] used for land surface temperature estimation:

$$L\lambda=((LMAX_{\lambda}-LMIN_{\lambda})/(QCALMAXMIN)))*-(QCAL–QCALMIN)+LMIN_{\lambda} \ldots\ldots (1.1)$$

Where $L\lambda$ = spectral radiance (wm^{-2}sr^{-1}µm^{-1}), *QCAL* = digital number value at band i, $LMIN_{\lambda}$= minimum value of spectral radiance at band i (wm^{-2}sr^{-1}m$^{-1)}$, $LMAX_{\lambda}$ = maximum value of spectral radiance at band I (wm^{-2}sr^{-1}m$^{-1)}$, QCALMIN = the minimum quantized pixel value (typically DN equal to 1) corresponding to $LMIN_{\lambda}$, QCALMAX = the maximum quantized calibrated pixel value (typically DN = 255) corresponding to *LMAX*. Spectral radiance conversion to temperature [*Hernina et al., 2008*; *Tursilawati et. al.,* 2012] with equation:

$$T=K2/\ln((K1/L\lambda)+1) \ldots\ldots (1.2)$$

Where *T* is the temperature obtained from satellite sensor (Kelvin), *K*1 is the calibration constant 1 for Landsat TM (607.76 wm^{-2}sr^{-1}m^{-1}) and Landsat ETM+ (666.09 wm^{-2}sr^{-1}m^{-1}), *K2* is the calibration constant 2 for Landsat TM (1260.57 K) and Landsat ETM+ (1282.71 K), and $L\lambda$ is the spectral radiance from the 6th band [*Tursilawati et. al.,* 2012]. The last process is conversion from Kelvin to Celsius, using equation:

$$\text{Temp-CELCIUS} = \text{Temp-KELVIN} - 272.15 = T - 272.15 \ldots\ldots (1.3)$$

The derivation of *UHI* value is done by using a simple formula [*Wataru and Noorazuan*, 2010] equation 1.4. *UHI*= Urban Heat Island Intensity, max=maximum value of LSTu, min=minimum value of LSTr, u=urban point and r=rural point.

$$UHI = \max(LSTu) - \min(LSTr) \ldots\ldots (1.4)$$

UHI phenomenon uses temperature upper than 30^{0}C to identify *UHI* phenomena of Air Surface Temperature and Land Surface Temperature. *UHI* is compare temperature in urban and surrounding area (rural) called *UHI* Index. *UHI* Index basically used Temperature Urban Max – Temperature Rural Min. This study uses temperature average from total sample air temperature. *UHI* index uses equation:

$$UHI\ Index = Tmax\text{-}p - T\text{-}avg \ldots\ldots (1.5.)$$

UHI Index=*UHI* Index *AST*, Tmax-p= Temperature maximum in sample location, T-avg=Temperature average from total temperature sample location. If in one location *UHI* Index is higher than 5^0C, it means that the location represent rural than *UHI* Index near 1^0C (urban area). If *UHI* negative, it means that location maximum temperature lower than average temperature. *UHI* variation depends on spatial (location) and temporal data coverage. Final analysis conducted by generateing map of *GIS* modelling for *UHI* phenomenon (spatial and temporal) and *UHI* Index for identifying *UHI* phenomena in Tangerang.

RESULT AND DISCUSSION

Land Cover and Land Use Change

Based on land cover change data in Figure 1, the area has been classified to street, open space, build up and impermeable area, water body, vegetation cover, cloud cover and cloud shadow. Build-up and permeable areas changed from 7,065.41 ha in 2011 to 11,252.58 ha in 2012 (increasing to +4,187.17 ha). Detailed land cover change is shown in Table 1.

Table 1. Land Cover Change 2001-2012

No	Land Cover	2001 (hectare)	2012 (hectare)	Changed (Hectare)
1	Cloud Cover	373.59	0.00	-373.6
2	Cloud Shadow	150.75	0.00	-150.8
3	Street	1,945.58	1,945.58	0.0
4	Open Space	2,572,10	35.17	-2,607.3
5	Build up and water proof area	7,065.41	11,252.58	+4,187.2
6	Water body	28.31	171.55	+143.2
7	Vegetation Cover	6,428.63	5,159.49	-1,269.1
	Total	18,564..37	18,564..37	

Source: Image Analysis, 2001 and 2012

Generally, land cover change generates negative impacts, but in special condition has positive value. For example, the artificial lake in the study area, known as Situ Pondoh, became larger than earlier in 2001. Vegetation cover also changed, but not as larger as open space, build-up and impermeable area. Green area almost observed at wide area in south area of Tangerang, bigger than green area in the west, south and north area of Tangerang.

Land cover changed in accordance with land land use, which represent equal condition. For example, there are many locations that changed from natural land area (open space, vegetation cover) to build-up area (building, street, and impermeable area). Interestingly, a water body in the study area, called Lake Cipondoh, was getting larger in 2012 compared to 2001. (Figure 2).

Spatial-Temporal Air Surface Temperature (AST) in 2012

This research started by collecting air surface temperature since April 2012. The result for all locations are shown at Table 2. For example, temperature data in Cipete sub-district and Cikokol Flyover collected twice (in April and July). Temperature data at Duta Garden Market collected twice, firstly in April and secondly in September. Temperature data from other location collected for three times (in April, July and August). Data recorded from 9.00 am until 5.30 pm at local time. Air surface temperature varied between 25.6^0C (at Office of Karawaci sub-district) to 38.3^0C (at Cikokol Flyover) in April 2012. Air surface temperature in July 2012 ranged from 29^0C until 35^0C, temperature in August 2012 ranged from 31^0C until 35^0C, and temperature in September 2012 ranged from 30^0C until 34^0C. Average air temperature April-September 2012 is 30^0C until 36^0C, temperature in April is 32.74^0C, July is 32.31^0C, August is 33.18^0C, September is 33.57^0C and average April-September is 32.98^0C. Air surface temperature in Tangerang are different from spatial and temporal basis. Related to *UHI* phenolmena, urban heat that were higher than 30^0C gave an indication of *UHI* phenomenon. This phenomenon already observed at Tangerang city in 2012, expressed by average temperature at day time in April ($32,74^0$C), July ($32,31^0$C), August ($33,18^0$C) and September ($33,57^0$C).

