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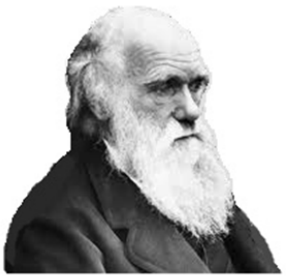

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The Impacts of Population Growth on the Land use Changes in Batticaloa Municipal Council, Sri Lanka

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ABSTRACT

Urbanization is a new development of city centres within its original boundaries to satisfy a growing population. Today, rapid population growth collapses the land use pattern due to the developments of housing and infrastructure. This study aims to identify the impacts of population growth on land-use changes in the Batticaloa Municipal Council. Various methods were used to interpret and analyze the maps, such as the supervised maximum likelihood classification, density analysis, and Pearson's correlation coefficient analysis. The results revealed that a high population density was identified near the core city, which decreases from the city centre to the city limits. Commercial and residential categories strongly correlated with population growth, and agriculture mostly closed at a significant level. Rest categories were insignificant with population growth. Thus, land use planning should be implemented to control the effects on land use.

Keywords: Land use, residential, commercial, population growth, Batticaloa Municipal Council

1. INTRODUCTION

Different sizes and shapes of landscape elements are known as landscape patterns, which are spatially arranged, based on the utilization. Natural factors and human activities influence significant changes in these patterns. Human activities, including urbanization, population growth, and residential development, disrupt environmental attitudes in the landscape pattern (Dadashpoor, Azizi, and Moghadasi, 2019; Sati and Danwalis, 2020).

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Humans have played a vital role in the land use transformation worldwide (Heidarlou *et al*., 2019; Noszczyk, 2019), as the transformation of these land-use patterns changed due to the rapid population growth that is affecting urban expansion (Dadashpoor, Azizi, and Moghadasi, 2019). Understanding the dynamics of land-use change has become vital for a sustainable growth and utilization in developing countries. Land use generally mentions how the land associated with biophysical elements was used as agriculture, residential, and commercial. Land coverage also denotes actual biophysical coverage at the earth's surface (Msofe, Sheng, and Lyimo, 2019). Nowadays, land is becoming a scarce resource due to the population growth and current commercialization. Population growth has not only resulted in an uncontrollable expansion of the Batticaloa region but has also caused changes in the land use. The population and urban growth are making the maximum exploitation of land use in this area. This utilization involves many changes in the land use, such as the construction of land that cuts the vegetation cover and agricultural land that directly affects the natural environment. It is an important task to understand the effects of land use for sustainable development. Therefore, this study aims to identify the impact of population growth on land-use changes in the Batticaloa Municipal Council.

