GEO-SPATIAL MODEL OF HOUSEHOLD INHABITANTS' BEHAVIOUR ON CONVERSION OF LOW-LYING AREAS IN SUB-URBAN COLOMBO METROPOLITAN REGION, SRI LANKA

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by

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DEDICATION

This Thesis is dedicated to my beloved parents, my siblings, my wife Dilani and daughter Oshadhee. Thanks for their sincere love, patience and sacrifices.

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LIST OF ABBREVIATIONS

UN	United Nations
UNDP	United Nations Development Programme
CMR	Colombo Metropolitan Region
WRMMP	Western Region Magapolis Master Plan
CBSL	Central Bank of Sri Lanka
DCSSL	Department of Census and Statistics, Sri Lanka
GDP	Gross Domestic Product
JICA	Japan International Cooperation Agency
UDA	Urban Development Authority
SL_UDA	Sri Lanka - Urban Development Authority
GIS	Geographic Information System
FAO	Food and Agriculture Organization
NPP	Net Primary Production
LUCC	Land Use Change Category
GPS	Global Positioning System
ha	hectare
SLLRDC	Sri Lanka Land Reclamation Development Corporation
NPPD	National Physical Plan Department, Sri Lanka
GN	Grama Niladhari (literally, Village Officer)
OLS	Ordinary Least Squares
GLS	Generalized Least Squares
LLA	Low Lying Area
DS	Divisional Secretariat
GOSL	Government of Sri Lanka
PPP	Public Participatory Practice
LR	Logistic Regression
GVF	Goodness of Variance Fit

CI	Coefficient Interval
SDAM	Squared Deviations, Array Mean
SDCM	Squared Deviations, Class Mean
SLLR&DC	Sri Lanka Land Reclamation & Development Corporation
NHDA	National Housing Development Authority
GCEC	Greater Colombo Economic Commission
SPSS	Statistical Package for the Social Sciences

MODEL GEO-RUANG TINGKAHLAKU PENDUDUK ISIRUMAH KE ATAS PENUKARAN KAWASAN TANAH RENDAH DI WILAYAH PINGGIR BANDAR METROPOLITAN COLOMBO, SRI LANKA

ABSTRAK

Banyak kawasan metropolitan di wilayah tropika di Asia terletak di kawasan tanah rendah yang sensitif alam sekitar serta pada asalnya tidak didiami, tetapi disebabkan terdapat banyak faktor pemacu telah membawa kepada penukaran status tanah tersebut. Dalam hal ini, peranan yang dimainkan oleh setiap isirumah di kawasan pinggir bandar dalam penukaran guna tanah adalah penting. Dari tinjauan kajian awal tidak banyak perhatian diberikan kepada perilaku isirumah dan aspek geo-ruang dengan pembolehubah sosio-ekonomi dalam menilai kesan gabungan faktor tersebut ke atas penukaran tanah. Tiga objektif kajian digariskan iaitu menilai status fizikal semasa plot perumahan semasa peralihan dari tanah rendah ke taman perumahan, mengenal pasti faktor-faktor perubahan utama yang memacu transisi ini dari pandangan sektorial, dan memodel variasi dalam proses penukaran kepada plot individu. Untuk tinjauan ini, satu pangkalan data GIS telah dibangunkan yang membolehkan pengenalpastian kesemua plot perumahan. Dalam kajian ini, plot perumahan telah digunakan sebagai satu unit analisis. Berdasarkan imej satelit dan tinjauan literatur, kajian ini melibatkan 454 isirumah. Isirumah ini diklasifikasikan kepada tiga kumpulan iaitu rumah yang memang stabil dalam tahun 2005, rumah yang tidak stabil dalam tahun 2005 dan rumah yang dibina selepas tahun 2005. Setelah menetapkan keadaan rumah ‘stabil’ dan ‘tidak stabil’ sebagai pembolehubah bersandar berlandaskan kepada status fizikal rumah dalam tahun 2012, data melibatkan 294 isi rumah telah dianalisis dengan kaedah regresi logistik ruang yang

dibuat ke atas tiga set pembolehubah dan model keseluruhan mengandungi 19 pembolehubah. Model dinilai menggunakan data yang diperolehi dari 114 isirumah yang diperoleh daripada kajian lapangan yang dijalankan pada tahun 2005 sehingga pertengahan tahun 2012. Semua model adalah sepadan secara statistik dan ketepatan model keseluruhan adalah kira-kira 92.2%. Dapatan kajian yang utama ialah rumah yang stabil mempunyai potensi yang lebih besar untuk ditukarkan plot ini menjadi status taman perumahan dari rumah yang tidak stabil. Dapatan telah dibuktikan, berdasarkan kebarangkalian penukaran yang diperolehi dari setiap model. Nilai kebarangkalian yang diramal untuk setiap plot tanah telah dipetakan sebagai kebarangkalian penukaran untuk setiap blok perumahan bagi menunjukkan variasi di antara plot perumahan dan pengagihan ruangnya. Oleh hal yang demikian, model ini memberi sumbangan yang signifikan dalam menilai potensi penukaran tanah di kawasan tanah rendah. Ini akan membantu juru rancang bandar membentuk penyelesaian lestari dan membuat keputusan dengan lebih mudah bagi mengelak masalah yang disebabkan oleh penukaran tanah yang tidak dirancang.

