ANALYSIS OF RELATIONSHIP BETWEEN URBAN SPRAWL AND ITS DRIVING FACTORS: A CASE OF SMALL AND MEDIUM TOWN IN SRI LANKA

MANESHA E.P.P [1]* & AMILA JAYASINGHE[2]
[1,2] Department of Town & Country Planning, University of Moratuwa, Sri Lanka
[1]pamudimanesha1214@gmail.com, [2]amilabj@uom.lk

Abstract: Measuring the level of urban sprawl is a challenging task that lacks a clear universal method. Therefore, it is worthwhile to investigate whether results differ with the methods utilized, to compute the level of urban sprawl. Consequently, this paper will also contribute to overcome the two limitations of emerging researches. Frist, Recent studies have utilized various methods to measure urban sprawl. However, the results of these studies were not compared and contrasted. Second, empirical studies have given less attention to identify the relationship between the level of urban sprawl and its driving factors such as urban form, urban landscape, population density, built-up density, accessibility, etc. Hence, this study supposes to quantify urban sprawl and identify the key factors influence on the level of urban sprawl. The study was conducted using the Expansion Intensity Index, Shannon's Entropy value and Landscape Metrics. Ten small and medium towns were selected in the Sri Lankan context. The study able to demonstrate the influence of type of urban form, type of street pattern and changes in the accessibility of center compare to periphery area on the level of urban sprawl.

Keywords: *Urban sprawl, Methods, Density, Accessibility, Urban Form*

1. Introduction

"Urban sprawl is a form of spatial development, characterized by low densities, scattered and discontinuous leapfrog expansion, and segregation of land uses" (Frenkel & Ashkenazi, 2008). The urban sprawl is mostly influenced to change in land use patterns reducing rural areas into urban areas (Nejadi, et al., 2011). Dilorenzo, (2000) recognized it as a "cancerous growth or a virus". Urban sprawl is the opposite to be compact urban development as well as it is more concerned about the unplanned, uncoordinated and uncontrolled growth of the city. The major challenges of urban sprawl are negatively affected sustainable urban development. The causes of urban sprawl differ between developed and developing countries as a results diverse strategy are required to tackle the issue (Sinha, 2018). Accordingly, planners and spatial decision-makers need to correctly measure the level of urban sprawl and determine the factors that influence urban sprawl in formulation for urban and regional plans (Al-Sharif, et al., 2017).

Urban sprawl is a multi-dimensional phenomenon that made the various scales and parameters to quantify the urban sprawl (Bhatta, et al., 2010). Bhatta, Saraswati, and Bandyopadhyay, (2010) stated that urban sprawl could be evaluated in relative and absolute scales. Absolute assessments can create a "black and white distinction between a sprawled city and a compact city" (Bhatta, et al., 2010). In the studies of other researchers proposed several metrics that could be detected black and white characteristics of urban sprawl from using RS data. The Shannon's Entropy value is well-known technique specially to determine whether urban growth is compact or dispersed, as well as Urban Expansion Intensity Index is powerful quantitative method to reveal the speed of urban sprawl (Aburas et al., 2017; Al-sharif et al., 2017; Maher Milad et al., 2017; Ren et al., 2013). Apart from that, relative assessments compute several aspects of urban growth that can be compared among various cities, regions, zones, or different time periods. Landscape

*Corresponding author: Tel: +94 717632720 Email Address: pamudimanesha1214@gmail.com
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metrics are employed to assess spatial temporal patterns of urban sprawl such as "clumpiness, aggregation, complexity, and level of dispersion of urban area classes in the study area landscape" (Taubenböck, et al., 2009; Al-Sharif, et al., 2017). Nevertheless, related literature states that the ambiguous concept is not measured by only one or two measurements (Bhatta, et al., 2010). Because "its various dimensions are independent and not significantly correlated with one another" (Frenkel & Ashkenazi, 2008). Hence, there is a need to identify whether results are different based on the method. Urban planners and other related professionals need to understand what is the most suitable methods to assess and identify urban sprawl (Abdullahi, et al., 2017).

Generally, urban sprawl dynamic was investigated considering influence factors. Sudhira, Ramachandra, & Jagadish, (2004) stated that population is known as a crucial factor of urban sprawl. Moreover, density (Torrens & Alberti, 2000; Ewing, et al., 2002; Sudhira, et al., 2004; Tsai, 2005; Karakayachi, 2016; Tian, et al., 2017), growth rate (Frenkel & Ashkenazi, 2008; Bart, 2010; Tian, et al., 2017; Liua, et al., 2018; Guite, 2018), accessibility (Anas & Rhee, 2006; Frenkel & Ashkenazi, 2008; Karakayachi, 2016), urban infrastructure (Torrens & Alberti, 2000; Sudhira, et al., 2004; Karakayachi, 2016) seems to drive urban sprawl. Limited attention is given on factors such as street patterns, urban form, and urban facilities (Tsai, 2005; Sudhira, et al., 2004). Nevertheless, empirical studies have given less attention to identify the relationship between the level of urban sprawl and its driving factors, and not concerned in real world urban background (Sabri & Yaakup, 2008; Polyzos, et al., 2013). On the other hand, different scholars hypothesized different criteria related to urban sprawl as well as studies are carried out different ways. Hence, identified factors of analytical approaches for urban sprawl has been limited and the empirical result of such a methodology unable to show realistic outcome.

