

## **Analytical review of Spatio-temporal Urban Growth in the Colombo District, Sri Lanka**

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### **Abstract**

Urbanization is a continuous socioeconomic, physical and demographic process. As a result of urbanization, more than half of the world's population are living in urban areas and cities are responsible for accommodating this population in the limited urban space. When cities become unable to accommodate this urban demand successfully, the urban growth spillover unevenly. Most Asian countries fail to accommodate this spillover demand within the limited urban space due to lack of infrastructure and strong planning regulations. Hence, identification of this even or uneven, extended urban spaces are significant for preparing future planning guidelines. Theoretically, this spatial growth process occurs over a long period. Therefore, it is considered as a spatial and a temporal process and can be termed as a spatial-temporal process. Planners face continuous challenges in identifying and quantifying this spatial-temporal process. During the past four decades, Colombo's urban growth took place in an uneven manner due to lack of strong planning guidelines. Previous urban scholars attempted to understand the urban growth in Colombo from time to time, but there lacks studies that quantify the urban growth. This study attempted to fill this research gap. Therefore, the aim of this study is identification and quantification of the Colombo district urban growth during the past four decades. Descriptive analysis and GIS based quantitative analysis are used for that. The findings indicate that Colombo district has an uneven growth pattern and its temporal variations spread outwards from the city of Colombo. Edge expansion and outlying growth are two prominent growth types in the district.

## **Introduction**

The term ‘urban development’ can be considered as a simple process but its consequences are complex, because this spatial process encompasses changes in the economic, social, and political structure of a region. This rapid and complicated urbanisation process results in the spillover of physical growth to the surrounding areas and this phenomenon is commonly referred to as ‘urban growth’. Thus, urban growth is considered as a spatial, demographic (Clark, 1982) and non-spatial social process. Spatial process is the process of evolution of non-built up areas to built-up areas, while during the same period demographic changes will occur, because the population is attracted to built-up areas. Urban growth is a continuous process that keeps changing the spatial structure of cities. Some scholars have considered it as a static phenomenon, whereas some have regarded it as a dynamic phenomenon; however, most researchers have acknowledged both as spatial-temporal processes.

At the beginning of the 19th century, most scholars attempted to describe this urban growth using various conceptual models and theories. Burgess’s concentric zone theory in 1925 was based on the idea that the growth of a city took place outwards from its central area to form a series of concentric zones of various land uses. In 1939, Hoyt proposed the ‘sector theory’, which differed somewhat from the concentric zone theory. According to it, the patterns of urban land use were influenced by the road networks that radiated outwards from the city centre. Further, it mentioned that the sectorial pattern of land values was based on road accessibility, which in turn influenced the urban land use pattern. However, both these theories assumed that the city grew around a single nucleus, but the actual pattern of urban growth proved to be rather more complex. In 1945, Harris and Ullman adopted a new approach and proposed a multiple-nuclei theory, which suggested that urban growth in large cities was not centered on a single nucleus but that growth took place around multiple nuclei. Each of these theories attempted to formulate a comprehensive, but differing model of urban growth (Harvey, 2004).

Later in the 20th century, urban growth studies focused on development of the main urban centres ignoring the attraction of the periphery. With regard to this, the centre dominant model, core-periphery model and Gibbs model are significant. The centre dominant model was proposed by Myrdal (1957) and this model discussed the development of the main urban centre of influence and little about peripheral attraction. Labour, capital and raw materials are concentrated at the centre due to agglomeration economies and operation of the multiplier effect. This encourages an adverse ‘backwash effect’ such as selective migration of skilled labour and transfer of capital through the reverse flow of savings from the periphery to the centre (cited Wanasingha, 1985). The growth process in Colombo is similar to the process described in the centre dominant model. Colombo initially developed as a port city and the advantages this offered to exporters and traders led to the centralisation of services here and the development of its infrastructure. In addition, agglomeration economies and multiplier effects attracted industries, trade, commerce, labour, and capital due to the lure of maximum profit potential. Inevitably, Colombo has emerged as the most highly developed and densely populated core area in the island. The core processes offer all the advantages so that the city is able to readily attract natural, human and capital resources. It is the financial, commercial, industrial, and administrative centre and the primary hub of the rail and road transport system, thus accessible from all parts of the country.

## **Urban Growth in the Colombo District**

### **Role of Colombo District in the Western Region**

Sri Lanka is divided into nine regions (or provinces) for administrative purposes and the western region is the most urbanised of them. The geographical area of the western region covers a total extent of 369,420 ha, which comprises 5.6% of the total land area of the country (UN Habitat, 2012). The Western Region consists of 3 districts, namely, Colombo, Kalutara, and Gampaha as shown in Figure 1. Many employment opportunities have been created in the Western Region because of agglomeration economies and the economies of scale made possible by the

volume of trade activities in the Colombo port city. Therefore, the advancement of the economic and service sectors is one of the key features that attracted one-fourth of the total population to this region. As a result of that, the Western Region became the premier urban region of the country.



**Figure 1      Location of the Colombo in the Western Region**

Table 1 shows the total population figures over the past four decades in each of the districts within the region.