GEO-SPATIAL MODEL OF HOUSEHOLD INHABITANTS' BEHAVIOUR ON CONVERSION OF LOW-LYING AREAS IN SUB-URBAN COLOMBO METROPOLITAN REGION, SRI LANKA

ABSTRACT

Many metropolises in the tropical Asian region are situated in environmentally sensitive low lying areas that were originally uninhabited, but many driving forces had led to the conversion of the land. Of those, the role played by individual households in suburban areas as converter of lands is crucial. A notable gap in earlier studies is that little attention was paid to modelling the household behaviour and geo-spatial aspects with socio-economic variables to assess their combined effect on the conversion of lands. Three objectives of this study were to assess the present physical status of the housing plots during their transition from low land to home garden condition, to identify the key conversion factors driving this transition from the sectorial views, and to model the variations in the process of conversion of individual plots. To this end, a GIS database was developed that enabled ready identification of all the housing plots. Hence, the housing plot is used as the unit of analysis. According to the images and field surveys, there were 454 households in the core study area. The households were classified into three groups, houses that were already stable in 2005, houses that were non-stable in 2005 and houses that were built after 2005. Having set ‘stable’ and ‘non-stable’ as the dependent variables on the basis of physical status of houses in 2012, data relating to 294 households were applied to the main model running spatial logistic regression on three sets of variables with the overall model comprising 19 variables. The model was validated using data obtained from 114 households established from mid-2005 to

mid-2012. All models are statistically fit and accuracy of overall model is about 92.2%. The main research argument is that stable houses have greater potentials to be converted into the home garden status than non-stable houses. This has been proven conclusively, based on the probability of conversion for each model. Predicted probability value of each land plot has been mapped as conversion potentiality of each housing block to indicate variations among the housing plots and their spatial distribution. Therefore, this model will make a significant contribution to the problem of assessing conversion potential of low lying plots reliably when compared to existing processes. This will help urban planners to formulate sustainable solutions and make decisions more easily to avoid problems caused by unplanned land conversion.

CHAPTER 1

INTRODUCTION

1.1 Introduction of Chapter One

This chapter presents the background of this study and provides basic information about the study area including figures required to construct the research elements, and about the problem statement, research questions, objectives of study, main hypothesis, scope and limitations of study and the chapter layout.

1.2 Background of Study

Urbanization is one of the issues that can be clearly identified as being responsible for many of the environmental changes occurring in the closing stages of the twentieth century and beginning of the twenty-first century. This is because more than one half of the world's population lives in urban areas that cover only between 2% to 3% of the entire land surface of the earth (Braimoh & Onishi, 2007; Seto & Kaufmann, 2003). This has immense implications for now and the future because the world's urban population has increased from roughly 200 million in 1900 to about 2.9 billion in 2000 and is estimated to rise to about 5 billion by 2030 (UN, 2012). Hence, the impact of land use in the urban sprawl has created several major environmental and health related issues at both the local level and on a global scale (Hasse & Lathrop, 2003), because urban expansion is inevitably accompanied by the increased use of motorized transport, greater energy consumption, air, water and noise pollution and loss of arable land that leads to a reduction of bio-diversity (Seto and Kaufmann, 2003).

It is thus seen that the expansion of cities into outlying areas due to rapid urbanization has become one of the major environmental problems faced by developing countries lately. Rapid urbanization always results in a deterioration of living conditions and an increase in serious health problems, which are usually caused by inadequate potable water supply, lack of sanitation, bad drainage and flood control, poor solid and industrial waste management, as well as air pollution (Satterthwaite, 2010)**.** The management of household waste by disposal in landfills and through recycling efforts needs to be monitored and measured carefully due to the increasing extents of low lying areas that are currently being converted into urban lands (Barr, 2007; Oskamp et al., 1991)**.**

Another factor propelling conversion of low lying areas surrounding urban centres is land value. High demand for land by commercial concerns drives land values up around cities where businesses need to be located. This naturally changes the existing land use to commerce based activities. Because commerce can generate substantially higher revenues than agriculture from a given land area, it has become economically more advantageous for land owners to divert their land resources to commercial activities in preference to agricultural activities. But change of land use in this manner has a very bad effect on many environment related issues as explained earlier. Adopting a sustainable development approach is one solution that has been proposed to overcome these undesirable changes that impact negatively on the quality of life as well as the ecology (Yeh & Li, 1998)**.**

1.3 Land Conversion in the Global Context

Land use change / conversion: this has become a global issue because it directly challenges the sustainable development model envisioned by some, as well as causing climate changes around the world. The scale of land use change can vary from a localized level to a continental level, and sometimes the combined effect of all these changes can impact on the climate at a global level by changing the weather patterns adversely (Agarwal et al., 2002; Herrmann & Osinski, 1999).

Land use conversion is an essential action in the context of physical development and economic growth of a country because without making any changes to existing land use it is not possible or practical to build up an infrastructure or boost the economy. Therefore, there will always be an innate conflict when a choice has to be made between preserving the status quo in land use or converting the land and utilizing it on physical development projects (Antrop, 2004). Thus, there can be no argument that a certain extent of land use/ land cover conversion needs to be made to meet the economic growth goals of the central, provincial and local governments. In this context, as land is a scarce resource, different kinds of existing land are likely to be targeted for conversion by developers. Lands in low lying areas are among the most vulnerable to conversion by human intervention, because large tracts of low lying lands have been situated adjacent to urban areas, especially in the tropical regions.