In such a situation, this study attempt to address two key limitations of the emerging research in the field of urban and regional planning. Frist, Recent studies have utilized various methods to measure the level of urban sprawl. However, the results of these studies were not compared and contrasted. Second, what are the significant factors influence on the level of urban sprawl. Overall, the studies concern on factors such as population density, built up density, economic growth rate, population growth rate, built up the growth rate, urban landscape, change in urban landscape, accessibility, change in accessibility, urban infrastructure, change in urban infrastructure, urban facilities, change in urban facilities, street pattern and urban form. Considering above, the main objective of the study is to identify the significant factors which influence on the level of urban sprawl. Ten Sri Lankan small and medium towns were selected as case study areas, where limited studies have been carried out to investigate urban sprawl.

2. Method and Material

2.1 CASE STUDY AREA

The case study areas were selected based on the criteria mentioned in the following table 1. These towns were selected according to their (I.) The population size of the towns (less than 500,000 - 2012 census), (II). Diverse urban forms (Mono-centric, Linear, Poly-centric, Satellite) (Munasinghe, 2005), and III. Data availability.

Category	Population size of entire town (2012)	Urban form			
		Mono centric	Poly-centric	Satellite	Linear
Negombo	142,449	■			
Kandy	98,828		■		
Galle	86,333		■		
Anuradhapura	50,595			■	
Trincomalee	48,351		■		
Rathnapura	46,229			■	
Badulla	42,237	■			
Kaluthara	32,417				■
Kurunegala	24,833	■			
Kegalle	15,993				■

Table 1: Case Study Area

The UN classification refers to medium towns with population size is between 1,000,000 to 5,000,000. However, according to Munasinghe (2005), these towns in Sri Lanka are classified as such when the population size reaches 200,000. As well as, the small towns, separated by the benchmark of total population less than 100,000 (as per the UN classification) will be pivotal in the future (Bandara, et al., 2010). As per the literature need to get same size area for comparison and its should be largest study area. (Al-sharif, et al., 2014). Accordingly, the selected 6km buffer zone from the city center as study area.

2.2. DATA COLLECTION AND PREPROCESSING

Land use changes and urban growth patterns were assessed using Landsat 07 ETM satellite imageries for the years 2001 and 2012. Satellite images were acquired from United States Geology Survey (USGS). Data were detected urban growth pattern and land use changes using remote sensing and GIS methods. The Image Pre-processing, Supervise Classification and Accuracy Assessment steps were used to process the data respectively.

Data	Year	Source of Data
Landsat 7 image 2001 (30m resolution)	2001	USGS
Landsat 7 image 2012 (30m resolution)	2012	USGS
Road Network (Shape file)	2011	Survey department, Sri Lanka
Population data census	2001 &2012	Census and Statistic Department, Sri Lanka
Mean income per month (per household)	2012 & 2016	Census and Statistic Department, Sri Lanka
Household data	2012 & 2016	Census and Statistic Department, Sri Lanka
Urban Infrastructure	2011	Survey department, Sri Lanka
Urban Facility	2011	Survey department, Sri Lanka

Table 2: Description of Data and Sources

2.3 COMPUTATION OF URBAN SPRAWL

The following three methods determine the level of the urban sprawl in selected small and medium towns in Sri Lanka.

2.3.1. Urban Expansion Intensity Index (UEII)

Urban Expansion Intensity Index is used to evaluate and analysis the urban spatial expansions different quantitatively. Additionally, UEII could be employed to recognize preferences of urban growth and compare the speed or intensity of urban land use changes in certain period. Equation 1 illustrates the formula to calculate UEII.

$$UEII_{it} = \left[\frac{ULA_{i,b} - ULA_{i,a}}{t}\right] / TLA_i \times 100 \quad (1)$$

Where; "$UEII_{it}$ is the annual average urban expansion intensity index of (i^{th}) zone in time period (t) $ULA_{i,a}$ and $ULA_{i,b}$ are the quantity of built-up area at time periods a and b in (i^{th}) spatial zone, respectively. TLA_i is the total area of (i^{th}) spatial zone" (Al-Sharif, et al., 2017). The division standard for interpreting UEII values ranging from 0 to 0.28, 0.28 to 0.59, 0.59 to 1.05, 1.05 to 1.92, and >1.92 indicate slow, low-speed, medium-speed, and high-speed respectively.

2.3.2 Shannon's Entropy Model

Shannon's entropy model is widely used to reveal the spatial concentration or dispersion of a given town. It can be used to evaluate the orientation and configuration of spatial patterns and the spatial variables with the integration of ArcGIS software. (Yeh & Xia, 2001)

Shannon's Entropy Model	Description
Absolute entropy $H_n = \sum_i^n P_i \log_e\left(\frac{1}{P_i}\right)$	**Pi** Proportion of the variable (built up area) in the ith zone **n** Total number of zones. The Absolute Shannon's entropy values vary between 0 and ln(n). Zero entropy value means very compact distribution and closer to log(n) denotes high dispersed distribution.
The relative value $H_n = \sum_i^n P_i \log e\left(\frac{1}{P_i}\right) / \log_e(n)$	**Pi** Proportion of the variable (built up area) in the ith zone **n** Total number of zones. The relative Shannon's entropy always varies between 0 to 1
The changing rate $\Delta H_n = H_n(t_2) - H_n(t_1)$	**Hn (t1)** Relative entropy at time(t1) **Hn (t2)** Relative entropy at time (t2)

Table 3: Description of Shannon's Entropy Model

2.3.3 Landscape Metrics

Various landscape metrics were used to analyse the spatial temporal trend of land use changes and urban growth. The study was performed using the FRAGSTATS software. The study utilized landscape matrices, as shown in Table 4.

