GIS Integrated Growth Type Index (GTI) for Analysis of Spatiotemporal Urban Growth in the Colombo District Sri Lanka

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Introduction

More than half of the world's population is urbanised (United Nations, 2014).Urbanisation and urban growth create high urban densities around mega cities of the world. The emergence of mega cities and their rising spatial influence mark a movement of people from sprawling rural areas to predominantly urban places in either a haphazard or a planned manner. This rapid and complicated urbanisation process resulted in the spillover of physical growth to the surrounding areas and this phenomenonis referred to as 'urban growth'. Urban growth is not an instant spatial process.It happens over a long period. Hence, it can be considered as a spatio-temporal growth (Bhatta et al., 2010).

Research Problem

At present, Sri Lanka's urban vision is focused on an accelerated process; most areas of the Colombo district have been identified as potential zones for new urban developments. Exploring urban growth in spatial-temporal scale is a necessity for urban planners and decision makers for their future planning and developments. However, indistinct past growth trends, lack of control measures and absence of knowledge about past growth drivers in the Colombo urban fringe are clear research gaps that exist in the Sri Lankan urban studies.

Objectives of the Study

This research aims to address above mentioned research gap by analyzing its spatio-temporal growth pattern. Hence, the objectives focuses on analyze the spatio temporal urban growth in the Colombo district using the Growth Type Index (GTI). it is further analysis of the study of Weerakoon (2017) focused on GIS integrated urban gradient analysis in the Colombo District.

Theoretical background

Changes in urban growth can arise due to redevelopment of existing built-up areas at higher densities, or through infill of new developments in the non-built-up areas. New developments can take place adjoining the existing built-up areas or in undeveloped land that are separate from the existing built-up areas. Wilson et al. (2003) have identified three different types of urban growth; namely, infill, edge expansion, and outlying growth. Mostly, outlying growth occurs in open areas and environmentally sensitive land in and around the city. Infill growth is the main growth type and it takes place within the built-up area. Expansion growth is centred around infill growth and directly connected with existing

built-up areas, whereas the outlying growth occurs separately from existing built-up areas. Outlying growth can be further divided into isolated, linear branch, and clustered branch growth. In 2010,Lie et.al. explore the above mentioned growth types using GIS integrated Landscape Expansion Index (LEI) for analyzing urban expansion in China. Likewise, Nong et al. (2014) used the LEI for measuring the spatio-temporal pattern of urban growth in Hanoi, Vietnam. These two studies used GIS technologies to monitor and manage fast urban growth. Advanced GIS technologies provide extensive methods to review and quantify urban change and this study will use the same tools to assess the spatio-temporal urban growth pattern.

Methodology

For analyzing urban expansion in the Colombo district, Growth Type Index (GTI) was developed. It mainly focuses on calculating landscape changes from non-urban to urban. GTI was calculated using the following formula.

$$GTI = LCB/PNA$$

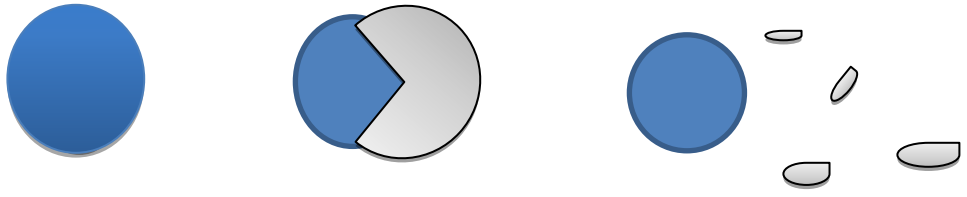
GTI = Growth Type Index

LCB = Length of the Common Boundary of early and new urban patches

PNA = Perimeter of New growth Area

Growth Type Index ranges from 0 – 1 and the type of urban growth depends on the index value. Accordingly, GTI value less than 0.5 indicates infill growth and GTI greater than 0.5 indicates edge expansion growth. GTI value equal to 0 indicates outlying growth. Figure 1 illustrates the above different types of urban growth.

Figure 1: Different Growth Types



Infill Growth Edge Expansion Outlying Growth

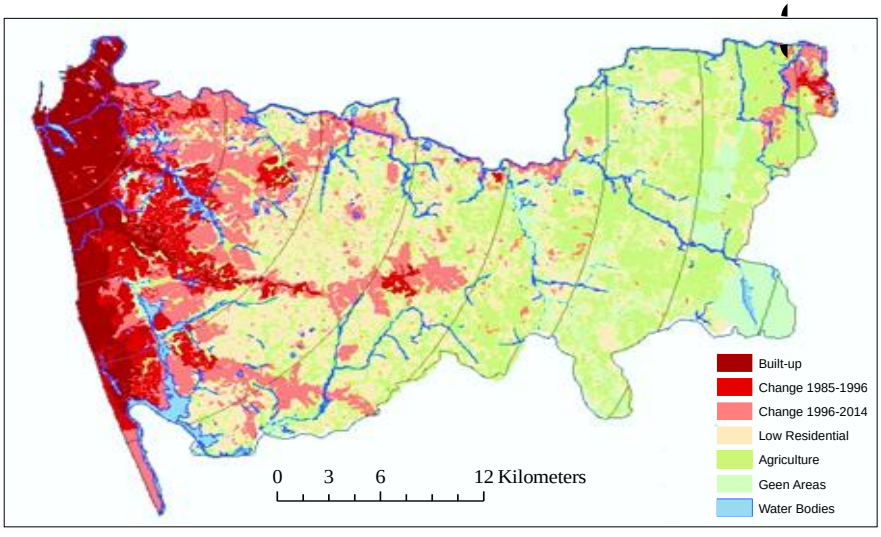
Several sources of data used for the study and details are shown in Table 1.

