The Relationship between Temperature Patterns and Urban Morfometri in the Jakarta City, Indonesia

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ABSTRACT

Sky View Factor (SVF) is one of the urban morfometri parameters that impact on the Urban Heat Island (UHI). SVF analisys was conducted in the city of Jakarta to investigate the relationship between urban temperature with urban morfometri. Jakarta City is the most populous city in the world that has a surrounding area 66,152 km^2 and the total population around 23 million people. The population of the city is the sixth highest in the world today. SVF measurements done by taking pictures at the six stations that have different morphological characteristics namely (1) the narrow streets Apartment Cempaka Mas (JS ITC), (2) the width of the road Apartment Cempaka Mas (JL ITC), (3) in front of Colleges Kanisius (DKK), (4) in front of office Journalist of Indonesia (DKWI), (5) Utan Kayu (UK), and (6) Tambun (TB). SVF value is obtained from the photgraphic image. Taking pictures at the location using a Nikon D90 camera with a Nikon Fisheye Nikkor 10.5 mm 1 : 2.8 G ED, further processed through a global mapper program. Therefore, the SVF derived from the six stations that vary 0.21 to 0.78. Temperature measurement is done during daylight hours from 06:00 am to 18:00 pm during the Western Part of Indonesia (WIB). Measurements performed at three different times, namely working days (HK) regular holidays (HCB) national holidays (HCN). The results showed that the highest average temperature of 33.32°C, occurring at UK station (SVF=0.45) at the time of HCB. Meanwhile, the average low temperature of 31.22°C occurred at JLITC station (SVF= 0.42). The two-time occurred on ordinary holidays. Maximum temperature of 38.4°C occurred in Utan Kayu station (SFV=0.45) that occurred at 11.00 hrs, normal holidays. Furthermore minimum temperature 24.5 occurred at Tambun station (SVF=0.78) at 06.00 hrs in the morning at the usual holidays and national holidays. In general, the results showed that areas with large SVF has a lower temperature compared with areas with smaller SVF. Though, are not the only factors that matter, but this research may show that an increase in temperature in the city of Jakarta. Therefore, it is necessary to mitigate the serious from the government or society.

Key words: SVF, Urban Heat Island (UHI), The urban morfometri, Climate change, Temperature, Urban climate

1. INTRODUCTION

Climate change is a change in the weather parameters are directly affected or indirectly by human activities (Trembeth *et al*., 1995). Climate change is a phenomenon. which requires serious attention, as it can have an impact on population discomfort. One element that is very significant climate change impacts. for life on the surface of the earth is the change in temperature, as estimated by the IPPC (2007) that the rise in average surface temperatures reach 2-3°C per year. The IPPC is an institution set up by the World Meteorological Organization (WMO) and the United Nations Environments Programme (UNEP) in 1988.

Analysis of climate change in the city of Jakarta has been reviewed by Hidayati (1990); Avia (2010); and Maru *et al*. (2011). Secondary data used by Hidayati year 1916-1987, the 1901-2002 data used by Avia, and data from 2008-2010 used by Rosmini *et al*.. All three studies showed an increase in temperature of Jakarta City from time to time. According to Avia that the most significant change that is the period of 1991-2002, the temperature increased an average of 0.124°C per year. Even achieve an improvement of 0.6°C in the last 10 years (Maru *et al*., 2011).

The temperature change due to urban surface conditions and human activities referred to UHI. UHI is the temperature rise of the city as the impact of surface geometry, surface thermal properties, surface conditions (Khusaini, 2008), anthropogenic heat, greenhouse

gases, and adveksi (Ahmad *et al.*, 2008; Ahmad and Hashim, 2006; Ahmad *et al.*, 2006; Voogt, 2002; Ahmad, 1994; Oke, 1982). Urban geometry is marked by many vertical building walls and the resulting high waves sun comes suffered repeated reflection to earnings and stored in a relatively long time. Retained heat during the day is released at night so that the effect of increasing the maximum and minimum ambient temperature (Ahmad, 2012; Karyono, 2001; Soedomo, 2001). Further, surface geometry and atmospheric conditions the heat released by urban use in buildings that have an impact on the limitation of view of the sky by buildings, trees, etc. are commonly referred to as sky view factor (SVF), all have an impact on increasing the formation of UHI in a city.