**Table 1 Total Population in the Western Region and Sri Lanka**

District	Total Population '000					Inter-censal Growth (%)			
	1971	1981	1994	2001	2012	1971	1981	1981	2001
	-	-	-	1981	1994	-	-	-	2012
Sri Lanka	12,689	14,846	2,0007	18797	20,274	2.2	1.7	1.2	0.71
Colombo	1,498	1,699	1,695	2251	2,322	1.25	1.28	1.41	0.35
Gampaha	1,173	1,390	1,390	2063	2,298	1.70	2.24	2.01	1.02
Kalutara	729	829	937	1066	1,214	1.10	0.94	1.26	1.23

Western Region	3,401	3,916	4023	5381	5,835	1.41	1.41	1.37	1.08
% of Western Region	26.8	26.4	20.1	28.6	28.8				

Source: Department of Census and Statistics

According to the table, the Western Region contained 28% of the total population of the country in 2012. Over the past four decades, this percentage showed only slight variations; 26.8% in 1971 and 28.8% in 2012. Table 2 indicates the percentage share of urban population in the Western Region and the country during the period from 1971 to 2012. According to this, in 2012 the total urban population in the country was 18.2%, and out of this urban population 61.27% was concentrated in the western region.

**Table 2 Urban Population Distribution in the Western Region and Sri Lanka**

District	1971(%)		1981(%)		2001(%)*		2012 (%)	
	District urban	Country urban						
Sri		22.6		21.5		14.6		18.2
Colomb	55	51.9	44.38	39.56	54.6	49.8	77.5	48.60
Gampaha	-	-	33	12	14.6	12.2	39.6	9.72
Kalutara	22.1	5.2	21	6	10.6	4.6	4.8	2.96
Western	47.9	57.6	42	57.56	45.8	66.6	38.77	61.27

\*2001 population figures do not include the Northern and Eastern provinces

Source: Department of Census and Statistics

The important feature of these figures is that in 2012, the Colombo District accounted for 79.3% of the Western Region's urban population and 48.6% of the country's urban population, respectively. Compared to other districts in Sri Lanka, Colombo shows the highest rating for urban population distribution. This can also be compared with population densities in other parts of the country. The Table 3, indicates Colombo district had the highest

population density of 3,438 persons per sq. km. in the region, making it the district with the highest population ranking in Sri Lanka in 2012.

**Table 3 Population Densities in the Western Region (per sq. km.)**

	1981	Rank in	2001	Rank in	2012	Rank in
Colombo	2605	1	3330	1	3438	1
Gampaha	994	2	1539	2	1714	2
Kalutara	517	5	677	3	771	3

Source: Department of Census and Statistics, 2012

The figures indicate that Colombo is the most congested and urbanised district in the country as well as the western region.

### **History of Colombo Urban Growth**

Colombo is the commercial capital of Sri Lanka and its growth mainly stems from the inheritance of a long history. Colombo has a natural harbour and it has proved to be a popular maritime destination from as far back as the 5th century, when it served as a sea port for trade between Asia, Africa, the Middle East, and the West. During the 8th century, Arab traders settled near the port and gradually Colombo became one of the popular trading destinations located in South Asia (Dayarathna, 2010). This was the key reason for the establishment of Colombo as an import/ export trade centre.

Development of Colombo as a port city took place to fulfill the needs of different colonial powers such as the Portuguese, the Dutch, and the British from 1505 to 1948. During the Portuguese and Dutch periods, their main objectives were to establish trade activities to obtain tropical goods and to maximize their profits. They used Colombo as the main commercial hub, but minimal attention was given to the physical development of the City (Rasanayagam, 1985). After the Portuguese and Dutch rule, the British took over and consolidated their power over the course of a long period of rule over the country. During the British period, they paid attention to developing Colombo as a main commercial city to fulfill their trading needs and for administrative purposes. They imposed their power on the plantation sector throughout the country and developed the main

commercial network for export of products through Colombo. At first, they developed the physical infrastructure of Colombo for their convenience. Secondly, they worked on the development of the main road and railway network from Colombo to the interior regions with the intention of expanding their trade activities throughout the country (Bandara & Munasingha, 2007). As a result, Colombo became the most attractive city in the country and large numbers of skilled and unskilled workers migrated to Colombo to find jobs that are more lucrative.

During the World War II period, the population of Colombo increased six fold due to large scale rural to urban migration (Rasanayagam, 1985). This happened mainly due to the rise in job opportunities and availability of better living facilities. When Sri Lanka achieved independence from British rule in 1948, the city became a major commercial and administrative hub and showed a high population concentration. In 1946, more than half the urban population in the country lived in the Colombo district and this was concentrated in Colombo City and the adjoining suburban localities (Panditarathna, 1960). By 1953, the City of Colombo was 95 times as densely populated as the rest of the Island (Rasanayagam, 1985). In the same year, 48.6% of the Island's urban population lived in Colombo district while Colombo City contained 34% of the Island's urban population (census and statistics, Sri Lanka). This was an almost four-fold increase compared to 1946. Therefore, during the period 1953-63, four new urban councils were demarcated in the areas surrounding Colombo as urban growth had spread over there. There are so many urban development plans, prepared for Colombo during last four decades period to control and formalize urban growth directions.