2. METHODOLOGY

2. 1. The Study Area

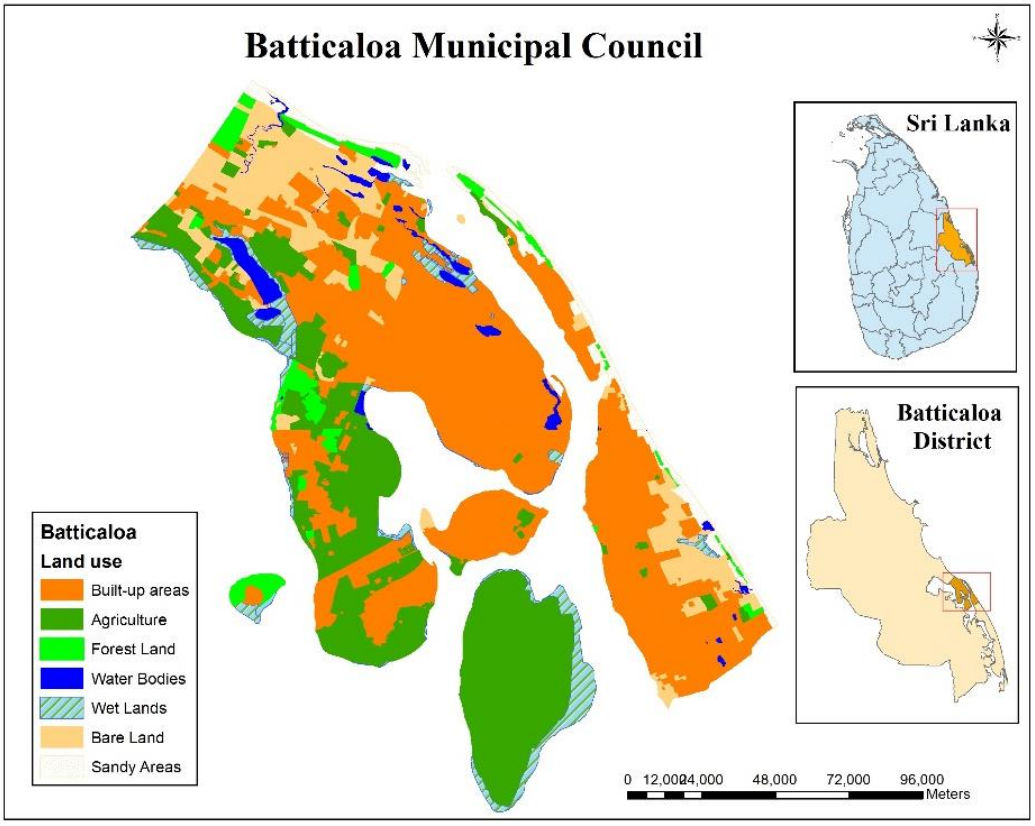

Figure 1. The study area - Batticaloa Municipal Council
(Modified from the Batticaloa MC Profile, 2020)

Batticaloa city is located on the east coast of Sri Lanka. The elevation of this area is 8,523 m. This area consists of 93,306 populations, and the population growth of this city has a high growth rate leading to the fastest growth of Sri Lankan cities. The population growth rate was 1.57% in the period 1971-1981, an increased to 2.07% during 2001-2010, and the level of population growth is approximately 2.5 to 3.0% now (Statistical Hand Book, 2019).

Batticaloa municipality has five (5) separate parcels with built-in water bodies. These parcels are connected to the bridges for transportation. This area shows the cluster development in each sector like commercial, recreational and settlement areas. This area is made up of different sectors, such as fishing, agriculture, small industries, and commercials. Therefore, this area should encompass changes in the land use.

2. 2. Data Sources

Different layers of maps are needed to understand the impact of population growth on the land use pattern. QGIS 3.10, Google Earth Pro, IBM SPSS 26.0 application software, and MS-Excel 2013 were used to produce the map layers and analyze the data. Land use maps were developed using satellite imagery, and population density maps developed using existing boundary maps of the Grama Niladhari Division and census data of the Batticaloa Municipality.

All four-satellite imagery scenes in 1990, 2000, 2010, and 2020 were downloaded from Earth Explorer, the US Geological Survey, which is Landsat TM (25-MAY-90), Landsat ETM+ (28- SEP-00), Landsat TM (24-SEP-10), Landsat 8 (03-MAR-20). Training ground samples were collected for classification with Google Earth Pro. Population data were obtained from the Census and Statistics Department, Sri Lanka. The closest figures from the 1992, 2002, 2010, and 2019 censuses were used to develop the population density map to identify population growth. These data were compared with the land use images.

2. 3. Data Analysis

A Supervised Maximum Likelihood classification is a type of classification method that classifies the land use pattern using training samples. These samples determine each class based on the most similarity in the training samples to carry out the classification (Msofe, Sheng and Lyimo, 2019). Seven land use classes were obtained as commercial (1), residential (2), agriculture (3), scrubland (4), mangrove (5), water bodies (6) and barren land (7) to understand the characteristics of the change in the land use. One hundred ninety-one (191) training samples based on the grid layout method were randomly selected for the years 1990, 2000, 2010, and 2020, which were distributed as 27 samples for commercial, 53 for residential, 32 for agriculture, 17 for scrubland, 21 for mangroves, 14 for water, and 27 for barren land. The grid cells in the classified maps were used to investigate the dynamics of changes in the land use. This method helps to identify how the land-use class changes for the selected periods.