Among studies that examine the relationship between the temperature of the city with urban morfometri is the study by Kusaka and Kimura (2004); Unger (2004); Giridaran *et al.* (2004); Giridaran *et al.* (2005); and Yang *et al.* (2010). The results showed the relationship between temperature and morfometri city especially SVF. While some of the results showed relationship is not significant but all describe the correlation the smaller the value of SVF then the temperature of the area is relatively high compared to the value larger SVF. Significant correlation between temperature and SVF, generally associated with a large increase in temperature (˚T) per year with the SVF. For example, the average intensity of the urban heat island (IPHB) (˚T) period of one year (April 2002 to March 2003) and SVF using linear regression showed a significant influence on the value of $r^2 = 0.4746$ (Unger, 2004). Determination of the SVF been done by various methods including: a) the method of photographic image (Chen *et al.*, 2012; Hammerle *et al.*, 2011; Yang *et al.*, 2010; Gál *et al.,* 2007; Grimmond *et al.*, 2001), b) method of measurement of building height (H) and road width (W) with the formula H/W (Unger 2004), and c) methods of Geographic Information System (GIS) (Gal *et al.*, 2007), and the method of LI-COR LAI-2000 Plant Canopy Analyzer (Welles and Norman, 1991).

Since the occurrence of rapid urbanization in 1991, now in the Jakarta City around the various buildings to retreat, office and industry. Rapid urbanization impacts of land use change from forest area to be built-up area (Ahmad *et al.,* 2010b; Teng and Weng, 2004). As a result, ensured that the SVF in Jakarta City impact on the heat retained by buildings and other objects, and reduce radiative heat emission, especially at night. Also, can result in a sheltering effect of reducing heat loss from the surface konvektif and the air near the surface. Until there is an increase UHI effect in the City of Jakarta.

The results showed that Jakarta has the SVF between 0.2 to 0.78 so this paper tries review and analyze the relationship between SVF and UHI development in Jakarta City. This study attempts to look at the temperature distribution during the day 06.00 am to 18.00 pm at six locations have different SVF, outside or even in the city center. This paper consists of the area and the study method, the study and discussion include the SVF, temperature changes daily on weekdays, regular holidays and national holidays. Next are the implications of the study and conclusions.

2. STUDY AREA AND METHODS

Selected study area is the City of Jakarta, Indonesia and surrounding areas. Jakarta is the Capital City of Indonesia with an area of around 66,152 km^2 and is located at an altitude of about eight meters from sea level. It is located on the north side of the island of Java bounded by the City of Bogor on the south and east is West Java and Banten province to the west. Map location shown in Fig. 1.