Landscape Metrics	Description
Edge Density	$ED = \frac{E}{A}(10{,}000)$ The total length of all edge segments per ha for the class or landscape of consideration (Unit: m/ha).
Shape Index	$SHAPE = \frac{0.25P_{ij}}{\sqrt{aij}}$ SHAPE equals patch perimeter (m) divided by the square root of patch area (m2), adjusted by a constant to adjust for a circular standard (vector) or square standard (raster).
Landscape Shape Index	$LSI = \frac{0.25E}{\sqrt{A}}$ A modified perimeter-area ratio of the form:
Patch Density	$PD = \frac{N}{A}(10{,}000)(100)$ The number of patches per unit area, e.g., per km2
Simpson's Evenness Index	$SIEI = \frac{1-\sum_{i=1}^{m} P_i^2}{1-\left(\frac{1}{m}\right)}$ SIEI equals 1 minus the sum, across all patch types, of the proportional abundance of each patch type squared, divided by 1 minus 1 divided by the number of patch types.
Largest Patch Index	$LPI = \frac{MAX_{(aij)}}{A}(100)$ The ratio of the area of the largest patch to the total area of the landscape (unit: %).

Table 4: Description of Landscape Metrics

2.4 QUANTIFYING FACTORS

The below table 5 identifies 08 key factors of urban sprawl.

Urban landscape was determined based on zones. Zone 01 was considered 2km buffer from city center. It includes non-built up, built up, water distribution as percentages. Zone 2 was considered 4km buffer from city center. Overall accessibility calculates based on average, maximum, minimum and standard deviation values of closeness centrality and between centrality. Subsequently accessibility was calculated regarding the closeness centrality and between centrality in 1km buffer, 2km buffer and 4km buffer. Average values of closeness centrality and between centrality in 1km buffer were divided by 6km buffer. Also, 1km buffer divided 2km buffer and that figure divided by 4 km buffer. As well as 1 km buffer divided by 2km buffer and that figure divided by 4km and finally it divided by 6km buffer. Urban infrastructure and urban facilities were also calculated using these buffers.

Data collection through GIS analysis had to be analyzed through a quantitative data analysis method such as SPSS (Statistical Package for Social 31 Scientistic), and Microsoft Excel Functions. SPSS was the data analysis technique used for this research as it covers a broad range of statistical procedure such as Regression analysis and Correlation of the between the several methods and factors as variables.

Factors	Indicators	Method of computation
Density	Population Density	Number of population in GND area/ Total GND area
	Built-Up Density	Number of built up area/ Total Land
Growth Rate	Population Growth Rate	Divide both sides by past figure, take the exponent to 1/n, then subtract 1.
	Built -Up Growth Rate	Divide both sides by past figure, take the exponent to 1/n, then subtract 1
	Economic Growth Rate	Divide both sides by past figure, take the exponent to 1/n, then subtract 1
Accessibility (Road Network)	Closeness Centrality	$CC = (N-1)/\sum_{j=1}^{k} Lij$
	Between Centrality	$CBk = \frac{\sum P_{ij}(K)}{(N-1)(N-2)}$

Urban Form	Linear, Satellite, Poly- Centric, Mono-Centric	Based on (Munasinghe, 2005)
Street pattern	Micro and Macro	Based on (Marshall, 2005)
Urban Landscape	Built up, Non-Built up and Water bodies	
Urban Infrastructure	Drinking and Lighting	$\frac{(Drinking \times Lighting)1/2 \times GND\ Area}{Total\ area}$
Urban Facility	Having access to urban facility	$\frac{Non\ weight \times GND\ Area}{Total\ area}$

Table 5: Description of Quantifying factors

3. Analysis and Results

3.1. QUANTIFYING LEVEL OF URBAN SPRAWL

3.1.1 Intensity of Urban Expansion Intensity Index

Towns	UEII	Agreement				
		Slow	Low-Speed	Medium-Speed	High-Speed	Very High Speed
Kurunegala	0.196	√				
Badulla	0.119	√				
Kandy	0.162	√				
Trincomalee	0.134	√				
Anuradhapura	0.096	√				
Rathnapura	0.037	√				
Kegalle	0.041	√				
Negombo	0.762			√		
Galle	0.254	√				
Kalutara	0.256	√				

Table 6: Values of the Urban Expansion Intensity Index

The result shows that Negombo has highest intensity of urban expansion index of 0.762 which medium urban expansion speed. The town displays the spatial characteristic of Mono-centric urban form. The Rathnapura town has lowest intensity of urban expansion index of 0.037 which slow urban expansion speed. Rathnapura town displays the spatial characteristic of satellite urban form.

3.1.2 Shannon's Entropy and Sprawl

Figure 1 illustrates the Shannon's Entropy for each town from 2001 to 2012. The concept of the Shannon's Entropy was to divide the towns into four zones based on the 2000m intervals around the city centers.

