

# GIS BASED ANALYSIS TO ASSESS THE BENEFITS OF GREEN AREAS IN THE URBAN CORE (WITH SPECIAL REFERENCE TO THE VIHARA MAHA DEVI PARK IN COLOMBO)

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## Abstract

*This research deals with the benefits of green spaces in urban areas. In order to get the priorities right in urban planning, it is necessary to begin the process by identifying the factors that will deliver the benefits of greenery as a first step, since sufficient research has not been done in this area. The benefits conferred by green spaces were studied using data collected from a basic questionnaire survey, as well as from interviews conducted with visitors to the Vihara Maha Devi Park in Colombo. Information on the distribution of plots with vegetation inside the park was marked on a map. Statistical analysis techniques based on multiple logistic regression were employed to discover whether there was any connection between potential predictor factors and the benefits of spaces in cities containing trees and plants, as these could provide a venue for physical activities and relaxation by the city dwellers. From the results it is evident that both personal and environmental factors play a part in the benefits derived from the presence of greenery in cities. Several factors relating to the visitors such as their age, education and the presence of young children in the family appear to have a connection with their visits to these parks. The picture becomes clearer if the respondents are classified into six groups, based on certain distinct characteristics that seem to go with particular patterns of use. Distance, travelling cost, heat problems, health related problems, monthly income and house conditions are the six variables that will be analyzed. According to the results of the analysis we can see that it is mostly the local residents who come to the green areas. Short travelling time and lower travelling cost are the main reasons for the higher numbers of local people. Another reason is that many people come to this area for their health related activities. Among them nearly all visitors are local residents. Outside visitors rarely come to this green area. Those who do, mainly visit for leisure activities. The survey also found temperature differences between the inside and outside of the park. According to the analysis, many people like to spend their leisure time inside the green area as it has a cool environment. Therefore, it is intended to use strategies adapted to suit local conditions and this will be followed up by making an in-depth study of both the neighborhood residents and the availability of green spaces to identify the main underlying factors. During the course of this project a few tools were developed that will facilitate in carrying out the analysis.*

**Keywords:** Global Information System, Inverse Distance Weighted

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## 1. INTRODUCTION

Humanity is rapidly urbanizing, and by 2030 more than 60% of the world's population would have made their homes in the cities[1]. But even if people are tending to flock around cities, they would still need to draw their sustenance from Nature as before. Cities for example, are dependent on the large tracts of rural lands to provide many essential materials and to absorb some of the output of the city. Since humanity is also a part of nature, cities themselves will have to be regarded as islands with their own ecosystems that are scattered about the globe. When compared with the unspoiled, wooded areas, the man-made jungles strike one as being monstrosities due to certain aspects like their uncontrolled expansion and wasteful use of resources such as energy and minerals and even water [2]. Odum has even observed that cities are the "only parasites in the biosphere."

However, it is possible to arrange for the presence of green areas within city limits through enlightened urban planning. Most of the problems endemic to urban areas are local in

origin, such as those due to over crowding and pollution[4]. Often the most effective remedy when dealing with these problems is to apply homemade solutions. This is where the green areas in cities can play a vital role [5].

Establishing green zones can prove to be a useful strategy for urban planners to enhance the esthetics of a city. For high-density urban living environments such as Colombo, the presence of greenery provides considerable visual appeal that helps to make urban dwellers feel more at ease [7]. The green concept has become a hot topic due to various factors over the past few years [6]. In the present time, this green concept is assuming greater importance for the cities. Most cities suffer from many problems. Increasing temperature, partly due to global warming, is one of the main problems [8]. Another thing is mental stress, as cities are hectically busy areas. Overcrowding, traffic congestion, noise pollution and bad smells brought about by poor sanitation cause stress to the inhabitants. Nobody likes cities that are in this situation [7]. Therefore, town planners have been trying

to change this situation. They have managed to change the outlook in the cities to some extent. One effective approach has been to include green areas in their town plans. This urban green area concept has provided various benefits to the society.