The population distribution of the study area was developed for the Grama Niladhari divisions using density analysis. Changes in the population growth were understood by the mapping years 1992, 2002, 2010, and 2019. Bagan and Yamagata (2012) used the grid cells to investigate the spatial relationship between changes in the land use and changes in population density. Moreover, land use classes and changes in population density were also calculated with correlation coefficients at three (3) intervals in their study. Therefore, Pearson's correlation coefficient analysis was used to find the relationship between each indicator for the land-use class and population growth. The value of the correlation coefficient varies between +1 and –1.

The sign in the coefficient indicates the direction of the relationship: a + sign indicates a positive relationship, and a "–" sign indicates a negative relationship. The significant level below 0.05 shows positively significant and above 0.05 is negatively significant.

3. RESULTS AND DISCUSSION

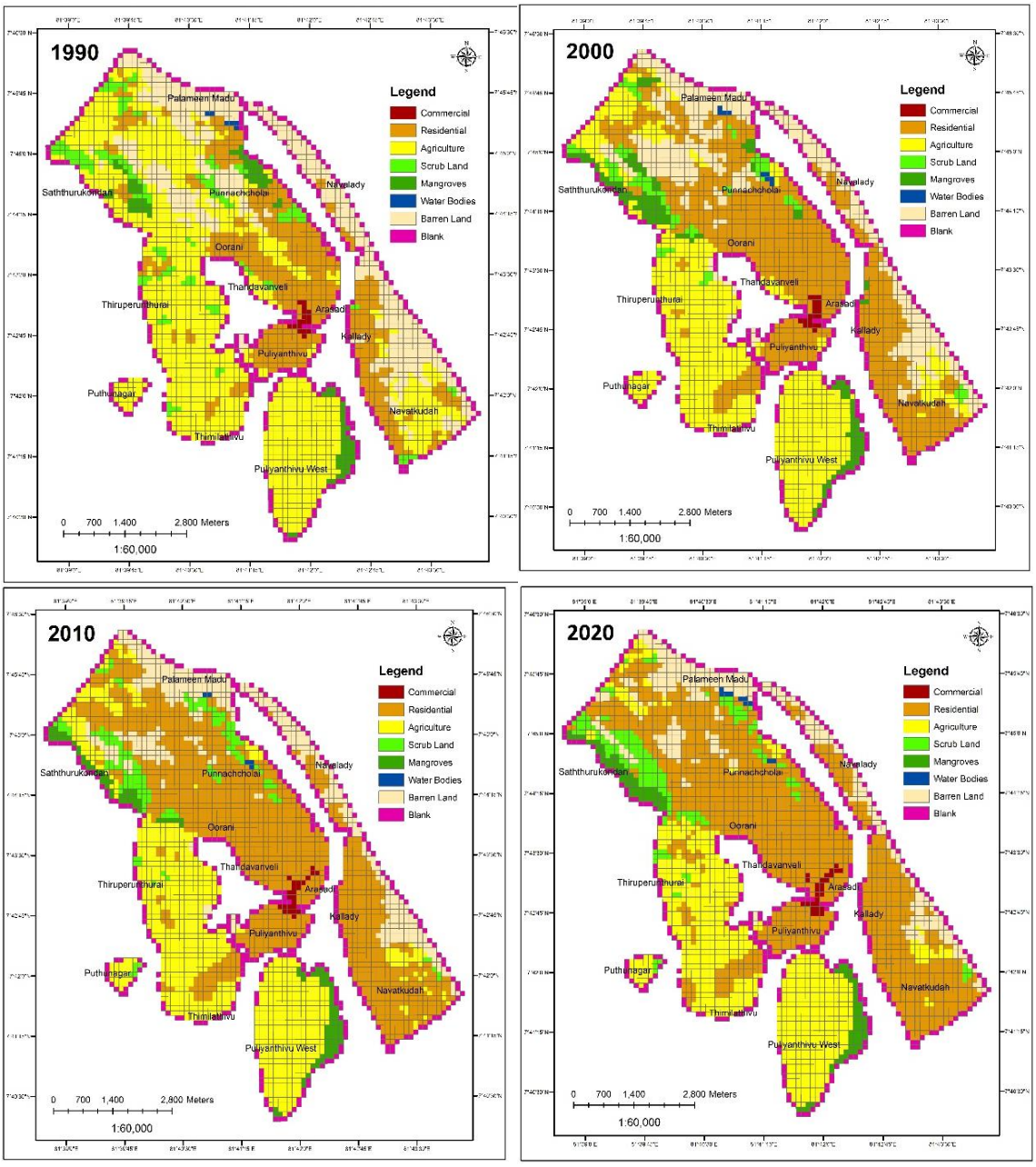

Figure 2. Land use patterns of Batticaloa MC from 1990 to 2020 (Based on the Landsat images 1990 – 2020)