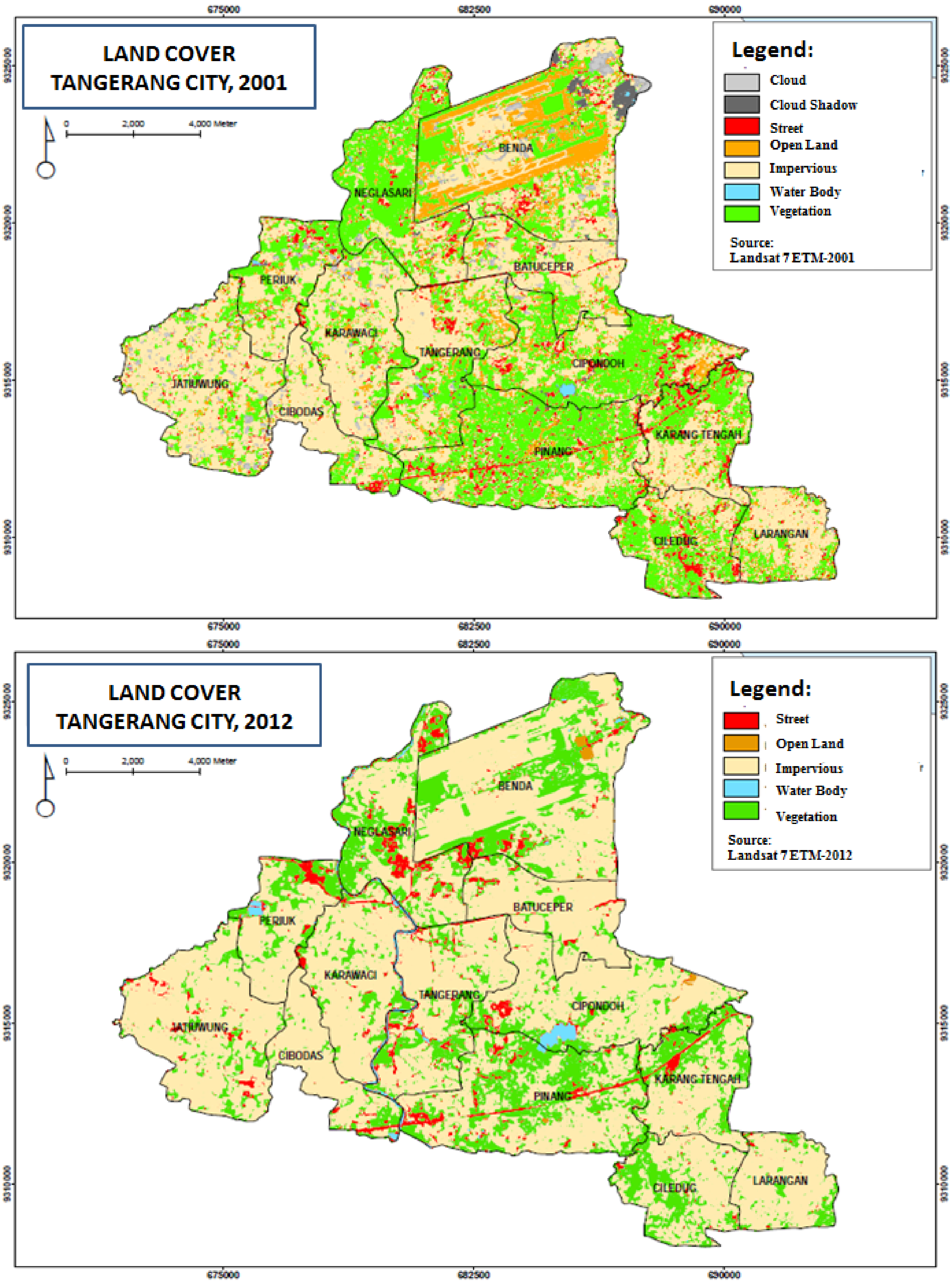


Figure 1. Land Cover Change 2001-2012

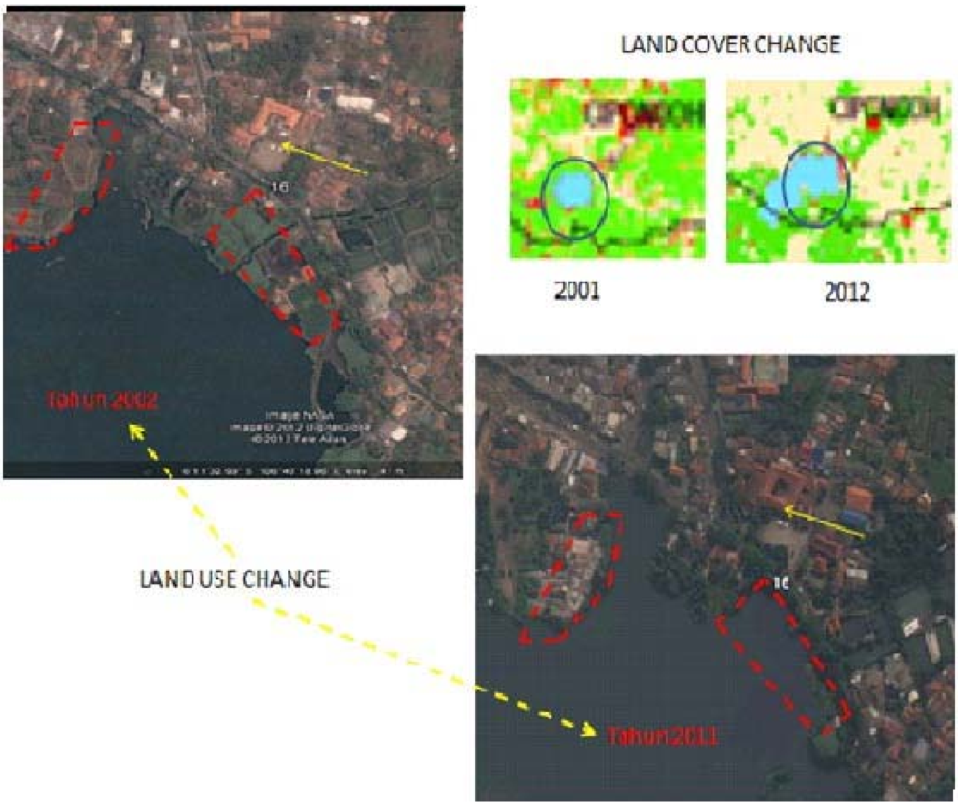


Figure 2. Sample Land Cover Change 2001-2012 and Land Use Change 2002-2012

Table 2. Air Surface Temperature at Tangerang City in 2012

No	Location	Average Air	Surfac	Temperature	(10 minute)	^{0}C
		April	July	August	Sept	Average
1	Penunggangan Village	32.6	29.0	32.9	-	31.5
2	Cipete Village	33.9	29.4	-	-	31.7
3	Pinang Sub-District	33.4	31.2	31.8	-	32.1
4	Graha Bintaro Housing	34.6	31.2	31.0	-	
5	Cimone Bus Stations	29.7	34.1	-	-	32.3
6	Pasir Jaya Village	33.4	35.0	-	-	31.9
7	Gembor Village	33.4	34.4	-	-	34.2
8	Karawaci Sub-District	25.6	33.9	34.0	-	33.9
9	Poris Plawad Bus Stations	34.5	33.1	34.4	-	31.2
10	Poris Indah Housing	34.8	31.9	33.8	-	34.0
11	Cipondoh Sub-District	33.2	32.4	-	-	33.5
12	Cikokol Flyover	38.3	-	34.1	-	32.8
13	Pupspem Building	33.8	-	33.6	-	36.2
14	Cisadaen Building	34.6	-	33.8	-	33.7
15	Malabar Market	31.9	-	35.0	-	34.2
16	Cibodas Sub-District	31.3	-	34.4	-	33.4
17	Islamic Villge	27.9	-	33.4	-	32.8
18	Bengkok Market	35.8	-	34.3	-	30.7
19	Duta Garden Market	31.8	-	-	33.2	35.1
20	Benda Sub-District	34.1	-	-	34.2	32.4
21	Benda Village	32.3	-	-	33.7	34.1
22	Neglasari Sub-District	29.8	-	-	33.3	33.0
23	Batuceper Sub District	35.7	-	-	33.6	31.6
24	Karang Tengah Sub-District	33.8	-	-	32.9	34.7
25	BPI Market Office	29.3	-	-	31.4	33.3
26	H. Mencong Street	31.9	-	-	30.8	30.4
	Avgerage Tempepature	32.7	32.3	33.2	33.6	31.0

Source: Survey and Data Processing, 2012

Detailed time series of air surface temperature for day time in Tangerang city, for example in April 2012, is shown in Table 3 and Figure 3. Table 3 explained dynamic of air surface temperature start in 9.00-9.29 a.m. The temperature is already reached 33.2^{0}C, and became maximum 35.7^{0}C for day time in 12.00-12.29 Then, temperature going down 29.0^{0}C in 05.00-05.29 pm. This result gave another perspective about *UHI* phenomenon in day time. In day time of April 2012 (since 9.00 am until 04.00 pm), air surface temperature were higher than 30^{0}C, meant that *UHI* phenomena has occurred in Tangerang city (temporaly during day time).