It is acknowledged that the cities in developed countries usually have more trees than the cities in developing countries. The World Health Organization's recommendation is that there should be at least 9m<sup>2</sup> of green open space for each inhabitant in a city, a standard that very few cities in developing countries can aspire to match.

Being a tropical country blessed with good weather for several months of the year and carpeted with green surroundings, especially in the interior, Sri Lanka offers plenty of wonderful spaces for good living [6]. The city development plan envisioned by the previous government and implemented quite efficiently by the Urban Development Authority, calls for the siting of numerous "green spaces" within cities, to uplift the quality of city dwelling [9].

Planning Policy Guidelines describe the various types of green spaces and other civic spaces that are now common in urban environments. The typology used by the PPG is recommended to ensure consistency.

A well planned urban green space program should therefore include, as necessary, the following types of green spaces:

- i) Public parks, gardens and children's playgrounds
- ii) Bare and undeveloped lands
- iii) Cycling paths
- iv) Sports grounds with facilities
- v) Jogging tracks
- vi) Open areas for children and young people
- vii) Community gardens and city farms
- viii) Cemeteries, churchyards and other grounds
- ix) Ready access to the countryside from urban fringe areas

All such green spaces are to be spaced out uniformly to cover the Colombo city and adjoining areas [7].

The aim of this research is to identify and analyze some of the benefits of these green areas. The focus will be on pinpointing the benefits and whenever possible to quantify and value them, and assess their applicability and usefulness to cities in Sri Lanka. Some green areas from Colombo will be scrutinized closely for this study by way of examples.

When discussing the importance of urban green areas and their benefits in a study such as this, it is difficult to draw generalized conclusions that would apply to every city in the world. The real benefits and value can vary significantly from city to city since they rise up in all kinds of locations and environments and can range in size considerably. The nature of the activities in cities would also call for different urban planning solutions and a 'one size fits all' approach will not work.

## 1.1 Problem Statement

Nowadays many cities face numerous problems. Among these increasing temperature and the creation of heat islands are main problems. Lack of green spaces is one reason for this situation. In the past, many city planners used to divide the city sharply into commercial areas, industrial areas, residential areas and so on. Currently though, they try to create green areas within urban areas. So they have to find suitable lands to build these green spaces but lack of land is the main problem. Today most people want to live in cities. So they try to buy land near the main cities, thereby increasing the demand for it and the price. Consequently, Colombo city planners could not find suitable lands to create green areas. However, despite the difficulties, over the past 10 years our city planners have tried to create green spaces within Colombo City. They strived to create home gardens, public and private parks, avenues, pedestrian paths, and green corridors [10]. Continuing this practice, today the city planners are recreating Vihara Maha Devi Park with more green spaces. A long-term lack of funding and investment has led to a decline in green spaces, in a way that has become progressively apparent to green space users. This is a national problem that is not just confined to Colombo. So we have to assess the importance of these green spaces to determine the need for more green spaces in urban areas. This research intends to measure the benefits of green areas at the urban core (Based on Vihara Maha Devi Park).

## 1.2 Research Questions

- i) Why are green spaces important in a city?
- ii) What are the benefits to the public from green spaces?

## 1.3 Objectives

- i) To assess the benefits to the public and the environment from green spaces.
- ii) To identify the variations in temperature between the green areas and the built-up, heat affected areas of the city.

## 1.4 Limitations of the Study

At the present time, there are many cities with planned Green Areas as the "Green Concept" is very popular in the world. Therefore, city planners create green areas in all new city plans. Developed countries maintain these green areas very efficiently and they are reaping many benefits. Most developing countries now try to follow this trend in their cities. Today, Green benefits are very important for all urban areas and so we can learn many things by studying some of those urban green areas in the world. However, that would be a very big undertaking as huge areas in distant places would have to be investigated. That would mean the expenditure of a great deal of time and money and involve risks. However, we can save ourselves all that trouble as today we can find urban green areas right here in Sri Lanka. Mainly, most of the green areas are scattered around Colombo city. Therefore, We have chosen Colombo city as our study area. However, Colombo's city planners seem to have created green areas in patches. Therefore, We will have to spend extra time and money to find those areas in the city

and further, Colombo city is a very busy place. Perhaps We would not find real data for some public facilities and offices. We believe these are limitations that would apply to our study.

