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OPTIMUM TREE DISTRIBUTION FOR PEDESTRIAN WALKWAY OF COMMERCIAL STREET IN TRIPOLI CITY

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Keywords: Tree distribution; Commercial street; Pedestrian walkway.

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Abstract

Designing a developed urban city requires sufficient methods to plan its principal parts that include walkways. These walkways are pedestrian connections that contain sidewalks, paths, and highway shoulders. Planning and executing a complete sidewalk require a fulfillment existence of all its parts from the pedestrian walkway, the street furniture, and the frontage zone. The objective of this paper is to increase the surface shadows for the pedestrian walking areas, to attract more people which, increase the economic value of the commercial street. Tripoli city and in particular "Achir El-Dayeh" street is the main case study, as the pedestrian walkway in this region contains several different problems: behavioral, poor design, and other problems related to the municipality. The research focuses on the poor design of this street that lacking in the essential street elements, the inappropriate distribution of trees in the pedestrian walkway.

The methodology used in this research initiates with a detailed analysis of the current pedestrian walkway situation to evaluate the tree distribution level in the selected street, and how far it is distributed properly. To renovating the street trees distribution, the software "Rhino Grasshopper" is applied to assess the proposed scenarios to find out the optimum design solution, it is found that using specific types of trees could provide the best shading for the pedestrian walkway.

Keywords

Tree distribution; Commercial street; Pedestrian walkway.

1. INTRODUCTION

The importance of maintaining a comfortable and good designing pedestrian walkway, especially in a commercial street is a significant manner to increase the economic value of this area. Looking at various streets proves that preserving the standard criteria of street elements provides a substantial importance for the region that preserve keeping arranged streets. The focus of this paper will be on one street component, that is, the trees as this element forms a main street part that could be ignored in designing a commercial street

This research aims to clarify the right way in distributing trees along the pedestrian sidewalk in a commercial street, for the purpose of the economic advantages that could increase the significance of the commercial street by attracting more people.

When discussing the economic value of a commercial street, the idea of maintaining all the street components, including the street trees should be taken into consideration to make an integrated design. Numerous researches prove the importance of street trees on one hand to achieve thermal comfort for the pedestrian when providing the best shading for a walkway (Li & Ratti, 2018). On the other hand, presently it is realized that trees serve different capacities, especially for marketing and business interests. Numerous research programs have explored how customers react to trees in different business settings in urban communities. Outcomes were extremely reliable that trees certainly influence decisions of visual quality, yet more fundamentally, seem to impact other purchaser reactions and practices. Business experts have observed that shopping was at one time an effective movement to satisfy requirements, however today customers are seeking after spots that compromise community. (Wolf, 2014)

The previous examples explained the benefits of a well-designing of a pedestrian walkway and the importance of the tree's existence to improve the street function.

In this research the main problem is the lack of concern about the entire street elements in the urban streetscape design, as in sometimes the urban design for streets might not consider the right existence of trees as an essential street element. By observing the condition of the pedestrian walkway in "Achir El-Dayeh" street in Tripoli; it is noticeable that the trees do not form a principal part of the street furnished area. The tool used in this research is the primary study of collecting data about the street trees, then adopting a software to propose the optimal method of distributing the trees and getting the analysis to ensure that the best solution in improving the surface shading for the pedestrian walkway is obtained.

2. PEDESTRIAN WALKWAY OF COMMERCIAL STREET

The pedestrian path has several essential characteristics such as: security, comfort, convenience, efficiency, and affordability (Yücel, 2013). Thus, these pedestrian pathways should maintain several features such as: comfort, safety, light, noise, capacity, facilities, and street furniture: like seating area and planting trees.