Spatial-Temporal Maximum, Minimum and Average of *AST* (2009, 2010, 2011, 2012)

Distribution of urban temperature for detecting the *UHI* phenomenon shown in Figure 4.

The maximum temperature of urban temperature >30^{0}C started from 2009 until 2012, almost of Tangerang area was higher than 30^{0}C. Even though the temperature each year was not increasing compared to the previous year since there were many variation in the temperature during that period, the trend is still positive. For example in Benda sub-district, first location indicated that maximum air surface temperature in 2009 is 33^{0}C, in 2011 is 32^{0}C and in 2012 is 34^{0}C. The maximum temperature at second location in 2009 is 33^{0}C, in 2011 is 34^{0}C and in 2012 is 38^{0}C. Other example in Tangerang sub-district also indicated that the maximum *AST* trend is positive. Maximum temperature at first location in 2009 is 32^{0}C, in 2011 is 32^{0}C and in 2012 is 33^{0}C. The temperature at second location in 2009 is 33^{0}C, in 2011 is 33^{0}C and in 2012 is 34^{0}C.

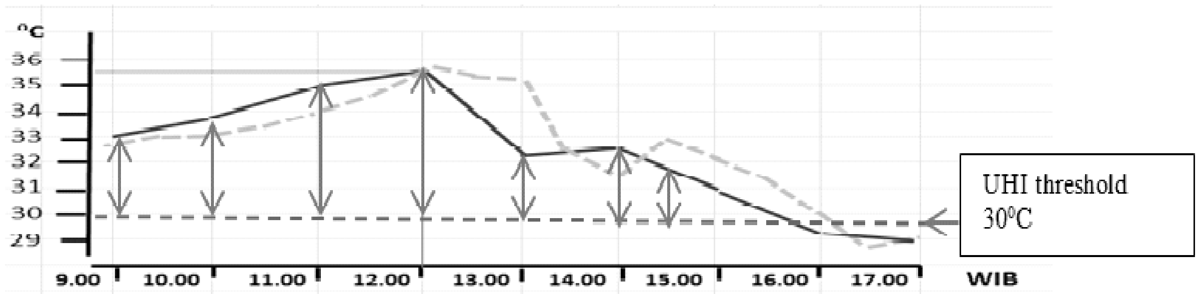


Figure 3. Air Surface Temperature of Tangerang City at Daytime in April 2012

Table 3. Air Surface Temperature at Tangerang City in April 2012

Date	Temeparature (Celcius)																
24/4/12	-	-	33.8	33.57	-	-	36.2	-	-	-	-	-	-	-	-	-	-
23/4/12	-	33.2	34.6	-	34.5	34.8	-	-	37.2	35.8	33.4	33.9	-	32.6	-	30.0	29.8
20/4/12	33.2	32.3	31.8	-	-	-	-	33.8	-	29.3	29.0	-	31.2	32.8	-	30.0	29.0
18/4/12	-	-	-	34.1	36.5	35.1	37.0	33.4	34.6	-	34.2	31.7	-	31.7	-	-	-
17/4/12	-	-	-	31.8	-	29.7	34.6	-	33.6	25.2	31.9	-	31.3	27.9	25.2	-	-
16/4/12	-	-	-	33.8	-	38.3	-	38.9	-	-	33.3	35.7	30.0	36.2	30.0	-	-
Average	33.2	33.1	33.3	33.9	34.8	35.1	35.7	35.3	32.6	31.5	32.9	32.3	31.7	30.9	28.8	30.0	29.7
	9.00 - 9.29	9.30 - 10.00	10.01 - 10.29	10.30 - 11.00	11.01 - 11.29	11.30 - 12.00	12.01 - 12.29	12.30 - 13.00	13.01 - 13.29	13.30 - 14.00	14.01 - 14.29	14.30 - 15.00	15.01 - 15.29	15.30 - 16.00	16.00 - 16.29	16.30 - 17.00	17.00 - 17.29