### **Urban Development Planning in Colombo since Independence**

Planning legislation in the country was practically nonexistent until 1915 except for the sanitary ordinances. In the early twentieth century, the necessity of invoking legal powers to control the haphazard development of towns was recognised and this resulted in the passing of the Housing and Town Improvement Ordinance in 1915. This ordinance became the first

major legislation dealing with physical planning in the country. It was to be applied within the administrative limits of municipal councils, urban councils and town councils and within any other limits in the built-up areas of village councils. It provided some guidelines for better housing for the people and the improvement of towns. However, its statutory powers were inadequate to encourage a strong urban development planning process in Sri Lanka. Subsequently, the town and country planning ordinance was introduced in 1946 leading to the establishment of the town and country planning department in the early 1970s to carry out urban planning. However, more specific urban development programs were still needed; so in 1968 this act was amended and some guidelines were added for urban development. In addition, the Ceiling on Property Law (No 1 of 1973) focused housing development of cities. Within this period of time, at several occasions different plans were prepared for Colombo and it can be separately considered as 1921 – 1977 and after 1977 period.

### **1921 – 1977 period**

Colombo can be considered as a planned city because physical plans have been prepared for Colombo since colonial times. In the early period, physical plans focused only on the city of Colombo. Sir Patrick Geddes made the first attempt in 1921, confining the planning area to the boundaries of the City of Colombo. He emphasised adoption of the garden city concept for Colombo, which concept was closely associated with the early days of the new town movement in Britain. His plan mostly stressed the importance of the harbour and related facilities. The “main concept of the plan was to preserve the rural spirit and to make the city of Colombo ‘the garden city of the East’” (CMRSP, 1998). The next plan was introduced in 1940 by Clifford Holiday and his proposal included some additional concepts. It proposed a green belt around the city, satellite towns to encourage outward migration, shifting of the main rail terminals outside the city limits, functional zoning and road development. In 1950 Sir Patrick prepared a new plan that elaborated on the Geddes plan, extending it beyond the city boundaries to the South, North, and 14 miles Eastwards, covering a total area of 220 sq. miles (Colombo Master Plan, 1978). The plan considered

decentralizing trade and commerce by introducing satellite towns as growth poles in the South, North and East. Abercrombie's plan focused on the concept of land use and density zoning, proposing specific usages and densities for the various zones (Dayarathna, 2010). None of those three plans were implemented due to a number of reasons such as lack of funds, lack of political will, lack of an institutional mechanism for implementing them, and rapidly changing situations which rendered the plans obsolete, etc.

### **The post-1977 period**

The year 1977 was an important landmark in Sri Lanka, as it was the first time that a liberal and open economic policy was introduced. It aimed to boost economic growth by encouraging investment and creating more employment. Import restrictions and price controls were eliminated and the open door policy opened up the private sector. Accordingly, several investment promotion zones were declared and many irrigation programmes were introduced. This implementation focused on accelerating the processes of the rural sector as well as urban development. To cope with the effects of the economic resurgence and keep pace with it, the Colombo Master Plan (CMP) project was introduced in 1978. The plan considered two planning units, a central sub-region, and an outer sub-region (Colombo urban area and outer urban cluster). Colombo urban area plan focused on the central sub-region of Colombo and 13 surrounding local authorities. The Colombo regional structure plan was prepared for the outer sub-region or periphery of the city, covering the entire Colombo District; it included towns in the Kalutara and Gampaha districts and a balanced spatial development was envisaged. To achieve this aim, special projects such as the Katunayake investment promotion zone and an administrative capital in Kotte-Sri Jayewardenepura were established. The regional structure plan considered Colombo's urban expansion and identified urban centers and rural centers. The present fringe area was at that time considered a rural area. In addition, the Urban Development Authority (UDA) was established to guide the island's urbanization process while the Greater Colombo Economic Commission (GCEC) was set up to promote and guide the

economic activities in the Colombo region. The concept of the plan made a lot of sense and it indicates Colombo's past growth pattern. Due to some financial restrictions, the whole plan could not be implemented.

Despite the rapid changes that had taken place in and around Colombo, there had been no significant planned development of Colombo in the 1980s and early 1990s, even after the preparation of the Colombo Master Plan in 1979. The socio-economic fabric and the physical condition of the Colombo region faced drastic changes during this period. The government proposed a new structure plan for the entire western province, namely the Colombo Metropolitan Regional Structure Plan (CMRSP, 1998). It was prepared in 1998 with the principal objective of providing "opportunities for increased economic development, employment generation, and improved living standards and quality of life for all inhabitants of the CMR" (CMRSP, 1998). In 2012 Gunarathna argued "it has two major advantages which the earlier plans did not; a strong environmental orientation and considerable exposure to stakeholders, which had led to responsive modifications" (2012, p. 44). This plan discussed the urbanisation trend and the mixed urban strategy for the western region to explain the growth trends. The structure plan included proposed expressways, growth centres, environmentally protected areas, regional centres, urban centres, town centres and satellite centres. It mentioned the major implications of future population growth. Due to several economic and political issues, this plan was limited to a policy document and nothing came of it.

In the late 1990s it was felt that there was a need to move beyond the Western Province and promote physical planning in other parts of the country. In 2002, the UDA prepared the Regional Structure Plan of the Western Region Megapolis (WRMP), which was a long-term perspective plan with proposals to achieve specific goals. A key objective of the plan was to separate the Western Region from the other regions of the country to promote a higher growth that will not only benefit the Western Region but also the other regions through a backward integration. The plan expected to develop the Western region into a strong economic powerhouse with the

spillover effects from this strong economic region launching investment into other regions (WRMP, 2002). In addition this plan attempted to identify the fringe area as a separate region, namely, as the peripheral region. The plan could not be implemented though due to the civil war raging during this period.