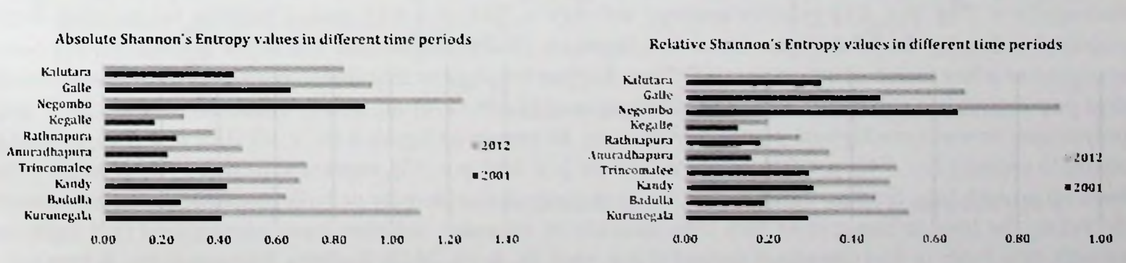


Figure 1: Shannon's Entropy Values for 2001 to 2012

The absolute value of Negombo is higher than the mid-point of $\log_e$ (i.e., 0.693), which indicates that its urban sprawl is uncontrolled. The relative entropy value was also higher in 2001 and 2012. The absolute and relative entropy values of Kegalle town is lowest in 2001 and 2012. The positive change in Kalutara Town was experienced than the other towns. The study also noted that the need for a sustainable urban management plan is crucial to control the urban growth.

3.1.3 Landscape Metrics

The rapid urban expansion in Sri Lanka has been observed in the past decade (2001 to 2012). Negombo and Kurunegala towns have shown significant increases in Patch Density and Edge Density. Huge increases reveal a high urban scatter and irregular formation of isolate urban patches. Patch Density and Edge Density have decreased in the entire study areas, especially Kegalle and Rathnapura. Totally, the Large Patch Index metric has decreased from 2001 to 2012. The huge urban patches have gradually shrunk. The SHAPE Metrics and Landscape metrics indicated the irregularity of the landscape. Landscape metrics revealed the uncontrolled growth and urban sprawl that occurred from 2001 to 2012.

