A GIS Based Analysis of Land Use Changes on Porativupattu DS Division in Sri Lanka between 2009 and 2019

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Abstract

The change in land use is becoming an important component of the country's current strategies for managing natural resources while promoting sustainable development. Land use changes as a spatial change that is largely dependent on remote sensing technology for a great potential in providing detailed and accurate land use information. This study aims to identify the land use changes of Porativupattu DS Division between 2009 and 2019. The GIS analysis and statistical analysis methods were used to achieve this goal. The results of the analysis, buildup and water bodies increased and agriculture and forests declined due to infrastructure development and population growth at the end of the civil war. Recommendations are formulated based on the findings.

Keywords: Land use, Remote sensing, Agriculture, Buildup

1. Introduction

Land use detection is very crucial for better understanding of land use dynamic during a known period of time for sustainable management and development. In the Sri Lankan context, land use changes is become one of the major issues in recent years. Thus land use change is becoming vital component in the country's current strategies for managing natural resources while promoting sustainable development. Different land use categories in the study area, they all change by the different purposes of utilization. The land use categorized in the study area based on the standard land use class by Department of Survey as agriculture, buildup, forest and water to identify the changes.

Rapid developments which has been done formally and informally to this area affects the land use of the study area. The growth of this area without proper planning led to create many complex problems. Basic amenities such as settlements, drainage, water supply, electricity are in this context. However, there are areas or sites that are not presently protected in the district. These land uses have to be protected in order to conserve the biodiversity and environment.

Land use changes are basically a spatial changes. Remote sensing technology has a great potential in acquisition of detailed and accurate land use information for land use change. The land use related data are the core components used to manage natural resources in urban planning and monitoring environmental changes. GIS application has many facilities to make the different kind of geospatial analysis using satellite images for the land use changes. It helps to make mapping effectively to identify the changes of land use.

Therefore the information about changing land use is very essential in assessing the cause and effect of changes in past, present and future. It highly depends on the future sustainable development.

2. Objectives

The main objective of the study is to identify the land use changes of Porativupattu DS Division between 2009 and 2019. The specific objectives are as follows;

- To evaluate the temporal changes of land use pattern between 2009 and 2019.

- To identify the relationship between population growth and the land use change.

3. Methodology

a. Data and data collection techniques

Primary and secondary data collection methods have been used to gather the data for analysis. Primary data have been collected through observation and interviews with officials and inhabitations of the study area. Direct interview conducted with Divisional Secretariat, Planning official, Development officials, Grama Niladharies about the experiences of land use change. A field survey has been done for proper validation of available data. Field survey also helped to understand the natural sitting of the study area as well as to understand the perception of the local people relevant to this study. Global Positioning System (GPS) coordinates were used to find the selected places mentioned in sampling to take the accuracy of ground truth.

Secondary data have been collected through published and unpublished earlier studies on the land use changes and related to this. Government Documents has been gathered from Porativupattu DSD, Batticaloa District Secretariat and Agrarian Department. Census Reports collected from Department of Census and Statistics to get the population changes of the study area. Satellite data have been downloaded from Earth Explorer and collection from the web about the related documents of land use changes.

b. Sampling

Hundred and twenty four (124) samples of land use locations have been collected using Mobile GPS tracker to identify the ground truth. The samples randomly selected from the locations of the different places of land use categories based on the grid based method. According to this samples, the land use categories have identified correctly.

c. Data Analysis

Data analysis includes collation of primary and secondary data. There were some methods use for spatial analysis of land use in GIS.

Supervised classification method using Maximum Likelihood classification has been used for preparing the land use map of the study area. Four classes achieved and land use classes analyzed in order to extract the area through a characteristic change in land use between 2009 and 2019.

Using the collected random points through GPS, each point with have valid class values for the classified and ground truth fields. The tool calculated the accuracy for each class as well as an overall kappa index of agreement. The confusion matrix used to find the accuracy. The accuracy of the classification determined to achieve the level of precision.

