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Climate sensitive urban design in cultural landscape
Case study: Old town Semarang

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ABSTRACT

Climate Sensitive Urban Design (CSUD) is a new paradigm in urban planning that is adaptive to climate change by adapting various elements that support the physical development. This study aims to determine the appropriate landscape design adjustment strategy in cultural landscape such as the Old Town Semarang. The data used are in the form of six CSUD components such as air temperature and thermal comfort, vegetation, shadows, materials, solar radiation, and frequency of regional activities. Data processing is carried out by simulating CSUD elements such as shadows, vegetation, and solar radiation using the Sunhour and Curic Sun menus in the Sketchup application. To determine the significant effect between test variables, the SPSS linear regression analysis method was used. The results obtained are several scenarios for the proper application of CSUD at four stations in the Old Town Semarang. The findings are in the form of the influence of the presence of vegetation and shadows of objects in minimizing heat stress. The addition of 1% shadow area can increase the area with moderate to low radiation levels by 1.083%.

Introduction

The increase in the earth's surface temperature is one of the main issues faced by various cities in the world (Nugroho 2020). Other issues related to rising global temperatures, such as the Urban Heat Island, have attracted the attention of various environmentalists and urban planning experts (Hamdy et al. 2023). Based on the 2014 Intergovernmental Panel on Climate Change (IPCC 2014). Report, it was noted that the average earth temperature has increased up to 1.1˚C, one of which is caused by human activities. Urban areas with a high level of built-up land with a massive density of population activity cause a faster increase in surface temperature. Based on a study conducted by Li et al. (2011) in Mathew, Khandelwal, and Kaul (2016) found that residents of urban areas are vulnerable to heat stress due to climate change.

The issue of climate change and the increase in the earth's surface temperature, especially in urban areas, has led experts to encourage a form of urban landscape arrangement that is more adaptive to climate change (Pradono 2019). Some experts such as landscape architecture have a great role and potential in modifying regional conditions in accordance with current climatic phenomena, through environmentally friendly designs (Brown 2011 in Syed Othman Thani, Nik Mohamad, and Idilfitri (2018)). Increasing outdoor thermal comfort such as optimizing the existence of green spaces in parks and gardens can minimize the occurrence of urban heat stroke (Srivanit and Jareemit 2020). Where outdoor

thermal comfort is a condition of air temperature, humidity, and wind speed that can make the human body feel comfortable doing activities (Nugroho et al. 2020). Meanwhile, based on ASHRAE standards, thermal comfort is a subjective assessment that results in satisfaction with the thermal conditions of the surrounding environment. Outdoor thermal comfort is an important consideration in creating urban designs that are adaptive to climate change and in creating a better quality microclimate (Coccolo et al. 2016). According to Emmanuel (2016) the difference between indoor thermal conditions and outdoor thermal conditions is the type of clothing, activity level, and solar radiation (Kusumastuty, Poerbo, and Koerniawan 2018).

Climate Sensitive Urban Design (CSUD) is one of the new paradigms in climate-adaptive urban area design planning. CSUD is generally defined as a process carried out by considering the basic elements of microclimate such as sun, wind conditions, and air temperature for planning purposes (Tapias and Schmitt 2014). Based on the statement of Emmanuel (2005) in Kusumastuty, Poerbo, and Koerniawan (2018) which states that the availability of public space and improving the quality of pedestrian walkways are important aspects in the planning approach for tropical areas. He also explained that there are two parameters used to analyze CSUD, namely physical and non-physical parameters. Physical parameters can be in the form of urban geometry and building configuration, while non-physical parameters can be air temperature, relative humidity, wind speed, and solar radiation (Bosselmann, 1995 in Kusumastuty, Poerbo, and Koerniawan 2018). On average, areas with warm-humid (tropical) characteristics have poor air temperatures, especially during the day, in contrast to areas with cold climates (Sitorus et al. 2023).

Previous research on CSUD and outdoor thermal comfort that has been carried out mostly emphasizes the elements of air temperature and thermal comfort as the main elements in producing a landscape design that is adaptive to climate change. The results of the CSUD research in Jakarta conducted by Kusumastuty, Poerbo, and Koerniawan (2018) found that the wind movement element has more influence on the cooling process of the outdoor space compared to the shadow element. Meanwhile, other studies state that location conditions greatly affect the formation of thermal comfort and the planning approach taken will also be different (Dursun and Yavas 2015). Meanwhile, outdoor thermal comfort research in Thailand found that vegetation with broad leaf crowns such as large trees was more effective in generating heat reduction compared to artificial approaches such as building modifications (Wattanachai et al. 2021).