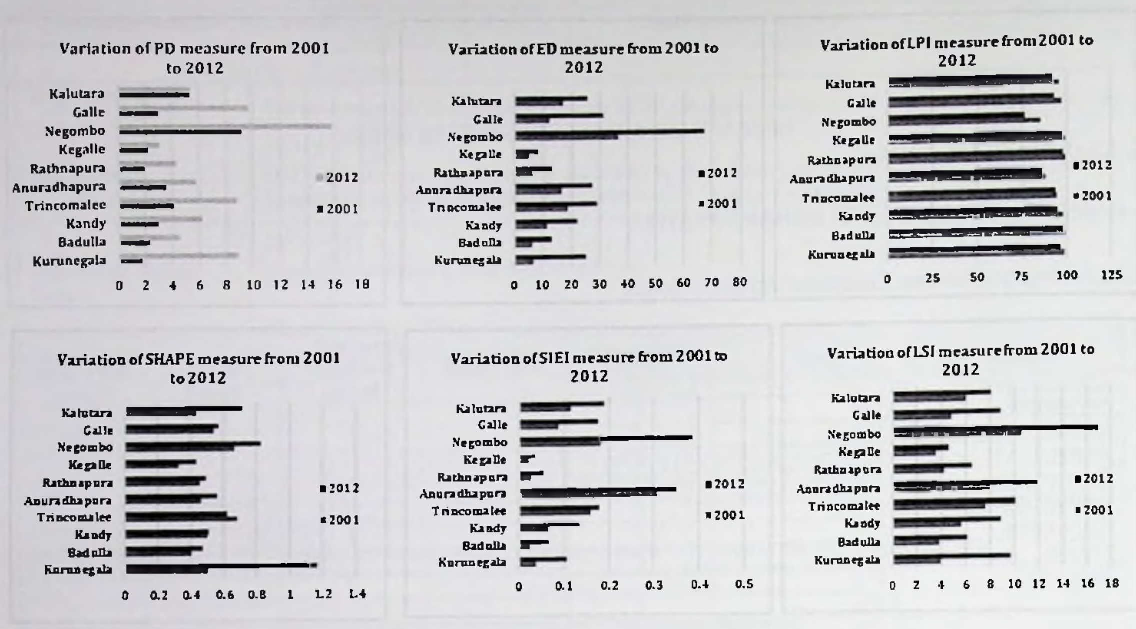


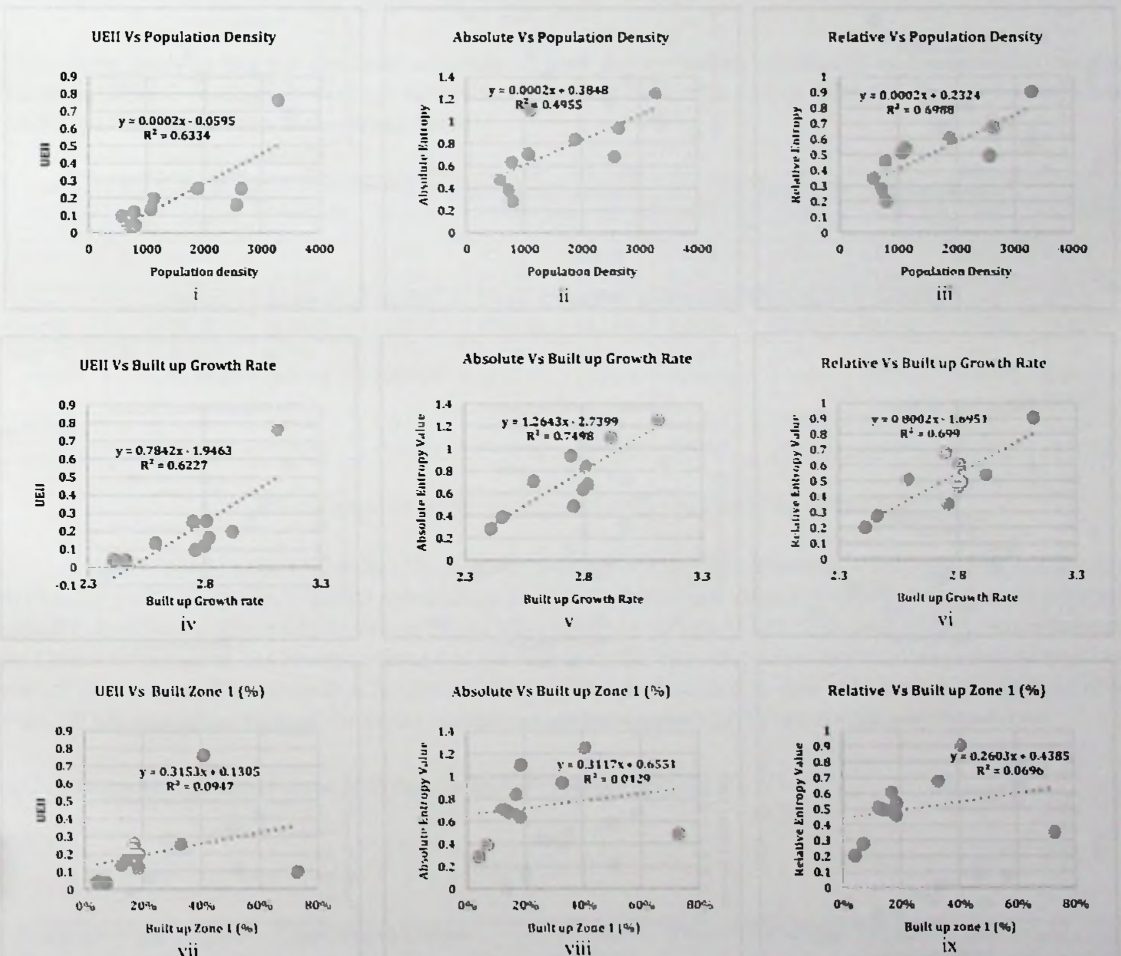
Figure 2: Variation of Landscape Metrics in Different Time Period

3.2. RELATIONSHIP ANALYSIS

Bivariate Pearson correlation coefficient test in SPSS (Statistical Package for social Science) software was utilized to test the relationship between the level of urban sprawl and factors (population density, built up density, population growth rate, built up growth rate, economic growth rate, urban forms, street patterns, urban landscape, accessibility, urban infrastructure and urban facilities.). Following figures 3 & 4 show positive and negative relationship with red, pink, green and blue color represent Mono-Centric, Poly-Centric, satellite, and Linear urban form respectively.

According to the below illustrated figure 3 (i, ii, iii) highlight that UEII ($r = .879$, $p < .01$), absolute entropy ($r = .794$, $p < .01$), relative entropy value ($r = .842$, $p < .01$), reveal positive relationship with population density. Sudhira, Ramachandra, & Jagadish, (2004) stated that "the factor population has been accepted as a key factor of urban sprawl". They further emphasize that linear regression analyses reveled that population is a significant factor of urban sprawl (Sudhira, et al., 2004). However, monocentric and polycentric towns have highest population density. As shown as figure 3 (iv, v, vi) UEII ($r = .745$, $p < .01$), absolute entropy ($r = .745$, $p < .01$), relative entropy ($r = .661$, $p < .05$), represent positive relationship with built up growth rate. Finding indicate that when the population density or built up growth rate increase or decrease, the level urban sprawl may also increase or decrease. Scholars have emphasized that built up growth rate seem to fuel the urban sprawl (Liua, Liua, Qi, & Jin, 2018; Sudhira, Ramachandra, & Jagadish, 2004). Figure 3 (vii, viii, ix) signify some of positive relationships among UEII ($r = .855$, $p < .01$), absolute entropy ($r = .903$, $p < .01$), relative entropy ($r = .891$, $p < .01$), and built up zone 01. Result indicates that if the percentage of built up area within 2km from city center increase or decrease, the level of urban sprawl may also increase or decreases. In addition, figure 3 (x, xi, xii) indicate that UEII ($r = .939$, $p < .01$), absolute entropy ($r = .927$, $p < .01$), relative entropy ($r = .988$, $p < .01$), reveal positive relationship with built up zone 02. It describes that when the percentage of built up area within 4km from city center increase or decrease the level of urban sprawl may also increase or decrease. The Negombo town with monocentric has highest deviation rather than other towns. Below figure 3 (xiii, xiv, xv) revealed the positive relationship for UEII ($r = .648$, $p < .05$), absolute entropy ($r = .648$, $p < .05$), relative entropy ($r = .685$, $p < .05$), against the average value of closeness centrality. Figures 3 (xvi, xvii, xviii) show that UEII ($r = .758$, $p < .01$), absolute entropy ($r = .782$, $p < .01$), relative entropy ($r = .855$, $p < .01$) signify the positive relationship with minimum value of between centrality. Result indicates that increase of overall accessibility increases the level of urban sprawl. The findings contradict the related literatures. Because many literature indicated that poor accessibility leads to urban sprawl whereas high accessibility reduce the level of urban sprawl (Frenkel & Ashkenazi, 2008; Ewing, et al., 2002; Torrens & Alberti, 2000).