The civil war ended in 2009 and urban development started at an accelerated pace with a new political programme called. Under this programme urban development was linked with the National Physical Planning Department on the basis of the National Physical Planning Policy and plan, 2011–2030. This plan's broad vision envisaged the strategic integration of national, regional and urban planning. It aimed to enhance the connectivity by building an expressway network that would closely link the major cities. "It will enable Sri Lanka to tap the resource based comparative advantages of its cities in tourism, agro-processing and fisheries, which are among the most dynamic foreign exchange earning sectors with a wide territorial distribution that would particularly benefit urban centres outside the Western Province" (National Physical Plan, 2011, p. 7).

During the 20th century to 21st century, altogether seven plans were developed for Colombo and most of these included urban growth directions and a transition zone. Furthermore, most of the above plans were not implemented fully except for a few projects focused on the Western region. The projects are satellite towns, industrial estates, highways, free trade zones, technological zones, residential suburbs, with most of the projects being distributed across the entire western region. Those projects creates expansion of urban growth in nuclear and scattered way in an unplanned manner.

### **Objectives of the Study**

According to the 1971 census figures, 51.8% of the Island's urban population lived in the Colombo District. The 2012 figures indicated that 77% of the Island's urban population lived in the Colombo District and this shows a continuous increase of urban population. One of the reasons for the above population changes occurred due to urban growth. Now Colombo

shows high urban growth and identification of urban growth after 1971 until present is significant in future planning. Hence exploring these past four decades of urban growth and identification of connected land use variations are main objectives of this study.

## **Research Method**

There are three types of methods used for data collection such as historical documents, observation and expert interviews. This study is concerned with urban growth over four decades and a large number of historical documents had to be studied to get an idea about past urban growth. Besides the historical documents, practical experiences of experts are important in documenting the past urban growth pattern. Therefore, data collected from experts was used to get an idea about past urban growth in the Colombo district and structured interviews were used for that purpose. In order to obtain expert views, 30 experts were interviewed including urban planners, environmentalists and architects engaged in the urban planning field in the western region. The interviews were based on a structured questionnaire. Part one of the questionnaire-included questions about the nature of urban growth in Colombo District over the past four decades, about specific urban development projects, and personal experiences about urban growth. Part two included questions about the driving factors of urban growth and their level of influence. Above data were used to analyse urban growth in a descriptive manner.

Apart from that, GIS based quantitative method is` used to analyse spatial and temporal urban growth. There is no exact definition of the term ‘urban’ in Sri Lanka except for the definition based on the census classification, which mentions municipal councils and urban councils as urban areas. This definition is broad and therefore an activity based definition is needed for urban growth analysis. During this study, some field observations had to be carried out in order to confirm the urban classification. Urban land use activities were initially classified using Godschalk’s urban land use classification system (Kaiser et.al., 1995)and some of those uses were identified and confirmed as urban uses by observation. Arc/GIS cross

tabulation, gradient analysis and Landscape Expansion Index is used to analyse quantitative changes of land use.

## **Results and discussion**

### **Colombo Urban Growth During Past Four Decades**

The outcome of historical records and experts' views were summarised in respect of four different periods, viz. 1971-1981, 1981-1991, 1991-2001 and 2001-2012. The next section discusses the urban growth pattern during each of these periods.

#### **5.1.1 1971-1981 Period**

A study of this early decade revealed a nuclear (Colombo City based) urbanisation process whose influence spread out into the adjoining local authority areas and other areas identified as suburban zones (Colombo Master Plan, 1978). In the earlier half of the first decade, a slow pace of urban change was seen. During that period no powerful laws, regulations, and specific authority were in place to regulate urban development. At that time, the City of Colombo faced severe problems in respect of underserved settlements located in valuable state owned lands. The initial stage of urbanisation occurred in the inner suburbs, which were very close to the city of Colombo (Perera, 2002). The urban fabric in the fringe showed less traffic, low population density, low building density, and had considerable extents of potential land suitable for development. This period showed minimal outward expansion due to limited physical infrastructure (Wanasingha, 1985). In the year 1977, a significant landmark was achieved in urban development activities with a new government being elected to office. It led to the introduction of new economic reforms, which were in sharp contrast to the retrograde economic policies of the 1970-1977 era. This new open economic system provided greater incentives to promote private sector involvement in the economy (People's Bank, 1978). At the same time, comprehensive urban development strategies were also introduced. Policy makers with the assistance of the UNDP addressed urban development issues with a new vision to avoid problems that could arise from unplanned urban development. Accordingly, administrative functions

were moved to Sri Jayewardenepura, Kotte and Colombo was designated as the commercial capital of Sri Lanka (Colombo Master Plan, 1978).

