A GIS-Based Analysis of Temporal Changes of Land Use Pattern in Batticaloa MC, Sri Lanka from 1980 to 2018

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ABSTRACT

Batticaloa MC, one of the fastest-growing cities in Sri Lanka, is the most vital agglomeration that should concentrate upon temporal changes in land use. Various land use categories, namely commercial, residential, agricultural, scrubland, mangroves, water and barren land in Batticaloa, have been modified by the different purposes of utilization. This study aims to identify the land-use changes of Batticaloa Municipal Council from 1980 to 2018. Primary and secondary data collection methods were used to gather the data for analysis. Comparison was made to the various land use categories in 1980, 1990, 2000, 2010 and 2018. The temporal pattern of land-use change was presented via a comparison of the five-time periods of land use. ArcGIS 10.4.1 and MS Excel 2013 were applied to analyse the maps and data. The finding of the study was that between 1980 and 2018, there were significant land-use changes in the study area. Commercial and residential areas increased by 20.17 ha and 1148.57 ha, respectively, and barren land and agricultural land lost 769.54 ha and 301.99 ha, respectively. In addition, rest land use categories were converted into other land use categories during these periods. The effects of human activities are immediate and often radical, while the natural effects are relatively long. The recommendations are to enforce future land use planning, and protect forest resources through land-use strategies by way of the government with community participation encouraging the approval of urban planners to make decisions about urban development.

Keywords: Land use changes, Temporal pattern, Barren land, Planning
1. INTRODUCTION

The urban centres in the Eastern region are located mainly along the coastline, which seems preferable for economic opportunities associated with transportation. This also includes designated entry points, a town core, a large public space and secondary public spaces.

The three city centres, Trincomalee, Batticaloa and Ampara, represent the administrative districts of these three districts. These three centres will remain and become important centres of growth over the next 25 years (Eastern Province Physical Plan 2012). Urban settlements lie within the developed areas between the planned highways of these regions. The Batticaloa MC is the main agglomeration and concentrates land use in this area.

While population growth, particularly in land and agricultural development is a known factor, modernization under commercialization is a new development that has had considerable impact on land-use changes in this area. However, all land use categories in Batticaloa have been changed by the different purposes of utilization. Land use categorized as commercial, residential, agricultural, scrub land, mangroves, water and barren land has been affected. To identify the changes, GIS applications have been used to make a different kind of geospatial analysis for land-use changes.

GIS also helps to make mapping effective for identifying and analysing the changes in land use. Therefore, the urban region of Batticaloa Municipal Council is preferred for exploring important aspects of the effect of applying sustainable development to ensure the future viability of the area.

2. OBJECTIVES

The main objective of the study is to identify the land-use changes of Batticaloa Municipal Council from 1980 to 2018. The specific objectives are as follows;

- To evaluate the temporal changes in land use pattern from 1980 to 2018.
- To identify the land-use change detection from 1980 to 2018.
- To assess the urban expansion to the study area between 1980 and 2018.

3. METHODOLOGY

3.1. Study Area

Batticaloa is a city is located at Sri Lanka with the GPS coordinates of 7° 43' 51.5892'' N and 81° 40' 29.028'' E. The elevation of Batticaloa is 8.523m. The total number of population of this area is 94,604 (Census report 2018).

Batticaloa MC consists of separate islets within a greater water body. These are connected by bridges for transportation purposes. Hence, this is a clustered city that used the land for several motives such as fisheries, agriculture, small industries and commercial, and the islets have different land use activity driven by cluster development in each sector, whether commercial, recreational or residential. Thus, this area urgently requires documentation of the land-use changes.
3.2. Data Collection Techniques

Primary and secondary data collection methods were utilized to gather the data for analysis.

3.2.1. Primary Data Collection

The following primary data collection tools and instruments have been used for this study.

- Reconnaissance Survey
First, demarcation of the boundaries with the available map resources was defined to understand the extent of the study. Field observation was made for the primary documentation. Objective identification included the previous survey evidence, while identification of importance was instituted during the primary field observation.

- **Questionnaire Survey**
  The questionnaire included structured closed and open questions for gathering information about land use. This data was distributed to selected people for study purposes.

- **Direct Interview**
  This was conducted with Chairman MC, Divisional Secretariat, Planning official, Development officials, Grama Niladharies about the experiences of land-use change. In addition, we talked with local people especially the older so as to understand their perception about the trends of Land use.