## 2. METHODOLOGY

The methodology of this study is implemented in two steps. Step One is running the Multivariate Logistic Model. For the analysis the Logistic Regression Methodology will be used. Logistic Regression methodology can be a powerful analytical technique when the outcome variable is dichotomous [11]. The results produced by the logistic model were shown to be supported by significance tests of the model as measured against the null model, the significance test of each predictor, descriptive and inferential goodness-of-fit indices, and predicted probabilities [12]. In the recent past, logistic regression analysis has become increasingly popular as it makes detailed and accurate analysis possible.

Researcher randomly chose 100 residents visiting Vihara Maha Devi Park. Then the residents' committees of the city's streets, which had records of the residents, chose residents on a random basis for interviews in February of 2016. A questionnaire survey was done covering Vihara Maha Devi Park, using a structured questionnaire to study the environmental and social impacts of increasing temperature. This helped to identify the green area benefits in this study location. There were 21 questions covering various topics. They were directed at 100 stakeholders in the study area, and among them were youths, elders, students and strollers who were the main stakeholders.

Six dependent variables were used for the analysis. They were urban heat problems, health related problems, travelling cost, distance, house condition, and monthly income. These were used as the dependent variables. Colombo Local Authority area inside and outside is the independent variable. Those correlations were studied using Logistic regression analysis.

In Step Two we made use of interpolation analysis for the interpolation. A mercury thermometer was used to record variations in temperature. An ordinary thermometer is commonly referred to as a dry-bulb thermometer [13]. This thermometer can also be used to measure temperature for other purposes, such as to determine humidity levels or the outside temperature. This thermometer can measure higher temperatures also because it is built to withstand a wide range of temperatures. However, to obtain the right humidity levels, the dry-bulb thermometer is paired with a wet-bulb thermometer. This makes it possible to record a relative number for the humidity level [14]. The working of the conventional mercury thermometer is based on the expansion of mercury, a liquid metal. It is made of a glass capillary tube that has one end formed into a hollow bulb, containing the mercury. Both ends of the glass tube are sealed. When the bulb is warmed the mercury expands and rises up along the hollow capillary. The stem of the thermometer is graduated in degrees Celsius enabling the

temperature to be read out. The larger the bulb and the narrower the capillary, the more sensitive the instrument will be. Mercury thermometers are capable of measuring to a tenth of a degree Celsius. The characteristics of this type of thermometer are based on the nature of this metal that exists in the liquid state at room temperature.

**Table1:** Properties of mercury

Advantages	Disadvantages
Mercury expands readily	It solidifies at -39°C and so cannot be used to measure lower temperatures than that
Despite being a liquid it has good thermal conductivity just like any other metal. So it responds fast to heat	It is expensive
It is silvery, opaque and clearly visible	The metal's vapor and its compounds are highly toxic
It does not wet glass and so will maintain accuracy	
A minimum-maximum thermometer can also be made with it	
It has a relatively high boiling point (357°C) and will work up to that temperature	

It was decided to observe ten hotspots inside Colombo City and two green spots inside the Vihara Maha Devi Park. The temperature data were then collected at those spots using the thermometer.

GIS analysis was based on GIS database. GIS spatial analysis and GIS graphs were used to identify the green spots and hot spots inside Colombo City. Finally the green areas' benefits in the urban core were identified. Then the green area map and temperature interpolation map were developed using spatial analysis technique on the GIS data.

## 3. RESULTS OF THE DATA ANALYSIS

The results of the questionnaire dealing with attitudes, values, and usage frequencies were collected and analyzed using the SPSS statistical package. The effect of the background properties was assessed using the Multivariate Logistic Model. The reported variations are statistically significant with a probability that is less than 0.05. Classification plots and Correlation estimates were made and variance analysis was used to test the ordinal scale variables. Factor analysis was also used to select the data needed for testing background properties [15]. The social values of the green plots as identified by the respondents in respect of each unit area were entered into a database, which indicated how often an area had been recognized as possessing some special social quality [16].