Source: Survey and Data Processing, 2012

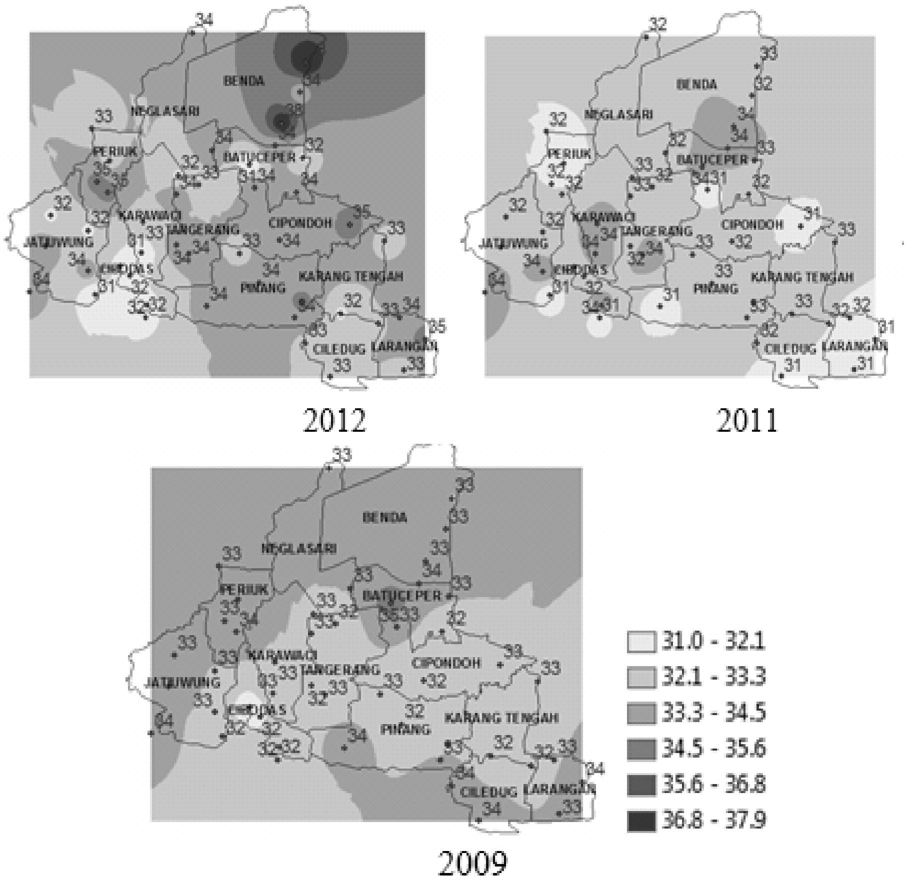


Figure 4. Maximum Air Surface Temperature in Tangerang City (in 2009, 2011 and 2012)

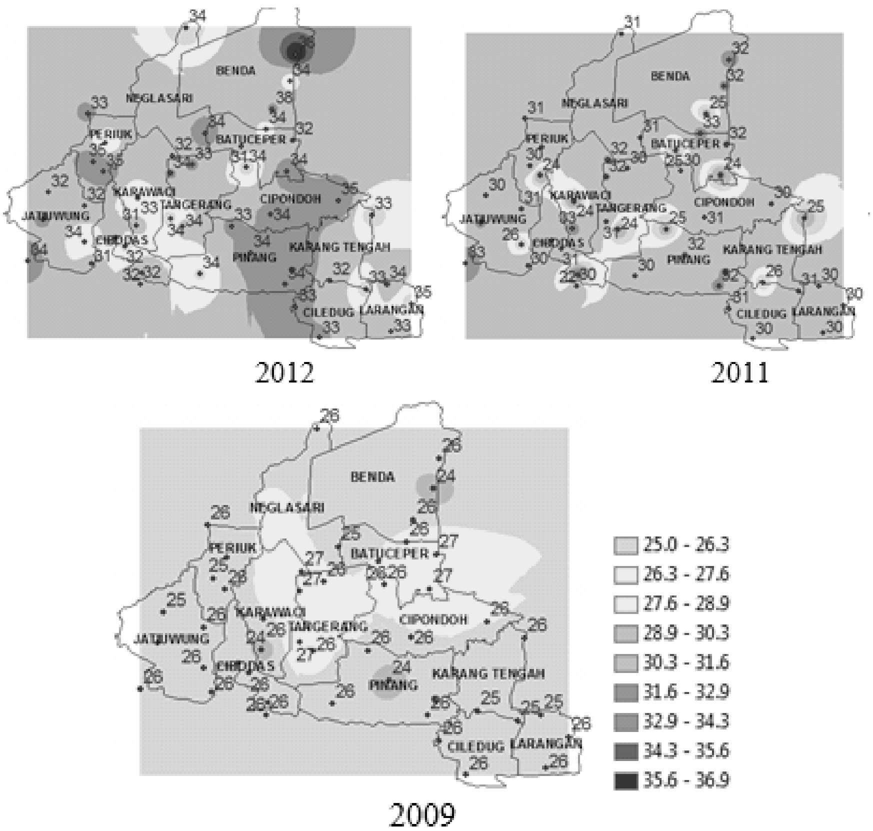


Figure 5. Minimum Air Surface Temperature in Tangerang City (in 2009, 2011 and 2012)

Distribution of minimum *AST* in Tangerang is shown in Figure 6. The minimum temperature in Tangerang is 22^0C (2011) to 25^0C (2012). For example, first location in Benda sub-district indicated minimum air surface temperature of 24^0C in 2009, and 28^0C in 2012. The second location minimum temperature in 2009 is 26^0C, and in 2012 is 28^0C. Other example is Tangerang sub-district, which also indicated the minimum *AST* trend is positive. The first location temperature in 2009 is 26^0C, and in 2012 is 30^0C, while the second location temperature in 2009 is 27^0C, and in 2012 is 28^0C.