- **Field Survey and Observation**
  Field survey also helped to understand the natural setting of the study area and to identify the existing land use classes, as well as to understand the perception of the local people relevant to this study. This was the urban area including closest to the bus stand, commercial, settlement and other administrative locations.

- **Global Positioning System (GPS) coordinates**
  This was used to find the selected places mentioned in sampling to establish the accuracy of ground truth.

3.2.2. **Secondary Data Collection**

Secondary data have been collected from the published and unpublished sources. The following sources of secondary data collection have been used in this study;

- Earlier published and unpublished studies on land-use changes and related material.
- Reports gathered from Batticaloa MC, Batticaloa District Secretariat, Agrarian Department and Forest Department.
- Census data collected from the Department of Census and Statistics to obtain the population changes of the study area.
- Printed Topographic Sheet No. 45 l collected to obtain land-use details from the Department of Survey.
- Satellite data from Landsat imageries from Earth Explorer, USGS.
- Collection from the web about the related documents of land-use changes.

3.2.3. **Sampling**

Eighty-nine (89) samples of land use locations were collected using the Mobile GPS tracker to identify the ground truth. These samples were randomly selected based on the grid method, from the locations of the different places of land use categories (19 samples from Agricultural, 26 samples from Residential, 08 samples from Mangroves, 05 samples from Water bodies, 07 samples from Commercial, 09 samples from Scrubland and 15 samples from Barren land). According to these samples, the land use categories were identified correctly from secondary sources.
One hundred and thirty-five (135) sample questionnaire collected from different stakeholders, using stratified random sampling methods. Of these, 13 samples were from agricultural stakeholders, 83 samples from commercial stakeholders and 39 samples from fishermen.

3. 3. Data Analysis

Data analysis includes collation of primary and secondary data. The following analysis methods were used to get the output.

3. 3.1. Supervised Maximum Likelihood Classification

Supervised classification methods using Maximum Likelihood classification were used for preparing the land use map of the study area. Eight classes were identified and the land use classes analyzed to extract their extent through characteristic change in land use coverage from 1980 to 2018. The current Batticaloa MC reality would be obtained from the above, land-use change compared to each indicator.

Table 1. Land use categories.

<table>
<thead>
<tr>
<th>Code</th>
<th>Land use class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Commercial</td>
<td>Administration, Shops, Banks</td>
</tr>
<tr>
<td>2</td>
<td>Residential</td>
<td>Houses</td>
</tr>
<tr>
<td>3</td>
<td>Agriculture</td>
<td>Paddy cultivation, Home garden, Crop field</td>
</tr>
<tr>
<td>4</td>
<td>Scrub Land</td>
<td>Scrub Land, Grassland, Wetland</td>
</tr>
<tr>
<td>5</td>
<td>Mangroves</td>
<td>Mangroves, Trees</td>
</tr>
<tr>
<td>6</td>
<td>Water</td>
<td>Reservoirs, River, Lake</td>
</tr>
<tr>
<td>7</td>
<td>Barren land</td>
<td>Abandon land, Sand</td>
</tr>
</tbody>
</table>

Source: Based on the Land use map of Batticaloa, Department of Survey, 2019

3. 3.2. Accuracy Assessment

Eighty-nine training samples for ground truth were archived, based on data collected as random points in certain locations during field visits and using known GPS points. Each point has valid class values for Classified and Ground Truth fields. The tool calculates the accuracy for each class, as well as an overall kappa index of agreement. The confusion matrix was used to find accuracy. Herein, a confusion matrix is computed that includes errors of omission and
commission, then a kappa index of agreement is derived and overall accuracy between the classified map and the reference data is assessed.

4. RESULT AND DISCUSSION

The highest proportion of land use nowadays is as habitation, and the next is agriculture. As one of the fastest growing cities in Sri Lanka, Batticaloa has more significant urban land use. The principal categories of land use in the Batticaloa MC have been commercial, residential, agriculture, scrubland, mangroves and Barren land, and these were classified to identify the spatial and temporal changes. The following maps (Figure 2) show the land use of study area in 1980, 1990, 2000, 2010 and 2018.