Individuals come to downtown areas daily for various purposes like business, instructional, work, and so forth. The central part of the main business area visits of individuals is improved by non-mechanized modes, particularly walking that is an ecological agreeable method of vehicle for short outings. Walking makes individuals physically healthy and provides no ozone depleting substances since no cars will be needed. Further, strolling is the perfect methods of transportation in urban downtown areas since it does not interest for stopping. Despite the favorable circumstances, this makes a circumstance where most downtown areas suit overwhelming pedestrian streams. Regardless of having adequate walkways, people on foot here and there use roadways making life dangers and aggravating the transportation stream. Walkway condition is for the most part an affecting variable to sidestep the utilization of walkways. Width of walkways, passerby stream rates, existence of obstructions, and inaccessibility of handrails are a portion of the components, which fundamentally impact the people on foot to abstain from utilizing the walkways. (Wicramasinghe & Dissanayake, 2016)

3. TREES DISTRIBUTION IN COMMERCIAL STREET

The trees are effective elements of the street furniture, as they have significant benefits: shading the pedestrian passages, refining the air from CO2 emitting, save wasted water and energy, in addition to the aesthetic role.

There are many aspects should be considered in choosing the convenience kinds of trees distributed in a commercial street, such as: the height of the trees, the density, the shade, the distance between trees, and trees location toward the street stores. In addition, the trees should be situated in the furnishing area beside the road, between 2 to 3 feet of the sidewalk. (Steiner, Hutcheson, & Ramos, 2016)

The trees present numerous ecological, medical, and economic advantages, although carrying attracted to our areas. Planting trees in walkway sides and alongside occupied business boulevards express testing, developing conditions that could restrict their long wellbeing and endurance. Fundamental factors influencing road tree development contain: solid soils from trash containers and pedestrian activity, dry season because of the constrained accessibility of water and soil, substantial trash receptacles, physical harm from equipment as bike curls, harm from the street and walkway snow and de-icing salt steady consideration, for example, watering and protecting, could essentially improve a road tree's ability to flourish. The urban woodland is a mutual asset, and in this way a common duty. (Leaf, 2017)

Selecting the potential tree species by managers is a necessity to limit the rundown of these types to those most appropriate for specific planting locations. The selection is restricted by standards ought to reflect known, predictable settings and constraints of the suggested planting spot. (Inc., 2016)

The previous literature reviews highlighted the benefits of encouraging people to walk instead of using the vehicles, especially in the commercial areas. This idea could become beneficial when providing an integrated design in urban streetscape and maintaining the street elements, in particular, the focus of this research, on the trees planted on the sidewalk for the purpose of achieving a valuable pedestrian walkway in a business area, which attract people and reach the economic benefits of the commercial street.

The next part illustrates the method assumed in this study, as the tools used to gather data, the program implemented to analysis the street trees to find out the optimal result.

4. OPTMIZING TREE DISTRIBUTION STAGES

This research proposes the following stages that include as a first step an analysis of the current situation of the pedestrian walkway in the selected street in Tripoli city, this street has an observable problem, the trees are distributed randomly in the pedestrian walkway. The analysis shows in detail the type, height, canopy size, and distance between the trees in a commercial street in Tripoli. The second step is applying “Rhino Grasshopper” software to suggest new solutions for trees distribution according to the international standards. Therefore, an optimal selection of the best trees’ types, and the best way to distribute the trees with considering the location and tree densities will be presented in this research.

5. CASE STUDY

The research case study takes place in “Achir El-Dayeh” street, in Tripoli - Lebanon. This street is selected for its importance in the location as it is considered a vital main street in Tripoli city, the second reason is the economic position of this new area as it became the new intent of businessmen to invest in this region; restaurants, shops (as shown as Fig. 1). So, encouraging people to come to this area will increase the economic value of this street. As it is mentioned previously, the first step in this study is the analysis of the street trees on one hand their distribution, and on the other hand the suitability of these trees on this street from the shape, type, shade, height, and the distance between the trees.

Fig.1: The selected street as a case study in Tripoli city
Source: ArcGIS Map modified by the author

5.1. The Standard Settings of Street Tree Selection

The following criteria should be considered in planning and designing a commercial street. The numbers shown below are taken from the resource (Seattle street illustrated, 2017)

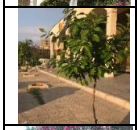
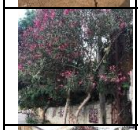
1. The pedestrian path standard width 2.5-3 m
2. The greening zone standard 1.8-2.4 m
3. The frontage zone standard 0-1.8 m
4. The distance between medium size trees standard 8 m
5. The type of street tree should be unified.

