Hyderabad City Land Use/Land Cover Changes Multi-spatio Temporal Comparison Using Spectral Angle Mapper with Maximum Likelihood Classification

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ABSTRACT

Aim: In this study the objective is to predict land use and land cover changes by using Spectral Angle Mapper (SAM) and Maximum Likelihood Classifier (MLC) and also to identify the algorithm that gives more accuracy. **Materials and Methods:** Landsat7 ETM+ (Enhanced Thematic Mapper plus) and Landsat 8 were used for the years 2001, 2011 and 2021 of study region. These satellite images were classified using two classifiers, namely, SAM classifier and MLC forming two groups. Each group contains 3 samples with a total of N = 6 samples. The pretest power is to be determined with 80% and with alpha value of 0.05 and Confidence Interval of 95%. **Results and Discussion:** The land use and land cover changes have been analyzed with novel supervised classifiers of SAM and MLC and percentages of different types of region have been noted.An independent samples - t test from SPSS statistical analysis it was observed that from a single tail test $p<0.05$ hence there is a significance difference between two groups of classifiers, namely, SAM and MLC.The mean and standard deviation of overall classification accuracy is 91.42 ± 6.13 and 98.89 ± 1.26 respectively. The mean and standard deviation for kappa coefficient is 0.87 ± 0.86 and 0.98 ± 0.17 for SAM and MLC respectively. **Conclusion:** From this research it can be concluded that Maximum Likelihood Classifier performs better than Spectral Angle Mapper.

Keywords: Land Use, Land Cover, Novel Supervised Classification, Spectral Angle Mapper, Maximum Likelihood Classification, Satellite Images, Hyderabad City.

INTRODUCTION

Land use and land cover changes describe the study of land surface change. Land use relates man-made activities on the land whereas land cover relates features present on land. Both the terms are closely related and interchangeable. The study of Land Use Land Cover changes is very important for proper planning, utilization of available natural resources and their management. Land use and land cover change has become a current trend for monitoring environmental changes. Land use and land cover changes have largely resulted in deforestation, biodiversity loss, global warming and natural disaster-flooding (Shirisha et al. 2019). The analysis of satellite images using novel supervised classification can be done for studying land use and land cover changes for managing various effects. With the help of available data on land use and land cover changes can provide decision-making of environmental management and planning

the future. In this paper Spectral Angle Mapper and Maximum Likelihood classifiers are used for novel supervised classification for analyzing change detection of land. The land use land cover classification with highest classification accuracy were acquired by using Maximum Likelihood Classification. The satellite images are used to predict future land use and land cover changes and further it can be used for future planning of the city.

Over the past few years a lot of researchers have published the articles on land use and land cover changes using SAM and MLC classification which are 171 articles on Google Scholar and 73 articles on ScienceDirect. From the most cited articles it was observed that MLC has higher accuracy than SAM. In the novel supervised classification MLC generates more accuracy than SAM . Due to the changes happening in Land use and land cover has an effect on land management practices . Urbanization does not affect agricultural area The best study out of above cited research works is carried out for prediction of urban area expansion with implementation of novel supervised Classifiers, this article found that MLC is better than SAM in terms of accuracy(Zare Naghadehi et al. 2021).Previously our team has a rich experience in working on various research projects across multiple disciplines(Madhesh et al. 2021; Bishir et al. 2020);(Vimalraj et al. 2020; Sivasamy, Venugopal, and Mosquera 2020)(Madhesh et al. 2021; Bishir et al. 2020)

Analyzing the detection of land use and land cover changes has been done by many researchers in Hyderabad city but they didn't perform from the year of 2001 to 2021 by using SAM and MLC classifiers. The aim of this study is to predict LULC changes by using those classifiers and also comparing which algorithm gives more accuracy.

MATERIALS AND METHODS

This study was conducted at the Geographic Information System (GIS) laboratory, Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences. There is no ethical approval as there are no human samples involved. For this study two algorithms are used which are spectral angle mapper and maximum likelihood classification to perform the supervised classification. The three test samples are used for each algorithm of three different years. A total of 6 samples are used for this classification (Benediktsson and Ghamisi 2015). The pretest power is to be determined with 80% and with alpha value of 0.05 and CI of 95%.

The test samples are downloaded from United States Geological Survey (USGS) Explorer (National Research Council et al. 2012). The satellite images are available in USGS Explorer for different years. In this study three satellite images of three different years (2001, 2011 and 2021) are used. In this study, classification is performed for Hyderabad city. For the first sample of 2001 year landsat 7 ETM+ data is collected and also for 2011 landsat 7 data is used. The landsat 8 data is collected for the year 2021 to perform classification. The classification is to be held for Hyderabad city but here in satellite image the downloaded content also contains extra regions. Before performing classification need to cut the shape file of the study region. The cloud cover should be less