4.1. Temporal Changes in land use pattern

According to Table 2, the total land area of Batticaloa MC was 4171.13 hectares in 1980. Therein, agriculture had more influence in this period and residential was of secondary importance. Agriculture covered 46.28% and residential covered 22.75% of the whole. In addition, commercial land was at 0.33% and water only 0.54% - the least of this land use categories. Barren land occupied 19.08% - the third rank of land use in this period.

Table 2. Temporal Distribution of land use in Batticaloa MC (hectare).

<table>
<thead>
<tr>
<th>Category</th>
<th>1980</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>13.77</td>
<td>20.72</td>
<td>24.40</td>
<td>27.98</td>
<td>33.96</td>
</tr>
<tr>
<td>Residential</td>
<td>949.00</td>
<td>962.10</td>
<td>1632.13</td>
<td>1953.26</td>
<td>2097.57</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1930.32</td>
<td>1980.51</td>
<td>1397.54</td>
<td>1282.29</td>
<td>1160.78</td>
</tr>
<tr>
<td>Scrub Land</td>
<td>312.47</td>
<td>223.55</td>
<td>140.86</td>
<td>187.67</td>
<td>229.63</td>
</tr>
<tr>
<td>Mangroves</td>
<td>147.34</td>
<td>130.77</td>
<td>198.45</td>
<td>140.09</td>
<td>140.94</td>
</tr>
<tr>
<td>Water</td>
<td>22.48</td>
<td>8.05</td>
<td>9.42</td>
<td>6.61</td>
<td>13.48</td>
</tr>
<tr>
<td>Barren Land</td>
<td>795.75</td>
<td>845.43</td>
<td>768.33</td>
<td>573.23</td>
<td>494.77</td>
</tr>
</tbody>
</table>

Source: Based on the classified images from Landsat images from 1980 to 2018

The land use in 1990 showed that agricultural land occupied 47.48% while residential (at second place) sprawled over 23.07% of the total land area. Commercial land was at 0.50% - a slight increase compared with 1980. Water land has the lowest percentage at 0.19% of the total land area. According to the survey, land-use changes have been comparatively less than during the war periods. The pattern, however, gradually changed in land uses such as commercial or
residential. Rapid population growth was seen to impact upon residential and commercial land use patterns - and this affected the other land use classes. In 2000, residential occupied the highest proportion of the total land area, covering around 39.13%. Agriculture land took second place at 33.51%, which is a big decrease compared with 1990, most lost land area going to residential use. This could indicate more people moving into the study area from various places of the district due to the civil war in the Eastern province. Further, the commercial area also increased to 0.58% in this period. Water bodies were at 0.23% the least land use in this area.

The high growth of the residential aspect after the 1990s, we think, was due to the civil war in the Eastern Province. The war effects can be seen in many places of Batticaloa district, as it had pushed the people to migrate to the city area. For example, many places such as Palugamam, Porativu, Thikkodai, Mandur and Thumpamkeny lost people by their moving to Batticaloa due to the need of finding security, work and education.

According to the survey, construction, road expansion and drainage development are the main activities to change the land utilization in the area. Building construction rapidly occurred from the beginning and this has caused the conversion into the urban land use category from other categories. Road expansion is one of the main processes continued in urban parts and has destroyed the roadside vegetation and the buildings. Most of the people have more than one home and they use the second for rent. This is considered one of the reasons for the building expansion.

In 2010, residential land use was around 46.83% and this was the leading land use during this period. Moreover, commercial area increased as 0.67%. The increase in the residential is negatively influenced agricultural land use patterns. The residential category was highly influenced by more people moving into the area to take advantage of facilities such as education, transportation, health and so on. Due to the incurred losses, agriculture land was around 30.74% and scrubland at 4.50%. Barren land covered 13.74% and water bodies were at 0.16% - the least land use. Further, the survey revealed the population is in agreement with the notion that this area has seen land-use change, as 80% of people interviewed said human migration is the main influencing factor to change the land by way of building construction and road expansion. On the other hand, some people build second homes in their vegetable garden and sold these or rented these out for settlement purpose. Still, 70% of all people interviewed did not have any ideas or knowledge about land use and its impacts. However, 30% of people blamed the government.

Residential land use occupied the highest proportion of the total land area in 2018. This is around 50.29% and was the dominant land use. Agriculture land fell to 27.83%, and the commercial category took up 0.81% - a gradual increase since 1980. Water bodies were around 0.32%.