Table 1: Data and Data Sources

Source	Scale	Map Source
Land use & Land Cover Map	1:10000	Survey department
Land use Map 1996	1:10000	Urban Development Authority, Sri Lanka
Land use Map 2014	1:10000	Land use Policy Planning department
Road Map 2014	1:10000	Survey department
GND boundary	1:10000	Survey department

The study focuses on analysing urban growth from 1980's to 2014. Availability of data land use maps of 1985, 1996 and 2014 were used for analysis. Accordingly, 1985 - 96 variation and 1996 - 2014 variations were considered. All Land use maps consist of 26 land use categories and the urban built-up category was defined and extracted from the above 26 categories. In addition, land use changes were considered at 5 km distance gradients from the city of Colombo. Figure 2 shows the urban land use pattern and its variation within 5 km buffer zones measured from the city of Colombo.

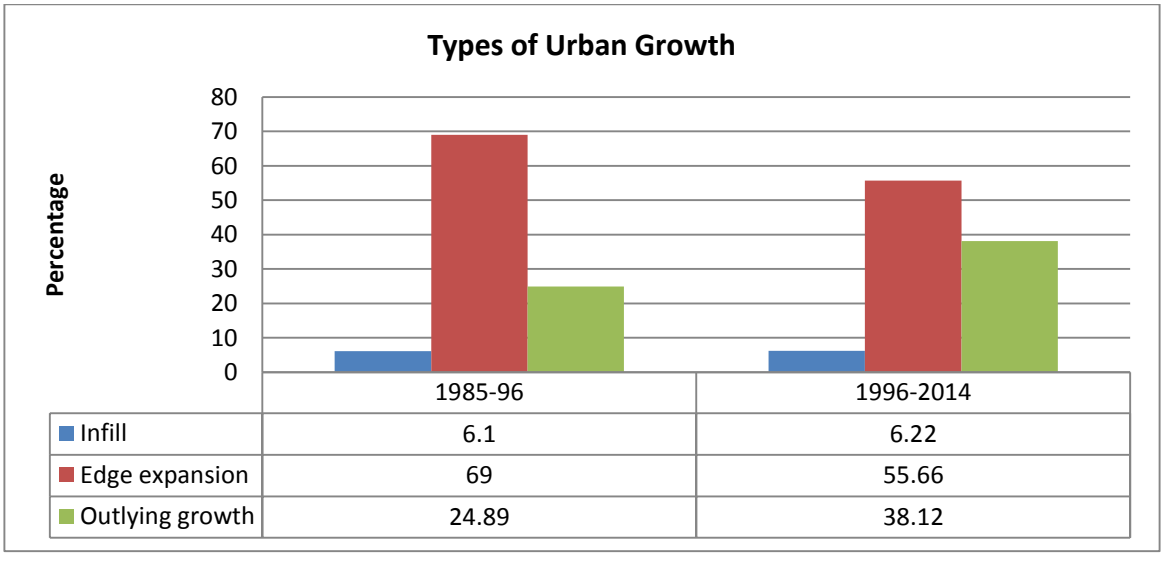
Figure 2: Colombo District Land use Pattern with Distance