Urban heat value scores from the database were entered into the GIS (Arc Map 10.1), making it possible to present that information on a map, combine it with other geographical

information, and perform further analyses. Because a lot of other data pertaining to the plots with greenery were available in the same GIS format, it became possible to make comparisons between the results of this study and the actual landscape, vegetation and urban heat values registered, as well as with the management classes for the various areas falling under the purview of the Colombo Local Authority. These types of comparisons were carried out by the urban town planners as a part of their program for establishing small parks and plots with vegetation in the city. The respondents' answers differed for different green area qualities, which made it necessary to adjust the scale of each thematic map manually to obtain four reasonable value classes. There were usually many green spots in the city that got no votes while typically a handful received a large number of votes.

### 3.1 Multivariate Logistic Model

In this study six variables were used. This is shown in Figure 1.

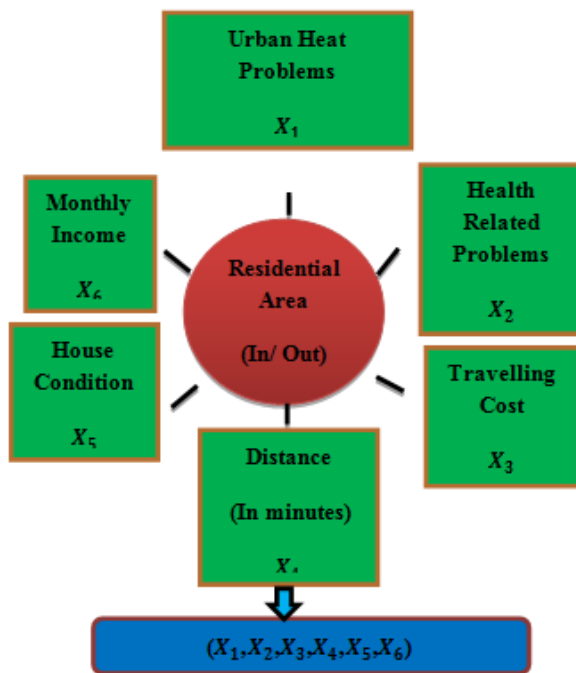


Fig 1: Adapted model

A Multivariate Logistic Model was used to analyze this relationship. It used the Mathematical Equation represented below.

$$Y = (B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6)$$

Y= Inside the Colombo Local Authority - Area 1

Outside the Colombo Local Authority - Area 2

X<sub>1</sub>= Urban Heat Problems

X<sub>2</sub>= Health Related Problems

X<sub>3</sub>= Travelling Cost

X<sub>4</sub>= Distance (In minutes)

X<sub>5</sub>= House Condition

X<sub>6</sub>= Monthly Income

This relationship could be analyzed using SPSS software. This relationship is justified by obtaining a score of 95 percent. It is shown in the number 2 classification data table. It is highly accurate because it managed to get 95 percent correct.

Table 2: Classification Table

Observed		Predicted		
		Residential Area		Percentage Correct
		Inside	Outside	
Residential Area	Inside	54	1	98.2
	Outside	4	41	91.1
Overall Percentage				95.0

#### 3.1.1 Relationship between Residential Areas and Dependent Variables

People who spend time in the green areas have 4.659 Wald value. That is a very good ratio. The significance value is 0.031, which is below 0.05 and that is also consistent with the database. Another important factor is the odds ratio, which has a value of 6.524. This indicates that the number of people who visit the green areas is about six times higher than the number of people not affected by urban heat problems.

Many people come to these green areas. They have 4.555 Wald value which is a strong ratio. Also, the significance value is 0.031 which is below 0.05 and is consistent with the database. The odds ratio value is important and it is 0.124. That indicates that the number of people who come to these green areas is higher than the number of people not having health related problems. Most people come to the green areas for their health related activities such as brisk walking and jogging or simply for the fresh air.

People who spend time in this green area have 14.613 Wald value. That is supposed to be a beneficial ratio. Another thing that is important is the significance value, which is 0.000. As it is below 0.05 it is also consistent with the database. Another important indicator is the odds ratio, which has a value of 1.038. That shows people who have to incur high travel costs do not visit frequently. Some people come to this green area only about once a year because they have to spend a lot of money to travel here.