These standards will be applied on “Achir El-Dayeh” street through the study application to compare it with the current street tree’s condition to obtain the optimum solution.

5.2. The Street Tree Analysis

As indicated in Table 1, it shows the different types of trees planted in the selected street with their properties. The database of the trees’ kinds is provided from the source (Talhouk, Fabian, & Dagher, 2015). The data collected for the street trees are done depending on observation of the street trees and taking photos for these trees, as indicated in the shape column in Table 1.

Table 1: Trees analysis in Achir El-Dayeh street
Source: The author

Shape	Type	Height	Current number	Canopy density	Canopy texture
	Cupressus Semperviens	15 m	10	dense	medium
	Ficus Australia	8-15 m	6	dense	fine
	Jakarnda Arborea	8-15 m	11	open	fine
	Melia Azedaradn	8-15 m	11	open	fine
	Archontophoenix Alexandrae	5-8 m	1	open	fine
	Albizia Lebbeek	15-23 m	5	medium	coarse
	Calistemon Viminalis	2-4 m	15	open	fine
	Citrus Singensis	3 m	7	medium	medium
	Derium Oleander	3-5 m	1	medium	medium
	Pyracantha Coccina	1.5-3 m	1	dense	coarse

As the street length is about 1.8 kilometers and depending on the previous assessment of the street trees (as indicated in Table 1), and the standard criteria in planting street trees (as mentioned in part 5.1.). The results are discussed as follows:

The previous table shows that the two best kinds of trees used for street are Jakarnda Arborea and Melia Azedaradn, as these trees have the finest properties from height, canopy density, and canopy texture. Although the number of these trees are too little as it forms 32% relative to the mixed tree types in the street.

The evaluation of tree types planted in “Achir El-Dayeh” street clarifies that 68% of the street trees are not appropriate to be planted. As these types of trees do not provide a shading role for the pedestrian walkway in the commercial street, in contrast, these trees play simply an aesthetic role which is not enough for the pedestrian in a commercial street (as shown as Fig. 2).

The types of trees: analyzing the types of trees planted in the selected commercial street provides a detailed study of the trees’ percentage according to type that help to determine if these kinds are suitable or not to fit the street. It is noticed that only 32% of the trees provide the required function (as shown as Fig. 2).

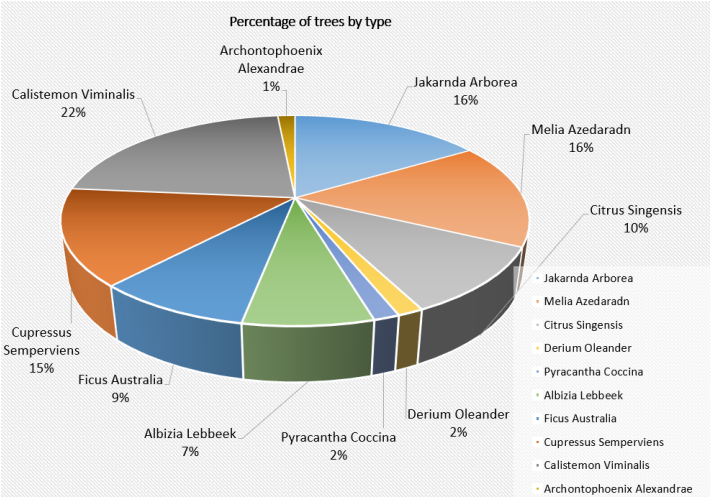


Fig.2: The mix types of trees planted in the street
Source: The author

The average height of the street trees: in comparing the numbers of the trees, according to their average height -as the minimum and maximum height is provided in table1- it is found that 28 trees' average height is about 11m, 22 trees' average height is about 3m, 10 trees' average height is about 15m, 5 trees' average height is about 19m, one tree's average height is about 6m, one tree's average height is about 4m, and one tree's average height is about 2m. This difference in the tree's heights back to the variation in trees types, and the time these trees were planted which proves the unorganized method in planting the street trees (as shown as Fig. 3).