According to the UN (2012), more people in developing countries will be living in the urban and suburban areas in 2030. In the year 2050, fully two-thirds of the total population of developing countries will live in such areas. Therefore, it will prove to be a challenging undertaking to protect all of the environmentally sensitive areas of

these cities and their surroundings from pollution, degradation and other ills. In this study, it is expected to carry out extensive research on a few prime examples of urban/ suburban localities with a vast number of households established on environmentally sensitive low lying lands in the Colombo Metropolitan Region (CMR). This study suggests that conversion of low lying lands be minimized by illustrating that any failure to do so will impact badly on the sustainability of this region with a consequent decline in the quality of life and moreover, that this conversion will contribute to overall climate change in a negative manner (Finlayson, 2007).

1.4 Colombo Metropolitan Region

Colombo Metropolitan Region (CMR) comprises three districts, namely Colombo, Gampaha and Kalutara. The entire CMR in fact constitutes the Western Province of Sri Lanka. It has a total land area of 3,658 sq. km and a total population of 5.36 million persons in 2001. The overall population density was 1,466 persons per sq. km then.

Table 1.1: Population and Land Area in the Western Region and the Rest of Sri Lanka, 2001-2012

District / Region	Population 2001	Percentage (%) 2001	Population 2012	Percentage (%) 2012	Land Area	Percentage (%) Land
Colombo	2,234,146	11.9	2,309,809	11.40	652.4	1.0
Gampaha	2,066,096	11.0	2,294,641	11.32	1,398.8	2.2
Kalutara	1,060,800	5.7	1,217,260	6.00	1,606.6	2.5
Western Region	5,361,042	28.6	5,821,710	28.73	3,657.8	5.7
Other Regions	13,371,213	71.4	14,442,013	71.27	60,994.0	94.3
Sri Lanka	18,732,255	100.0	20,263,723	100.00	64,651.8	100.0

Source: (DCSSL, 2012)

Whereas the land area of the Western Region amounts to only 5.7% of the total land area of 64,652 sq. km of Sri Lanka, the population here accounted for 28.6 % of the country total in 2001.

In terms of GDP, the Western Region consistently contributes more than 45% of the whole country's GDP. It is unquestionably the most important economic region of the country, as shown in Table 1.2.

Table 1.2: Regional Composition of GDP – 1996 to 2010

Year	Western Region	%	Other Regions	%	Sri Lanka	%
1996	304,377	43.7	391,559	56.3	695,936	100.0
1998	413,401	45.3	499,436	54.7	912,837	100.0
2000	558,157	49.6	567,102	50.4	1,125,259	100.0
2003	776,634	49.7	786,104	50.3	1,562,738	100.0
2005	1,065,154	50.8	1,032,850	49.2	2,098,004	100.0
2008	2,003,055	45.4	2,407,627	54.6	4,410,682	100.0
2010	2,525,240	45.1	3,078,864	54.9	5,604,104	100.0

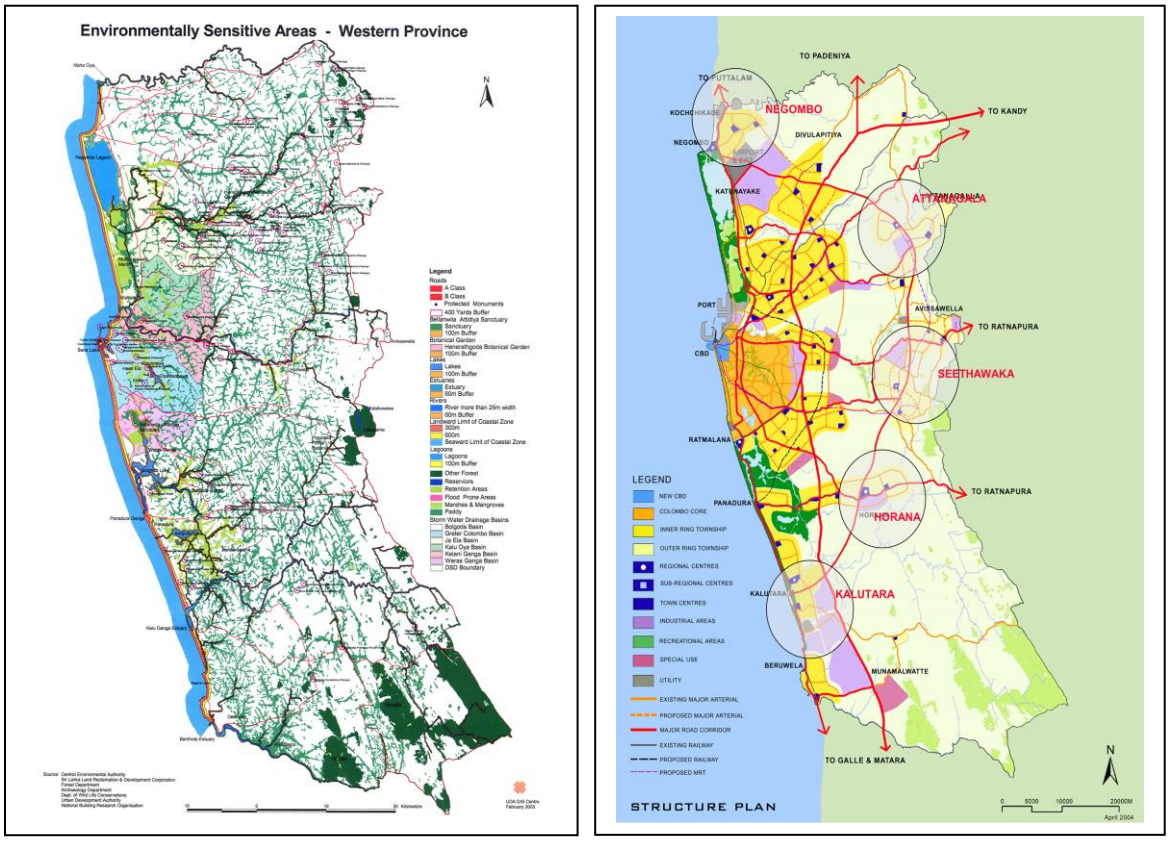
Source: CBSL (2012)