In this research the time taken to cover the distance between Vihara Maha Devi Park and their residential area is measured in minutes. People who spend time travelling have 3.462 Wald value. That indicates a good value. The accompanying significance value is 0.043. It is lower than 0.05. Odds ratio is 4.018. These values show that the number of people who come to this green area is higher for people who live close by than for people who have to visit from more distant places.

This research also focused on the relationship between residential area and house condition. It is categorized into two classes as apartments and single houses. People who





### 3.2 Incorporating Statistical Model into the GIS

A map was used to measure the green island areas inside the Vihara Maha Devi Park. Figure 2 shows this green island map.

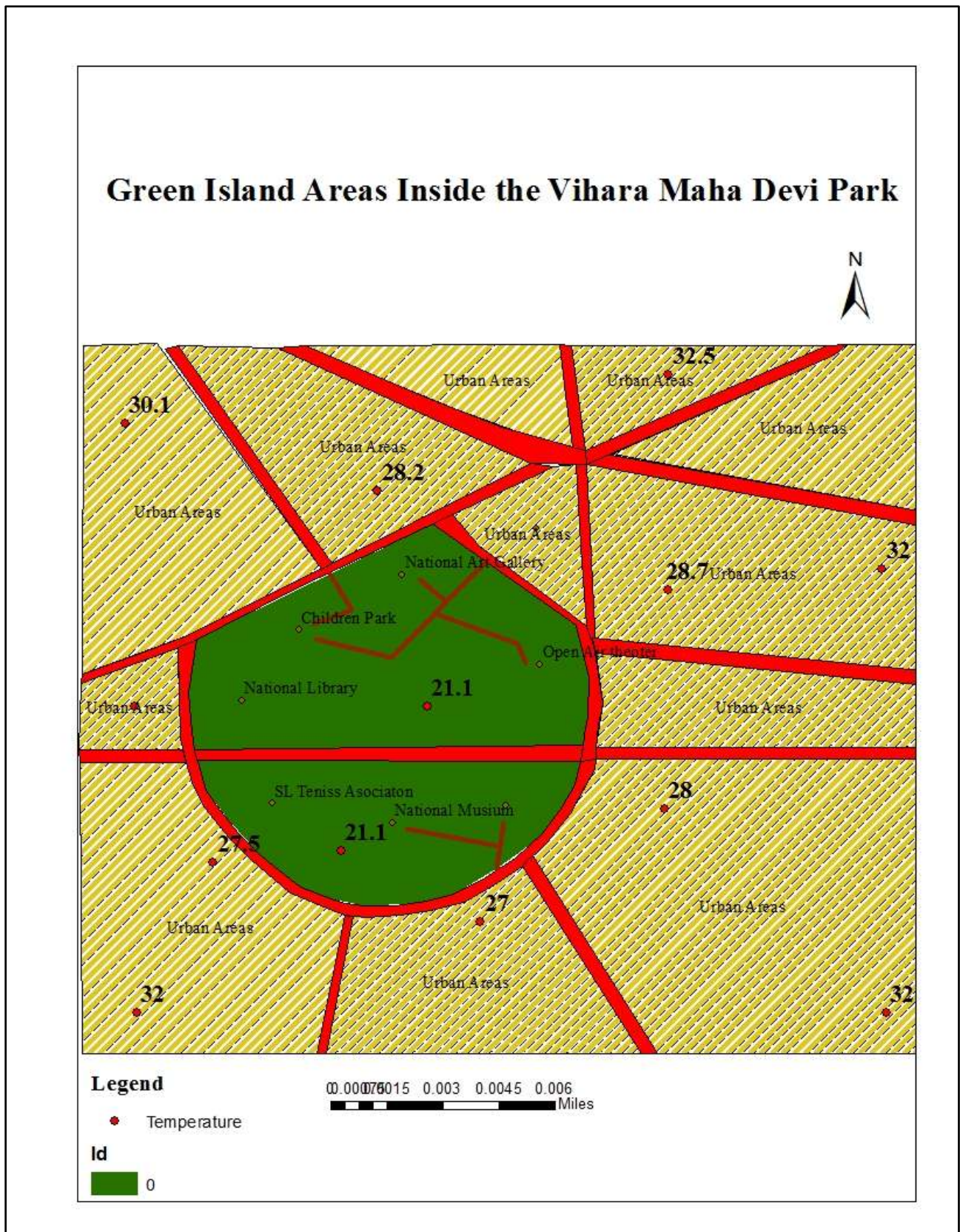


Fig 2: Green Island Areas in the Vihara Maha Devi Park

This is also statistically proved in the Multivariate Logistic Model. People who spend time in the green areas have 4.659 Wald value. That is a very good value. The significance value of 0.031 is below 0.05 so that is also consistent with the database. Another important statistic is the odds ratio of 6.524. That indicates that about six times as many people affected by heat problems visit the green areas than people not affected by urban heat problems.

It is clear that most people have urban heat problems. This study has determined that more local residents have urban heat problems than people who reside outside the city. So the urban dwellers come to this green area to enjoy the cool environment. From the map we can find out the temperature

data. It shows different temperatures in urban areas and green areas. The temperature is steadily increasing in urban areas. Therefore, most urban residents wish to spend some of their time in green areas to enjoy the cool breeze that is usually present here. It is expected to continue this research about green island areas into the future as well.

### 3.3 Interpolating the Statistical Model into GIS

The map shown in Figure 3 depicts the interpolation space relating to temperature inside the green areas and the urban areas.