Indonesia is a tropical country with an average thermal comfort level in urban areas between 27˚C to 28˚C (Karyono 2015). The application of the CSUD approach to urban planning policies in Indonesia is considered not to be carried out optimally, while other Asian cities have carried out large-scale development of climate change (Kusumastuty, Poerbo, and Koerniawan 2018). In fact, the increase in extreme temperatures, especially in coastal cities in Indonesia is getting worse every year. Based on this, this study aims to adjust CSUD to the cultural landscape of the Old Town as one of the areas with a high level of activity in the city of Semarang, Indonesia.

The provisional assumption from this research is that good planning and selecting the right landscape components can minimize the impact of climate change, especially in reducing outdoor air temperatures. It is hoped that this research will be useful for increasing thermal comfort for outdoor activities, especially in the old city of Semarang, resulting in increased income in the historic tourism sector. In addition, it is hoped that research findings will minimize damage to historic buildings while maintaining community activities that are adaptive to climate change.

This research has a special difference from previous research, namely at the level of simulating climate change components that adapt to the perceptions of the community (tourist visitors). This is expected to produce design component recommendations that are more targeted. Apart from that, research on the application of Climate Sensitive Urban Design (CSUD) in historical areas is still rarely carried out so that further similar research is needed. Research into the sustainability of historic areas will be carried out more massively in the future.

Based on this study, the research question to be answered in this study is "How can urban design components influence climate conditions?" or in other words, this research wants to carry out several simulations to find out what design components are able to minimize and adapt to climate change.

Climate sensitive urban design

Climate Sensitive Urban Design (CSUD) in general is a form of regional design approach that is adaptive to climate change. It is also important to know that CSUD is strongly influenced by the microclimate conditions of an area (Koerniawan 2017). Pedestrians as users have the highest probability of being exposed to environmental conditions, such as air temperature, humidity, wind speed, and solar radiation or are influenced by climate by microclimate (Chen & Ng, 2011 in Kim et al. 2023). The ideal CSUD application is not only beneficial for one site but also the surrounding environment through proper planning and design (Kusumastuty, Poerbo, and Koerniawan 2018). Therefore, CSUD is closely related to certain landscape characteristics as the basis for developing a plan.

Cultural landscape is a historical part of the structure of geographical space, where this space is created as a result of a combination of influences between the environment and culture, then forms a certain structure, with regional individuality which is considered a distinctive physiognomy (Myga-Piątek, 2011 in Putra et al. 2023). Physical expressions and lines have an important position in determining design decisions that are appropriate to the cultural and natural environment. Meanwhile, Rossler (2006) in Falk and Hagsten (2023) states that cultural landscape has the meaning as an area of land that has been managed or shaped by humans in the form of traditional land use. Based on this information, it can be interpreted that the cultural landscape is a part of the development of the natural landscape, which emphasizes the incorporation of environmental and cultural elements in society and has been carved traditionally.

Cultural landscape is part of the development of the primary landscape, in the form of a natural landscape that has existed since the neolithic era and will continue to grow. Meanwhile, according to Munárriz (2010) in Fernández Cacho (2023) cultural landscape is defined as the result of the transformation of the natural environment by humans in an effort to form, use, manage, and enjoy it, based on distinctive cultural patterns. Cultural landscape is considered as a link between nature and culture, tangible and intangible heritage, and cultural and biological diversity (Vlami et al. 2017). Data obtained from UNESCO (2023) contains three general categories of cultural landscapes, namely designed landscapes, living and or relict cultural landscapes, and also Associative cultural landscapes. Cultural landscape components such as ecological processes, natural resources, landscapes, and cultural biodiversity need to be conserved to maintain their sustainability (Sarmiento-Mateos et al. 2019; Gavin et al. 2015; Vlami et al. 2017).

Based on this description, it is obtained an overview of the relationship between CSUD and the cultural landscape, especially in this study, namely the existence of cultural lendscape as a control element that provides certain limitations on the implementation of climate-based urban design. It is intended that the development recommendations given do not damage the structure of the cultural heritage area and the surrounding environment as part of history.

