

Spatial modelling of the householders' perception and assessment of the potentiality to improve the urban green coverage in residential areas: A case study from Issadeen Town Matara, Sri Lanka

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Abstract. Urban forestry has become an important concept in modern city planning for many reasons. Different forms of urban green spaces can be seen in towns as open spaces, tree belts, parks and home gardens. The main objective of this research was to assess the urban green spaces in Issadeen Town, a small residential area in Matara, Sri Lanka. A questionnaire survey was conducted in the study area covering a zone with 200 individual houses. The collected data were entered into a Geographical Information System (GIS) platform, taking one house as the unit of analysis. There was a marked difference between the numbers of trees growing in owner-occupied houses and rental houses. It was also assessed that 11% of the study area had good green cover while 8% of this area had medium level green cover that had the potential to rise to a higher category. The occupants of houses who were living in the high green cover areas stated that they had a positive perception about their environment, especially cooler temperatures. Therefore, they intended to maintain the trees in their housing plots. However, there were other occupants accounting 50.5% of the total, who were not interested or involved in the process of increasing the green cover. This is a matter that the authorities may have to address in future.

Keywords: Environmental assessment, geospatial model, green space, urban planning, urban forestry

1 Introduction

The urban population in the world is increasing rapidly. By 2030 more than 60% of the world's population is expected to be living in cities (Bolund and Hunhammar 1999, United Nations 1997). Therefore, natural ecosystems are

increasingly being replaced by urban concrete jungles in the name of development. Urbanization increases the distance between people and the natural environment. To counter these trends, at least to a limited extent, it is important to make adequate provision of quality green spaces within urban areas and to improve access to the countryside from the cities.

Green spaces contribute significantly to ecosystem services, which are defined as “the benefits that human population derives, directly or indirectly, from ecosystem functions” (American Public Works Association 2007). Green spaces can absorb and assimilate carbon dioxide and produce oxygen to enrich the air and purify water, regulate the micro-climate, reduce noise, protect soil and water, and maintain biodiversity (Ritchie 2013). Green spaces also facilitate recreational activities and promote cultural and social values. Green spaces such as public parks, natural areas and even home gardens can have a statistically significant effect on the sale price of houses in close proximity to those facilities; in other words, the presence of green spaces can boost property values. Thus, urban green space can improve the urban environment, contributes to better public health and raise the quality of life of urban dwellers. In future, the social and spatial implications of new lifestyles, values, and attitudes towards nature and sustainability will lead to even higher demands for green spaces in urban areas (Miller *et al.* 2015).

Urban forestry is a specialized branch of forestry that has as its objectives, the cultivation and management of trees within the urban environment for the physical, social and economic well-being of urban society, both for now and the future. The contribution made by trees includes their over-all ameliorating effect on the environment, as well as their recreational and general amenity value (Konijnendijk *et al.* 2006). Urban biodiversity is essential for residents as the presence of natural recreational areas in the neighborhood is a much appreciated characteristic as reflected in property prices (Niemelä 1999).

Not only across the world but also in Sri Lanka, the urban areas are rapidly expanding and the vegetation cover of urban areas is depleting gradually. Due to the rapid urbanization and industrialization, the amount of CO₂ emitted into the atmosphere is steadily increasing. Atmospheric CO₂ concentrations have increased by more than 40% since pre-industrial times, from approximately 280 parts per million by volume (ppmv) in the 18th century to over 400 ppmv in 2015 (Melillo *et al.* 2014). Therefore, the urban forestry is emerging as an important concept in the modern world. When we consider the Matara urban area of Sri Lanka, the settlement of people has been increasing day by day. With increasing population, the city has to face many environmental, social, economic and even cultural problems. Urban forestry is an effective solution to ameliorate at least some of those problems. The present study to assess the householders’ perception and improvements needed in urban forestry in the context of urban planning using a selected residential area, i.e. the Issadeen Town of Matara municipal council area.