SVF measurements performed by the method of photographic image. The instrument used was a Nikon D90 digital camera with a Nikon Fisheye Nikkor 10.5 mm 1 : 2.8 G ED (Fig. 2). The SVF can be analyzed through the picture produced by the camera having a field of view (FOV) of 148˚ to 180˚. Initial activities in the calculation of SVF was taking pictures and measurements of several study sites, as follows: 1) Tambun, this area is located outside the city that has characterized as an open area. The location was chosen to give the impression that the open area has a large SVF. SVF great value expected to release heat into the atmosphere more quickly; 2) JLITC Apartment Cempaka Mas, this area is a shopping center that has a wide street that is about 8 to 10 meters. This area is visited by people who come to sell and buy goods in this area; 3) JSITS Apartment Cempaka Mas, the area is also a business center which is bordered by JLITC, however, the area has a more narrow streets compared with the previous quarter to around 4 meters. Therefore, the SVF is certainly smaller; 4) Utan Kayu (UK), this area is a dense residential area with concrete buildings. Therefore, this area has always traveled by many vehicles; 5) in the front of Department Journalists Indonesia (DKWI), which is an area that has a department with its high buildings and paved. In addition, a wide street and many traveled by the vehicle; and 6) in the front of Kolese Kanisius (DKK), the area is bordered by DKWI, but it has different characteristics, namely there was a garden, plants, and the num-
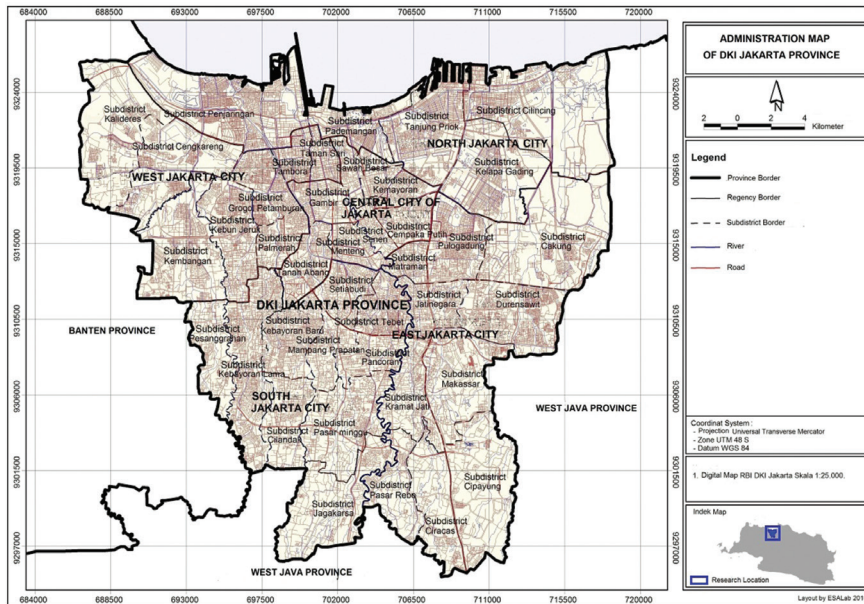
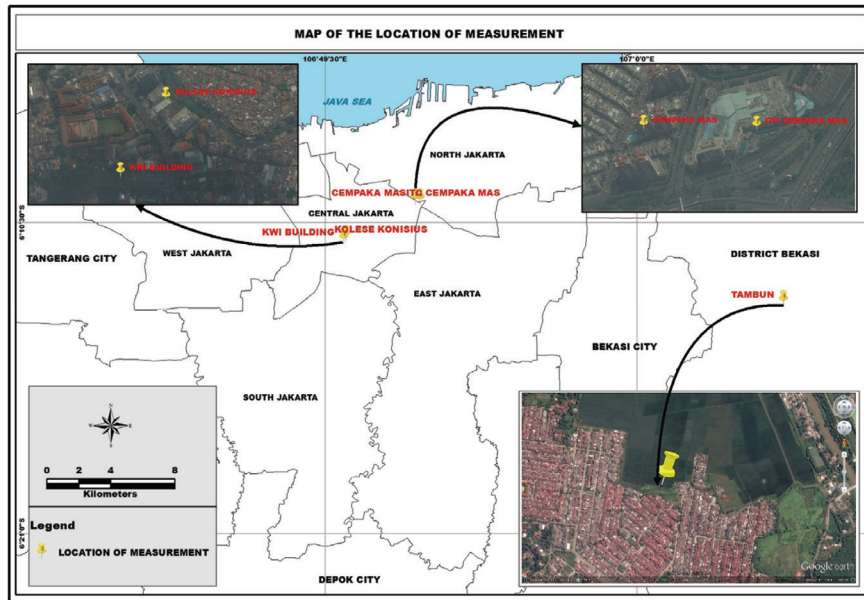**Fig. 1.** Map of DKI Jakarta Province location research station (Maru *et al.*, 2011).

Fig. 2. Map of location of measurment.

ber of vehicles and fewer. Areas with different characteristics is expected that the SVF are different. The sixth six locations is shown in Table 1 and Fig. 2.

The announcement was taking pictures and download pictures from the camera. Then do digitization using global mapper program to separate open area covered by buildings, plants and other objects. The open split green color while covered area divided black color.

Calculation of Surface Geometry or sky view factor (SVF) with formula KTB/KTT where KTB is open (skay view) and the minister is the area covered by buildings and other objects. This is in accordance with the formula height: width (H/W), where H is the area

Table 1. Area of SVF measurements and weather elements in Jakarta City.