The most important categories for the land use in Batticaloa are commercial, residential, agricultural, scrubland, mangrove, water bodies, and barren land were classified to understand the impact of population growth. The following maps (**Figure 2**) show the land use patterns for the Batticaloa area for the years 1990, 2000, 2010, and 2020.

The proportion of land use changed from year to year as identified by the web map analysis. **Tables 1** to **4** shows the changes in the land use from 1990 to 2020.

Table 1. The proportion of land usage in 1990.

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Commercial	17	.4	.4	.4
	Residential	772	20.0	20.0	20.5
	Agriculture	1637	42.5	42.5	63.0
	Scrub land	174	4.5	4.5	67.5
	Mangroves	104	2.7	2.7	70.2
	Water	6	.2	.2	70.4
	Barren land	706	18.3	18.3	88.7
	Blank	435	11.3	11.3	100.0
	Total	3851	100.0	100.0	

Table 2. The proportion of land usage in 2000.

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Commercial	20	.5	.5	.5
	Residential	1338	34.7	34.7	35.3
	Agriculture	1159	30.1	30.1	65.4
	Scrub land	110	2.9	2.9	68.2
	Mangroves	164	4.3	4.3	72.5
	Water	9	.2	.2	72.7

	Barren land	630	16.4	16.4	89.1
	Blank	421	10.9	10.9	100.0
	Total	3851	100.0	100.0	

Table 3. The proportion of land usage in 2010.

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Commercial	24	.6	.6	.6
	Residential	1597	41.5	41.5	42.1
	Agriculture	1056	27.4	27.4	69.5
	Scrub land	159	4.1	4.1	73.6
	Mangroves	114	3.0	3.0	76.6
	Water	5	.1	.1	76.7
	Barren land	469	12.2	12.2	88.9
	Blank	427	11.1	11.1	100.0
	Total	3851	100.0	100.0	

Table 4. The proportion of land usage in 2020.

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Commercial	27	.7	.7	.7
	Residential	1724	44.8	44.8	45.5
	Agriculture	957	24.9	24.9	70.3
	Scrub land	188	4.9	4.9	75.2
	Mangroves	117	3.0	3.0	78.2
	Water	10	.3	.3	78.5

	Barren land	404	10.5	10.5	89.0
	Blank	424	11.0	11.0	100.0
	Total	3851	100.0	100.0	

The change matrix was prepared according to the use classification from 1990 to 2020 (**Table 5**). A change detection matrix was prepared to understand the land encroachment for different land categories between 1990 and 2020. The highest conversion is around 689.05 hectares of agricultural area converted to the residential area, 98.55 hectares of land under barren land. However, a small area of almost 2.76 hectares of the commercial became a residential area, although, scrubland only 141.62 hectares became residential, and 49.36 hectares of land became agriculture. The residential area of approximately 22.54 hectares became a commercial area, including 26.15 hectares in agriculture. About 348.08 hectares of barren land was converted into residential, 15.90 hectares of area under agricultural land. Almost 26.59 hectares of mangrove have changed as scrubland, 16.60 hectares under agriculture.

Table 5. Land-use change matrix between 1990 and 2020 (hectares).

		Land use 2020 (ha)						
		Commercial	Residential	Agriculture	Scrub Land	Mangroves	Water	Barren Land
Land use 1990	Commercial	**10.60**	2.76	0.00	0.00	0.00	0.00	0.00
	Residential	22.54	**863.61**	26.15	16.78	0.00	0.28	16.31
	Agriculture	0.00	689.05	**1046.16**	57.52	31.41	0.00	98.55
	Scrub Land	0.00	141.62	49.36	**100.87**	9.40	3.41	6.71
	Mangroves	0.00	4.83	16.60	26.59	**95.22**	0.44	1.53
	Water	0.00	0.39	0.09	16.19	0.00	**5.69**	0.08
	Barren Land	0.00	384.08	15.90	20.77	0.00	3.64	**365.94**

The population growth exploited agricultural land and other land areas. Overcrowd of the population directly affected the other land area. For example, human needs, such as houses, shops, roads, and other buildings were formed, resulting in the reduction of the other land area. The agricultural area near the city centre was transformed into housing during this period, for example, Thandavavely (**Figure 3**).