With this massive re-ordering of economic and urban development plans, many opportunities in the trade, service, and industrial sectors were created in the Colombo district as well as in the western region. It attracted an additional number of people to the western region and applied much pressure on the Colombo district. With the transformation of the economy from a state controlled to an open system, the private sector played a leading role in boosting industrial and trade activities while market forces determined the allocation of resources (People's Bank, 1980). A key factor that influenced urban growth in this period was the launching of new development projects. Most of the urban growth in the surrounding areas was based on the proximity factor, which was the availability of infrastructure facilities. Hence, proximity to main roads, proximity to public bus routes, and proximity to suburban town centers could be considered as the most influential factors driving urban growth. An important feature of this period was that urban expansion did not spread to areas that were subject to physical constraints such as poor access, swampy terrain, and liability to flooding.

### **1981-1991 Period**

This period contributed much to the urban development and intensification of activities in the Colombo District. During the latter part of the period from 1971 to 1981, many urban development projects were implemented. As a result, land and housing prices rose in Colombo and its suburbs. Private property developers became involved in housing construction mainly after 1983. Prior to that, they were mainly engaged in activities like buying and selling of real estate and subdividing land into smaller blocks, without doing any real development. "Thus, after 1983, heavy involvement of the private sector in land sales and property development and its high pressure marketing strategies have triggered a spiraling increase in the prices of land and property in the City of Colombo as well as in the adjoining suburban areas" (People's Bank, 1977a). Abeygunawardane (1995: 35) identified the

years 1978-1984 as a booming period for the property development sector in Colombo.

At the initial stages, urban growth depended on the availability of physical infrastructure, which mainly covered those areas on either side of the main roads and within the town limits. Hence, accessibility to roads and town centres was the main factor influencing urban growth. Consequently, growth pockets and ribbon development became common features during this period. This development gave rise to unmanageable social and environmental problems because the planning regulations and legal enactments at this early stage were not strong enough to deal with such issues. The government introduced several housing schemes for the upper middle income and lower middle income family categories close to identified satellite towns (People's Bank, 1977b). As a result, basic physical infrastructure facilities developed in these areas. Most property developers used this opportunity to do business by engaging in land subdivision and blocking out. Thus, massive suburbanisation happened for the first time in the outer areas. Horizontal expansion spread out beyond the inner suburban areas and extended outwards converting the exurban areas too.

This process created an outer suburban circle. Most of the private property developers' interventions occurred here. The large number of land subdivisions created more urban residential spaces that were in great demand by the upper middle class and lower middle class people. However, the various governments that came into power were unable to provide adequate physical infrastructure facilities, especially water and telecommunication services, and the people faced serious problems related to infrastructure. The government regulations of this period were not strong enough to address the interventions of real estate developers and the high land conversion rate threatened the valuable agricultural lands. Furthermore, illegal land filling that targeted paddy and marshy lands threatened the environment, and the weak mitigation measures that prevailed proved totally ineffective. Apart from that, high level political intervention caused illegal land developments resulting in heavy suburban

sprawl (CMR Structure Plan, 1998). The nature of suburban development mostly followed the ribbon type model. However, new development projects, whether legal or not, were the most influential driving factors of urban growth. In addition, other factors such as proximity to main roads, suburban town centers, public bus routes, and quality neighborhood areas also influenced the urban growth significantly. The urban changes of this period were mostly influenced by environmental factors and physical factors.

### **1991-2001 Period**

With the continuous urban changes occurring in the previous decades, land values kept increasing rapidly and real estate developers' interventions were strong. Since the upper-middle class urban dwellers in the City of Colombo and exurban areas were attracted to high rise vertical developments, many condominiums were constructed. Ribbon type suburban developments expanded into the outer fringe area as well. At that time, vertical expansion occurred in the inner suburban areas. Infrastructure development projects were launched at this stage and a high demand for land prevailed in the inner areas, while infill growth occurred in the outer areas. Hence, people felt more encouraged about moving to the suburban areas. During this period, the majority of main road junctions became converted to small urban nodes that served as basic service centers and people generally preferred to reside close to these urban nodes. This was the first time the 'proximity to local sub centers' factor influenced urban growth. Consequently, this factor also influenced the urban growth, in addition to the other proximity factors mentioned earlier.

During the later stages, some important features were identified in the private sector property development activities. One of these was the rapid increase in the number of property developers in the City of Colombo and suburban areas, either as private companies, limited partnerships, or as individuals; others were the increased number of land subdivision schemes and the sales of buildings and residential blocks in Colombo and its suburbs (Abegunawardana, 1995). Some of the companies involved in land

subdivision schemes in the early stages, later turned to housing development activities. City centre developments gradually transformed to high-rise developments. At this stage, the urban fringe played an important role as a transition zone. Most of the agricultural lands in the fringe area that were close to main roads and town centres were converted to residential lands due to the high demand; most of these lands were subdivided into 10-15 perch blocks. The majority of housing developments focused on single or two-storied houses with small gardens and they showed low residential development; i.e. they were rather short on amenities. In any case, these developments could not have proceeded smoothly because of the serious civil war the country faced at that time, which affected the City of Colombo badly.

### **2001-2011 Period**

The civil war truly disrupted the development of the country during the period from 1981 to 2009. The war intensified during the latter part of this period (2001-2009) and it directly impeded the urban development and urban growth. The fringe urbanisation did continue, but very slowly. Exurban areas grew fast and ribbon type exurban areas were created in the outer urban areas. Another new suburban crescent was formed to the East, beyond the outer urban areas. Earlier, rurban areas in the periphery showed ribbon type development and the tiny urban nodes that existed at the road intersections were converted to small urban centres. During the latter part of the decade, the civil war ended and urban development continued at a faster pace. New road development projects such as the southern highway, Katunayake expressway, and the outer circular road, together with local road developments formed a sound road network in the fringe. The improved local road network, connected with small urban nodes, created a new urban fabric in the fringe. An infill growth rapidly continued from this new urban fabric. As a result, the former local sub centers massively coalesced into small urban centres. Horizontal expansion extended beyond the outer urban crescent with the formation of a new suburban crescent.