Density analysis has been done to identify the population density of the study area. The variation of population density used to analyze significant with land use change. Pearson correlation coefficient analysis used to find out the correlation between population and land use changes. This analysis used to find the relationship between each indicator of the land use categories.
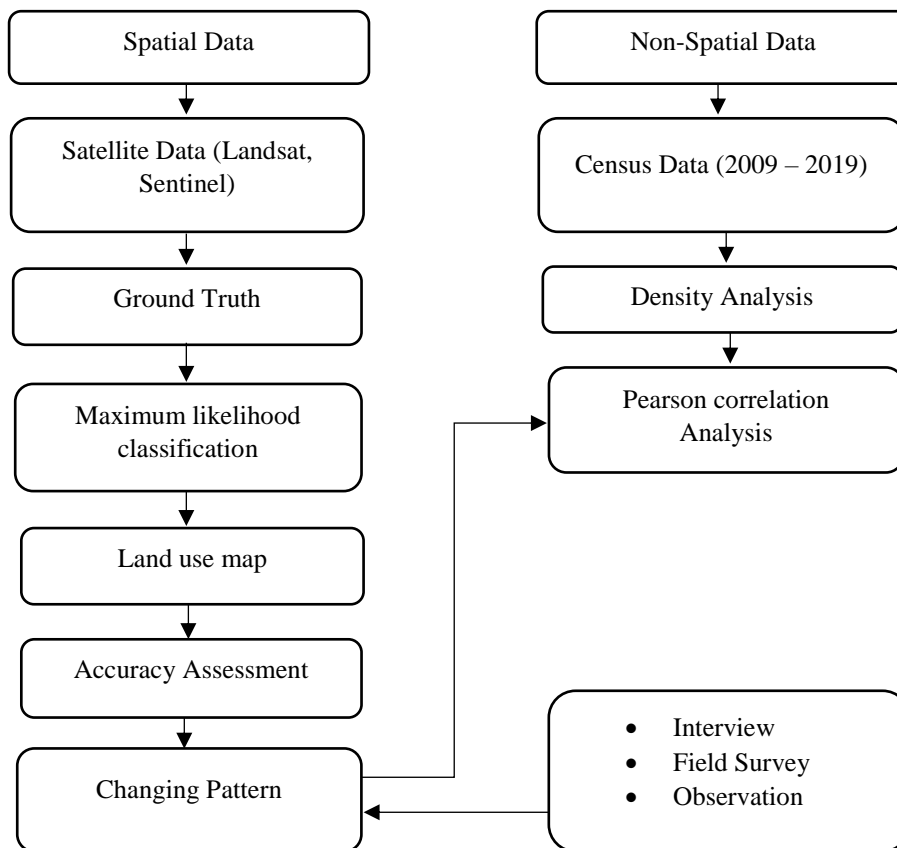

Fig. 1. Methodological framework

Source: Prepared by author, 2019

d. Data Analysis Tools

The data analyzed and tabulated by using different statistical tools are MS-Excel 2013, SPSS 22.0 and used for data processing, data analysis and interpretation of information collected. ArcGIS 10.4 used to make the mapping analysis and mobile GPS tracker used to gain the point data to reach the objectives.

4. Result and Discussion

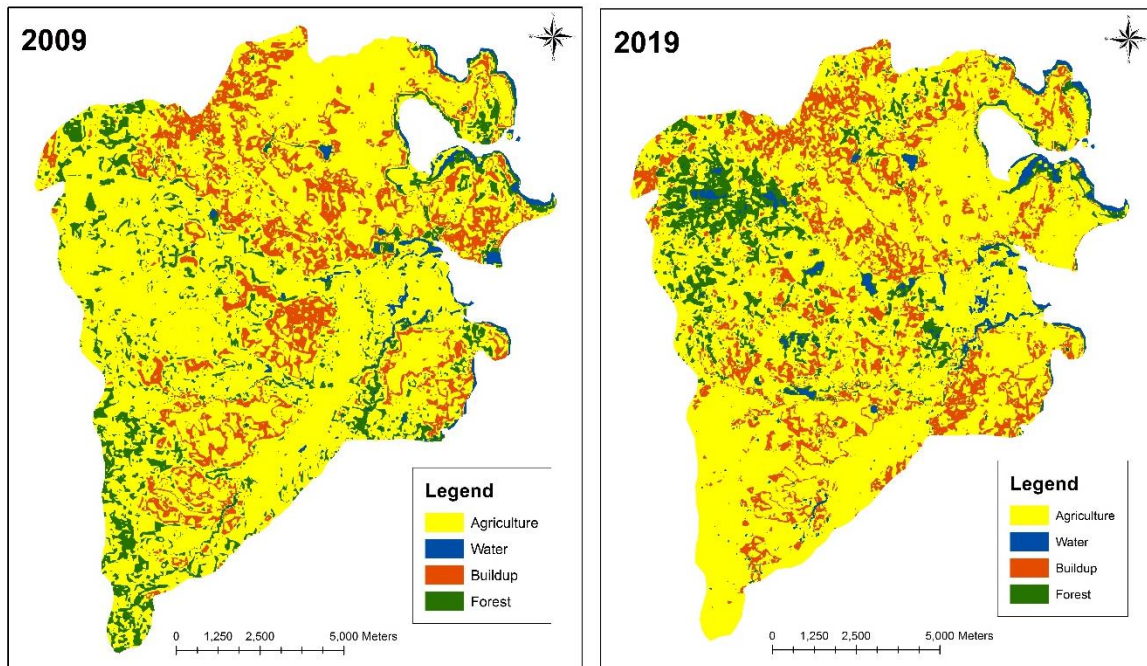Following maps (fig. 2) show land use of study area in 2009 and 2019.