Analysis

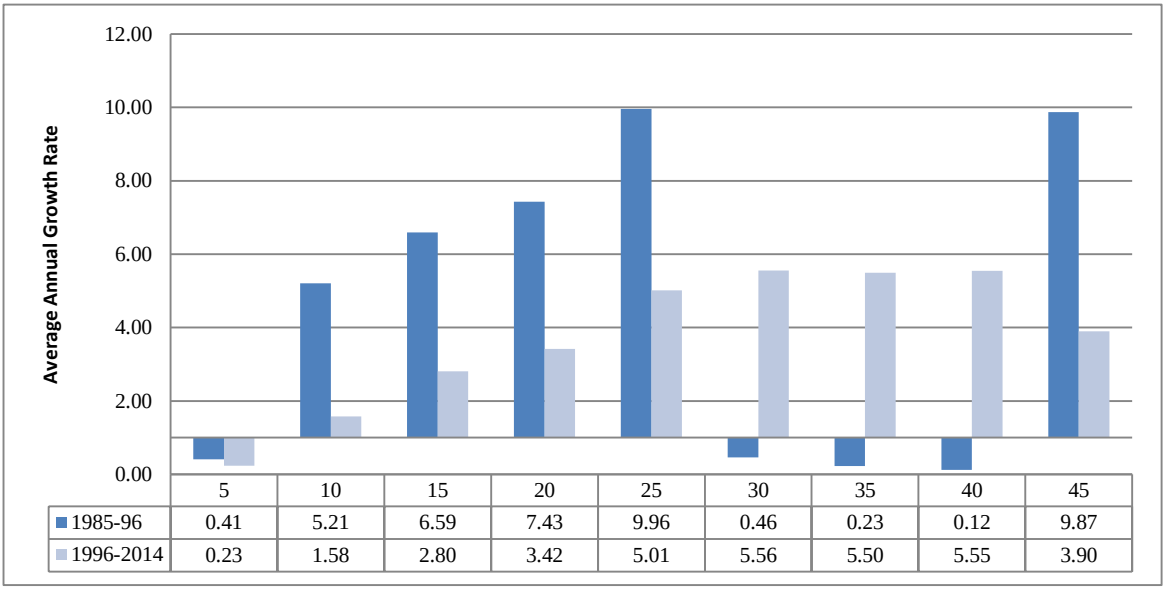
Growth Type Index (GTI) was calculated to identify different growth types;infill, edge expansion, and outlying growthin two different periods (Figure 3). When the growth types in the two different periods were considered, outlying growth was prominent in the latter period. It indicates that in general, there is an outward expansion in urban growth.

Figure 3: Types of Urban Growth



The above three different types vary with the distance from the City of Colombo and the below analysis focus on that. 5 km buffer distances were createdto measure the urban growth with distance gradients. The Figure 3 illustrates the overall urban change from 1985 to 2014 in the entire district. Following this, the annual growth rate of urban built-up land for the two periods within the above mentioned nine buffer zones was computed.

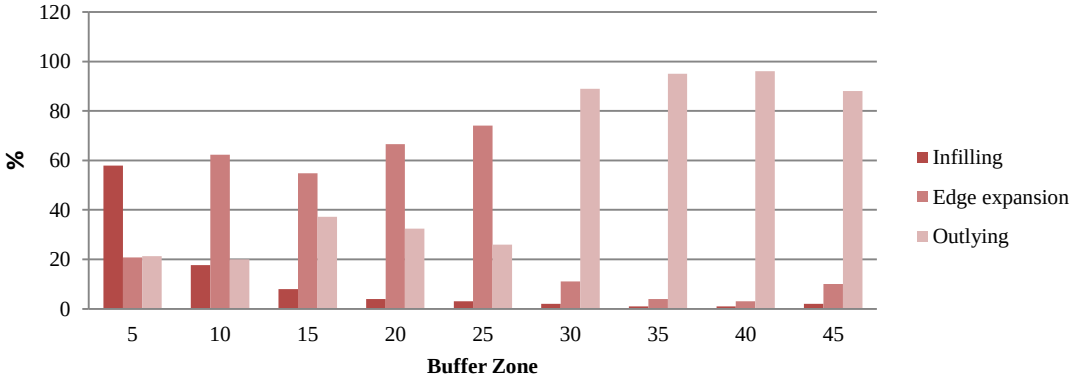
Figure 4: Urban Built-up Changes



	5	10	15	20	25	30	35	40	45
1985-96	0.41	5.21	6.59	7.43	9.96	0.46	0.23	0.12	9.87
1996-2014	0.23	1.58	2.80	3.42	5.01	5.56	5.50	5.55	3.90

Later, that average growth was identified with different growth types with buffer distance. Figure 4 illustrates urban growth expansion types in different buffer zones. It shows that more than 50 percent of urban growth in the 5 km buffer zone was infill growth but it gradually decreased as it neared the 45 km buffer zone. Edge expansion showed a gradual increase when moving from the 5 km buffer zone to 25 km buffer zone. Thereafter, it decreased up to the 40 km buffer zone, but showed a 10 percent increase within the 45 km buffer zone. Outlying growth was less than 40 percent from the 5 km to the 35 km buffer zone, and then it increased to more than 80 percent in the 30 km to 45 km buffer zones.

Figure 5: Urban Growths in Different Buffer Zones



Conclusion

GIS integrated techniques can be used to analysethe land use types, and Growth Type Index (GTI) has been sucessfully used for that purpose. Colombo district land use analysis pinpointed two land use dynamics; one was that land development activities were becoming more diverse and the other was that the land development process caused fragmentation and splitting up of land. Its physical growth types were analyzed using Growth Type Index connected with distance gradients. Accordingly, infill growth is prominent in the first 10 km zone, and edge expansion is noticeable up to the 25 km buffer zone. Beyond that, up to the 40 km buffer zone, outlying growth is significantly visible. It indicates that the urban fringe is gradually becoming converted to an urban area with edge expansion while the rest of the area shows 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.

Keywords: Urban Growth; GIS Urban Expansion; Spatio - Temporal Growth; Growth Type Index

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