The objectives of this study are 1) to assess the existing green cover in the residential housing plots of Issadeen Town of Matara, 2) to build a logistic model to assess householders' perception in relation to major variables of land plots, including the presence/absence of home gardens, perception on level of temperature, ownership and time spent on gardening, and 3) to identify housing plots that need green cover improvement based on the developed model.

2 Methodology

2.1 Study area

Matara city is the urban center in Matara District, in the Southern Province of Sri Lanka (UDA 2008). The town is located 160 km from the capital city Colombo along the main coastal road connecting Colombo, Galle, Hambanthota and Wellawaya, and continuing to Nilwala River port. The land extent of the town is 16.5 sq.km, comprising seven Grama Niladhari divisions out of a total 41 GN divisions in the Matara divisional Secretariat division (UDA 2008).

According to the land use survey of Matara municipal council area carried out in 2003, 1057.1 hectares had been categorized as being put to residential use; this corresponds to 64.0% of the total extent of land within the municipal limits. According to the Sri Lankan regulations enforced by Urban Development Authority, at least 35 % of open space should be available in each land plots as rear space or front space (UDA 2008). That is regulation is useful to emphasize the people's perception on their home garden to improve urban green coverage and tree planting in this area. The selected study area, i.e. Issadeen Town is one of the primary residential zones in Matara Development Plan (Figure 1). In this exercise we studied the ways to improve urban forestry in residential areas of Issadeen Town by assessing the tree and plants in housing plots.