Based on the above table, it is clear that the area comprising the CMR occupies a dominant position in respect of all economic activities taking place in the country. It is also notable that the CMR has a considerable number of environmentally sensitive locations scattered throughout its length and breadth as shown in figures 1.1A and 1.1B. But, as explained in the problem statement of this study, there is a lot of housing construction work in progress presently in the CMR. Some of these structures are being built without obtaining proper building permits and other approvals from the concerned authorities due to the intervention of local political

influences, a common occurrence in developing countries (Brindley, Rydin, & Stoker, 2005).

1.4.1 Suburban Encroachment of Environmentally Sensitive Areas in CMR

CMR is not only a core economic zone, but also a rather environmentally sensitive region of the country because it occupies a substantial area of the wet zone of Sri Lanka. Topography of the entire Western Province is generally flat.



(A) (B)

Figure 1.1: Environmentally Sensitive Areas (A) and Suburban Areas (B) in CMR, adapted from WRMMP (2005)

CMR and the surrounding areas have been vulnerable to flooding, as much of these comprise low lying land, less than 6 meters above sea level, while those areas that

are less than 1 meter above sea level function as ‘retention zones’ (JICA, 2003; Tortajada, 2006). Because of the presence of large extents of flood plains in the region, numerous flood and flood related problems arise periodically. This situation has been aggravated due to the following reasons:

- Location of industrial development projects in flood prone areas
- Excessive and often uncontrolled filling of low lying lands
- Blockage of waterways and water bodies by silting
- Inadequate and badly managed water drainage systems
- Formation of sand bars at canal mouths
- Poor solid waste management schemes

In this research, the second reason listed above has been identified as the most serious cause of flooding in the CMR (Gunaratna, 2006; UDA, 1998). Therefore, much attention has been paid to analysing this. The major problem here is the excessive and often uncontrolled filling of low lying areas in the CMR. This is partly due to massive land filling for development sites by both the government and the private sector without obtaining prior approval from the concerned authorities. A second contributory cause is the strong demand for suburban housing by migrating individuals who come in and occupy the low lying areas outside cities. They gradually encroach and capture a certain amount of the land area and their collective actions result in a significant conversion of land throughout the CMR (Nagabhatla, Finlayson, Sellamuttu, & Gunawardena, 2008). Figure 1.1.B shows the distribution of urban and suburban townships throughout the CMR according to the Western Region Megapolis Master Plan - 2005 of CMR (WRMMP, 2005)**.** As depicted in

figures 1.1.A and 1.1.B, numerous tracts of low lying areas adjacent to suburban townships are the main sites with high potential for conversion into home gardens.

1.4.2 Low Land Reclamation Policy

In the case of medium and small scale development projects in CMR, there are no concrete guidelines for evaluating proposals for land filling, especially from the aspect of its effect on the retention function of low land. The existing system for examining and granting approval may not stand up to political pressure and other factors, to the point that the recommended physical and environmental guidelines and scientific drainage analysis could be totally ignored (JICA, 2003). On the issue of housing construction on any particular land plot in suburban areas, the property owner forwards an application for approval and clearance of the house plan to the local authority, only if he intends to seek a bank loan or resell the house for a profit to a third party. Otherwise, if he simply intends to build a house, expecting to live in it indefinitely, then he is quite free to build the house as he wishes in these areas. Especially, people who manage to capture any marginal low land nearly always build their houses without proper permits and due to the massive number of unapproved houses in the CMR, the government is not in a position to take legal action against the offenders.

1.4.3 Urban - Rural Household Conditions in Sri Lanka

Condition of households in the Sri Lankan urban sectors is quite different from that prevailing in other South Asian countries where it may seem comparable to most upper grade households in the region. Within Sri Lanka though, there are not many differences in household characteristics between the urban and rural areas as shown in Table 1.3. In the last two decades, all underserved settlements in Colombo

Metropolitan Region have been upgraded by the provision of standard amenities. These facilities have been extended to other suburban areas too that are served by local authorities. Presently, almost all households in the CMR have been classified as permanent or semi-permanent households in the Census and Housing survey of 2012.