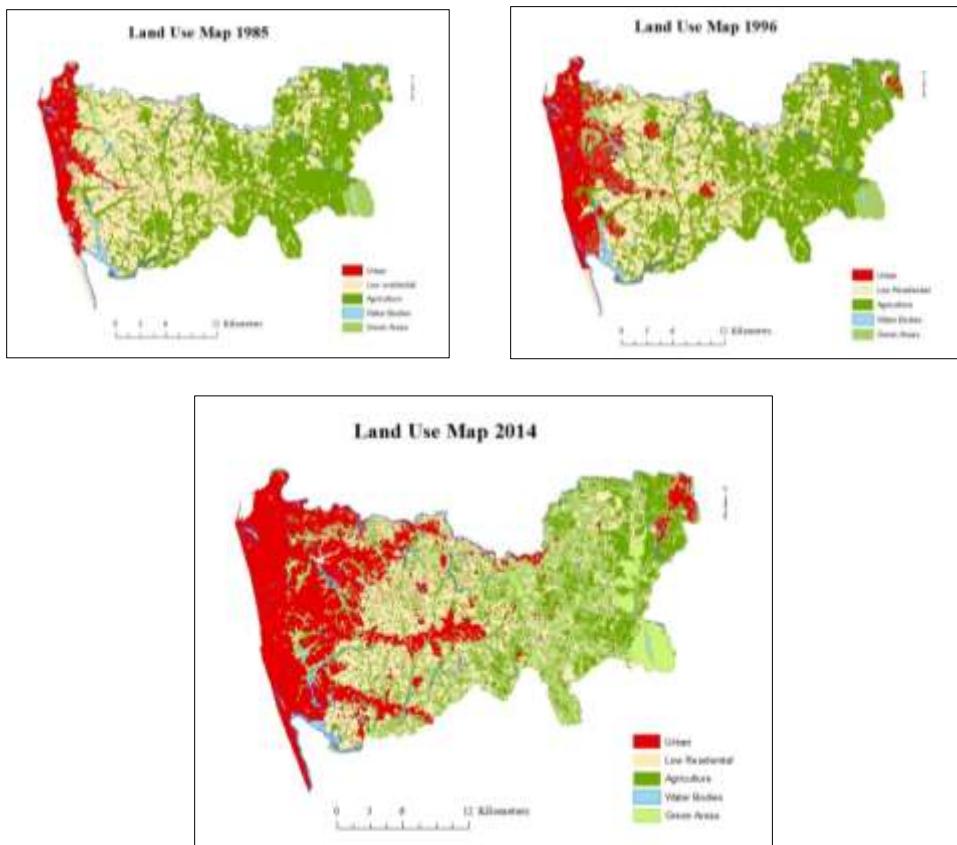
## **Spatial distribution of Land Use Pattern**

Colombo district land use consists of 26 land use categories and it reclassified into five categories namely urban, low residential, agriculture, water bodies and green areas. The 1985, 1996 and 2014 land use maps classified to above mentioned five categories and Figure 2 indicate these three maps.

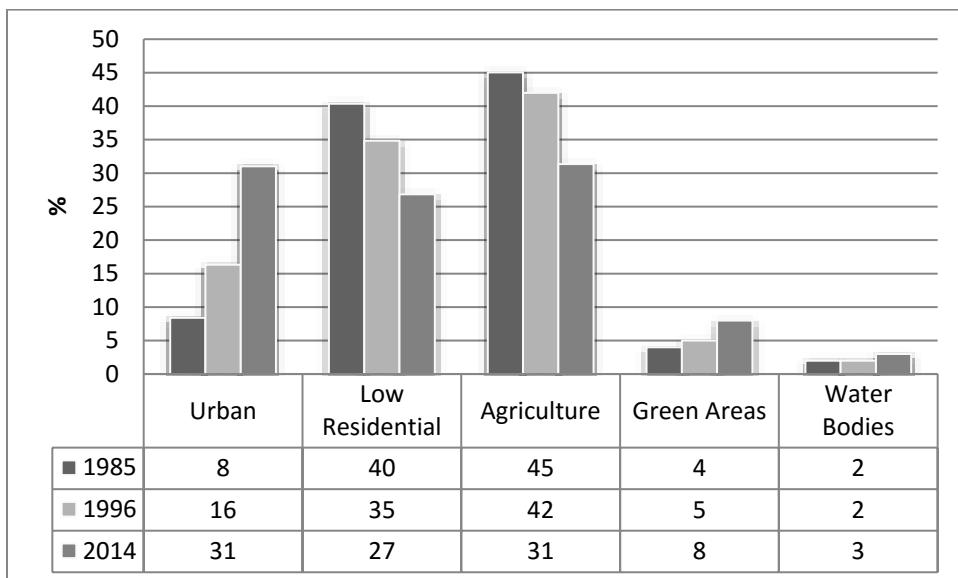
The land use maps that show urban growth in 1985, 1996 and 2014 draw attention to two important phenomena. First, the urban growth spread from the west in an easterly direction; i.e. from the City of Colombo to the countryside. Second, the urban growth pattern spread-out on either side of the main roads and outwards from the town centres. Above land use pattern was quantitatively measured and Figure 3 indicates the results expressed as percentages of different land use categories for the three recorded years.