Distribution of average temperature is shown in Figure 6. The minimum average temperature in Tangerang city is 26^0C (2010) and maximum average temperature is 38^0C (2012). In Benda sub-district, Observation at first location indicated that average air surface temperature in 2009 is 29.5^0C, in 2011 is 32.5^0C and in 2012 is 37.5^0C The second location maximum temperature in 2009 is 29.5^0C, in 2011 is 29.5^0C and in 2012 is 38^0C. Tangerang sub-district also indicated positive trend of average *AST*. The temperature at first location in 2009 is 29^0C, in 2011 is 31^0C and in 2012 is 32.5^0C. The second location temperature in 2009 is 29.5^0C, in 2011 is 29^0C and in 2012 is 32^0C.

Land Surface Temperature (*LST*)

Another way to understand *UHI* phenomenon in the sudy area conducted by using satellite image data from Landsat *ETM+* through Land Surface Temperature (*LST*). *LST* is temperature estimation from land cover, in this case, obtained in 2001 and 2012. Result of LST is then validated with temperature data from sample locations and weather stations (near or include the area of study). Spatial distribution of LST at Tangerang city in 2001 is shown Figure 7, The *LST* is about 17.7^0C until 31.8^0C. The *LST* with temperature category 24-28^0C is most dominant than temperature of 21.2 – 24.7^0C, and temperature 28.3 – 31.8^0C. The *LST* covering small area is temperature category of 17.7-21.2^0C. For those area, validation taken by sample locations for air surface temperature. LST with temperature upper than 28.01^0C were distributed in Tajur housing area and Ciledug sub-district. Minimum *LST* with temperature less than 24.12^0C were distributed in Kelapa Indah sub-sub district and Tangerang sub-district. Average *LST* in 2001 is 26.23^0C.

The *LST* in July 26, 2012 (Figure.7) shown that condition of temperature in Tangerang city with dominated by temperature higher than 28.3^0C and maximum temperature of 31.0^0C. The *LST* with minimum temperature less than 22^0C still shown, with dominant minimum temperature is 26.6^0C. This condition indicated that during 10 years period (2001-2012), the trend of urban temperature increasing very fast (average + 3^0C/10 years, or $0,3^0$C/year).

Urban Heat Island Phenomenon

UHI phenomenon for AST

The UHI phenomenon in Tangerang City is indicated by temperature higher than 30^0C that occurred since 2009. It means the *UHI* phenomenon occurred in Tangerang city by day time and night time. therefore it is almost 24 hour occurred Tangerang city. Validation of this condition conducted by comparing with weather stations in Tangerang City. Ciledug and Pondok Betung shown that *UHI* phenome started in 1979 at Pondok Betung and Ciledug started in 1983, based on maximum temperature. Two weather stations shown *UHI* phenomena still happen in 2006 (Pondok Betung) and 2008 (Ciledug). (Figure 8).

AST had occurred in the maximum and average temperature in Tangerang City. Temperature of maximum *AST* in Tangerang city is 38^0C (2012). That is an indication that *UHI* phenomenon for AST has occurred in Tangerang City. That condition validated by maximum average of Air Surface Temperature (*AST*) in Tangerang City, which is 32^{0}C. This temperature is based on a survey conducted by Environmental Bureau of Tangerang City from 2009 until 2012 (Table 4). The trend of maximum temperature is 0.5^{0}C/year, or 2^{0}C/four years. This condition is in line with thr positive trend of *UHI* phenomenon for maximum *AST* since 2009 to 2012.