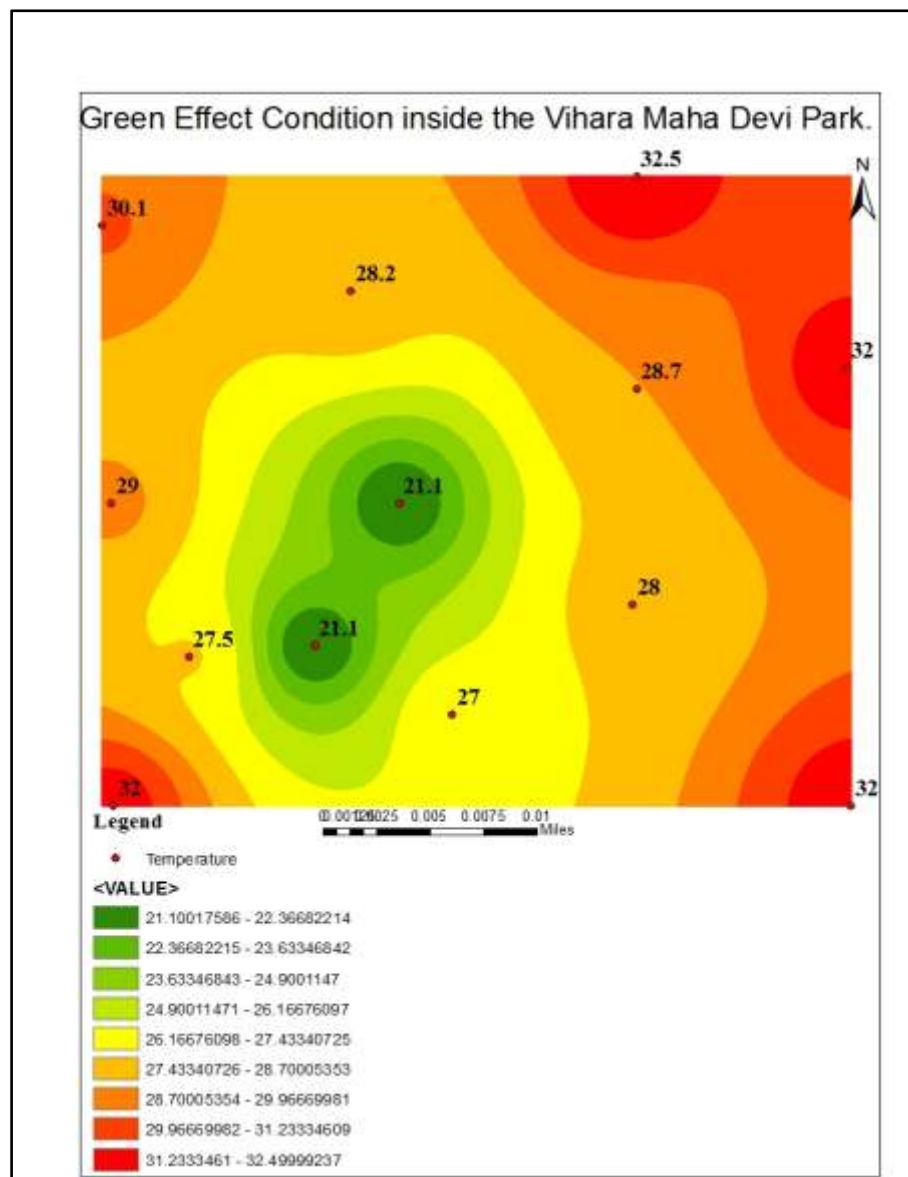


Fig 3: Green Effect inside the Vihara Maha Devi Park

The Interpolation map was created using Arc GIS Software. Arc GIS Spatial Analyst version 9 offers several interpolation tools for generating surface maps from coordinate data. Many new interpolation methods have been added to those that were already available in Arc GIS 8.3

3D Analyst, although the Trend method is only accessible programmatically [17]. Each method uses its own unique technique for determining output cell values. The most appropriate method must be chosen, and this will depend on the distribution of sample points and the phenomenon being

studied. To create the above map the IDW analytical method was used [18]. The IDW function should be used only when the set of points is thickly distributed so that the full extent of local surface variations required for analysis might be resolved with good accuracy. The IDW method works out the cell values using a linear-weighted combination set of sample points. The weight assigned is based on the distance between an input point and the output cell [19]. The further apart they are, the less influence the cell has on the output value.

This map indicates variations of temperature inside the Vihara Maha Devi Park and the surrounding urban areas. The Logistic Regression Analysis showed the relationship between the residential areas and urban heat problems. People who come to this green area have 4.659 Wald value inside the Colombo local authority area. Accuracy is 0.031, which is very high. Another important statistic is the odds ratio, which has a value of 6.524. That indicates people with heat problems visit the green areas about six times more frequently than people who do not have urban heat problems. According to the temperature values recorded, lower temperatures prevail inside the green areas while urban areas have higher temperature. So according to these results it is clear that people living inside the city have more urban heat problems than people living outside. That relationship is proved by the interpolation map shown in Figure 3. According to this map we can distinctly identify the Green Islands as having lower temperatures than urban areas.