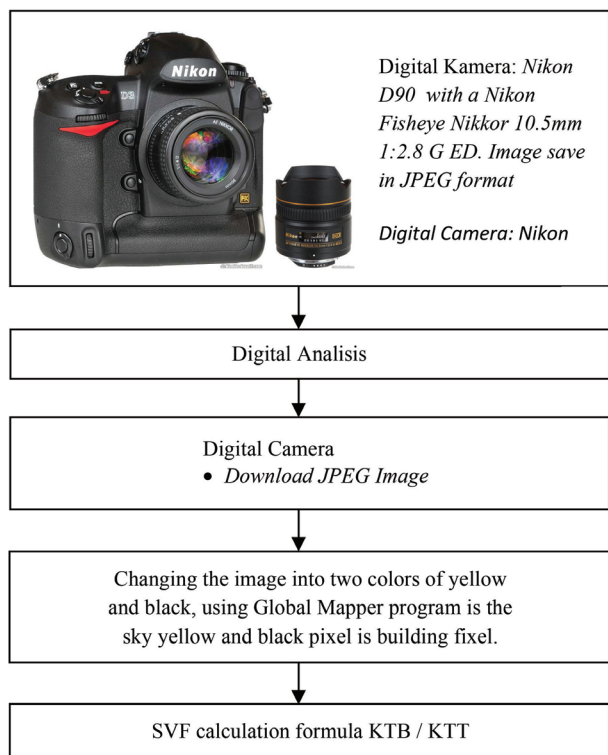| No.	Station	Longitude/Latitude	Land use
1	Tambun	S 06° 13′ 21″ E 107° 04′ 480″	Fields
2	JLITC Cempaka Mas	S 06° 09′ 52,0″ E 106° 52′ 35,8″	Cemteral business district
3	JSITC Cempaka Mas	S 06° 19′ 48,2″ E 106° 52′ 12,3″	Cemteral business district
4	Utan Kayu	S 06° 17′ 05,5″ E 106° 49′ 20,5″	Compact settlements., And many vehicles
5	Jalan Cikini Raya (in the front KWI)	S 06° 20′ 41,7″ E 106° 49′ 52,2″	Office area
6	Jalan Cikini Raya (in the front Kolese Kanisius)	S 06° 21′ 27.0″ E 106° 49′ 49,6″	High-class residential area that are covered with green plants

Digital Kamera: *Nikon D90 with a Nikon Fisheye Nikkor 10.5mm 1:2.8 G ED. Image save in JPEG format*

Digital Camera: Nikon

Digital Analisis

Digital Camera
• *Download JPEG Image*

Changing the image into two colors of yellow and black, using Global Mapper program is the sky yellow and black pixel is building fixel.

SVF calculation formula KTB / KTT

Fig. 3. Flow performance measurement and calculation of the SVF.

TB, SVF = 0.78   JLITC, SVF = 0.42   JSITC, SVF = 0.21

UK, SVF = 0.45   DKWI, SVF = 0.47   DKK, SVF = 0.56

Fig. 4. Hemisferic fisheye photos taken in March 2012 using a Digital Camera: Nikon CoolPix 950 D90 with a Nikon Fisheye Nikkor 10.5 mm 1 : 2.8 G ED.

that is not enclosed buildings, plants and other objects, while W is a vast hemisphere picked up by the camera (Oke, 1982).

At early in the selection of the measurement SVF is. The time chosen is represented three times with very different activities are as follows: the work day Monday, October 17, 2011, the regular holidays Saturday, September 10, 2011 and a national holiday or feast of Idul Fitri Tuesday, August 30, 2011. Implementation flow chart shown in Fig. 3.

Afterward, the temperature measurement in the six area. Once the temperature data obtained then per-
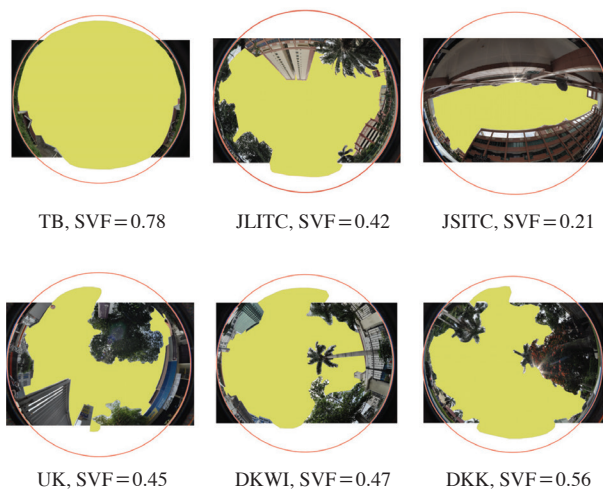
formed simple regression analysis to see the correlations between SVF with temperatures in the area. Relationship between UHI and SVF conducted to see the connectedness between UHII and SVF value. Independent variable is the SVF, while the dependent variables is the temperature.