Table 1.3: Urban and Rural Housing Characteristics

Sector	Characteristic (percentage)	
	Tenure	
	Owned/rented/leased/rent free	**Other**
Urban	91.3	8.7
Rural	92.2	7.8
	Type of housing	
	Attached/detached housing units	Slums/shanties/row houses
Urban	93.8	6.2
Rural	98.6	1.4
	Number of rooms	
	At least one room (separated spaces)	No rooms (separated spaces)
Urban	97.8	2.2
Rural	98.7	1.3
	Drinking water	
	Safe water	Unsafe water
Urban	96.8	3.2
Rural	87.1	12.9
	Sanitation	
	Safe sanitation	Unsafe sanitation
Urban	85.1	14.9
Rural	90.3	9.7
	Electricity	
	Use electricity	Other
Urban	96.5	3.5
Rural	83.2	16.8

Source: (DCSSL, 2012)

1.3.4 Housing Requirements in CMR

However, the demand for housing in the CMR is very high as this constitutes the core economic region. It will be difficult to meet the demand in the future if this is not treated as a serious issue and addressed earnestly now. According to Table 1.4 below, the present housing stock in CMR is approximately 1.75 million units. It is estimated that the shortfall in the housing requirement of CMR is approximately half a million units currently. The problem though is that neither the government nor the

private sector has any definite scheme to address the serious shortage in housing requirements of the lower middle income group in CMR. Therefore, most of the lower income groups will in all likelihood first settle down in the existing low lying areas adjacent to the CMR's core urban areas. Once they settle down, their next step will probably be conversion of their low land into a home garden; that is a long term process though and will depend upon several factors.

Table 1.4: Number of Households, Projected Number of Households and Household Size in CMR

Year	Number of Households and Projected No. of Households	Average Household Size
2000	1,245,421	4.17
2005	1,457,925	3.90
2010	1,671,203	3.68
2015	1,899,584	3.47
2020	2,123,239	3.30
2025	2,345,466	3.16
2030	2,552,101	3.06

Source: (CMR, 1998; WRMMP, 2005)

Table 1.5: Projected Housing Needs in 2010 and 2030

Year	No. of Housing Units available	No. of Housing Units required over the period	Annual Requirement that must be built
2000	1239446	-	-
2010	1671203	431760	43176
2030	2552101	880898	44045

Source: (CMR, 1998; WRMMP, 2005)

According to projections made from data obtained from the census department and other sources, it will be necessary to construct approximately 50,000 housing units annually in the CMR (CMR, 1998; WRMMP, 2005). However, it would be a very challenging task to meet this quota as Sri Lanka is still a developing country, with

limited resources. Therefore, this housing requirement will most likely be met in an ad hoc manner within the low lying areas of CMR as an initial step. At a later stage, the land will gradually be converted according to the occupying household's social imperatives and economic capacity as well as the plot's geo-spatial characteristics.