Method

Old town is one of the cultural heritage areas as well as a tourist center located in the city of Semarang as one of the big cities in Indonesia. old town is a cultural heritage consisting of many colonial architectures on an area of 33 hectares (Kurniati et al. 2021). This area is referred to as "The Little Nederland" because of the many historical buildings in the Dutch colonial style and the distinctive history of its formation (Pratiwo in Kurniati et al. 2020). This area is located in the trade and service development zone in the city of Semarang, thus making the activity in the area is always high every day.

Old town of Semarang became one of the locations considered by UNESCO as a UNESCO WORLD HERITAGE in 2015. Where there are as many as 50 cultural heritage buildings with different functions and conditions. Based on the Law of the Republic of Indonesia number 11 of 2010 there are rules that must be obeyed in carrying out the development process in cultural heritage areas, namely:

- Pay attention to the authenticity of the layout, style, material, shape, funds or workmanship technology used.
- Pay attention to the initial conditions by making the smallest possible changes.
- The use of techniques, methods, and materials that are environmentally friendly and non-destructive.
- Pay attention to the competence of implementation in the field of restoration or development.

Based on figure 1 shows that this study took samples at 4 stations in the old town of Semarang. The stations consist of the surrounding Spiegel building (station 1), the surrounding Srigunting Park (station 2), the Marba building (station 3), and the Indonesian Trade Ltd (station 4). The selection to the four stations is based on the number of visits and the highest activity is at these location points, especially along the main road in the area.

Figure 1. Study area old town of Semarang

In general, the parameters in analyzing CSUD consist of physical and non-physical parameters. based on table 1, the author uses six kinds of variables in conducting the CSUD analysis in the old town of Semarang. These variables consist of air temperature and thermal comfort variables, solar radiation, and shadows as non-physical variables. Meanwhile, the physical variables consist of material, vegetation, and area activities. The variables of air temperature and thermal comfort also solar radiation are controller variabel while the other four variables are supporting variables in the CSUD analysis of the old town Semarang area. The selection of these variables is based on the general landscape conditions in the old town of Semarang and the suitability of the needs of research analysis.

Table 1. Variables analysis of CSUD

Num	Variable	Category	Main variable	Complementer variable
1	Air temperature and thermal comfort	Non-physical	V	-
2	Solar radiation		V	-
3	Shadow		-	V
4	Vegetation	Physical	-	V
5	Material		-	V
6	Activity frequency		-	V

This research was conducted during the COVID-19 pandemic, which is 2021. The data collection consisted of primary data collection through field observations and secondary data collection through relevant literature. In addition, researchers also conducted a structured survey

using a questionnaire form which was distributed online to 40 respondents to determine the trend of visits and perceptions of the thermal comfort of the area. Air temperature data collection is carried out using an air measuring application (Outdoor Thermometer) at each sample location point (station) within one week, both weekdays and weekends. Air temperature measurements were carried out at 09.30, 12.30 and 15.30 to see the average thermal conditions of the area.

Based on figure 2, the air temperature data at 09.30 to 15.30 as well as data on the frequency of visits were analyzed using quantitative descriptive analysis method to see the general characteristics. In addition, the material and land cover data used an observative descriptive method with the same goal, namely to determine the general characteristics of CSUD in the old town of Semarang. Curic sun in the sketchup application is used to process data on the physical condition of buildings and vegetation which will produce a shadow simulation on the area. The next stage is a simulation of solar radiation data using sunhours on the sketchup application with an average radiation time of 09.30 to 15.30. The final result that is expected in this analysis process is to provide general recommendations for a cultural landscape design that is adaptive and suitable for use in the old town of Semarang.