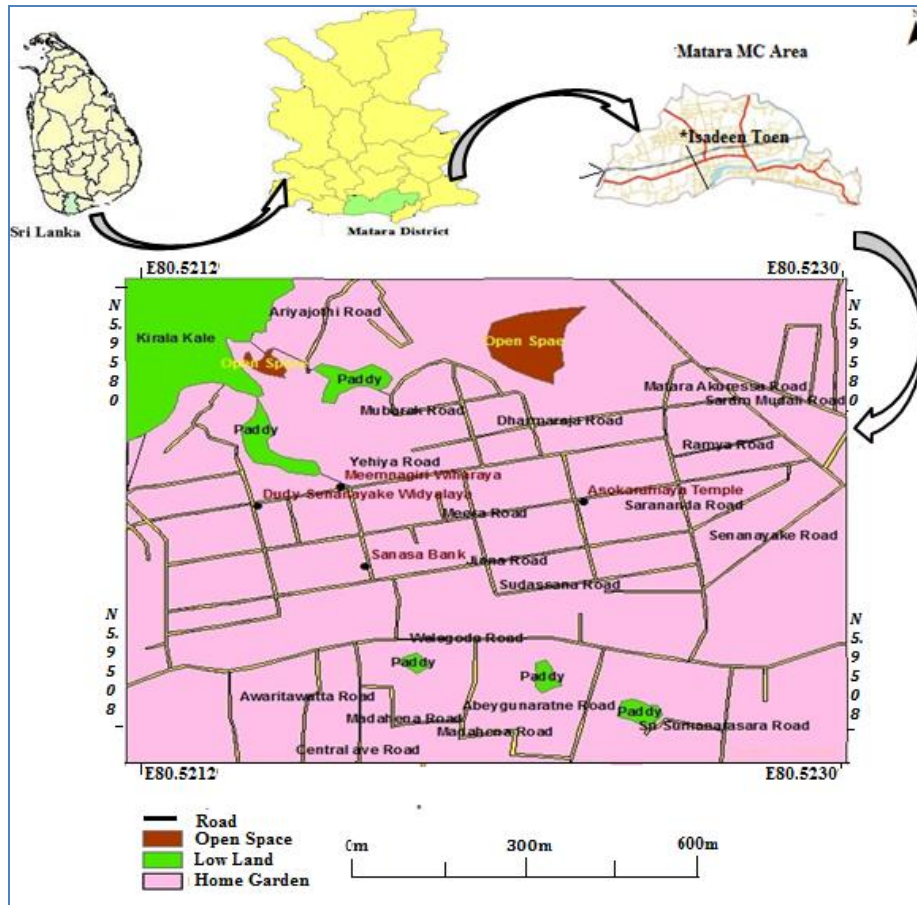


Fig. 1. Location of Issadeen Town, Matara in Southern Province, Sri Lanka

For this study, 200 randomly selected families in Issadeen Town, Matara were surveyed in January, 2017. According to the Matara Urban Development office data, Issadeen Town has the highest population density and many people living in this area are reported to be not poor. Therefore, Issadeen Town was selected for this study; the map in Figure 2 shows those 200 housing locations which were captured using Garmin handheld GIS.

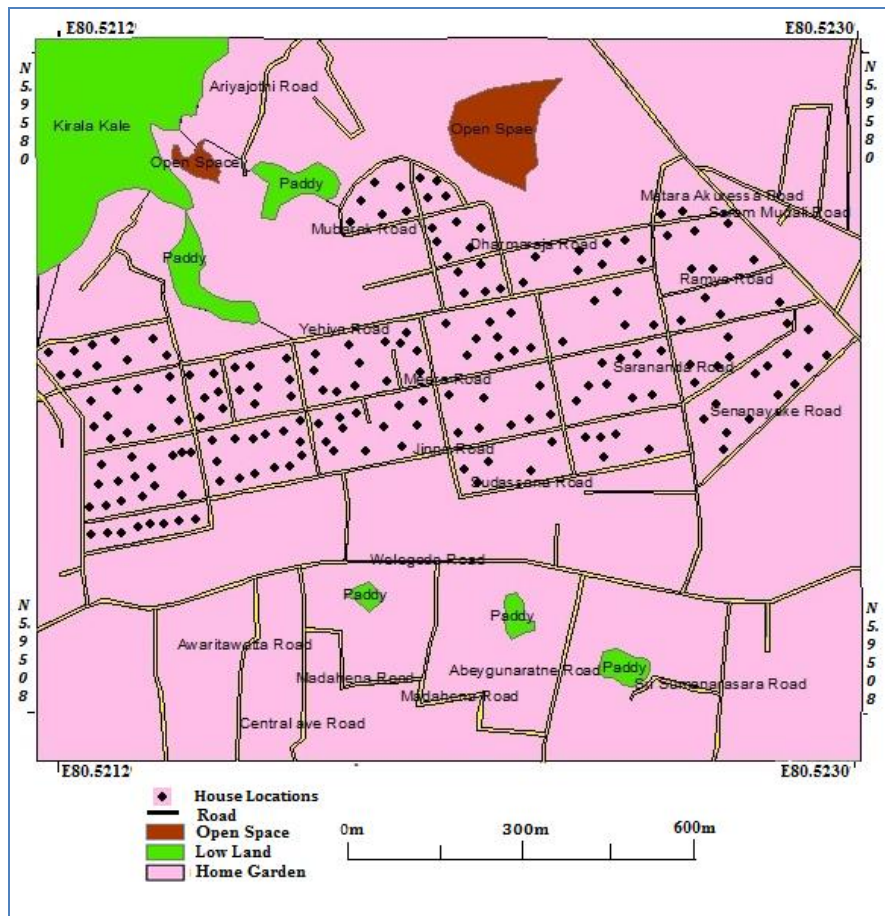


Fig. 2. The location map of households in Issadeen Town, Matara selected for the survey.

2.2 Data collection and analysis

Three types of data, primary data, secondary data and literature were used for this research; primary data was collected from field observations. The secondary data consisted of census data and digital GIS data such as land use shape file, and urban boundaries. Census data provided land use information, green coverage information and residential information. All these were collected from the Matara District Secretariat and the Urban Development Authority in Matara.