2004 **2020**

Figure 3. Conversion of agriculture area to built-up area in Thandavanvely

Table 1 illustrates that a high proportion of the agricultural area became a residential area in the selected periods. The rapid urban growth of post-civil war has profoundly affected the enormous land use. The increase in the buildup area has resulted in the high growth in urban change.

Table 6 displays that 76.3% of the land was utilized for the same category from 1990 to 2020. Among them, 29% of the land has been used for agricultural purposes from 1990 to 2020. The land was followed by 18.9% for residential, 0.3 for commercial use and 2.1 for water bodies. According to this, the rest, 23.7% were transformed and used for other categories.

The distribution of the population of the study area has varied throughout the region. Some areas have a highly populated division, and others are a low population division that showed an unequal distribution of this area. The total population in this area in 1992 was approximately 71,910, in 2002 about 78,480, in 2010 around 91,525, and in 2019 nearly 93,306. The average population density is 2,253 per km^2.

Table 6. The proportion of land with no change.

		Frequency	Per cent	Valid Percent
Valid	Only for commercial purpose	11	.3	0.3
	Only for residential purpose	653	17.0	18.9
	Only for agricultural purpose	1001	26.0	29.0
	Remaining Scrubland	45	1.2	1.3

	Remaining Mangroves	148	3.8	4.3
	Only for getting water	74	1.9	2.1
	Remaining Barren land	296	7.7	8.6
	Blank	402	10.4	11.7
	Total	**2630**	**68.3**	**76.3**

There is a gradual population growth in this area. The high population has been identified near the hospital, the school, the main road, and the shopping area. Other areas have an average population. There is little or no population in the paddy area, the forest area, and some area of barren land.

When population growth was observed in this area, the density gradually decreased from the town centre. In some developed areas, apart from the town centre, which is the school, the university and the hospital, the population density is high. As usual, the population density is very low in the study area. In 1992 and 2002, the high population growth was experienced due to the increases of human migration to the urban area for security reasons of civil war.

Table 7 shows the relationship between population growth and land use categories with a significant level below 0.01 and 0.05. The relationship between population and commercial, the correlation value is 0.968, and that is significant at the 5% level because the significant value (0.007) is less than the significant level of 0.05, which is a strong relationship. Due to this, it can be concluded that there is a statistically significant relationship between the variables.

The relationship between population and residential, the correlation value is 0.904, and it is significant at the 5% level because the significant value (0.035) is less than the significant level of 0.05, which is statistically a strong relationship between the variables. The expansion of commercial and residential gradually increased from 1990 to 2019. Also, the number of the population showed an intensive growth. Therefore, it was established that the importance of these variables is more reliable from the analysis.

The correlation value between population and agriculture is –0.866, which is insignificant at the 5% level because the significant value (0.058) is higher than the significant level of 0.05 due to the migration from the rural area that affected the agricultural land. People violated agricultural land in Batticaloa MC for residential purposes. However, the correlation value was very close to a significant level.

The relationship between the population and the scrubland, the correlation value is –0.591 and that it is insignificant at the 5% level, because of the significant value (0.294) is higher than the significant level of 0.05, which is a negative impact between the variables.

The correlation between the population and mangroves is –0.032 and it is insignificant at the 5% level. Because the significant value (0.959) is higher than the significant level of 0.05, this is a very negative relationship between the variables.

The relationship between population and water bodies, the correlation value is –0.703, and that is insignificant at the 5% level. Because the significant value (0.166) is higher than the significant level of 0.05, so it has a negative correlation between the variables.