Figure 4 (vii, viii, ix) show that UEII (r = .758, p < .01), absolute entropy (r = .721, p < .01), relative entropy reveal (r = .794, p < .01) significant coefficient of correlation with changes in closeness centrality of center compare to periphery area. As correlation of those indicators are negative it can be signified that if the closeness centrality of center compare to periphery area increases, level of urban sprawl decreases. Figure 4 (x, xi, xii) show that UEII (r = .855, p < .01), absolute entropy (r = .692, p < .05), relative entropy (r = .794, p < .01) reveal negative relationship with changes in betweenness centrality of center compare to periphery area increase, the level of urban sprawl decrease. This can be considered as a novel finding of the study compare to contemporary literature. Figure 4 (i, ii, iii) revealed the negative relationship for UEII (r = .964, p < .01), absolute entropy (r = .903, p < .01), relative entropy (r = .964, p < .01) against the built-up density. It clarifies that when the built-up density increases the level of urban sprawl decrease. Most of scholars utilize the concept of low-density development to define urban sprawl (Sinha, 2016; Unicef, 2012; Ewing, et al., 2002; Lowry & Lowry, 2014). Nevertheless, this has not been adequately or quantitatively explained (Chin, 2002). Figures 4 (iv, v, vi) show UEII (r = .745, p < .01), absolute entropy (r = .721, p < .01) and relative entropy (r = .770, p < .01) signify negative relationship with non-built up zone 1. It can be concluded that if the percentage of non-built up area within 2km area from the city center increase the level of urban sprawl decrease. Because, non-built up area has been changed into build up area and city center (Bhat, et al., 2017).



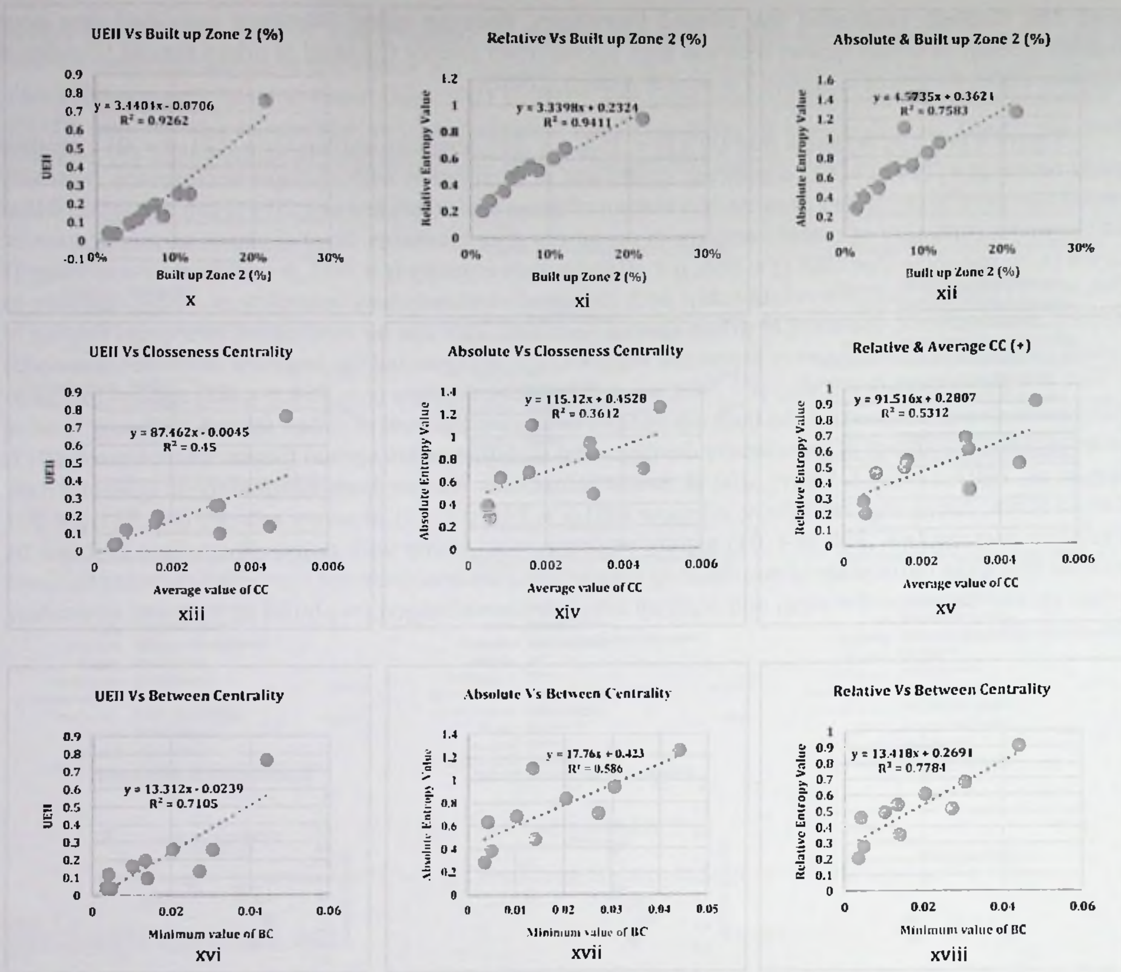
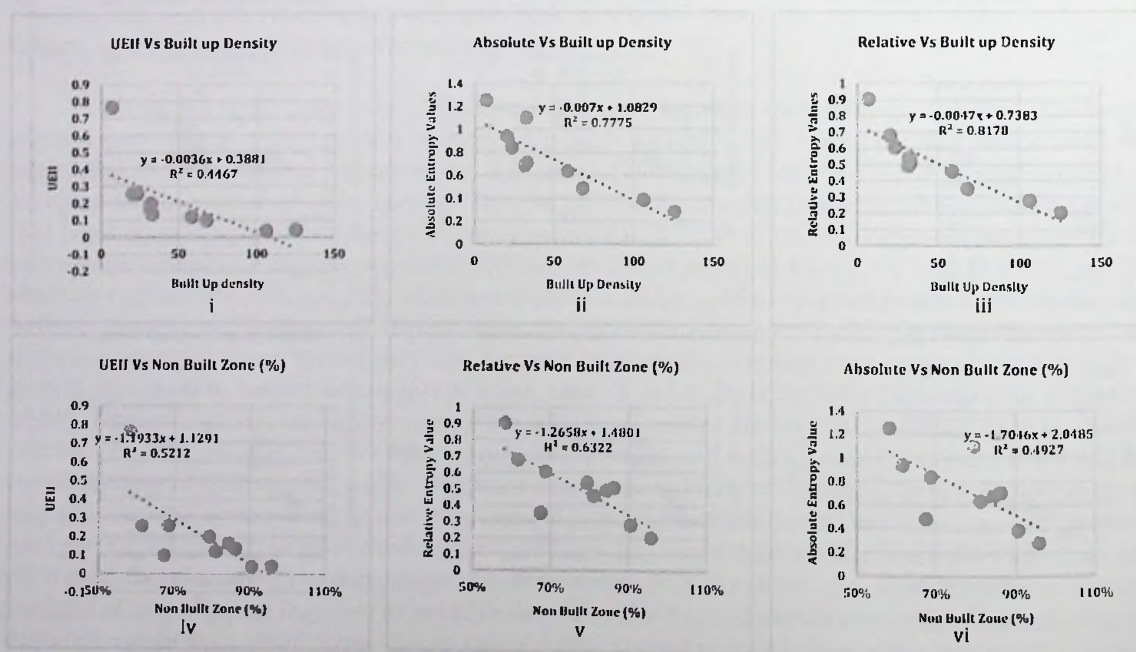