Fig. 2. Land use map for 2009 and 2019

Source: Prepared by author based on the Landsat images 2009 and 2019

According to Table 1, the total land area is 15810.28 hectare in 2009. Agriculture had more influence in this period. Agriculture covered by 73.48% and buildup covered by 14.39%. There are forest land at 10.17% and water only 1.97% the least of this land use categories.

The land use in 2019 showed that agricultural land occupied 72.63% and buildup has occupied 15.75% of the total land area. Forest land had 9.36 % which is the slight decrease compared with 2009. Water land have the lowest percentage occupying 2.26 % of the total land area.

According to the survey, the land use changes has been comparatively less than during the war periods. This was gradually changing the pattern and rapid population growth impacts on the buildup land that affects the other land use classes. 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 which caused to the conversion of land use from other categories.

Table 1 displays the land use changes between 2009 and 2019. There are two categories which gained the land area and two categories lost the land area. Buildup and water were increased as 214.13 hectare and 47.37 hectare respectively. Agriculture and forest land were decreased 133.56 hectare and 127.93 hectare respectively. The rapid population growth end of the civil war caused to the increment of the buildup and the irrigation development have reasoned for the increment of water bodies.

Table 1. Land use temporal changes and conversion (ha)

Category	2009 Area (ha)	2019 Area (ha)	Conversion (+/-) Area (ha)
Agriculture	11616.99	11483.43	-133.56
Water	310.71	358.08	+47.37
Buildup	2275.27	2489.40	+214.13
Forest	1607.31	1479.37	-127.94

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

In 2009, the producer accuracy of land use was low at 87.5% for buildup and forest land while the user accuracy was 70% and 100% respectively. User accuracy was 94.44% for agriculture but producer accuracy was 85%. Rest category was very good in accuracy level. The overall accuracy of land use in 2009 is 92.80% and the Kappa Index Accuracy is 0.90637. Overall analysis of accuracy, there is a very good agreement on land use.

The producer accuracy of land use in 2019 occupied at 88.89% for agriculture, 100% for water, 100% for buildup and 91..67% for forest cover while the user accuracy was 94.12%, 100%, 88.89% and 100% respectively. The overall accuracy of 2019 land use is 95.20% and the Kappa Index Accuracy is 0.93634. Overall analysis of accuracy, there is a very good agreement in the land use.
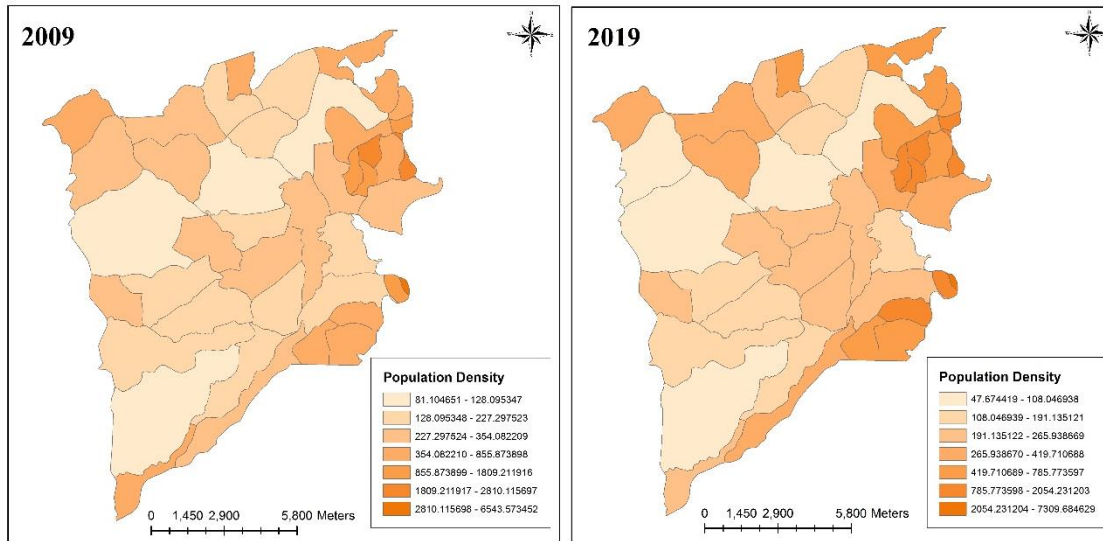