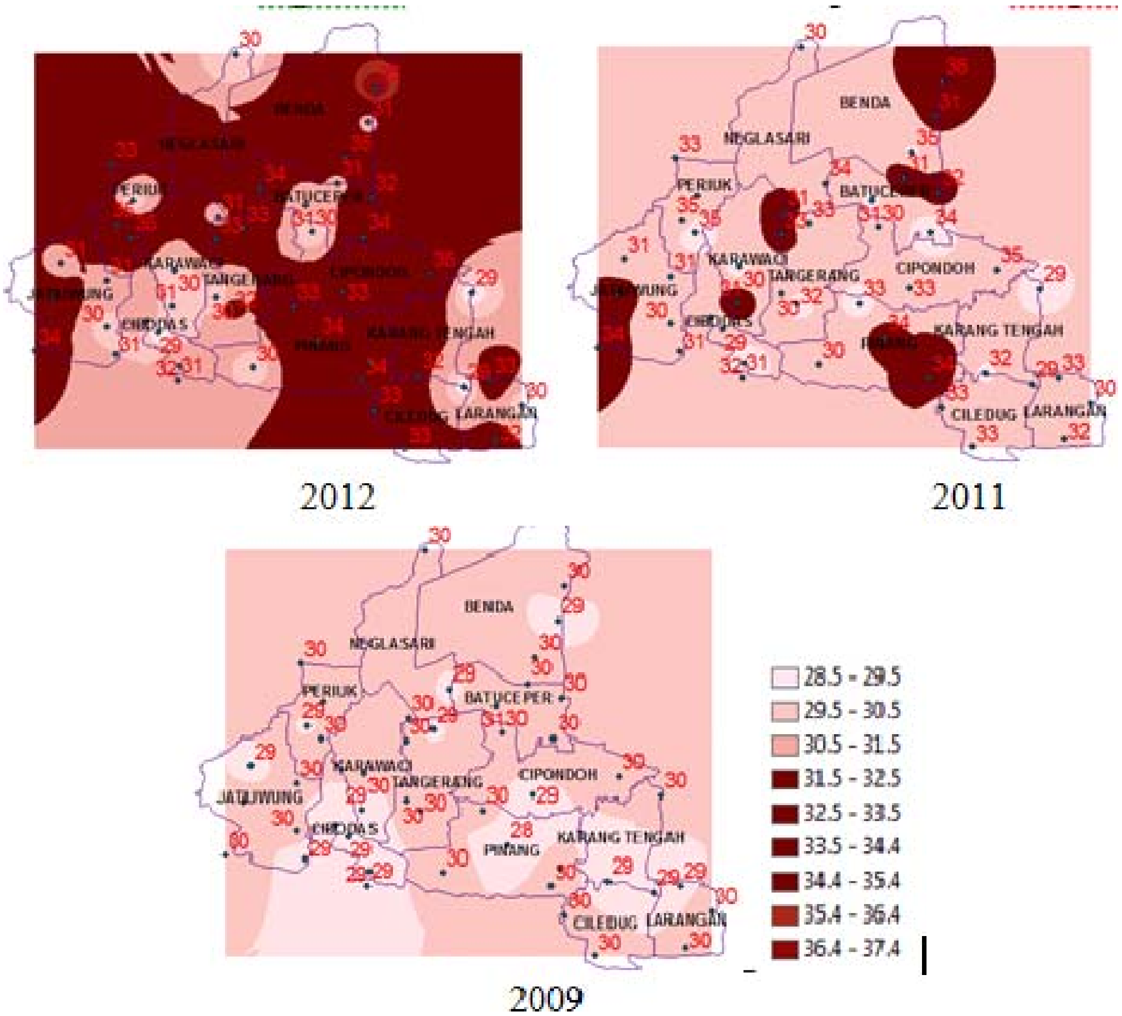


Figure 6. Average Air Surface Temperature in Tangerang City (2009, 2011 and 2012)

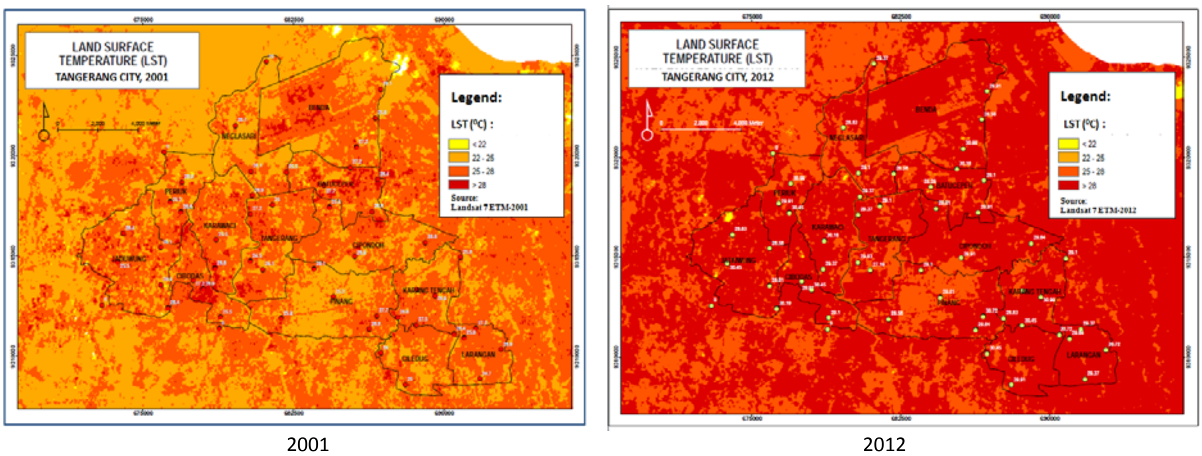
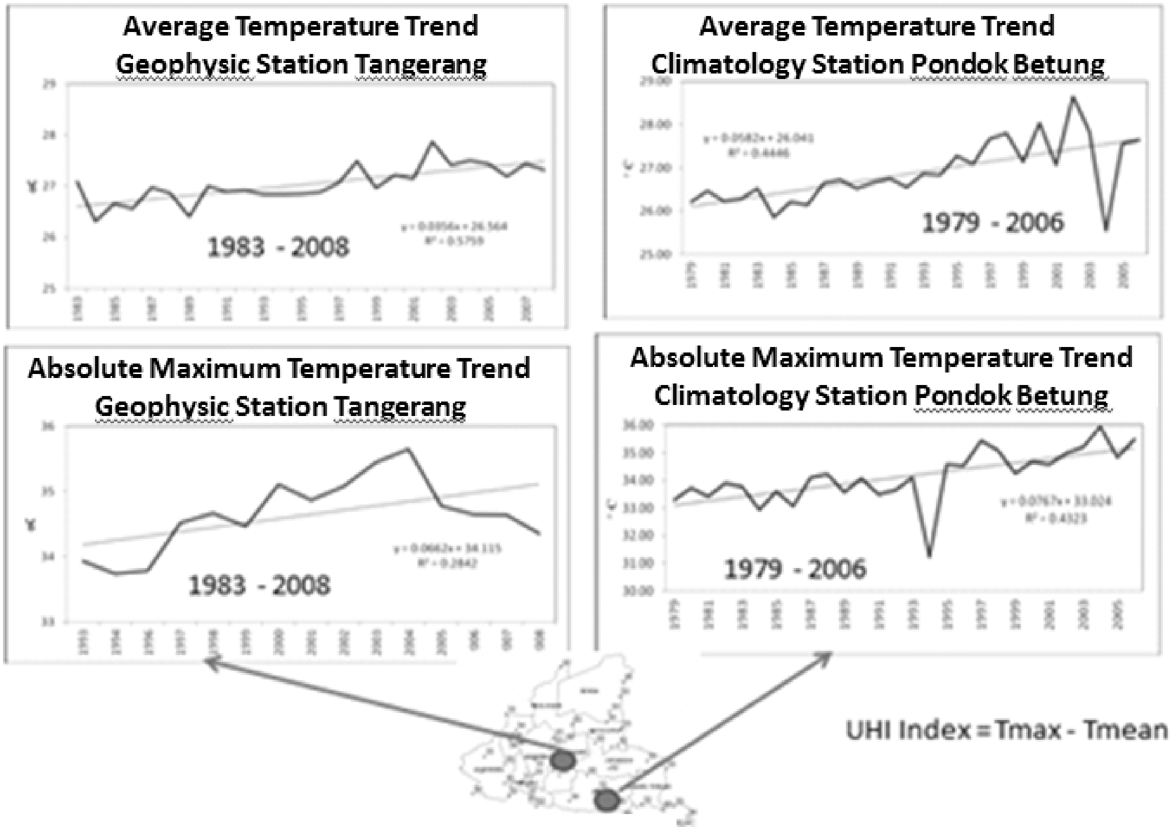


Figure 7. Spatial-Temporal of Land Surface Temperature in Tangerang City (2001and 2012)



Source: Meteorological. Climatological and Geophysical Bureau

Figure 8. Air Surface Temperature in Weather Station Laid on Tangerang City.