The survey revealed that the economic activities of this area also highly dependent on land use. Rapid urban development increases the commercial zone and also negatively changed agriculture. The commercial area has been gradually increasing from 1980 to 2018 due to urban expansion. Further, there were many changes in the agricultural economy that was badly impacted within the past three decades. Moreover, flash flooding due to loss of tree cover caused loss of more agricultural area during the rainy seasons.
Figure 2(a-e). Land use patterns of Batticaloa MC from 1980 to 2018
Source: Prepared by the author based on the Landsat images, 2019
4. 2. Land Use Change Detection

Change detection was indicated due to the map evidence of maps of 1980, 1990, 2000, 2010 and 2018.

Table 3 displays the land-use changes between 1980 and 2018. There are two categories that gained land area and five categories that lost land area. Residential and commercial land use categories increased to 1148.57 hectares and 20.17 hectares, respectively, while agriculture and barren land decreased to 769.54 hectares and 301.99 hectares respectively. Rapid urbanization was seen as the reason for this.

When the 1990 land use classification is compared with 1980, we can see a change that showed both decreases and increases in particular land use. The land-use categories showed increase in commercial, residential, agriculture and barren land. The average rates of change for these were, respectively, 0.20%, 0.23%, 1.03% and 1.47%. Increase in population growth was the main driver for this increase. Many who came from different parts of Batticaloa probably developed more agricultural land because agriculture was their likelihood. On the other hand, the land use categories such as scrubland, mangroves, and water decreased by 2.15%, 0.42% and 0.35%, respectively. Exploitation by the population for infrastructure development was the cause of this reduction.

When the 2000 land use classification is compared with 1990, the land use categories showed an increase in commercial, residential, water and mangrove ranges of 0.08%, 16.15%, 0.04% and 1.64%, respectively. On the other hand, land use categories such as agriculture, scrubland and barren land shown a declining trend amounting to 13.81%, 1.96% and 2.13%, respectively. After 1990, population growth increased sharply and this again was the driver of changes in land use. In 2000, the population of Batticaloa increased by approximately 27,443 inhabitants from 1981 onwards. This was a significant increase in the chosen study period.

<table>
<thead>
<tr>
<th>Category</th>
<th>1980 Area (ha)</th>
<th>2018 Area (ha)</th>
<th>Conversion (+/-) Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>13.77</td>
<td>33.94</td>
<td>+20.17</td>
</tr>
<tr>
<td>Residential</td>
<td>949.00</td>
<td>2097.57</td>
<td>+1148.57</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1930.32</td>
<td>1160.78</td>
<td>-769.54</td>
</tr>
<tr>
<td>Scrub Land</td>
<td>312.47</td>
<td>239.63</td>
<td>-72.84</td>
</tr>
<tr>
<td>Mangroves</td>
<td>147.34</td>
<td>140.94</td>
<td>-6.40</td>
</tr>
<tr>
<td>Water</td>
<td>22.48</td>
<td>13.48</td>
<td>-9.00</td>
</tr>
<tr>
<td>Barren Land</td>
<td>795.75</td>
<td>493.77</td>
<td>-301.99</td>
</tr>
</tbody>
</table>

Source: Prepared by the author based on the classified image from Landsat images, 2019
When the 2010 land use classification is compared with 2000, some changes showed a decrease or increase in particular land use. The land-use categories show increase in commercial, residential and scrubland. The average rates of change for these were 0.08%, 7.60% and 1.30%, respectively. In contrast, the land use categories of agriculture, mangroves, water and barren land decreased by 2.82%, 1.41%, 0.07% and 4.69%, respectively. The high rise of the residential during this time was due to enhance standards of living of the people. Therein lifestyle had changed through the modernization and urbanization. Larger houses were built, as well as detached houses used as rental properties. This increase has had a significant impact on agricultural land and other related categories. For example, Thandavanvelly, Puthunagar and Kallady areas lost their agricultural land due to settlement growth.

When the 2018 land use classification is compared with 2010, several changes indicate decrease or increase in particular land usage. The land-use categories that showed an increase were commercial, residential, scrubland, mangroves and water, at 0.14%, 3.45%, 1.05%, 0.02% and 0.16%, respectively. Again, in contrast, the land use categories such as agriculture and barren land showed reduction to 2.91% and 1.92%, respectively. Herein, rapid urban growth and infrastructure development, including road construction, drainage, public and private
building fabrication, playground, hotels and restaurants development have direct connection to the decline in agricultural land and barren land use categories.