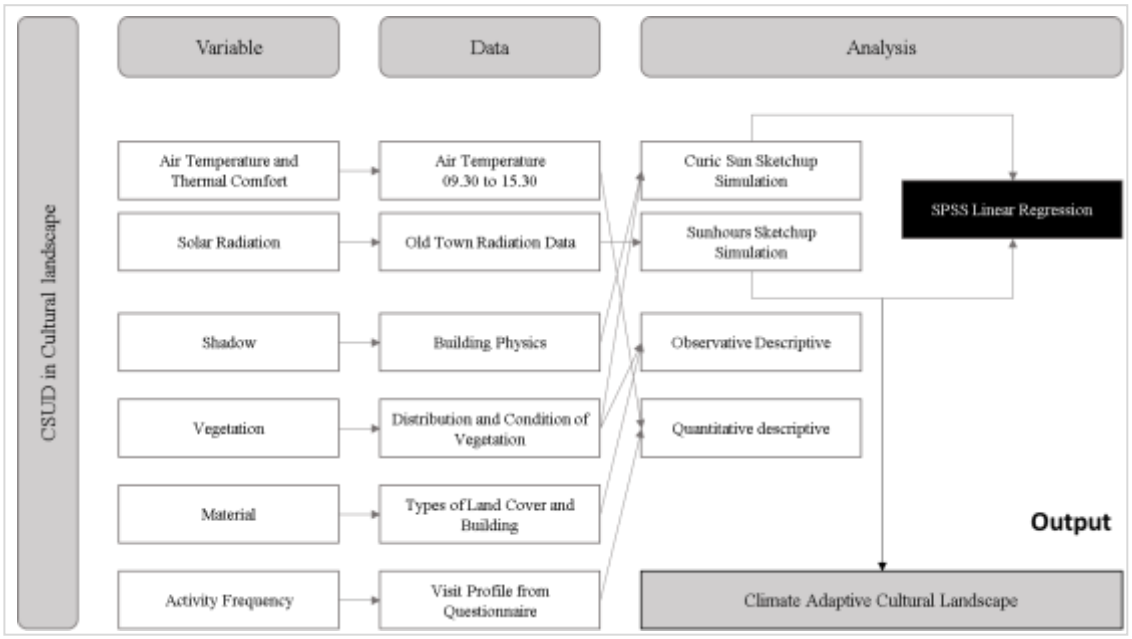


Figure 2. Research method flowchart

The simulation results between variables will be further processed using linear regression analysis on the SPSS application to determine the magnitude of the effect given. What needs to be considered in this process is if the significance value is less than 0.05 (<0.05), then the variables are closely related. The value of the control variable that can be seen based on the results of the value of (a), and the supporting variables that can be seen from the value of (b) can form a linear relationship model with a certain value or magnitude (See formula 1). These results can be considered in determining the quantity of supporting variables to influence the main variable (control).

$$Y = \alpha + bX \quad [1]$$

Where;
Y : Controller variable
α : Constant
b : Coeficient
X : Independent variable

Result and discussion

CSUD in the Old Town Semarang

The general condition of CSUD in the Old Town of Semarang includes air temperature

conditions inside and outside the shadow, the shape of the vegetation, the type of vegetation, the material of the area, the shadow formed, and the frequency of activities, especially tourist visits. Based on table 2 shows that station 1 has an average temperature of 32.5ºC with the temperature in the shadow 1ºC lower than the temperature outside the shadow. Around station 1, there tends to be no vegetation, especially shade vegetation, which causes the temperature during the day to become uncomfortable for outdoor activities.

The average air temperature produced also exceeds the thermal comfort threshold in Indonesia, which is 27ºC to 28ºC. In addition, the condition of building materials and land cover around Station 1 consists of concrete and paving which have a high tendency to store heat. The shadow produced at 15.30 is the longest, which can reach 10 meters from the building boundary towards the road or yard. As one of the main tourist attractions in the area, station 1, namely the Spiegel building, has a high level of activity, especially at night on weekends.

Station 2, which is located in Taman Srigunting and the Blenduk Church building area, has an average temperature of 30.5ºC with the temperature in the shadow 3ºC lower than the temperature outside the shadow. The difference in the microclimate in the park with the outside area which is >10 meters has a significant difference in air temperature. Therefore, visitors or people in the area will often be active in the park, especially during the day. The characteristics of the plant in the form of a shade tree with a leaf canopy of approximately 15 meters can produce a fairly high shadow in the garden area. Materials in the garden in the form of green grass and natural soil add to the internal cooling process in Srigunting Park. Along the main road, the area for pedestrians, cyclists, and motorized vehicles becomes one so that it tends to be crowded both on weekdays and weekends.

Marba building at station 3 is the only station facing north compared to the other three stations. It is located in front of Srigunting Park with very high activity. During the day, tourists are usually rarely around this station because the average air temperature at this station is 36ºC, even at 12.30 no shadows are produced from the 10 meters high building. The vegetation available at this station is in the form of ornamental plants such as potted plants and small hanging plants. Of course, the existence of such vegetation is not sufficient to minimize solar radiation during the day.