3. RESULTS AND DISCUSSION

3. 1 The SVF

SVF obtained from six locations. Five locations in the city of narrow streets Apartment Cempaka Mas (JSITC), the path width Apartment Cempaka Mas (JLITC), in the front Colleges Kanisius (DKK), Utan Kayu (UK), in the front KWI (DKWI). The rest of the locations are in rural areas of Tambun (TB). Hemisferic fisheye image taken in March 2012 using a digital camera: Nikon CoolPix 950 fited with a Nicon FC-E8 Fisheye lens.
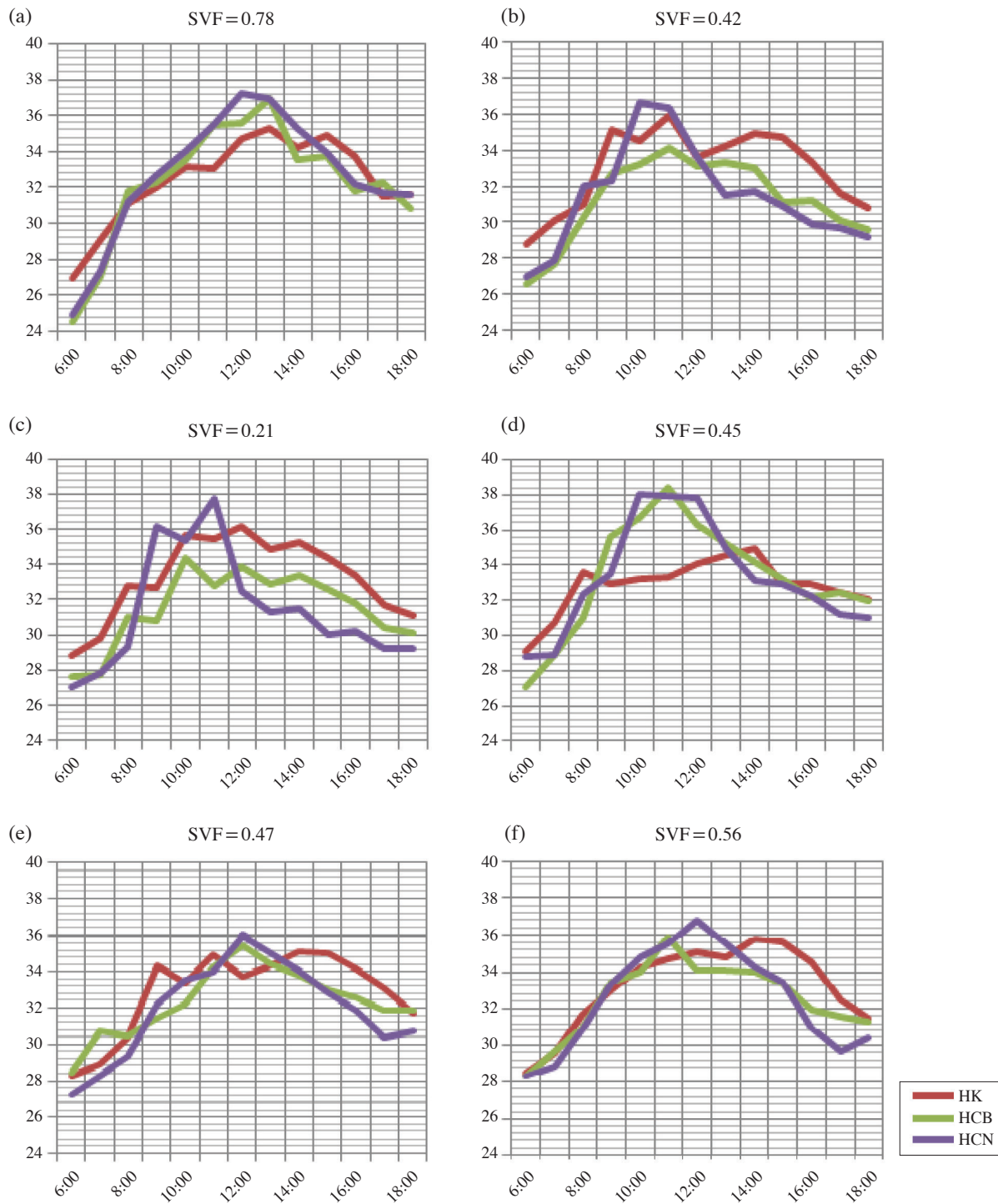
Fig. 5. Shifting the temperature at the time of the workday, regular holidays and national holidays (a) TB, (b) JLITC, (c) JSITC, (d) UK, (e) DKWI, and (e) DKK.