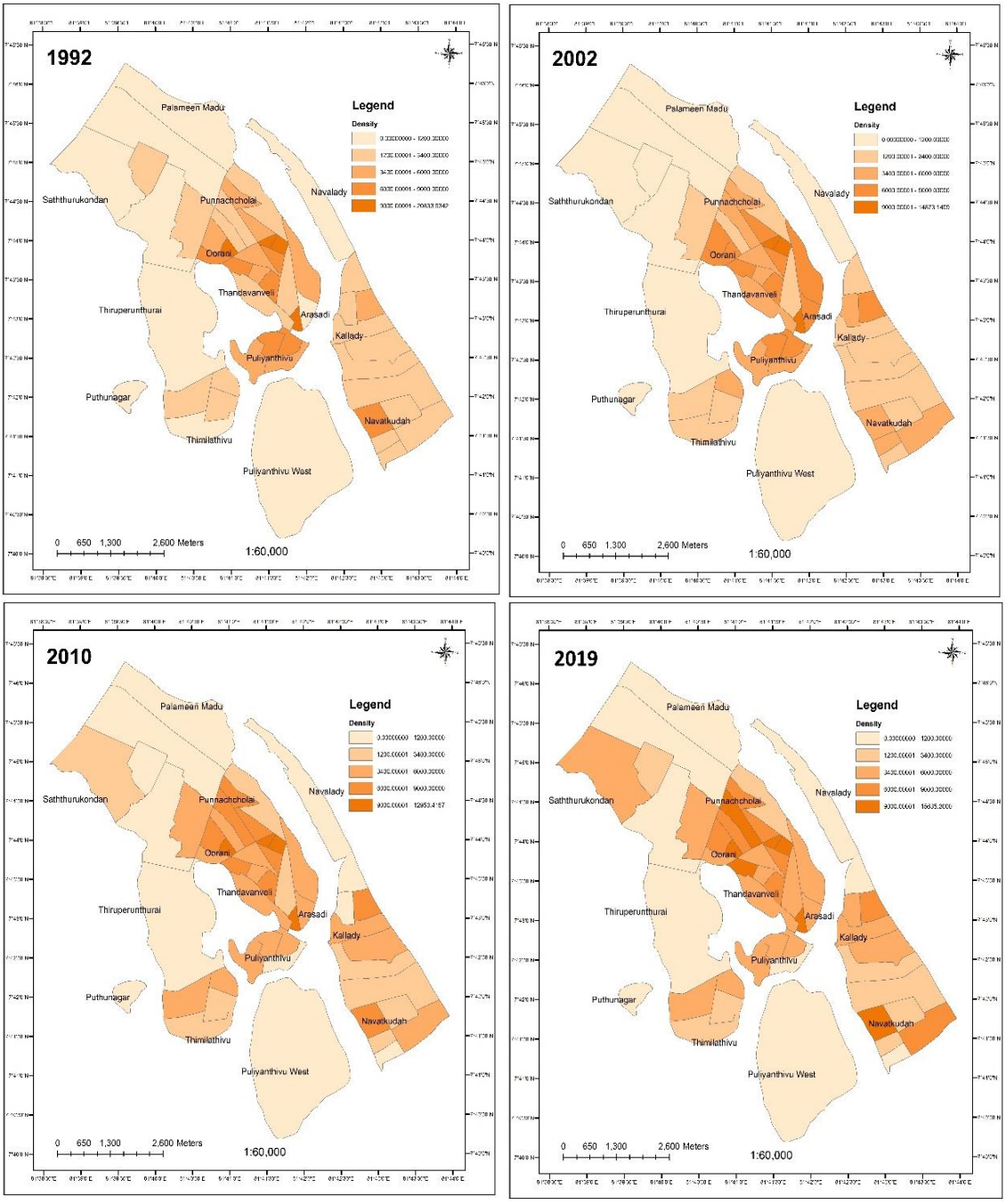

Figure 4. Population density of Batticaloa Municipal Council (Based on the Census data)

The correlation between the population and the barren land is –0.758, and that is insignificant at the 5% level. Because the significant value (0.116) is greater than the significant level of 0.05, so due to this, it can be concluded that there is a statistically insignificant relationship between the variables. Two categories of land use only have positive significant level with population growth, which are commercial and residential. Rest categories are

insignificant with the population growth. Furthermore, agriculture is very close to a significant level. According to the results, it was revealed that human impact, such as buildings, roads and drains, has interrupted the categories of land use.