Figure 3: Positive Relationship between Level of Urban Sprawl and Factors



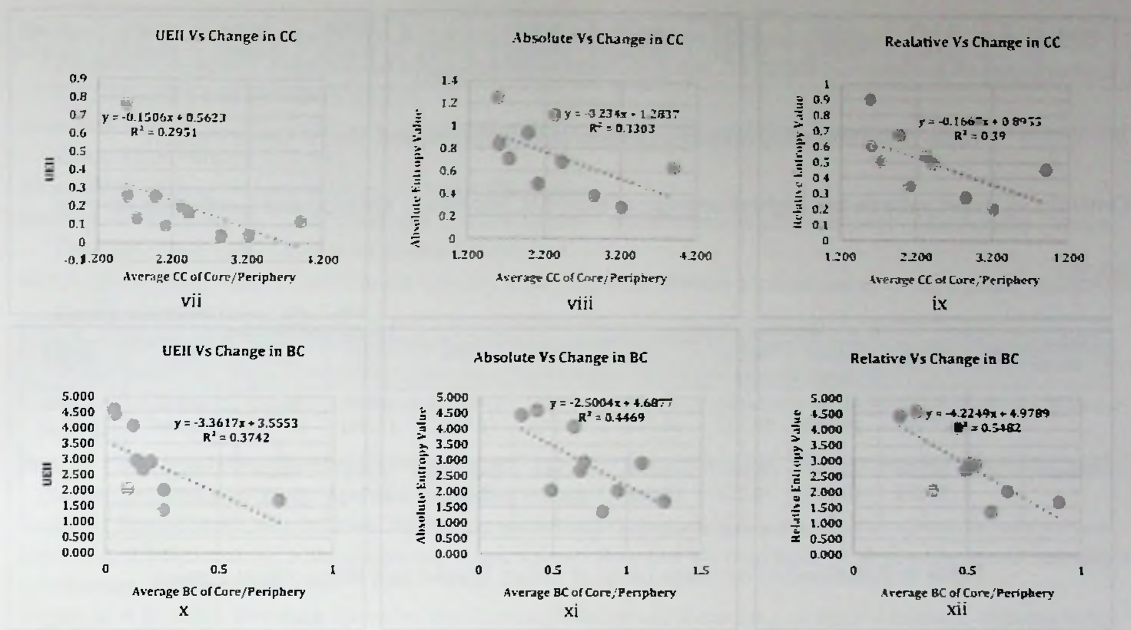


Figure 4: Negative Relationship between Level of Urban Sprawl and Factors

3.2.1 Relationship between Urban Sprawl and Urban Form

Urban form analysis against the level of urban sprawl demonstrates significant and sequential results. Following table 7 consists in average values and standard deviation values UEII, Shannon's Entropy and Landscape Metrics in each of the urban form.