According to the residential zone map of Matara Municipal Council area, Issadeen Town had the highest population density. A survey was conducted on the topic of green coverage in Issadeen Town, using a structured

questionnaire to study various aspects of the urban forestry in that zone. This helped to identify the context of urban green coverage of Issadeen Town to the respondents. There were 33 questions covering three sub-topics; basic information regarding the residents, condition of house and land, green coverage and peoples' attitudes towards green coverage. Participants were youth, elders, and students including both male and female.

The data analysis of this study mainly consisted of running the multivariate binary logistic model. Logistic regression methodology can be a powerful analytical technique when the outcome variable is dichotomous (De Vaus 2002). 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 (Kinzig *et al.* 2005). In recent times, logistic regression analysis has become increasingly popular as it makes detailed and accurate analysis possible. In this study five variables were used. Structure of logistic model is shown in Figure 3.

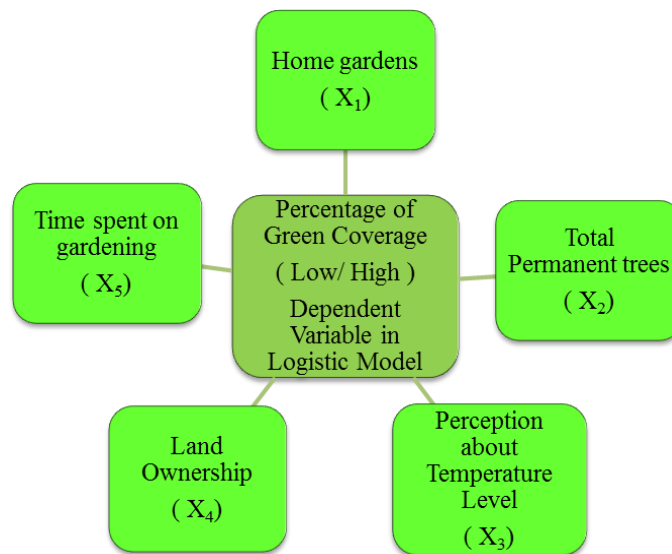


Fig. 3. Structure of logistic model with its explanatory variables

A multivariate binary logistic model was used to analyze this relationship between dependent of percentage of green coverage in the land plots and its independent variables as mentioned in above Figure 3. It uses the mathematical equation represented below.

$$Y = \text{Logit}(P) = \ln[p/(1 - P0)] = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 \dots \dots \dots (1)$$

If p is the probability that the dependent variable (Y) is 1, then $p(1-p)$ is what is known as the odds or likelihood ratio; B_0 is the intercept, and B_1, \dots, B_5 are coefficients that measure the contribution of independent factors X_1, \dots, X_5 to the variations in Y . In order to interpret the meaning of Eq. (1) appropriately, it is necessary to express the coefficients as a power of the natural log (e), which gives the value of the odds ratio.

Housing plots were units of analysis and all houses were observed to record whether houses have low greenery coverage (0) or high greenery coverage (1) in their land plots.

Y = High Green coverage houses 1
Low green coverage houses 0

Five independent variables (X) were used for the analysis. They were home gardens, permanent trees in a land plot, level of temperature change, land ownership and time spent on gardening (minutes). Percentage of green coverage in home plots was the dependent variable. Those correlations were studied using logistic regression analysis. X_1 is Home gardens (Yes or No on whether there are any elements related to home garden agriculture activities such as fruit, vegetable etc. X_2 is total permanent trees in plot, X_3 is perception about temperature level (High or Normal in Day time), X_4 is land ownership because it is assumed that own land owners have engaged to grow the more plants than others hence land owners = 1 and other categories = 0), and X_5 is time spent (minutes) within a day in the garden.

After collecting the data generated by the questionnaire, spatial data were developed using a GIS software. GIS analysis was based on attribute table of GIS. GIS spatial analysis and GIS graphs were used to assess the green coverage of Issadeen Town in Matara. Areas with green coverage were identified according to the probability value of each housing plot. Thereafter, the green coverage was marked on the residential map using spatial analysis technique on the GIS platform.