The results showed differences in the extents depending on the view of the sky (sky fixel) that looks green in the picture. The vast sky fixel larger the SVF, but the narrower the smaller the sky fixel about the SVF. Thus, the SVF of the six locations, 0.21 to 0.78 as shown in Fig. 4.

3. 2 Daily Temperature Shifts on Weekdays (HK) Regular Holidays (HCB), and National Holidays (HCN)

Measurements carried out at six stations with the measurement of three-time basis at the time of the work day (HK) regular holidays (HCB), and national holidays (HCN) at each location. Measurement time from 06:00 am West Indonesian time (WIB) to 18:00 pm each evening an hour for 12 hours each day of measurement.

The minimum temperature at six stations occur in the morning 06.00 hrs. The lowest temperature occurs in TB with SVF=0.78 respectively: working day of 26.9°C, ordinary holidays 24.5°C, and the national holidays of 24.87°C. Instead highest maximum temperature occurs in the UK with SVF=0.45 in the reg-

ular holidays 38.4°C, and the national holidays of 38°C. The lowest temperature occurred at locations with SVF 0.78 outside the city, while the highest temperature in the location with the SVF 0.45 in the city center which has characteristics as compact settlements with general transport links.

Shifting the temperature reaches a maximum temperature varies at each location (Fig. 5). In sunny weather conditions indicate a shift in temperature from minimum to maximum temperatures generally occur from 09:00 am to 15:00 pm with a peak maximum temperature at 11:00 and 12:00 am. Various stations according to the pattern is JSITC (SVF=0.21) and DKWI (SVF =0.47), and at 12 in JLITC (SVF=0.42). Meanwhile, TB (SVF=0.78) with the use of paddy land in the rural areas suffer attrition normal temperature according to
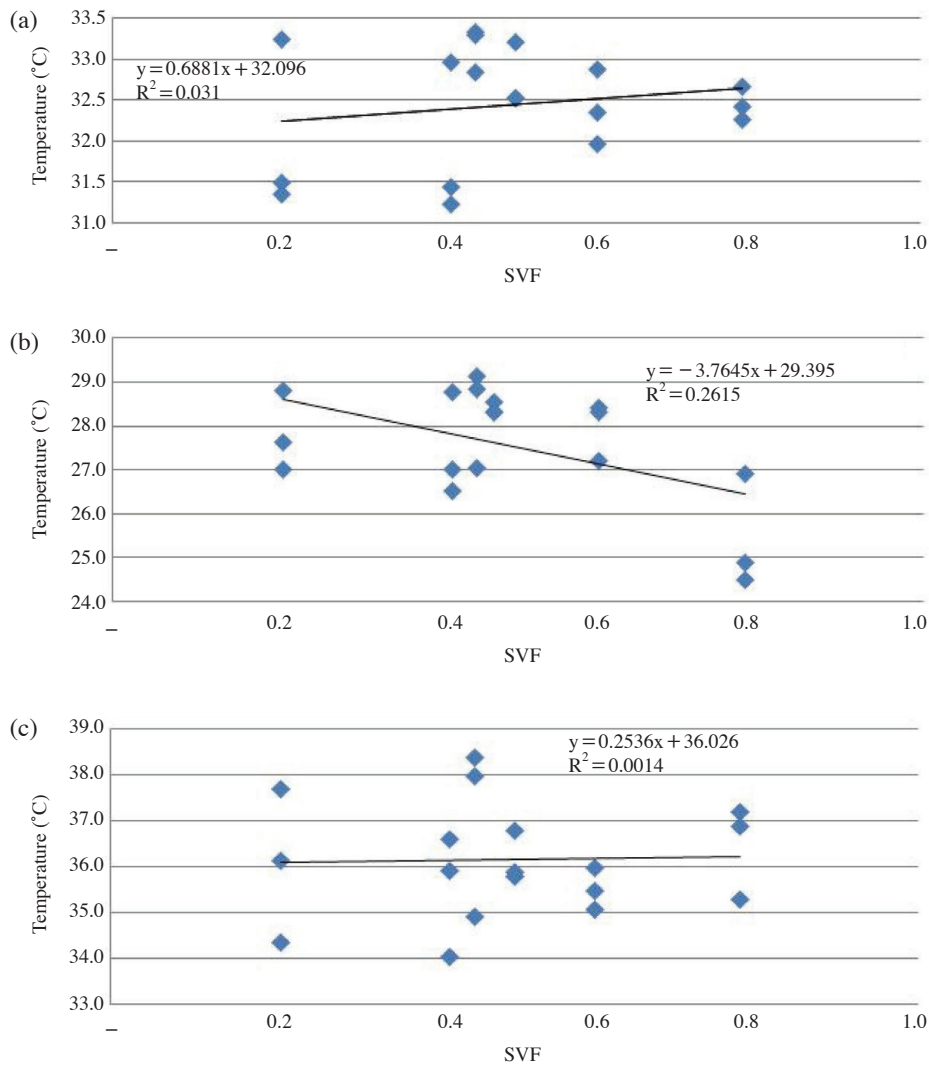