Meanwhile, station 4, namely Indonesia Trade Ltd and the surrounding area is the station with the lowest average temperature compared to other stations. The average temperature of this station is 30ºC with the same temperature inside and outside the shadow. However, this condition is still classified as an uncomfortable air temperature for outdoor activities. The vegetation available at this station is a shrub with an average height of 15 meters and a dense leaf canopy. The building height of Indonesia Trade Ltd and the surrounding area is an average of 10 meters with a fairly narrow road geometry. This causes the image of objects produced to be more optimal compared to other stations. The activity of tourist visitors at this station also tends to be minimal so that the resulting air quality is better. Building materials and land cover consist of natural stone which is good at reducing heat during the day.

Table 2. Characteristics of CSUD in Old Town of Semarang

Stat	Location	CSUD Element							
		TIS	TES	Av	Vegetation form	Vegetation type	Material	Shadow	Activity
1	Spoegel building	32ºC	33ºC	32.5ºC	None	None	Concrete and paving	Medium	High
2	Srigunting park	29ºC	31ºC	30.5ºC		Shrub	Land	High	High

Stat	Location	CSUD Element							
		TIS	TES	Av	Vegetation form	Vegetation type	Material	Shadow	Activity
3	Marba building	36°C	36°C	36°C		Decorative plants	Concrete and paving	Low	High
4	Indonesia Trade Ltd building	30°C	30°C	30°C		Shrub	Natural stone and paving	High	Medium

Source: Field observation, 2021; (TIS) Temperature Internal Shadow; (TES) Temperature External Shadow; (Av) Average

Figure 3 is the result of questionnaire data from 40 respondents from within and from outside the city of Semarang. Based on visitor perceptions, Srigunting Park (station 2) and Indonesia Trade Ltd are locations with a good level of thermal comfort compared to other locations. These two locations are the most convenient locations for visitors to visit during the day at 12.30. Marba building (station 3) and its surroundings are the locations with the lowest level of comfort according to visitor perceptions. They argue that the Marba building and its surroundings cannot be used for activities during the day because the air temperature is very hot with very minimal vegetation. Its location which is at a crossroads and the main activity center of the area makes this location very dense for motorized vehicle activity. The existence of a building canopy in the north with a size of 0.5 meters cannot minimize the high air temperature during the day.

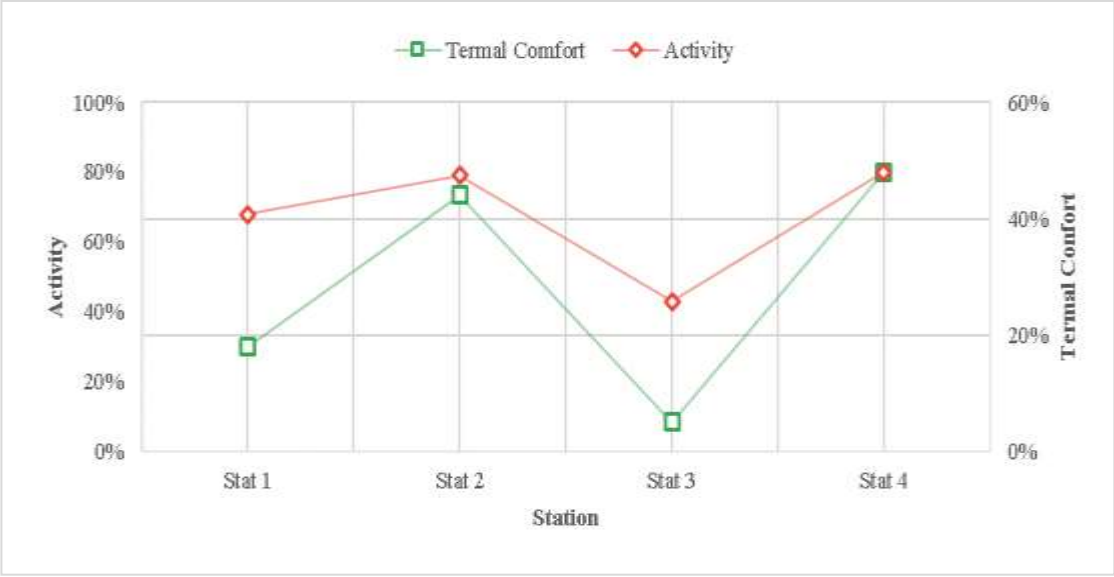


Figure 3. Activity levels and thermal comfort based on visitors' perception

Simulation scenario for CSUD was carried out using the Sketchup application with a three-dimensional display. Simulations were carried out on data on vegetation distribution, physical distribution of buildings, and solar radiation from 09.30 to 15.30 at four stations. The shadow simulation in figure 4 is taken on a building with a position facing north. At 09.30 the sun is in the northeast direction of the area with a sun azimuth of 69°46 and a sun altitude of 35°34. The resulting