Table 7. Correlation between population and land use categories.

Correlations									
		Popula-tion	Com-mercial	Residen-tial	Agricul-ture	Scrub Land	Man-groves	Water	Barren Land
Population	Pearson Correlation	1	.968**	.904*	–.866	–.591	–.032	–.703	–.785
	Sig. (2-tailed)		.007	.035	.058	.294	.959	.186	.116
	N	5	5	5	5	5	5	5	5
Commercial	Pearson Correlation	.968**	1	.925*	–.894*	–.469	–.026	–.528	–.848
	Sig. (2-tailed)	.007		.024	.041	.426	.967	.360	.069
	N	5	5	5	5	5	5	5	5
Residential	Pearson Correlation	.904*	.925*	1	–.992**	–.462	.140	–.401	–.916*
	Sig. (2-tailed)	.035	.024		.001	.433	.822	.504	.029
	N	5	5	5	5	5	5	5	5
Agriculture	Pearson Correlation	–.866	–.894*	–.992**	1	.500	–.257	.362	.880*
	Sig. (2-tailed)	.058	.041	.001		.392	.676	.549	.049
	N	5	5	5	5	5	5	5	5
Scrub Land	Pearson Correlation	–.591	–.469	–.462	.500	1	–.607	.810	.078
	Sig. (2-tailed)	.294	.426	.433	.392		.277	.096	.901
	N	5	5	5	5	5	5	5	5
Mangroves	Pearson Correlation	–.032	–.026	.140	–.257	–.607	1	–.033	.184
	Sig. (2-tailed)	.959	.967	.822	.676	.277		.957	.767
	N	5	5	5	5	5	5	5	5
Water	Pearson Correlation	–.703	–.528	–.401	.362	.810	–.033	1	.148
	Sig. (2-tailed)	.186	.360	.504	.549	.096	.957		.812
	N	5	5	5	5	5	5	5	5
Barren Land	Pearson Correlation	–.785	–.848	–.916*	.880*	.078	.184	.148	1
	Sig. (2-tailed)	.116	.069	.029	.049	.901	.767	.812	
	N	5	5	5	5	5	5	5	5

*. Correlation is significant at the 0.05 level (2-tailed).

Batticaloa, one of the fastest-growing cities in Sri Lanka, has been immensely influenced by the rapid growth of its population in recent decades. The total population of Batticaloa Municipality in 1981 was 51,037, which increased in 1999 to around 78,092. This growth increased in 19 years by 27,055. In 2011, there were approximately 86,227 people, which increased in 2019 to 93,306 **(Figure 4**). It took 13 years to increase the population between 1999 and 2011 that the changes were around 8,135. The lowest population growth during this period was the civil war situation. Between 2011 and 2019, the number of population increased by almost 8,377, which was a high growth compared to the previous decade. It was towards the end of the civil war in 2009.

Besides, the rapid urbanization development that has been done formally and informally in this area affects the land use of this area. The growth of the city without proper planning leads to the creation of many complex urban problems. In this context, basic services, such as drainage, water supply, electricity, are included. Many changes due to the arbitrary development seriously affect the urban land use. For example, agricultural land and wetlands changed as settlements or other areas with accumulation.

Therefore, the number of population increased in the last four decades, approximately by 43,267, which had a significant growth and was a challenge for the land use. This growth directly affects the change of land use in this area. In order to cope with demographic pressure, more and more settlements and other infrastructure are being built around the study area, which directly and indirectly disrupts the land use.

3. CONCLUSION

Land use is dynamic and is an essential component in understanding the interaction between human activities and the environment. The findings revealed that the population density was very high near the commercial area, and this gradually decreased from the city centre. In comparison, two categories of land use are only relevant to the population growth, which were commercial and residential. Rest categories were insignificant with the population. Human influence has been shown to alter land use categories. Population pressure is believed to be one of the most important driving forces for changes in the study area in order to reach a relevant conclusion. Regarding this analysis, the most important driving force for changes in the land use is increasing demographic change, urban growth, and public needs.

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