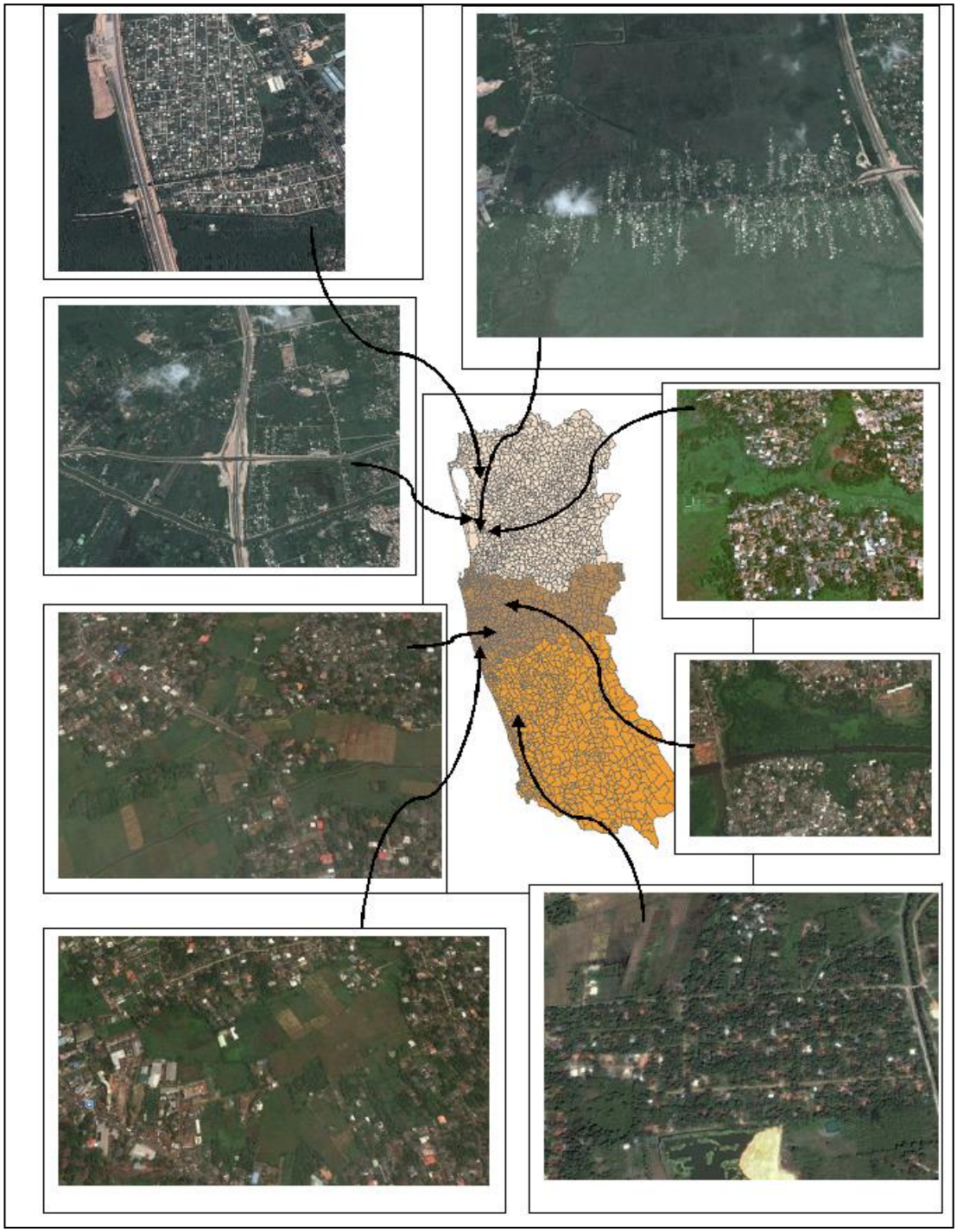


Figure 1.2 Households Scattered Across the Low Lying Areas of the Colombo Metropolitan Region, Adapted from Amerasinghe & d'Auria,. (2007).

1.5 Problem Statement

Many metropolises in the tropical Asian region are situated in environmentally sensitive low lying wetlands or monsoon rainfall areas. The heavy and extensive urbanization of these zones cannot be sustained indefinitely due to inadequate fresh water supplies, atmospheric pollution caused by factories and vehicle exhaust emissions, pollution, poor drainage, and sewage/ solid waste disposal problems. Many of these metropolitan areas are prone to flooding in the rainy season as much of the land is sealed under asphalt, cement and concrete so that rain water cannot seep into the ground. Many householders have dumped their non-degradable solid waste materials in environmentally sensitive areas (Barr, 2007; Oskamp et al., 1991**).** Urban boundaries have been expanding steadily by creeping into low lying areas, especially paddy fields. The encroachers are commercial establishments, industries, as well as individuals and developers who construct residences (Braimoh & Onishi, 2007).

The driving forces behind the conversion of land are many and they can generally be identified; they can also be restricted by enforcing government regulations (UDA, 1978). There is an exception though; the role played by the individual household in suburban areas as converter of low lying land is very crucial, but it cannot be identified clearly or the actors prosecuted under existing regulations.

There are many underlying factors based on social, economic and geo-spatial aspects that have acted as the driving forces behind the conversion of low lying lands, wetlands and paddy fields. Several studies have been conducted in the past to identify the forces behind general land use conversion (Hasse & Lathrop, 2003;

Walker, 2001; Y. Xie, Mei, Guangjin, & Xuerong, 2005). A notable lacuna in these studies is that very little attention has been paid to modelling the household behaviour with other variables (Irwin & Geoghegan, 2001) and its effects in the context of low lying land conversion in suburban conditions.

1.6 Research Questions:

The conversion of low lying areas is supposed to be restricted, controlled and managed by the authorities. Despite this the conversion continues unabated. Generally, it is necessary to answer where are the low lying areas that are still being threatened by new households emerging? Thereafter, the following three research questions will be discussed in this research.

1. What are the main physical characteristics of households in the low lying areas?

2. What are the influencing factors behind the conversion of low lying areas brought about by the emergence of households?

3. How can we measure the low lying area conversion caused by households emerging over the period 2001 to 2012? And at what rate is the land being converted?

1.7 Objectives of Research

As one of the tasks of this research, it is necessary to find the locations of low lying areas that were most at risk of conversion due to emergence of households during the period 2001 – 2012 in CMR and thereafter, the following three objectives will be pursued.

1. To assess the present physical status of the housing plots those are in the process of being converted from low land to home garden condition.

2. To identify the key conversion factors involved in the transition from low land to home garden (converted land) in individual housing plots, based on influences such as household behaviour, socio-economic forces and geo-spatial factors.

3. To Model the variations in the process of conversion of individual household plots from low lying lands to home gardens.

1.8 Main Hypotheses of Study

Two main hypotheses will be developed based on empirical evidence that will be gathered from field observations and on statistical technical considerations referred to in the literature review, as cited below.

1. Stable householders in low lying areas have high potential capacity to convert their land plots from low lands to home gardens (comparing its probability value).

2. Geo-spatial variables and behaviour variables have high potentiality to convert these land plots from low lands to home gardens as compared to socio-economic variables (comparing its correct classification percentage value).

Null hypothesis can be expressed as zero value or a value very close to zero for the predicted probability of Logistic model. If it is greater than zero value for predicted probability, then the null hypothesis is rejected and if it is very close to probability value of 1, then the null hypothesis is totally rejected (Halkidi, Batistakis, & Vazirgiannis, 2001; Peng, Lee, & Ingersoll, 2002).

In addition to the two main hypotheses, a series of sub-hypotheses will be proposed to establish the relationships between several independent variables (Oskamp et al., 1991) and to make any adjustments as necessary to realize the objectives of the study. For the sake of clarity, all sub-hypotheses will be explained in the section on definitions of the variables.

1.9 Scope and Limitations of the Study

According to Urban Development Authority of Sri Lanka (UDA), presently there are hundreds of non-contiguous low lying areas in the CMR that are occupied by suburban householders. Using the Geographical Information System (GIS), it is now possible to focus systematically on each of the problem areas in turn. However, many other areas outside of the CMR also suffer the same problems and there is a need to gather information about these at a later stage.

Therefore, this empirical model and GIS analysis can be used as a pilot project to acquire greater knowledge and insight about the issues surrounding land conversion. To obtain the full benefit of this research, it is recommended that an effort be made to identify all the land conversion hot spots for detailed analysis as that would be helpful in finding solutions. Naturally, this will be a time consuming and expensive exercise.