shadow is on the left side of the building with the amount of shadow produced by 55%. Then at 12.30 the sun was directly above the area, precisely in the northwest direction with a sun azimuth of 90º8 and a sun altitude of 73º57. At this time the shadow produced is on the right of the building with the smallest shadow percentage compared to other times, which is only 30%. In the afternoon to the afternoon at 15.30 the sun is low in the west of the area with a sun azimuth value of 93º53 and a sun altitude of 29º19. At this time the shadow formed is very large compared to other times, reaching 182 % with an average shadow length of up to 20 meters. Therefore, in the afternoon the level of thermal comfort is relatively good because the average area is covered by the shadow of the building.

In general, buildings in the old town area of Semarang are oriented to the north and south. This causes the shadow to only fall on the right or left side of the building, the front and back tend to be hot (hot area). Especially in buildings facing north such as the Marba Building (station 3) at 12.30 when the sun is perpendicular to the area, this location tends to not produce shadows so that the surface temperature continues to increase. On the other hand, the vegetation available at this station is also very minimal so it cannot filter air pollution and suppress solar radiation optimally.

The next design landscape simulation is a simulation of shadowing and solar radiation at 09.30 to 15.30 at each station. Two CSUD modeling scenarios were carried out at each station using the Sunhours plugin on the Sketchup pro 2021 application. The planned scenario is an estimate or a recommended strategy according to current needs and existing conditions. As one of the cultural heritage areas, the development carried out in the old town of Semarang is also limited and minimally damages the physical structure of the building. The following is a scenario planned for each station:

a. Station 1; in its existing condition, this location has no vegetation and the shadow of objects produced per day is also minimal. 80% of the solar radiation produced is at high radiation levels (red zone). The first scenario is the addition of shade vegetation in the parking lot in front of the Spiegel building by 10%. As a result, there is a reduction in the level of solar radiation, especially in the zone where vegetation is added to a yellow color. The second scenario is the addition of 40% of vegetation and the extension of the canopy of the Spiegel building on both the right and left sides. As a result, there is a greater reduction in solar radiation with an estimated reduction of the red zone by 30% compared to the original condition.
b. Station 2; in its existing condition, this location has vegetation in the form of shrubs in Srigunting Park with a canopy diameter of 10 meters. While the Blenduk Church building has a few shrubs around it. However, the current presence of vegetation is still less than optimal in shaping the microclimate of the area so that radiation levels are still high at some points. The first scenario is the addition of vegetation to the western part of the Blenduk Church building and the expansion of the Srigunting Park tree diameter to 20 meters. As a result, there is a reduction in the high radiation zone by approximately 15% compared to the initial conditions. The second scenario is to increase the amount of vegetation in the middle of Srigunting Park and the eastern part of the Blenduk Church. As a result, there is a reduction of the high radiation zone by approximately 40% compared to the initial conditions. In addition, the area within Srigunting Park, especially under shade trees and in the eastern part of the Blenduk Church, is at a very low radiation level (blue zone) which is comfortable for activities during the day.
c. Station 3; in its existing condition, this location has almost no vegetation, especially shade vegetation. The currently available vegetation is in the form of ornamental plants which cannot help minimize solar radiation and heat attacks during the day. The part that is at low radiation levels is the center of the building that produces shadows. The first scenario is the addition of some shade vegetation on the northern part of the Marba building. The addition of this vegetation is still less influential in reducing the radiation level of the area. The second scenario is the addition of several shade plants in the southern part of the area with a larger canopy diameter and the lengthening of the canopy in front of the Marba building. As a result, there is a reduction in solar radiation of approximately 10% compared to the initial conditions. This zone is one of the zones that need to be considered in the

adjustment of CSUD in the old town of Semarang. This is because the thermal comfort conditions are very low with the average air temperature relatively high throughout the day. The provision of a small amount of shade vegetation is not very influential in shaping the microclimate.

d. Station 4; in its existing condition, this location already has a fairly good quality of thermal comfort compared to other locations. Shade vegetation has also been provided in the northern part of the Indonesia Trade Ltd building with a fairly good shade, especially during the day. The first scenario is the addition of a shade vegetation on the northern part of the building parallel to the existing shade vegetation and the addition of a canopy on the eastern part of the Indonesia Trade Ltd building. As a result, there is a 20% reduction in the high radiation zone compared to the initial conditions. The shaded shadow on the building's canopy blends with the shaded vegetation plan at station 2, precisely at the Blenduk Church building so as to form better thermal comfort. The second scenario is to add one shade vegetation in the western part of the area with a canopy diameter of approximately 20 meters. The result is a 30% reduction in the high radiation zone compared to the initial conditions.