Fig. 6. Correlations between (a) average temperature and SVF, (b) minimum temperature and SVF, and (c) maximum temperature and SVF.

the sun's rays that the maximum temperature of 35.3°C on weekdays, 35.9°C on ordinary holidays, and 37°C on holidays nationally. The maximum temperature at the three time took place at 13.00 noon.

4. STUDY IMPLICATIONS

Although research in this short time of three days, but because this study was conducted at the time of which has different characteristics, namely HK, HCB and HCN, it generally can describe the actual temperature conditions prevailing in the city of Jakarta at present. The results showed an enormous increase in temperature in the city of Jakarta today. Based on the findings obtained an average temperature of 32.44°C. When

compared with the results of studies performed by Avia (2010); Maru and Ahmad (2014a, b) the increase in temperature in the last 10 years a very significant upward trend reflects the Jakarta city temperatures increased very significantly. Avia (2010) describe the magnitude of the average temperature in the period 1991-2002, namely 27.9°C compared with the previous period, the average temperature of 26.4°C. As a result, the temperature rise in 10 years in 2002 to 2012 of 0.6°C per year.

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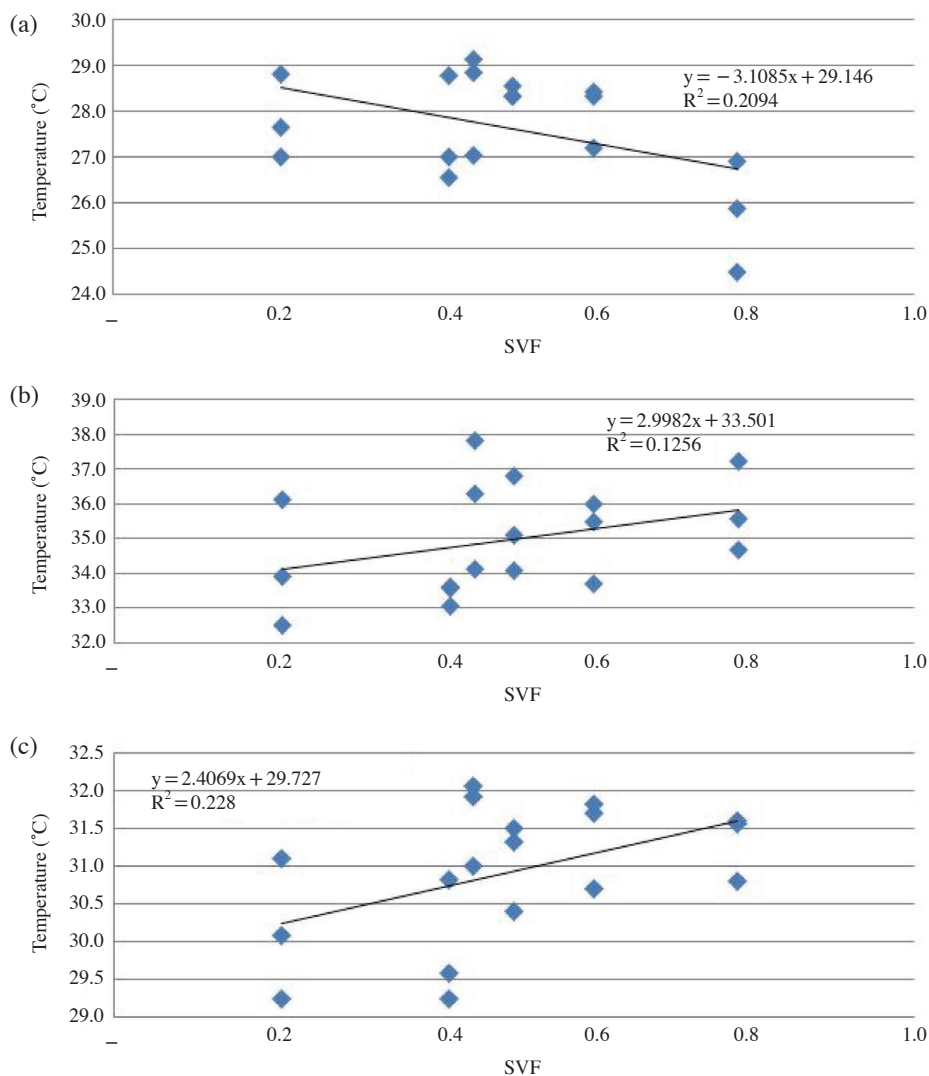