As explained in the problem statement, the scope of this study will be limited to gathering data and analysing the issues relating to the conversion of low lying lands caused by the establishment of individual households. Its scope will also be restricted to a selected, fast growing residential area under highest low-lying condition of the CMR as it will not be practical to survey the entire CMR. A limitation of this study is that it will not take into account other driving forces influencing land conversion such as road construction, infrastructure development projects, industrial and vehicular pollution, commercial activities, etc.

1.10 Outline of the Thesis

The outline of this thesis is as follows:

Chapter 1 provides important information about this study, such as an introduction, overview of study, description about issues related to land conversion in low lying areas, problem statement, research questions, objectives of study and the scope and limitations of the study.

Chapter 2 presents the literature review about key definitions, theories, applications and models about land conversion, household related issues, factors influencing land conversion, and techniques and applications about the measuring of land conversion. It will suggest how models should be made to measure the variations in low lying land conversion due to household factors. Finally, the research gap and theoretical framework will be identified based on literature review.

Chapter 3 consists of three parts. Part 1 is about theoretical framework that has been derived from literature review. Theoretical framework shows how to tackle the issues of low lying land conversion in suburban areas due to the emergence of households.

Part 2 is about model building. The definitions of all models in this study are elaborated as follows: Socio-economic model (model 1), behaviour model (model 2), geo-spatial model (model 3) and overall model (model 4). It indicates in detail how to set the independent variables for each of the models according to the research argument, especially the categorical variables setting. In addition, empirical ideas will be incorporated into the models with explanations to enhance understanding of

the models. Part 3 of chapter 3: Research methodology will be discussed regarding incorporation of all elements of the research so as to obtain valid results for the research objectives. This incorporation of all components of the research is depicted in Figure 3.5.

Chapter 4 deals with the spatial database development. In this chapter, the entire research areas and their spatial issues will be evaluated in the context of the research gap this study intends to fill. Hence, GIS vector database of the entire CMR will be set up with the necessary secondary data. Based on this information the locations of the core research areas where the most vigorous conversion of low lying areas occur will be identified. Secondly, an explanation will be given on how micro level land plots GIS database (polygon based) is to be developed and also how information can be gathered using an interview questionnaire so as to readily identify spatial variations among the land plots. Finally, this chapter will explain how land plots information consisting of 19 variables falling under 3 sub-sections will be run on the logistic models.

Chapter 5 presents a descriptive analysis of model data, providing information about model testing and goodness of fit of the model data with logistic model; it also presents results of models with explanation about how they match the research objectives. Finally, it explains how the model results link with spatial land plots to assess conversion levels accurately.

Chapter 6 deals with validation of the model using a part of dataset from the study area, consisting of 114 household samples. Results of validation model will indicate reliability of main models and their sensitivity to variables.

Chapter 7 is the last chapter of this study and it discusses how the model's testing outcome fits in with the objectives of the study, what the most highlighted points in the study are, and what the benefits of this study are. Chapter 7 will also provide details of the recommendations, implications and contributions to knowledge of this study and suggest directions for future research in this field.

1.11 Summary of Chapter One

In this chapter an explanation of the background of this study is given, which includes basic information regarding the study area. The data needed to construct the problem statement is provided. Three research questions and their related objectives are identified. The two main hypotheses are elaborated on, and following this there is a brief discussion of the scope and limitations of the study. Further, the chapter layout of the thesis is presented.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review refers to the collecting of comprehensive and relevant research materials and thoroughly reading the past studies in order to identify the research gaps and assess the potential for advancement of existing research (Baker, 2000). Hence, literature review is "a form of research that reviews, critiques, and summarises representative literature on a topic in an integrated way such that a new framework and perspectives on the topic are generated" (Torraco, 2005, p. 356). On the other hand, the term Literature review is often interchanged and sometimes confused with other terms such as theoretical framework and conceptual framework (Rocco, 2009). However, theoretical framework and conceptual framework have their own boundaries which are different from that of literature review. Rocco et al. declare that literature review, theoretical framework and conceptual framework share five functions in a research:

a) to build a foundation

b) to demonstrate how a study advances knowledge

c) to conceptualize the study

d) to assess research design and instrumentation

e) to provide a reference point for interpretation

According to the above mentioned aspects, this research also has made a literature survey plan as mentioned on figure 2.1. Areas of literature have been selected as the key areas of the study and accordingly there are six category of literature review as mentioned on figure 2.1.