4.3. Urban Expansion

Urban expansion gradually increased from 1980 to 2018. According to Table 4, the change affected approximately 1168.74 hectares in the 38 years. There was some change in the buildup area during the 1980s. Then, there was a large increase in change of around 673.71 hectares between 1990 and 2000. The reason was that the inhabitants of the different parts of Batticaloa district migrated into the city due to the effects of the civil war. Most of the influx was permanent, albeit, some was temporary.

Table 4. Urban Expansion.

<table>
<thead>
<tr>
<th>Period</th>
<th>Buildup Area (ha)</th>
<th>Changes (ha)</th>
<th>TimeSpan (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980 - 1990</td>
<td>962.77 – 982.82</td>
<td>+20.05</td>
<td>10</td>
</tr>
<tr>
<td>1990 - 2000</td>
<td>982.82 – 1656.53</td>
<td>+673.71</td>
<td>10</td>
</tr>
<tr>
<td>2000 - 2010</td>
<td>1656.53 – 1981.25</td>
<td>+324.72</td>
<td>10</td>
</tr>
<tr>
<td>2010 - 2018</td>
<td>1981.25 – 2131.51</td>
<td>+150.26</td>
<td>08</td>
</tr>
</tbody>
</table>

Source: Prepared by the author based on the classified image from Landsat images, 2019

Thereafter, the increase of the buildup area was reduced from 2000 to 2010 by 324.72 hectares. This also had more effect in the urban change. Compared with the previous decade, the buildup area has been partially reduced, although, urban growth increased by 1018.48 hectares, from 1980 to 2010. Indeed, every 10 years from 1980 onwards, various changes occurred in the study area and showed the growth of rapid urban development. After 2010, the buildup area met with reduction, with the agent being vertical development which starting within this period. Hence, there was less urban sprawl.

The accuracy of the land use pattern has been identified using classified land use maps of the study area. The analysis revealed that producer accuracy and user accuracy varied during the selected periods. Some years showed high producer accuracy and low user accuracy, but some years showed high user accuracy and low producer accuracy.

The overall accuracy of land use in 1980 was 77.5%, while the Kappa Index Accuracy was 0.71875. The reason for the low accuracy level was that satellite imagery had low resolution during this time. Overall, however, there is a good agreement in the land use classification. The overall accuracy of land use 1990 is 80% and the Kappa Index Accuracy is 0.74946. Hence, there is good agreement on land use. The overall accuracy of land use in 2000 is 88.75% and the Kappa Index Accuracy is 0.85827. The overall analysis of accuracy, at this time shows very good agreement on land use.
The overall accuracy of 2010 land use is 95 % and the Kappa Index Accuracy is 0.93632. The overall analysis of accuracy, thus, shows very good agreement in land use. The overall accuracy of land use in 2018 is 92.5% and the Kappa Index Accuracy is 0.90367. The reason for the high accuracy level in 2000, 2010 and 2018 is the high resolution of the satellite image which gathered during these periods. The overall analysis of accuracy, there is a very strong agreement on land use. Moreover, the civil war had ended and areas previously inaccessible for geographers, became accessible.

Table 5. Land use accuracy from 1980 – 2018.

<table>
<thead>
<tr>
<th>Category</th>
<th>1980</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Accuracy</td>
<td>77.50</td>
<td>80.00</td>
<td>88.75</td>
<td>95.00</td>
<td>92.50</td>
</tr>
<tr>
<td>Kappa Index Accuracy</td>
<td>0.71875</td>
<td>0.74946</td>
<td>0.85827</td>
<td>0.93632</td>
<td>0.90367</td>
</tr>
</tbody>
</table>

Source: Prepared by the author based on the classified Land use maps, 2019

The error of commission in 1980 was around 100% in water and 37.93% in agriculture. There are no errors attributed to commercial and barren land. The errors of omission were 50.0% in water and 33.33% in scrubland. There was less omission for residential, agriculture and mangroves at 11.76%, 10.0% and 12.50%, respectively. The user accuracy was 62.07% in agriculture and 66.67% in scrubland – this is considered low in comparison to an overall accuracy of 77.5%.