Fig. 7. Correlations between (a) the temperature at 6:00 am and SVF, (b) the temperature at 12.00 noon and SVF, and (c) temperature at 18:00 pm and SVF.

city of Jakarta today. Based on the findings obtained an average temperature of 32.44˚C. When compared with the results of studies performed by Avia (2010); and Maru *et al.* (2010), the increase in temperature in the last 10 years a very significant upward trend reflects the Jakarta city temperatures increased very significantly. Avia (2010) describes mainly in the period 1991-2002 the average temperature of 27.9˚C. average temperature is comparable with the previous period of 26.4˚C. As a result, the temperature rise in 10 years in 2002 to 2012 of 0.6˚C per year.

Fig. 6 shows the correlation between the average temperature and SVF with $R^2 = 0.031$, minimum temperature and SVF with $R^2 = 0.2615$, and the maximum temperature and SVF with $R^2 = 0.0014$. The same trend is shown in Fig. 7, the temperature at 6:00 am and SVF with $R^2 = 0.2094$, temperature 12.00 noon. and SVF with $R^2 = 0.1256$, and the temperature at 18:00 pm. and SVF with $R^2 = 0.228$. These values indicate that SVF impact on increasing minimum temperature in the morning. While the graphics do not show a significant correlation, but this study shows that there is a correlation between morfometri urban of SVF to increase the temperature of Jakarta.

While the correlation does not show a very significant, but both figure shows the effect of SVF minimum temperature is large. However, SVF effect on the maximum temperature is insignificant. This has an impact on the occurrence of maximum and minimum temperature differences are shrinking in the City of Jakarta.

The results showed that in addition to SVF, there are many other factors that affect the improvement UHII in the Jakarta City. Among the factors that affected the solar radiation, wind velocity, humidity, anthropogenic activities that vehicle congestion, and others. Until further research can be seen massive impact of these factors.

5. CONCLUSIONS

This simple study has provided an overview of the. impact of SVF on increasing temperature of Jakarta. The temperature rise is significantly better on weekdays, ordinary holidays or national holidays. UHII significant increase over the last 10 years fueled by the increasing anthropogenic activities, have an impact on increasing the number of tall buildings, resulting in increased ambient temperature. Maximum temperature of 38.4˚C occurred in the UK (SFV = 0.45) that occurred at 11.00 hrs, normal holidays. Instead minimum temperature in the urban area is 27˚C. Meanwhile, in rural areas (TB) SVF = 0.78 with a maximum temperature

of 36.9 and a minimum temperature of 24.5˚C. Thus there is a difference between maximum and minimum temperatures of urban and rural areas (UHII). Maximum temperature difference of 1.5˚C and a minimum temperature of 2.5˚C. The Fig. is very large, so we can have an impact on the urban thermal discomfort, especially the City of Jakarta. Thus, the problem of increasing UHII should get serious attention by both government and society.

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