3 Results and Discussion

The results of the questionnaire dealing with attitudes, values and usage of green coverage and probability value were collected, tabulated and analyzed using the SPSS statistical package (George and Mallery 2016). In binary logistic regression, the outcome is usually coded as "0" or "1", as this leads to the most straightforward interpretation. If a particular observed outcome for the dependent variable is the noteworthy, possible outcome referred to as a "success" (high green cover with respect this study), it is usually coded as "1" and the contrary outcome referred to as a failure (in this study low greenery coverage) is coded as "0". Binary logistic regression is used to predict the odds of being a case based on the values of the

independent variables (predictors). The odds are defined as the probability that a particular outcome (or success) is a case divided by the probability of failure (Homer *et al.* 2013).

The effect of the background properties was assessed using the Multivariate binary Logistic Model (Cokluk 2010). This relationship could be analyzed using SPSS software. According to the data, accuracy of this analysis is 85%. This is satisfactory as it reflects a high percentage of accuracy. The results are shown in Table 1. Of the 135 low green coverage at the observed stage, the model correctly identified 121 (89.6%) of them as not likely to score '0' (hence Low green coverage) at the predicted level. Similarly, out of the 65 housing plots that were high green coverage at the observed stage, the model correctly identified 49 (75.4 %) as likely to score '1' (high green coverage) at the predicted level. Hence, out of the 200 housing plots, the model correctly identified and classified 170 (i.e. 121+49) households correctly, corresponding to an accuracy of 85% as shown in the Table 1.

Table 1. Classification table for model consistency

Observed		Predicted			
		Green coverage		Percentage Correct	
		Low	High		
Step 1	Green coverage	Low	121	14	89.6
		High	16	49	75.4
Overall Percentage					85.0

3.1 Relationship between the green coverage and independent variables

A summary of the relationship between green coverage and other explanatory variables of home garden availability, total number of permanent trees, perception about the levels of temperature change, land ownership, and time (minutes) spending in garden can be explained below based on the result. According to the data, the multivariate logistic model demonstrates relationship with scale data and categorical data as explained above. In this analysis green coverage is the dependent variable. When considering the relationship between the independent variables and green coverage, it is seen that there are five independent variables in this multiple logistic model. These are home gardens availability, total permanent trees, and perception about the level of temperature change, land ownership and average time spent at the garden per day (minutes). According to the results given in Table 2, the relationship between green coverage and land ownership shows Wald value of

8.766; the significance value is 0.003 and odds ratio 0.027. From this study was found the density of urban trees and greenery in the urban condition. Our study area is highly populated and houses are built on small land plots. But plants were a regular feature in these small plots on which the residences stood, showing that the lands are being used effectively, However, maintaining of greenery conditions in certain time period in land plots is quiet challengeable and it is depended on a number of other factors as explaining in explanatory variables of this study.

Table 2. Explanatory variables in the equation with model results.

	B ¹	S.E. ²	Wald ³	Df ⁴	p ⁵	Exp(B) ⁶	95% C.I. for EXP(B) ⁷	
							Lower	Upper
Land ownership	-3.605	1.218	8.766	1	0.003	0.027	0.002	0.296
Home garden	1.463	0.469	9.738	1	0.002	4.318	1.723	10.823
Temperature level	-2.709	0.625	18.798	1	<0.001	0.067	1.723	0.227
Total permanent trees	0.785	0.147	28.504	1	<0.001	2.191	1.643	2.923
Time (minutes)	0.024	0.008	9.282	1	0.002	1.025	1.009	1.041
Constant	3.673	1.740	4.459	1	0.035	39.388		

¹ the coefficient for the constant (also called the "intercept") in the model.

² the standard error around the coefficient for the constant.