In 1990, the error of commission was around 50.0% in water and 32.14% in agriculture. There were no errors attributed to scrubland and mangroves at 0%. The errors of omission were 50.0% in scrubland and 28.57% in the commercial, but there was no omission for agriculture and water. The producer accuracy was 50.0% to scrubland and 66.67% to barren land – this indicates poor accuracy of land use. The user accuracy was 50.0% in water and 66.67% in agriculture – this is low when the overall accuracy was 80%.

In 2000, the error of commission was around 30.0% in mangroves, 15.0% in agriculture, 11.54% in residential. There was no commission to commercial, scrubland, water and barren land. The errors of omission were 66.67% to scrubland and 14.29% to commercial. There was no omission for residential and water. The producer accuracy was 33.33% in scrubland, which reflects poor accuracy of land use match. The user accuracy was 70.0% in mangroves, which is also of poor accuracy when the overall accuracy was 88.75%. An overall analysis of accuracy, holds that there is very good agreement in the land use.

In 2010, the error of commission was around 10% in agriculture and 7.14% in residential. There is a commission to other categories. The errors of omission were 16.67% to scrubland and 5.26% to agriculture. There were no omission errors indicated within other categories. The producer accuracy was 33.33% to scrubland, which reflects low accuracy of land use. The user accuracy was 70% to mangroves which is poor accuracy when the overall accuracy was 95%. Overall analysis of accuracy indicates very strong agreement in the land use.
In 2018, the error of commission attributed around 12.90% to residential, 11.11% to mangroves and 5.88% to agriculture. There was no commission to the rest of the categories. The errors of omission were 33.33% to scrubland and 14.29% to commercial, and no omission for residential, mangroves and water. The producer accuracy was 66.67% in scrubland, which reflects low accuracy of land use, while the user accuracy was 87.10% to residential, which is also a low accuracy attribution when the overall accuracy was 92.5%. The low resolution of the satellite images was the reason for more errors in the land use classes being seen. The overall analysis of accuracy, however, reveals that there is a very good agreement in the land use.

5. CONCLUSIONS

The detection of land-use changes in the urban area of Batticaloa MC is significant for local authorities in the process of urban planning. Thus, this study was carried out to identify the spatial and temporal changes in land use in Batticaloa MC during 1980 to 2018, and did so through spatially identifying the temporal and spatial pattern of changes in land use and identifying the relationship in between the land use categories and population growth. Changes of spatial extent in different land-use classes were found to be interrelated with land-use transformations and the generated statistical data. This study will assist in enhancing current land management practices and drive future policy formulations.

Consequences of the land-use change during the past 38 years in the study area are very significant in this study. The temporal pattern of land use changes are presented via a comparison of five time periods of land use maps. The analysis revealed that commercial and residential land area increased and barren land and agricultural land have been lost during the 1980 to 2018 period. To a certain extent, this is land use category change from one to another category.

Some land uses showed increasing change during the first-period comparison and showed decreasing change during the second comparison (agriculture and barren land). Over all, agriculture land decreased and commercial, residential increased. However, commercial, residential and scrubland displayed a similar pattern of change, in which scrub land showed decreasing change patterns and commercial and residential saw increasing change pattern during the two periods of comparison.

This implies that population pressure is one of the major driving forces for the changes of land use in Batticaloa MC. Hence, in the case of this analysis, the major driving force to changes in land use is increased population, urban growth and public needs.

However, some recommendations are given below: Awareness of the community situation by means of school level program to the Ordinary Level and Advanced Level students, women’s club, Lions club in Batticaloa MC about the impacts of land use can be enhanced. Neighborhoods should be protected from inappropriate residential, commercial and institutional encroachment by the municipality. Natural plants have to be protected and the appropriate authorities such as the forest department and Central Environmental Authority must enforce the law and raise awareness of the importance of the natural environment.

The natural environment must be promoted in the eyes of the public to grow through such measures as Environmental day or Wetlands day and free trees must be given out – such as through the coconut tree program by the Coconut Cultivation Board, or the mango tree program of the Department of Agriculture.
Participation of the community, urban planners, environmental specialists and obtaining their approval is highly required before urban development decisions are made so as to avoid conflicts. Change must be concentrated in designated areas and not allowed to take the form of strip development along the major roads in the planning areas.

References