The land use percentages show two important features; the urban category and the ‘green area’ category had increased, while the low residential and agriculture categories had decreased. When the percentages of land uses are compared, urban built-up shows a drastic increase of nearly 4 times from 1985 to 2014, while agricultural land had gradually decreased in the same period. The next main category of low residential also shows a steady decline over the same period, dropping to 0.325 times of the original value. Except for these three main categories, the other two land uses do not show any significant variances. However, this basic analysis does not show which category of land use decrease led to the increase of another land use category. However, this problem will not be seen in the cross tabulation of the land use conversion matrix. Thus, it is a better method of tabulation of data than the normal table. The ArcGIS 10 cross tabulation tool provides a wide range of advantages in cross tabulating land uses. Most scholars use the ArcGIS cross tabulation method for analysing land conversions in the spatio-temporal scale (Xiao et al.,2006; Hung et al.,2008; Pelorosso et al. 2009) used cross tabulation for analysing spatio-temporal changes in the land use pattern. Land uses named Green areas and water bodies do not show much variation and so those two categories are combined for cross

tabulation of land uses and this category is named as ‘other’. Tables 4 and 5 show the cross tabulation figures for land uses from 1985-1996 and from 1996-2014, respectively.



**Figure 2 Colombo District Land Use 1985, 1996 and 2014**



**Figure 3 Percentages of Land Uses from 1985 to 2014**

#### **Cross tabulation of Land Use Changes from 1985-1996**

Table 4 shows the cross tabulated matrix of land use change from 1985-1996. Land use changes of this period show two significant features.

**Table 4 Cross Tabulation of Land use 1985-1996**

	Urban	Low Residential	Agriculture	Other	Total 1985
Urban	5722.58	-	-	-	5722.58
Low Residential	5332.84	22148.94	0.00	43.72	27525.50
Agriculture	46.91	1615.36	28625.04	426.19	30713.50
Other	22.07	0.00	0.00	4204.20	4226.27
Total 1996	11124.40	23764.30	28625.04	4674.11	

During this period, urban uses show a prominent feature because low residential, agricultural and other uses were converted to urban uses, but urban uses were not converted to any of the other three uses. Second, agricultural uses have been converted to the other three uses. Low residential category is also prominent because most of the agricultural land

was converted to low residential and low residential in turn converted to urban uses. During this period, most of the paddy lands and marshy lands located in these areas were filled to convert them for urban uses. In addition, most paddy fields were not harvested due to low yields and high costs and became converted to abandoned paddy lands. The CMR structure plan Report (1998) noted that 340 hectares of paddy lands were converted to urban and other uses during this period.

### **Cross Tabulation of Land Use Changes from 1996-2014**

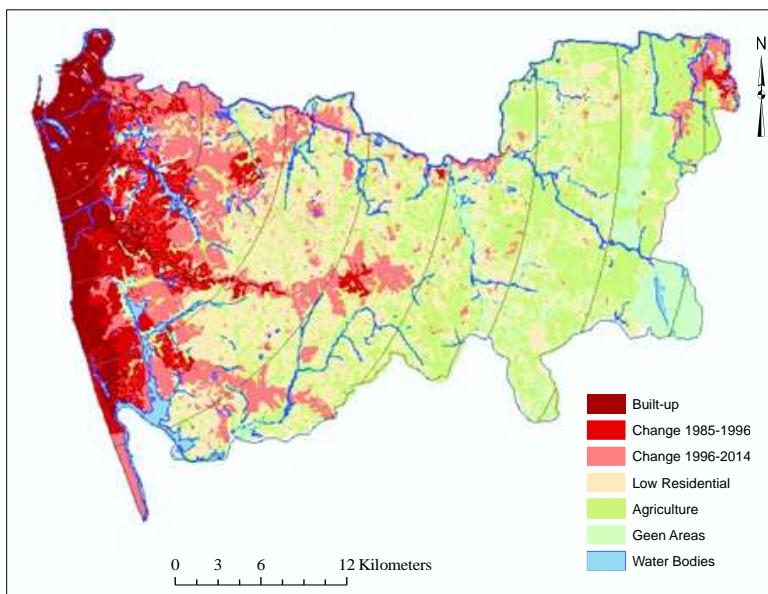
**Table 5 indicates the cross tabulation matrix of land use changes from 1996 to 2014.**

Table 5 Cross Tabulation of Land Use 1996 - 2014					
	Urban	Low Residential	Agriculture	Other	Total 1996
Urban	11054.05	-	-	70.35	11124.40
Low Residential	7407.82	11202.73	4466.76	686.98	23764.30
Agriculture	2144.57	6963.35	16735.96	2781.16	28625.04
Other	540.76	140.71	176.57	3816.07	4674.11
Total 2014	21147.20	18306.79	21379.30	7354.57	-

According to the Table 5, urban category remained the same as it did previously with only slight differences. However, 70.35 hectares of the urban category converted to other uses; most urban green spaces were expanded in the previous decade and that is the main reason for that. Urban conversion was high in this period and 75% of the urban areas were converted from low residential areas and 20% were converted from agricultural land. Further, 95% of the low residential areas were converted from agricultural uses. During the same period, agriculture lands decreased 25%. ‘Other’ land was also converted to all three main uses in small amounts.