³ the Wald chi-square test that tests the null hypothesis that the constant equals 0. This hypothesis is rejected because the p-value (listed in the column called "Sig.") is smaller than the critical p-value of .05 (or .01). Hence, it can be concluded that the constant is not 0.

⁴ the degrees of freedom for the Wald chi-square test. There is only one degree of freedom because there is only one predictor in the model, namely the constant.

⁵ probability level

⁶ the exponentiation of the B coefficient, which is an odds ratio. This value is given by default because odds ratios can be easier to interpret than the coefficient, which is in log-odds units.

⁷ confidence interval (95%) for Exp(B). Example, it can be anywhere between 1.723 and 10.823 for variable of home garden.

Some of these residences have permanent owner occupants whereas others are occupied by tenants who have taken them on rent. A notable feature is that the majority of tenants are not interested in growing plants and trees in these small plots because sometimes it is not allowed by owner. Therefore, it would appear that land ownership is a very important factor in deciding whether there should be any green coverage in such small premises.

When considering the green coverage and home gardens, the Wald value is 9.738; significance value is 0.002 and odds value is 4.318. According to the results of this analysis it is clear that there are some people who do not like to grow vegetables, fruits etc. in their home gardens for their needs. They prefer to buy vegetables and fruits from the market, supermarkets or village fairs. But there are some residents who grow vegetables and fruits successfully in their home gardens for their needs in Issadeen Town as illustrate in below Figure 4.



Fig. 4. Home gardens of residences in Issadeen Town, Matara. (Source: Field observations, December, 2016)

As for the relationship between green coverage and the peoples' perceptions regarding temperature change, its results are Wald value of 18.798, significance value of 0.000 and Odds value of 0.067. Further, this research found a few more things about the effect of green cover on temperature change. The occupants who enjoyed a high percentage of green cover said that they did not feel any noticeable rise in the temperature. However, others who did not live in green coverage areas said that they could feel a rise of temperature level in their land plots during past decade in the environment. When considering the green coverage and total number of permanent trees, Wald value is 28.504, significance value is 0.000 and Odds value is 2.191. Coconut, king coconut, mango, teak, wormwood and breadfruit trees are the most common permanent trees in Issadeen Town (Figure 5).

According to the relationship between time spent in the garden (in minutes) and the green coverage, the Wald value is 9.282, significance value is 0.002 and Odds value is 1.025. Most of the people who live in Issadeen Town are very busy as they have their own businesses or work at jobs. Some of them manage to allocate enough time for their gardening activities but there are others who say they do not have enough time for that.



Fig. 5. Permanent trees in Issadeen Town (Source: Field Observations, December, 2016)

4.2 Variables Running and Levels of Probability

Figure 6 gives the probability values of green coverage and other factors obtained from a multiple logistic regression model running SPSS 22 package incorporating a link with Arc GIS 10.2.