Table 4. Urban Temperature Change in Tangerang City (2001-2012)

No	LOCATION	LST			AST		LST	AST
		2001	2009	2010	2011	2012	2012	2012
1	Puspem Building	24.9	29.0	36.3	31.1	32.5	29.1	33.7
2	Cikokol Flyover	24.5	29.5	30.5	31.5	29.5	28.8	36.2
3	Office Batuceper Sub-District	27.7	30.5	29.8	29.5	30.5	28.3	34.7
4	Office Cibodas Sub-District	27.2	28.5	34.4	32.5	31.5	29.9	32.8
5	Malabar Market	26.9	29.0	31.0	31.5	28.5	30.4	33.4
6	Islamic Village	26.4	29.0	30.5	30.5	30.5	30.2	30.7
7	Office Karawaci Sub-District	26.6	28.5	29.4	33.5	30.5	29.4	31.2
8	Cisadane Building	26.9	30.0	31.0	32.5	32.0	29.4	34.2
9	Cimone Bus Station	25.5	29.5	29.9	29.0	29.5	30.2	31.9
10	Office Pasir Jaya Village	25.5	29.5	31.5	32.5	33.0	30.4	34.2
11	Office Gembor Village	26.4	29.0	30.8	31.0	31.0	28.8	33.9
12	Office Neglasari Sub-District	26.1	29.0	29.6	30.5	32.0	29.1	31.6
13	Duta Garden Market	27.2	29.5	33.2	29.5	38.0	31.0	32.4

Table 4 (cont.). Urban Temperature Change in Tangerang City (2001-2012)

No	LOCATION	LST	AST				LST	AST
		2001	2009	2010	2011	2012	2012	2012
14	Benda Sub-District	25.8	28.5	31.0	32.0	31.0	28.6	34.1
15	Benda Village	26.1	29.5	29.8	32.5	37.5	29.9	33.0
16	Karang Tengah Sub-District	25.0	28.5	30.9	32.5	32.0	28.8	33.3
17	BPI Building	25.8	29.5	34.2	29.0	29.0	29.1	30.4
18	Cipondih Sub-District	26.9	29	31.2	31.5	33.0	29.9	33.5
19	Poris Plawad Bus Station	25.5	29.5	33.4	30.5	29.5	28,0	34.0
20	Poris Indah Housing	26.6	29.5	35.7	28	33.5	29.9	32.8
21	Bengkok Market	27.7	29.5	30.8	32.5	34.5	30.7	35.1
22	Graha Bintaro Housing	26.6	29.5	31.7	32.5	33.5	29.6	32.3
23	Cipete Village	26.0	29.5	30.9	29.0	32.5	29.1	31.7
24	Pinang Sub-District	25.2	28.0	29.1	32.5	33.5	28.0	32.1
25	Panu nggangan Village	25.8	30.0	26.6	30.5	30.0	28.6	31.5
26	H. Mencong Street	26.4	28.5	34.9	31.5	29.0	30.7	30.4

Source: Survey, and Data Process in 2012

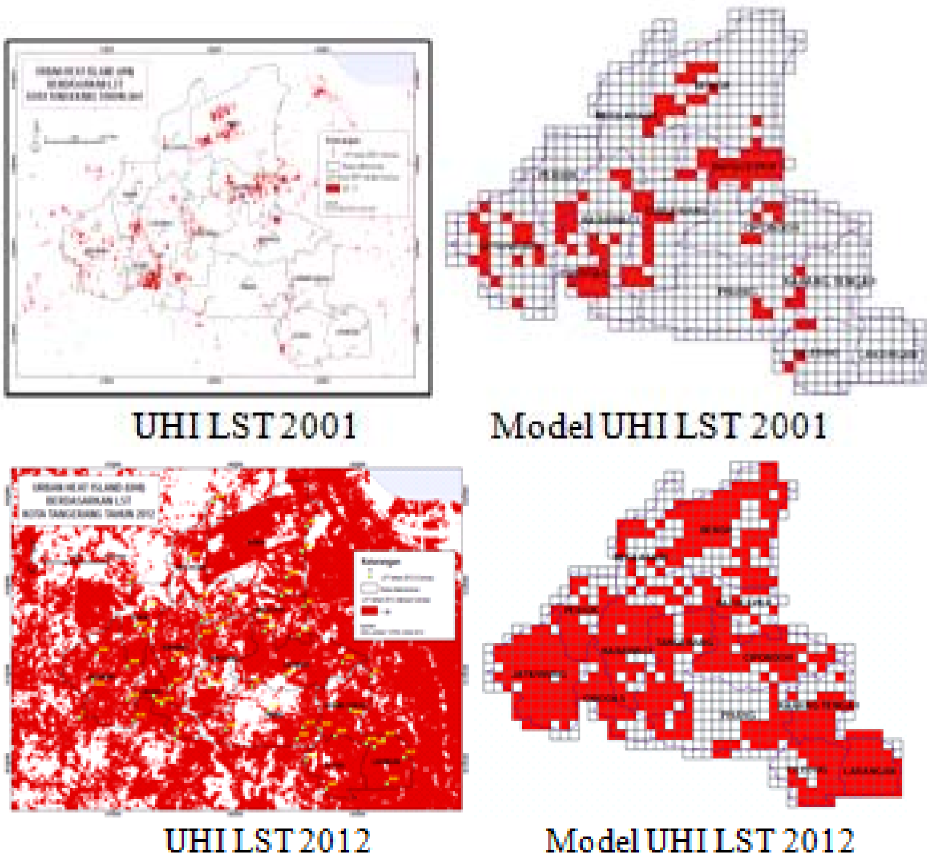


Figure 9. Spatial-Temporal Urban Heat Island LST in Tangerang City (Model from LST, 2001 and 2012)