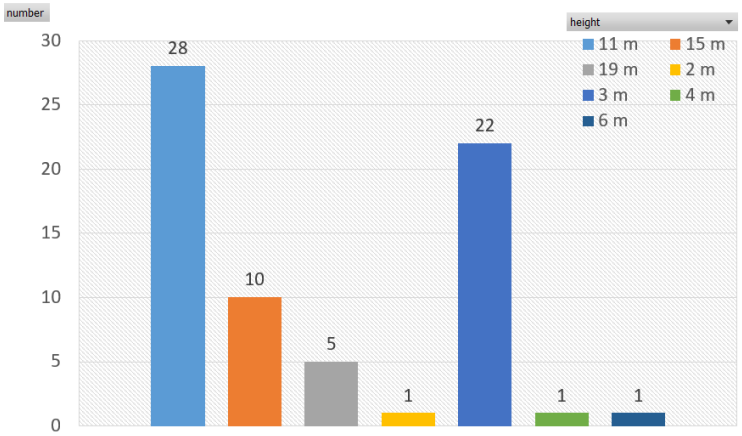


Fig.3: The numbers of trees according to the average height
Source: The author

The canopy of the trees: The analysis of the street trees provides a clear explanation of the canopy density of these types of trees that vary as 56% of trees canopy density is open, 19% medium, and 25% is dense. For the canopy texture, it is varied as 65% of tree canopy texture is fine, 26% is medium, and 9% is coarse. These percentages indicate that the open canopy density and the fine canopy texture have the highest level in comparing with the other tree 'canopy and texture (as shown as Fig. 4, 5).