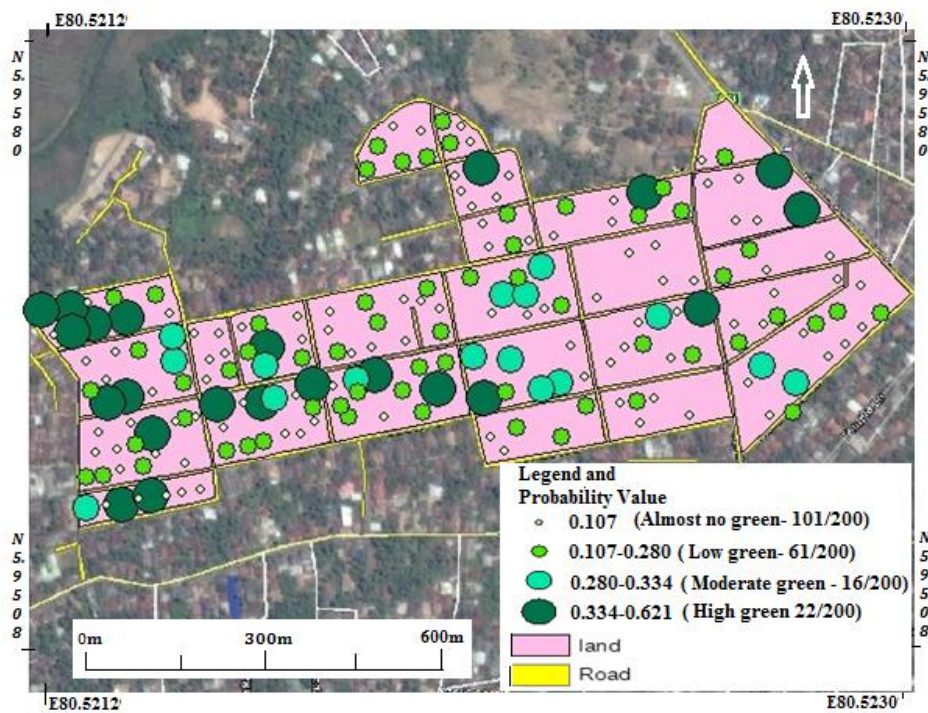


Fig. 6. Probability value of green coverage in residential areas of Issadeen Town (Source: Field survey, December, 2016).

Hence, data has been collected in respect of two hundred houses, with the map in Figure 2 giving their probability values and relationship to this study. Accordingly, dark green color locations show the home plots having a high growth of greenery in them. The maximum quantification here is between 0.332 and 0.621 on a 0 to 1 scale. Only 22 houses maintain good green coverage in their plots out of the 200 housing units. It is seen though that there are still a lot of houses with low green coverage as mentioned in the table giving their probabilities against the five independent variables. Maintaining low green coverage will lead numerous issues in urban condition, accordingly WHO standard, it should maintain 9.5m²/person (Singh *et al.* 2010). However, Sri Lanka context in the urban green coverage is far below of the world average in most of urban areas (Senanayake *et al.* 2013). Hence, results shows in figure 6 will give awareness how to assess urban green coverage in household level that will lead to maintain and improve the green coverage. As shown figure 6, there are 101 houses whose occupants do not seem to be interested in growing any greenery at all. However, there are altogether 99 houses, accounting for about 49.5% of the total, whose occupants are interested in having some greenery in their lands. Western part of study area has better green cover because this area located far from the main road of the Issadeen Town and Eastern part has located faced to Matara-Akuressa main road where land values are high. According to the research, people want to gain more knowledge about growing plants and trees and how to maintain a regular green status in their land plots. They also wish to know who can supply those plants and other equipment that are needed to plant successfully. The most important thing is the guidance and encouragement that must be provided by government and private institutions. It is also necessary to identify what should be grown and what should not be grown in the zone because lately the spreading of dengue fever has increased in this zone. For example, the planting of banana and pineapple are prohibited in this area because these plants can collect pockets of rain water that can harbour mosquito larvae. So, it is necessary to introduce the most suitable plants and trees for growing in this zone.

5 Conclusions

This study intended to learn more about the perception of urban green spaces by the resident population, was based on two hundred housing plots in Issadeen Town, which is a main residential zone of Matara city, Sri Lanka. Accordingly, we assess these housing plots into three classes based on its individual probability value of houses as low greenery, moderate greenery and high greenery. It came to light that only the occupants of 22 housing units were interested in maintaining high greenery in their housing plots. Another

16 houses had a moderate level of green coverage, while 61 houses had low green coverage. Therefore, it was evident that 50.5% of the occupants of the houses in this study area were not interested in having any green coverage in their land plots. Therefore, it is necessary to organize both government and private institutional support to persuade and encourage the occupants of houses to grow more plants and trees in their housing plots to increase the green coverage in their areas. It is recommended that urban planners, authorities and environmentalists prepare a suitable action plan and implement a programme to improve and increase urban green spaces.

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