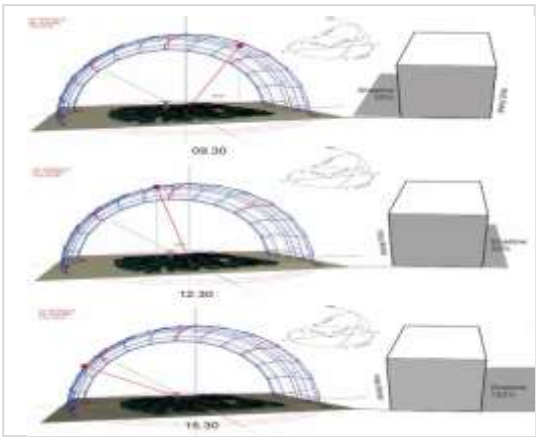
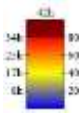
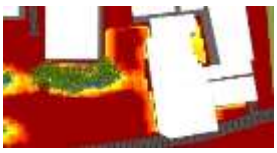
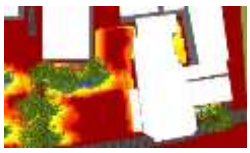
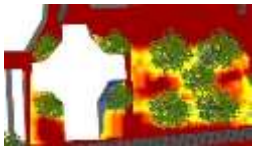
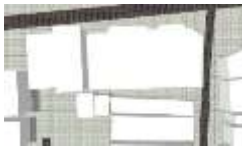
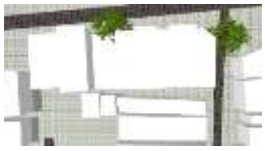
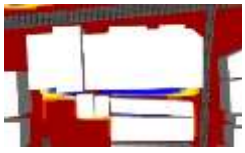


Figure 4. Shadowing simulation

Based on the simulation results of shadows and solar radiation that have been carried out, it can be concluded that the presence of vegetation and the shading of objects with a certain size and number can affect the reduction of solar radiation to increase micro-scale thermal comfort.

Table 3. Landscape design adjustment scenario 09.30 to 15.30

Time	Station	Code	Base	Case 1	Case 2
09.30-15.30 WIB **Legend** 	Stat 1	A	 None vegetation	 Add 10% shade vegetation	 Addition of 40% shade vegetation and addition of 1 meter of building canopy
		B	 High radiation zone (red zone) 80% of station area	 High radiation zone (red zone) to 70% of station area	 High radiation zone (red zone) to 50% of station area
	Stat 2	A			

Time	Station	Code	Base	Case 1	Case 2
			Shade vegetation fills 30% of station area	Addition of shade vegetation of 10% of station area and addition of tree canopy diameter of Srigunting Park to 20 meters	Addition of shade vegetation by 30% of station area
		B			
			High radiation zone (red zone) 70% of station area	High radiation zone (red zone) 55% of station area	High radiation zone (red zone) 75% of station area
	Stat 3	A			
			Almost no vegetation at all	Addition of 10% vegetation from station area	Addition of 35% of vegetation from area and addition of canopy length to 1 meter
		B			
			High radiation zone (red zone) 85% of station area	No significant effect on reduction of high radiation zone (redzone)	High radiation zone (red zone) 75% of station area
		A			
			20% shade vegetation on pedestrian walkways	Addition of 10% vegetation from station area and addition of 1 meter canopy	Addition of 40% vegetation from station area and addition of 1 meter canopy
		B			
			High radiation zone (red zone) 70% of station area	High radiation zone (red zone) 40% of station area	High radiation zone (red zone) 30% of station area

(A) Shadow and vegetation; (B) Solar radiation

This study tries to show the magnitude of the influence of the presence of shadows and vegetation on solar radiation which represents temperature. Table 4 shows the SPSS resulting significance value of 0.010 (< 0.05), which means the data is feasible to be processed further (valid).