In order to quantify the scale and impact of urbanisation the distance gradient analysis was used. Some scholars ( Wu et.al., ,2012; Zhang et al. 2004; and Nong et al. 2014) used urban gradient analysis to determine, how

urban growth was influenced by distance gradients. Distance is one of the main factors that affect Colombo District's urban growth and urban gradient analysis was used to explore different urban growth types at different proximity buffer zones from Colombo City (Figure 4).

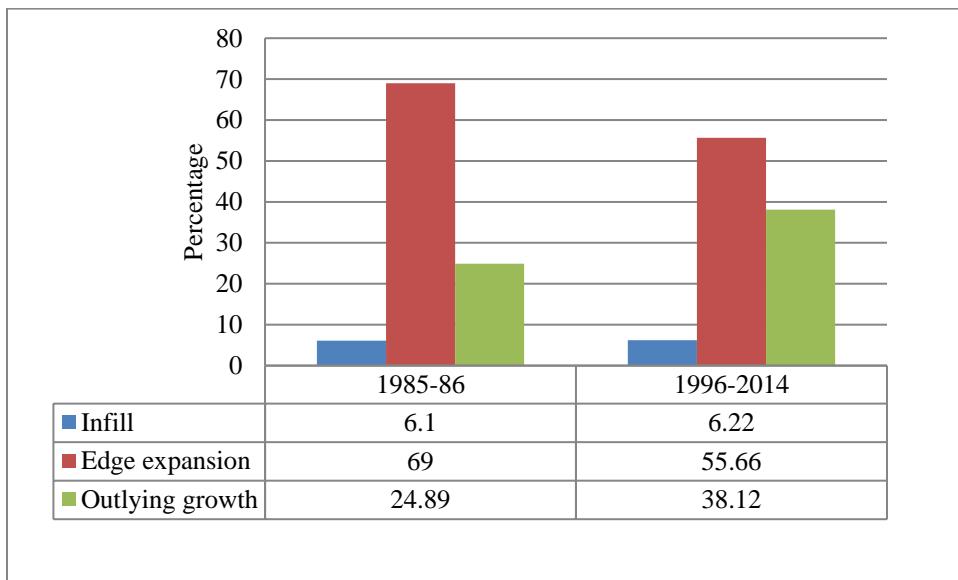


**Figure 4 Colombo District Land use Pattern with Distance**

Different growth types were calculated for the two periods, 1985-1996 and 1996-2014. At first, within each buffer zone the annual urban growth was calculated, and after that the different growth types were analysed using the landscape expansion index.

### **Types of Urban Growth**

The Landscape Expansion Index (LEI) was calculated for different growth types for the two different periods. Those growth types were categorized as infill, edge expansion, and outlying growth (Figure 5).



**Figure 5 Growth Types**

As shown in Figure 5, the main growth type at both periods was edge expansion. While it had accounted for nearly 70% of growth in the 1985-1996 period it had decreased to 55% in the 1996-2014 period. Percentage of infill growth was nearly unchanged in the two periods. However, compared to the 1985-96 period, the outlying growth in 1996-2014 was high. There was an almost 15% increase over the 1985-96 period. Accordingly, Colombo outlying growth shows a linear and clustered growth pattern. A small percentage of isolated growth exists in a few places.

## Conclusions

During the past four decades, Colombo's urban growth has taken place in an uneven pattern. The growth type is mainly based on the distance from the core city to countryside in a concentric pattern. Measurement of this growth pattern and identification of different growth types is essential to forecast future growth directions. Furthermore, the urban fringe is the potential area that accommodates urban growth, and presently Colombo's fringe growth is spreading out in a haphazard manner due to lack of strong planning regulations.

Land use variations were evaluated using cross tabulation and the results showed significant variations. Different types of urban growth were evaluated and the landscape expansion index was used for that. It was first considered at district level and later divided into sections (crescents) with buffer gradients. Accordingly, up to the 25 km buffer zone edge expansion was prominent in the urban growth. Beyond that, up to the 40 km buffer zone, outlying growth was prominent. It indicated that the urban fringe is gradually becoming converted to an urban area with edge expansion while the rest of the area showed outlying growth.

The land use pattern presents a different picture and it shows the urban area gradually expanding by spreading out through peripheral areas with the urban fringe functioning as a transition zone. As a result, fringe land keeps getting converted to urban uses on a massive scale. It is important to measure this conversion pattern as well as the conversion type. The existing urban development policies in Sri Lanka provide a pathway for movement of the population to the other two districts in the Western region and outer regions. Apart from that, an advanced transport network, good road infrastructure, low land values and less pollution are some of the reasons why developers were able to attract people from the core area to the edge of the district and outer regions. The outer regions show rural land uses and major urban nodes exist at the main road junctions. New developments had taken place at these urban nodes, and this was another key reason that attracted people. The above pattern needs to be recognized and understood for future planning and growth directions, and the use of a conceptual model is one of the best approaches that can be adopted to achieve this.

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