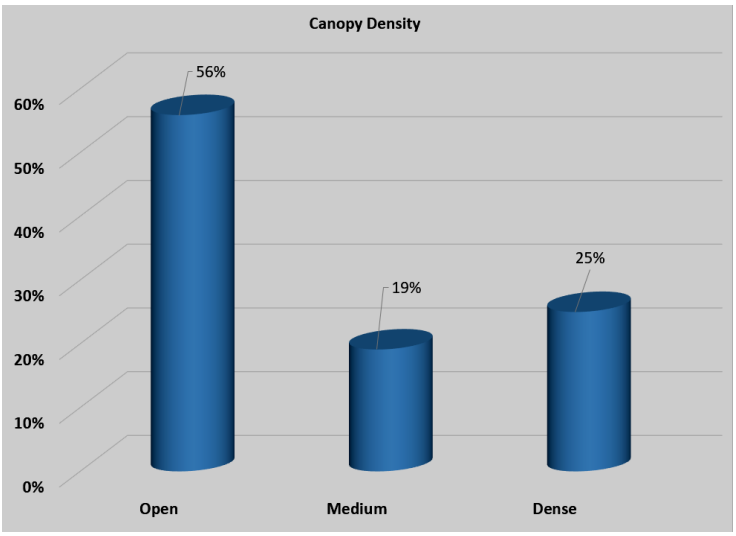


Fig.4: The canopy density of the street trees
Source: The author

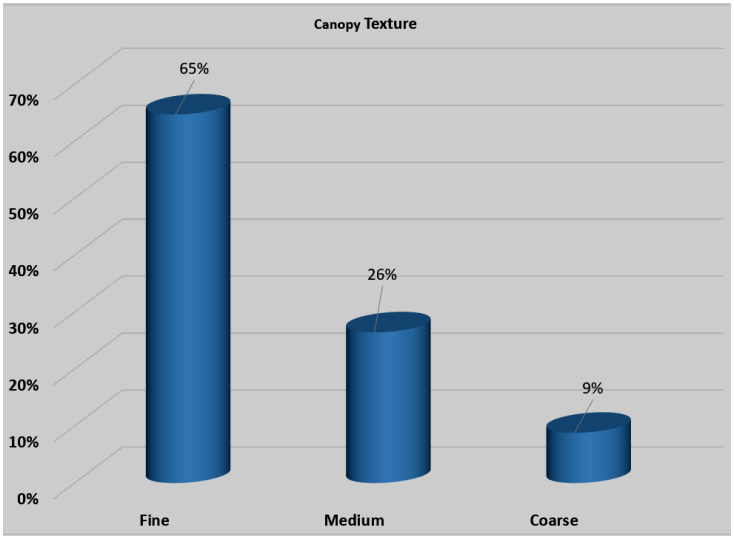


Fig.5: The canopy texture of the street trees
Source: The author

The location of trees: it is observed that no logic distribution is adopted in planting the trees in "Achir El-Dayeh" street. It is noticed that almost 65% of trees is planted in the middle of the pedestrian walkway which cause a disturbance for the pedestrian movement on the sidewalk, on the other hand 35% of trees are located at the side of the walkway in a right way.

The distance between the street trees: 30% of trees keeps an acceptable distance between each two of them that ranges between six to eight meters, in contrast 70% of trees is expanded in anarchical way. In addition, a large distance of the street is vacant of any kind of trees.

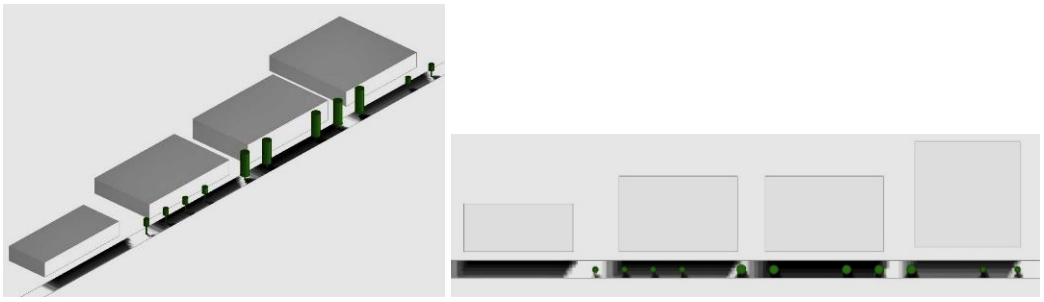
5.3. Study Application

The software "Rhino Grasshopper" is applied on the research case study in order to analysis "Achir El-Dayeh" street trees. This analysis shows the shading provided from the trees existed on the street. For this purpose, the plugin used in the program is the "Ladybug" that provides an environmental analysis on "Grasshopper". Using this plugin, it is encoded an "Energy Plus Weather" file created by a weather station that records information for the whole year in the location needed, providing data as temperature, humidity, wind speed and direction, sun direction. The parameters needed is the radius of the existing trees, the space between trees.

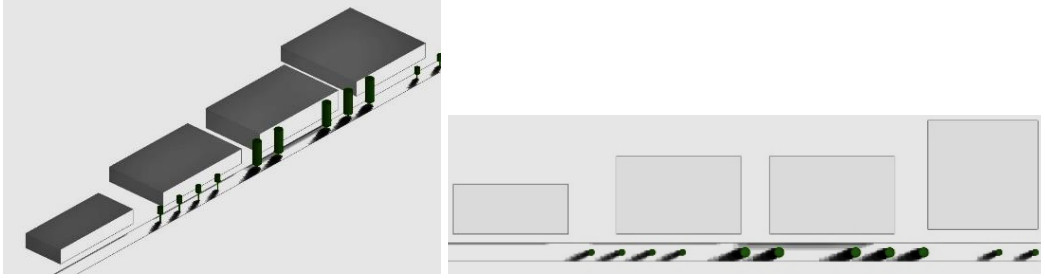
The next step is proposing the solution for distributing the trees on the sidewalk according to the standard criteria and test it in the program to get the optimum result. The street length is about 1.8 kilometers, and it includes two traveled ways with a center median, and one pedestrian realm on each side. The focus of this study is on one side of the selected street that contains a pedestrian walkway, furnished zone, and the frontage zone of the commercial shops and restaurants.