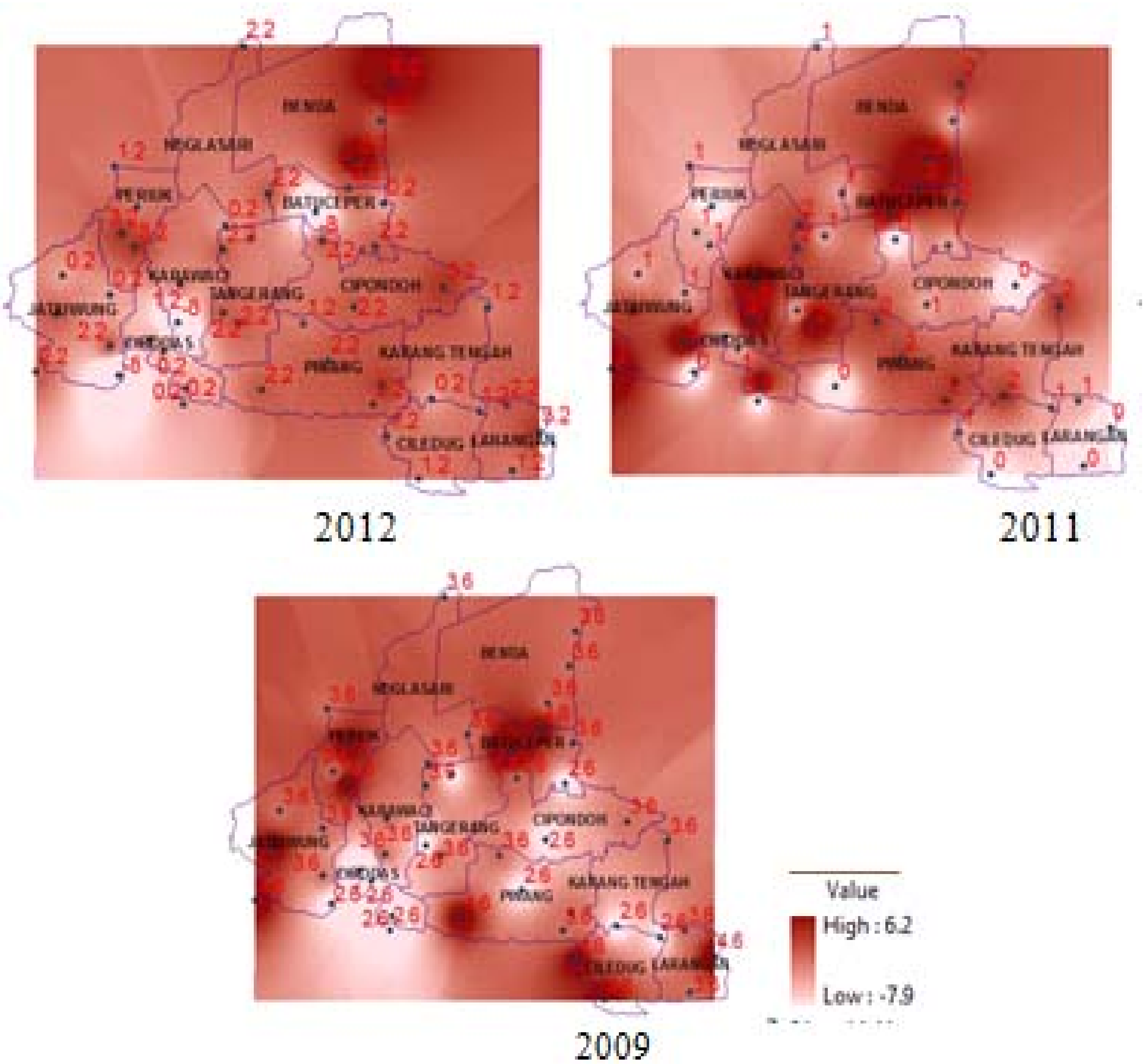


Figure 10. Spatial-Temporal UHI Index in Tangerang City (2009, 2011 and 2012)

UHI* phenomenon *LST

GIS Modeling from *LST* in Tangerang City is shown in Figure 9. *UHI LST*. The figure indicates that areal composition of *UHI LST* with temperature higher than 30^0C in 2012 is larger than in 2001. Percentage area in 2001 for *UHI LST* with temperature higher than 30^0C was less than 20% (mainly in Benda, Batuceper, and Jatiuwung sub-district). In 2012, *UHI LST* increased to higher than 80% for the area with temperature higher than 30^0C, expressed by red color covering almost entire area of the city. *UHI* phenomena in Tangerang City indicated by temperature higher than 30^0C. Based on land surface temperature, *UHI* phenomenon in 2001 already covered small area. *UHI* phenomenon in 2012 almost covered the entire area of Tangerang.

UHI* Index *AST* and *LST

Average UHI Index in 2009 is 3.6^0C, in 2011 is 1.5^0C, and then in 2012 become 1.2^0C. The study of *UHI* phenomena in Tangerang city identified that there is a trend of *UHII* since 2009, with average *UHI* Index of 2^0C. Spatio-temporal analysis of the *UHI* Index *AST* is shown in Figure 10. The *UHI* Index *LST* in 2001 is 9.78^0C (*LST*_max=31.78^0C, *LST*_min =22^0C) and *UHI* Index LST in 2012 is 13.96^0C (LST_max=35.96^0C, *LST*_min =22^0C).

CONCLUSION

This reseach reveals that there were changing temperature conditions, both air surface and land surface temperature in Tangerang City. *UHI* phenomenon in Tangerang City indicated by temperature higher than 30^{0}C. Based on land surface temperature, *UHI* phenomenon in 2001 already covered small area. However, *UHI* phenomenon in 2012 almost covered the entire Tangerang area. *UHI* Index in 2009 is 3.6^{0}C, in 2011 is 1.5^{0}C and in 2012 reached up to 1.2^{0}C. *UHI* phenomenon occurred since 2001 and the trend of *UHI* Index AST increasing since 2009, with average *UHI* Index AST of 2^{0}C. *UHI* Index *LST* in 2001 is 9.78^{0}C, while in 2012 is 13.96^{0}C.

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