Urban Form	No	UEII	Shannon's Entropy			Landscape Metrics					
			Absolute	Relative	CR	PD	LPI	ED	LSI	SIEI	SHAPE
Linear	2	0.149 (0.152)	0.559 (0.394)	0.403 (0.284)	0.174 (0.143)	0.018 (0.026)	(-0.002) (0.001)	0.056 (0.011)	0.03 (0.002)	0.057 (0.002)	0.043 (0.020)
Mono Centric	3	0.359 (0.351)	0.995 (0.322)	0.632 (0.237)	0.250 (0.012)	0.171 (0.167)	(-0.004) 0.004	0.140 (0.091)	0.080 (0.045)	0.143 (0.036)	0.052 (0.059)
Poly Centric	3	0.183 (0.063)	0.775 (0.141)	0.559 (0.102)	0.198 (0.015)	0.135 (0.060)	(-0.002) (0.001)	0.093 0.046)	0.053 (0.024)	0.065 (0.047)	(-0.001) (0.007)
Satellite	2	0.066 (0.042)	0.434 (0.070)	0.313 (0.051)	0.142 (0.066)	0.080 (0.038)	(-0.001) (0.001)	0.079 (0.026)	0.048 (0.004)	0.052 (0.055)	0.014 (0.009)

Table 7: Relationship between Level of urban Sprawl and Urban Form

Mono centric urban form has the highest average of the UEII, Shannon's Entropy, and Landscape Metrics. In addition to that, Satellite urban form have lowest average values of UEII and Shannon's entropy values. Correspondingly, satellite urban forms have lowest average of LPI, SIEI, and SHAPE. Nevertheless, the Linear urban form has lowest average of PD, ED, and LSI. The contemporary studies revealed that the level of urban sprawl is minimal in Satellite towns which are designed to deal with issues of urban sprawl (Puri, 2019) and urban sprawl for mono centric is comparatively high (Tsai, 2005).

3.2.2 Relationship between Level of Urban Sprawl and Street Pattern

MACRO

Urban Form	No	UEII	Shannon's Entropy			Landscape Metrics					
			Absolute	Relative	CR	PD	LPI	ED	LSI	SIEI	SHAPE
Centralized	8	0.220 (0.229)	0.772 (0.300)	0.525 (0.194)	0.203 (0.053)	0.135 (0.103)	(-0.003) (0.003)	0.107 (0.062)	0.062 (0.031)	0.091 (0.058)	0.023 (0.041)

Linear	2	0.149 (0.152)	0.559 (0.394)	0.403 (0.284)	0.174 (0.143)	0.018 (0.026)	(-0.002) (0.001)	0.056 0.011)	0.030 (0.002)	0.057 (0.002)	0.043 (0.020)

Table 8: Relationship between Level of Urban Sprawl and Macro Street Pattern

Centralized street pattern has highest average of the UEII, Shannon's Entropy and Landscape metrics.

MICRO

Urban Form	No	UEII	Shannon's Entropy			Landscape Metrics					
			Absolute	Relative	CR	PD	LPI	ED	LSI	SIEI	SHAPE
Grid	4	0.161 (0.067)	0.702 (0.185)	0.507 (0.137)	0.196 (0.013)	0.115 (0.064)	(-0.002) (0.001)	0.085 (0.041)	0.051 (0.020)	0.052 (0.046)	0.005 (0.012)
Linear	6	0.235 (0.272)	0.748 (0.387)	0.497 (0.251)	0.199 (0.090)	0.110 (0.130)	(-0.003) (0.003)	0.105 0.071)	0.059 (0.037)	0.106 (0.049)	0.041 (0.042)

Table 9: Relationship between Level of Urban Sprawl and Micro Street Pattern

Overall, the result shows that Grid street patterns has lowest average values and standard deviation. This can be considered as a novel finding of the study compare to contemporary literatures.

4. Discussion & Conclusion

The study investigates the urban sprawl of small and medium towns with objective of identify the significant factors which influence on the level of urban sprawl. In order to achieve the main objective, the study was consisted of three stage. In the first stage of the study reviewed literature on methods which are utilized to measure level of urban sprawl and influence factors on level of urban sprawl. In the second stage, Urban Expansion Intensity Index, Shannon's Entropy value and Landscape metrics were used to measure the level of urban sprawl of each case study areas. The third stage, the study analysis the relationship between factors and level of urban sprawl. The key findings of the study are summarized as follows:

- The simple and significant analysis tool based on built-up area data, can be especially utilized for identifying and measuring urban sprawl.
- The study able to demonstrate level of urban sprawl is change based on method utilized in the quantification process.
- The study able to identify the key factors influence on level of urban sprawl.
- The study able to demonstrate influence of type of urban form, type of street pattern and changes in accessibility of center compare to periphery area on level of urban sprawl.

In conclusion, urban and regional planner, policy makers, academics, and researchers who more concerned with urban sprawl benefited based on the results presented in this research paper. Because the study confirm that level of urban sprawl will changes based on the method of quantifying urban sprawl and it is worthwhile to quantifying urban sprawl by utilizing the various method while capturing multidimensions.

The study analysis only 10 case studies in Sri Lanka and temporal analysis limited to two time series. Therefore, the study suggested to expand the study by doing more case Sri Lanka as well as International and enhance analysis, to increase the applicability and accuracy of the results.

5. References

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