5.3.1. Shading analysis of existing trees

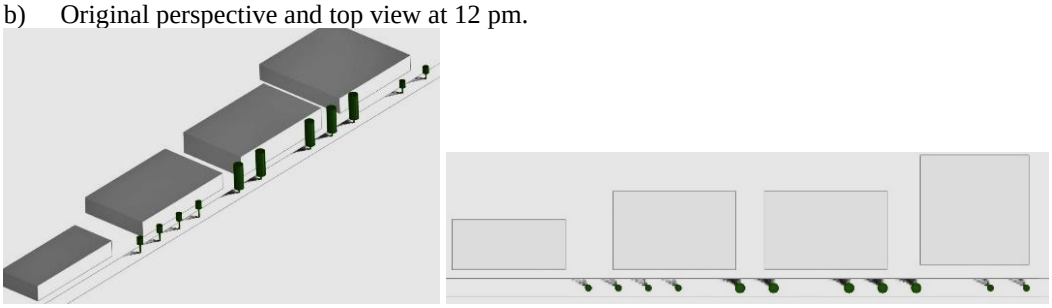
The results are obtained through the application of the "Rhino Grasshopper" software that shows the shading provided from the trees and existing buildings in the street (as shown as Fig.6).



a) Original perspective and top view at 9 am.



b) Original perspective and top view at 12 pm.



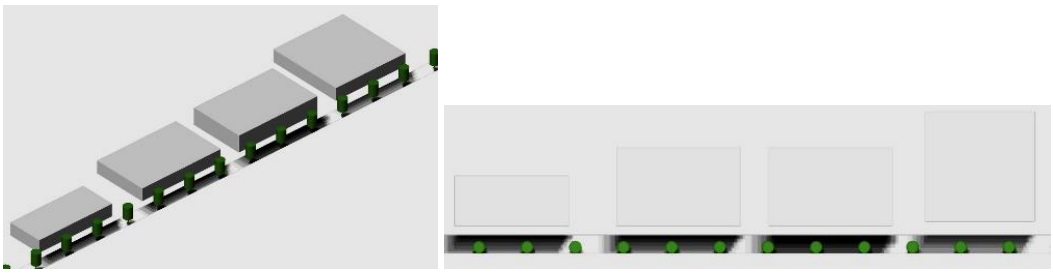
c) Original perspective and top view at 16 pm.

Fig.6: The original street shading Source: The author

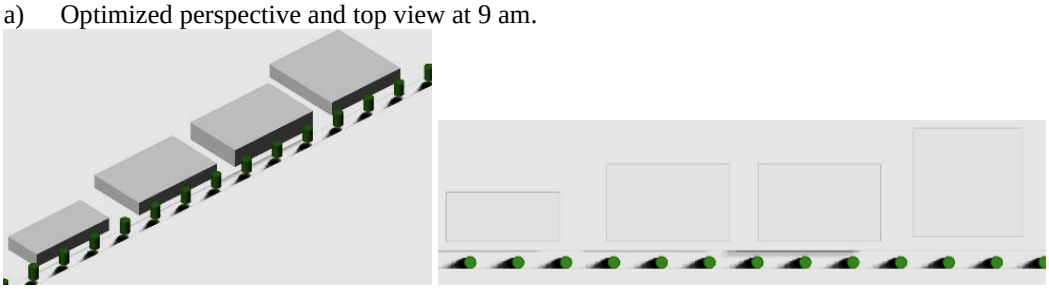
The simulation is done for the street at three different times; at 9 am, 12 pm, and 16 pm, to show the differences in shading the street in the current situation.

5.3.2. Optimization street trees distribution shading analysis

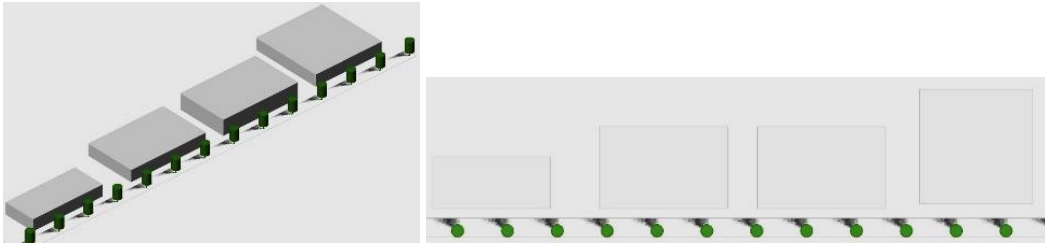
The next part of the simulation is done according to the standard criteria in planting street trees for a commercial street (as mentioned in part 5.2), and the results are shown as below (as shown as Fig. 7)



a) Optimized perspective and top view at 9 am.



b) Optimized perspective and top view at 12 pm.



c) Optimized perspective and top view at 16 pm.