#### 4. CONCLUSION

Returning to the question “What have green spaces ever done for Colombo?” the strongest evidence currently points to the positive impact they have on the environment and on people’s health and well-being. This is seen in the section dealing with the statistical model of this research where the overall model is correct 95 percent of the time with positive correlation of its independent variable. In addition to helping to counteract major urban sustainability challenges such as atmospheric heating, they provide space for exercise, play, events and relaxation as mentioned and proved in the statistical model of this study. This is particularly pronounced in the case of larger green spaces. As such, the strongest evidence of this can be provided by examples, particularly applicable to large green spaces such as Epping Forest and Hampstead Heath outside the Square Mile in the UK. The benefits of smaller green spaces in Colombo, such as those within the Square KMs, should also not be underestimated. Collectively, they contribute to rainwater storage and pollutant capture, and can provide important space for relaxation, restoration and social events. It is also important to note that the far reaching environmental and health benefits created by large green spaces in and around Colombo can be enjoyed by all of Colombo’s residents and workers as these are public facilities, and ones that contribute to Colombo’s overall ecosystem. However, there is currently only little evidence to support the importance of green spaces for Colombo’s businesses and its international competitiveness. The one exception is the potentially significant contribution that Colombo’s green spaces make

to its overall appeal as the world’s foremost city destination for international tourists. The evidence that does exist is encouraging, but it is very limited.

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