Fig. 3. Population Density for 2009 and 2019

Source: Prepared by author based on the Census Data 2009 and 2019

Statistical data which obtained from the land use classification and census data were analyzed to get the result. The below table displays the relationship between population and land use categories with the significant level

below 0.01 and 0.05. When Pearson's correlation is close to 1, this means that there is a strong relationship between two variables. The results suggest that 2 out of 4 correlations were statistically significant.

The relationship between the population and agriculture, the correlation value is 0.904 and which is significant at the level of 5% because the significant value (0.035) is less than the significant level of 0.05 that is a strong relationship. Because of this, it can conclude that there is a statistically significant correlation between the variables.

The relationship between the population and water, the correlation value is -0.758 and which is insignificant at the level of 5% because the significant value (0.116) is greater than the significant level of 0.05. Because, migration end of the civil war from the other area caused to the development of water bodies. The agricultural land in the study area was developed by the people for the paddy cultivation and other cultivations.

The relationship between the population and buildup, the correlation value is 0.968 and which is significant at the level of 5% because the significant value (0.007) is less than the significant level of 0.05 that is statistically a strong relationship between the variables. Thus, this established that the significant of these variables are more reliable.

The relationship between the population and forest, the correlation value is -0.866 and which is insignificant at the level of 5% because the p value (0.058) is greater than the significant level of 0.05.

There are two land use categories only significant with population growth which are buildup and agriculture. Rest categories are insignificant with the population. Further, forest is very close to the significant level. According to the result, it revealed that the human influence has been interrupting the land use categories.

5. Conclusion and Recommendations

The detection of land use changes in Porativupattu DS Division which is a rural area has become significant for local authorities in the process of rural planning. Thus, this study is carried out with the aim to identify the temporal changes land use in Porativupattu DS Division between 2009 to 2019 through spatially identify the temporal pattern of changes in land use and identify the relationship in between the land use categories and population growth.

Consequences of the land use change during past 10 years in the study area are very significant in this study. The temporal pattern of land use changes presented via compared the two time periods of land use maps. The analysis revealed that buildup and water body increased while agriculture and forest land have been lost the land during this period. The certain extent of particular land use category converted to another land use category.

Comparatively there are two land use categories only significant with population growth which were buildup as a very high significant and agriculture as high significant. Forest was very close to the significant level and rest category was insignificant with the population. Finally, it revealed that the human influence has been interrupting the land use categories.

This implies that population pressure is believed to be one of the major driving forces for the changes of land use in Porativupattu DS Division. Hence, in the case of this analysis, the major driving force to changes in land use is increased population change, infrastructure development and public needs.

Recommendations are aware to community such as school level program to the Ordinary Level and Advanced Level students, women club about the impacts of land use especially in the effects of agricultural land diminishing; neighborhoods should be protected from inappropriate residential and institutional encroachment by the Pradesiya Sabha; natural plants has to regard as its responsibilities to protection and land use strategies by the authorities such as forest department, Central Environmental Authority; promote the public to grow the vegetation at home and motivate them through the awarding in Environmental day or Wetland day and provide the trees such as coconut tree by Coconut Cultivation Board, mango tree by the Department of Agriculture.

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