When viewed from formula 2, the shadow variables formed artificially and naturally from vegetation have a positive effect on decreasing solar radiation. Every 1% addition of the shadow area will increase the area with moderate to low radiation levels by 1.083%. So, it can be concluded that the shadows generated from vegetation such as shade trees and artificial shadows from building physical modifications such as canopies have a significant effect on the microclimate of the area.

Table 4. The effect of shadows on radiation (SPSS result)

Coefficients						
Model		**Unstandardized coefficients**		**Standardized coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	0.054	0.046		1.175	0.361
	Shade	1.083	0.110	0.990	9.827	0.010

a. Dependent variable: Radiation

$$Y = 0.054 + 1.083X$$

Based on the simulation results and scenarios in the analysis section, it was found that the addition of shade vegetation and artificial structures such as canopies with a certain size and quantity can help in reducing the level of solar radiation, especially during the day. This is in line with the results of a study conducted by Wattanachai et al. (2021) on thermal comfort conditions in Thailand which states that vegetation with a relatively wide canopy can minimize the increase in surface temperature. At the same time denying the statement that artificial structures such as building canopies are considered less capable of lowering surface temperatures, especially during the day.

In addition, the statement of Kusumastuty, Poerbo, and Koerniawan (2018) about the wind element can minimize the high surface temperature of the area has not been proven because in this study the wind variable has not been used. His statement about the shadow that is less able to minimize regional heat stress also needs to be studied more deeply. Because in this study it was found that the number of shadows that can be produced can also be influenced by the position of the building and the formation of the surrounding environment.

Another finding in this study is that there is a positive influence between the shadow variables and solar radiation. Where 1% addition of the shadow area from natural or artificial vegetation from the building canopy can increase the area with moderate to low radiation levels as much as 1.083% of the initial area. Previous research mostly only shows the extent of the visual simulation results and has not seen quantitatively the relationships formed between variables.

Furthermore, different location characteristics will result in different planning approaches (Thani, Mohamad, & Idilfitri, 2018; Dursun and Yavas 2015). This is evidenced by the different conditions that exist at each station that can affect the recommendations or planning scenarios that will be made. However, this will also be different overall in countries with cold climates as well as other climates. In cold climates countries such as the study in Turkey found that they need to pay attention to winter winds, maximizing solar radiation, using isolation systems, and preparing integrated plans in dealing with extreme weather (Dursun & Yavas, 2014). The vegetation and landscape arrangement used will also be different from tropical countries such as Indonesia.

In addition, the most important thing in the results of this study is the need for an in-depth study of the physical implementation of plants such as planting methods and distribution patterns so as not to interfere with the process of preserving cultural heritage buildings in the old town area of Semarang. This is because the cultural landscape emphasizes the incorporation of environmental and cultural elements in society (Myga-Piątek, 2011 in Putra et al. (2023). Therefore, it is feared that significant changes in the natural environment will eliminate the authenticity of the culture as a whole. Based on the Law of the Republic of Indonesia number 11 of 2010, the construction or restoration of cultural heritage is strictly regulated for environmental sustainability. Demolition of foundations or materials for planting trees with large trunks is likely to be severely restricted in this area. Therefore, it is possible to optimize plants with

thin stems by optimizing pots as planting containers, or optimizing vines with large frequencies on several sides of areas with high heat stress levels.

Conclusions

Based on the research question, namely "How can urban design components influence climate conditions?" The results of this research show that there are several components of urban design that can influence outdoor climate conditions in the old town of Semarang.

The results of the general analysis show that the addition of vegetation and shading of objects has an effect on minimizing solar radiation and increasing surface temperature in the old town area of Semarang. However, what needs to be considered is that the quantity, size, and pattern of placement greatly affect the formation of the microclimate of the region.

In addition, there is a need for further research on other CSUD elements such as the condition of wind movement on reducing the surface temperature of the area. This research also still needs further confirmation regarding the form of landscape arrangement that is allowed and suitable for cultural heritage areas such as old town of Semarang. It is hoped that this research can help in pushing the concept of planning and development of urban areas that are adaptive to climate change to a more serious direction, especially in the city of Semarang.

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Rina Kurniati contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Wakhidah Kurniawati contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

Diah Intan Kusumo Dewi contribute to methodology, supervision, and validation.

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