Fig.7: The optimized street shading
Source: The author

The simulation performed in the street, according to the standards in planting trees in commercial street, proves that the proposed solution is the optimal tree's performance in shading the pedestrian walkway (as shown as Fig. 8).

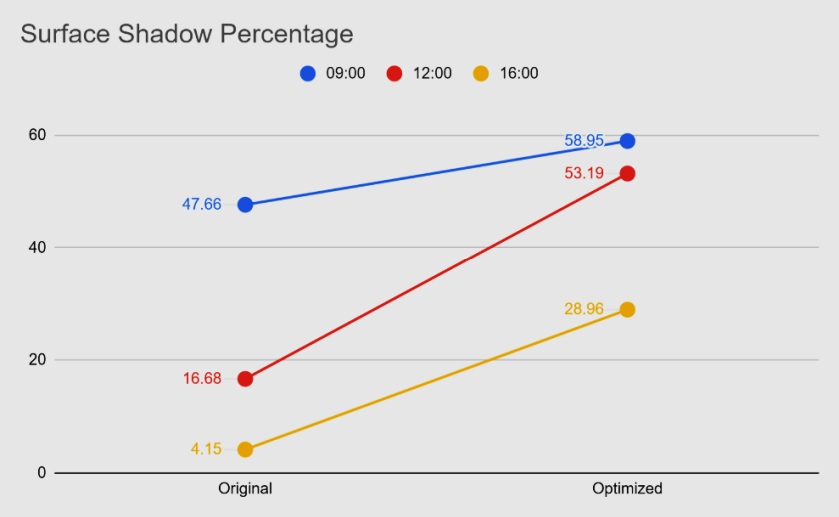


Fig.8: Surface shadow percentage. Source: The author

The software indicates that the surface shadow percentage has raised when applying the new solution as the optimized solution has achieved. The percentage of shading increased from 4.15% at 16pm in the original situation to 28.96% at the same time, from 16.68% at 12pm to 53.19% at the same time, and from 47.66% at 9am to

58.95% at the same time. As it is noticed the difference in shadow percentage differs according to each daytime, the least difference is at 9 am as the percentage raised 11.29% although at the same time it is the highest percentage in shading the street. At 16 pm the percentage raised 24.81%, and at 12 pm the percentage raised 36.51% that is the most percentage increased in shading the surface.

6. CONCLUSION

The commercial street has economic benefits, this street has multi functions that should be existed. However, the focus of this paper was on re-arranged the street trees to achieve the optimum solution in distributing the trees to gain the maximum shading surfaces. The study initiated with an analysis to "Achie El-Dayeh" street tree, this analysis presented the tree types, location on the street sidewalk, and the distance between trees. The next part was the application of "Rhino-Grasshopper" software to find out the shading provided by street trees at different day times, then proposing new solution in distributing the street trees, according to standards to figure out the optimum solution in planting trees in a commercial street. The simulation results showed that the new distribution of street trees raised the surface shadow percentage as depending on one type of tree "Melia Azedaradn" or "Jakarnda Arborea" as these kinds provide the best shading for the pedestrian walkway beside the visual shape as it is mentioned in the canopy density and canopy texture. In addition, of maintaining the distance between the trees and its location on the sidewalk without disturbing the pedestrian as before. The number of the street trees ought to raise from 68 trees to 225 trees, according to street length and the standard of eight meters between each two trees. The goal of this paper in optimizing the way of tree distribution in a commercial street has been proved in the simulation, especially at 12 pm as the shading increased 36.51% comparing the final distribution with the current situation of the trees. This study ensures the value of this problem as it looks simply as it is important to maintain the streetscape design conditions to achieve the optimum result, in order to maximize the shading surface for a pedestrian walkway in a commercial street.

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