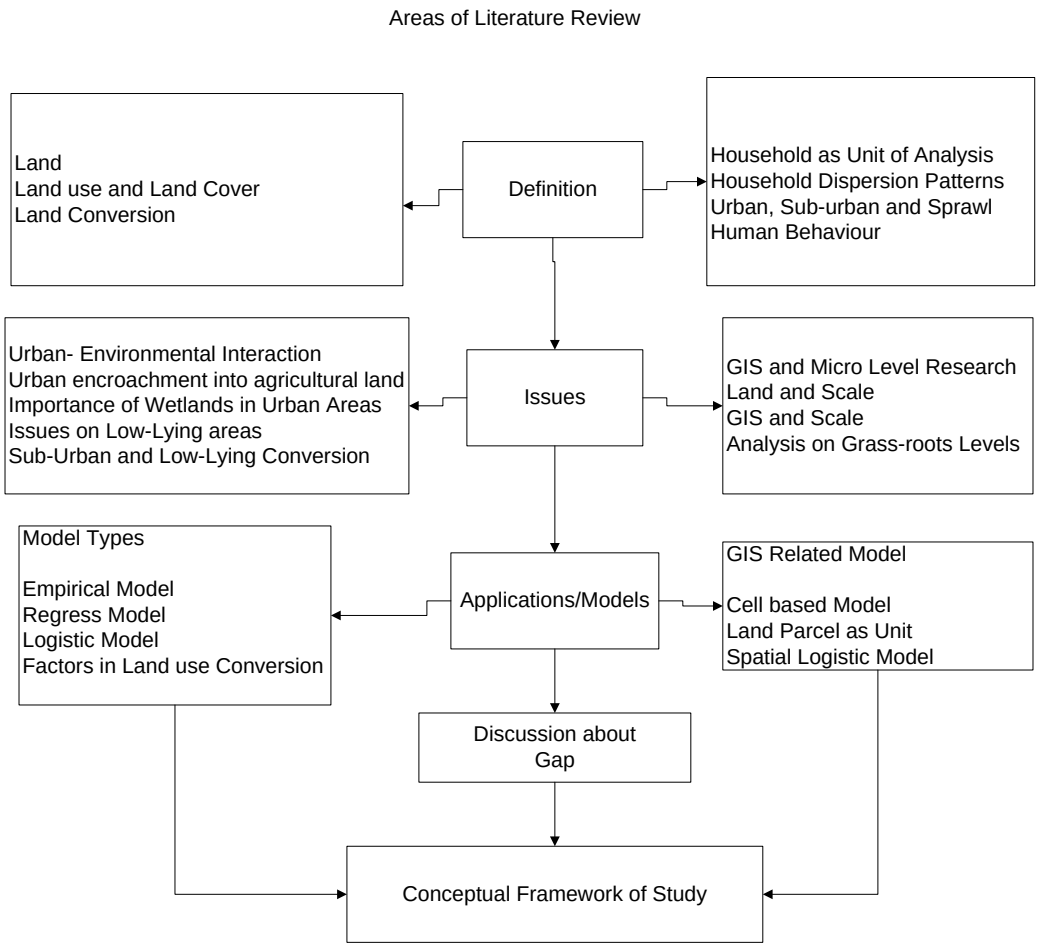


Figure 2.1 Area of Review under the Research Topic

2.2 Land and Its Different Definitions

Studies of land use change do not always employ identical definitions of the principal terms land, land use and land use change. Definitions and descriptions of these terms vary with the purpose of the application and the context of their use. Hence, it is necessary to look at alternative definitions and descriptions of these terms that are frequently used in these studies, especially those offered by official sources of land and land use data (Briassoulis, 2000**).**

2.2.1 Land

The FAO (1995) defines land as follows: “Land is a physical entity in terms of its topography and spatial nature; this is often associated with an economic value, expressed in price per hectare at ownership transfer.” Briassoulis (2000) cites Wolman’s (1987) definition of land: "the term land is used in a comprehensive, integrating sense to refer to a wide array of natural resource attributes in a profile from the atmosphere above the land surface and extending down to some meters below the surface. The main natural resource attributes are climate, land form and soil.”

Hoover and Giarratani (1984) state that the qualities of land include, in addition to such attributes as the topographic, structural, agricultural and mineral properties of the site, the climate, the availability of clean air and water, as well as a host of immediate environmental characteristics such as quiet, privacy, aesthetic appearance, accessibility and so on.

2.2.2 Land Use and Land Cover

The terms land use and land cover are not synonymous and the literature draws attention to their differences so that they are used properly in studies of land use and land cover change. Land cover is the bio-physical state of the earth’s surface that “describes the physical state of the land surface using such terms as cropland, swamp, mountain or forest and type of surface vegetation, as well as the presence of water and other earth materials" (Meyer & Turner, 1996; Moser, 1996; Turner & Meyer, 1994). Moser (1996) notes that the term originally referred to the type of vegetation that covered the land surface, but has broadened subsequently to include human structures, such as buildings or pavement, and other aspects of the physical

environment, such as soils, biodiversity, the nature of surfaces and presence of groundwater.

Briefly, land use "denotes the human employment of land" (Turner and Meyer, 1994). Skole (1994) expands further and states that Land use in itself is the human employment of a land cover type, the means by which human activity appropriates the results of net primary production (NPP) as determined by a complex of socio-economic factors. Finally, FAO (1995**)** states that land use concerns the function or purpose for which the land is used by the local human population and can be defined as those human activities that are directly related to land, making use of its resources or having an impact on it.

2.2.3 Land Use Definition on Urban Scale

Definitions of land use refer mostly to larger, territorial scales, but at the urban scale, interest focuses on other aspects of the term. In the words of Chapin and Kaiser (1979), "At territorial scales involving large land areas, there is a strong predisposition to think of land in terms of the yields of raw materials that can be extracted from it to sustain people and their activities. At these scales, 'land' is a resource and 'land use' means 'resource use'. In contrast, at the urban scale, instead of characterizing land in terms of the production potential of its soils and its sub-soil mineral content, the emphasis is more on the use potential of the land's surface for the location of various activities" (Chapin & Kaiser, 1979)**.** This connotation of the term "land use" is implicit in several other texts dealing with land use in the context of urban and regional analysis and planning (Hoover & Giarratani, 1984).