than 5% for all three years. The bands should be extracted from downloaded data. The test setup was done in ENVI software, system hardware requirements are intel i7 processor of 8th gen and requires 8 GB random access memory and configuration of system is windows 10 operating system. The procedure for performing classification, preprocessing should be done for landsat7 ETM+ data for 2001 and 2011 i.e to combine bands which are band2, band3 and band4 called layerstacking. For landsat8 data the band3, band4 and band5 should be combined, with this the preprocessing has completed. With the layerstacked data change RGB bands and adjust the stretch so that map is clearly visible. Now classify the image into some of the regions which are urban, forest, vegetation, dry land and water. Add a new Region of Interest (ROI) for each region by selecting different colours and identify specific regions and mark a few pixels for a specified region. Doing the same thing for every region and marking pixels. Now start Spectral Angle Mapper classification for the map and cut the shape file of Hyderabad city from the map. The same procedure should be done for Maximum likelihood classification for 2001. Now do the same process for 2011 and 2021 year by adding new ROIs and perform both classifications. The overall accuracy and kappa coefficient should be obtained from the confusion matrix using ground truth ROI. The percentages are then used for statistical analysis.

Statistical Analysis

Statistical analysis is done by comparing SAM and MLC classifications through Statistical Package of the Social Sciences (SPSS) version 23. The independent sample t test is performed. There are no dependent and independent variables in the study (Benediktsson and Ghamisi 2015).

RESULTS

A range of results obtained as a part of research work are listed here. The methodology of this study is represented in Fig. 1. The two classifiers used for classification are SAM and MLC. The classifiers have yielded land use and land cover map for the chosen study area. Figures. 2, 3 and 4 show classified output of the years 2001, 2011 and 2021 for SAM classification. In Figures 5, 6 and 7 the output of the classification process for the years of 2001, 2011 and 2021 is depicted by MLC classifier. By using SAM and MLC classifiers the changes happened in land use and land cover for years 2001, 2011 and 2021 has been observed as shown in Figs. 8 and 9.

The land use and land cover of Hyderabad city was observed in years 2001, 2011 and 2021 by using SAM and MLC classifiers by dividing study area into five classes which are: urban, forest, vegetation, dry land and water. It was found that MLC performs better than SAM classifier. Table 1 shows overall accuracy and kappa coefficient from classification output from both classifiers. The mean accuracy of all years for SAM and MLC classifiers are 91.42% and 98.89% also kappa coefficient are 0.87 and 0.98 respectively. Statistical analysis revealed that MLC outperformed SAM in terms of both accuracy and kappa coefficient as is evident from Figs. 10 and 11. From statistical analysis it was observed that from a single tail test $p<0.05$ hence there is a significance difference between two groups.

DISCUSSION

Figure 1 represents the methodology of this study . In this research it is clearly observed that Maximum Likelihood Classification outperformed Spectral Angle Mapper Classifier in terms of both accuracy and kappa coefficient. The percentages of different classes of Hyderabad city shown in Fig. 8 and 9. For all three samples MLC outperformed SAM. The overall accuracy and kappa coefficient of SAM and MLC were shown in Table 1 obtained from the accuracy assessment test. From Table 2 it was observed that mean overall accuracy for SAM and MLC were 91.42% and 98.89% and kappa coefficient 0.87 and 0.98, from overall accuracy and kappa coefficient MLC performed better results. Table 3 shows the results of the independent samples-t-test analysis performed.

The performance of SAM and MLC classifiers has been evaluated for detection of land use and land cover changes in Hyderabad city of different regions which are urban, forest, vegetation, dry land and water. The bar charts are plotted for different regions for all three years of SAM and MLC . The Spectral Angle Mapper and Maximum Likelihood Classifiers were used for LULC changes (Brannstrom and Filippi 2008). For supervised classification MLC was a very well known parametric classifier. As shown in Fig. 8 and 9 percentages of different regions are gradually increasing/decreasing based on type of region. The urban region is gradually increasing from 2001 to 2021. The dry land is gradually decreasing from 2001 to present. Here it was observed that urban and vegetation regions are increasing year wise. As the city grows rapidly dry land is getting reduced, whereas urban region and vegetation are occupying dry land. Now by comparing both algorithms MLC has performed better than SAM in terms of accuracy. The article which supports for this research of finding classification accuracy is higher for MLC than SAM classifier is "Prediction of Urban Area Expansion with Implementation of MLC, SAM and SVMs' Classifiers Incorporating Artificial Neural Network Using Landsat Data (Zare Naghadehi et al. 2021)".

The farming system may get affected due to land changes (Challa 2014). Due to lack of high resolution data classification has stopped for level 1 hence further it can be classified into level 2 classification by using high resolution data.

CONCLUSION

This study explains how to analyze change detection of land use and land cover by SAM and MLC. The percentages of different types of regions have been found. In this study, it is concluded that Maximum Likelihood Classifier has performed significantly better than Spectral Angle Mapper in detecting land use and land cover changes in all datasets.

DECLARATIONS

Conflict of Interests

No conflict of interests in this manuscripts

Authors Contributions

Author ARK was involved in data collection, data analysis, manuscript writing. Author SVL was involved in conceptualization, data validation, and critical review of the manuscript.

Acknowledgements

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical

and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding

We would also like to thank following organizations for providing the financial assistance to complete the study

1. Sigma Constructions
2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences
4. Saveetha School of Engineering

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TABLES AND FIGURES

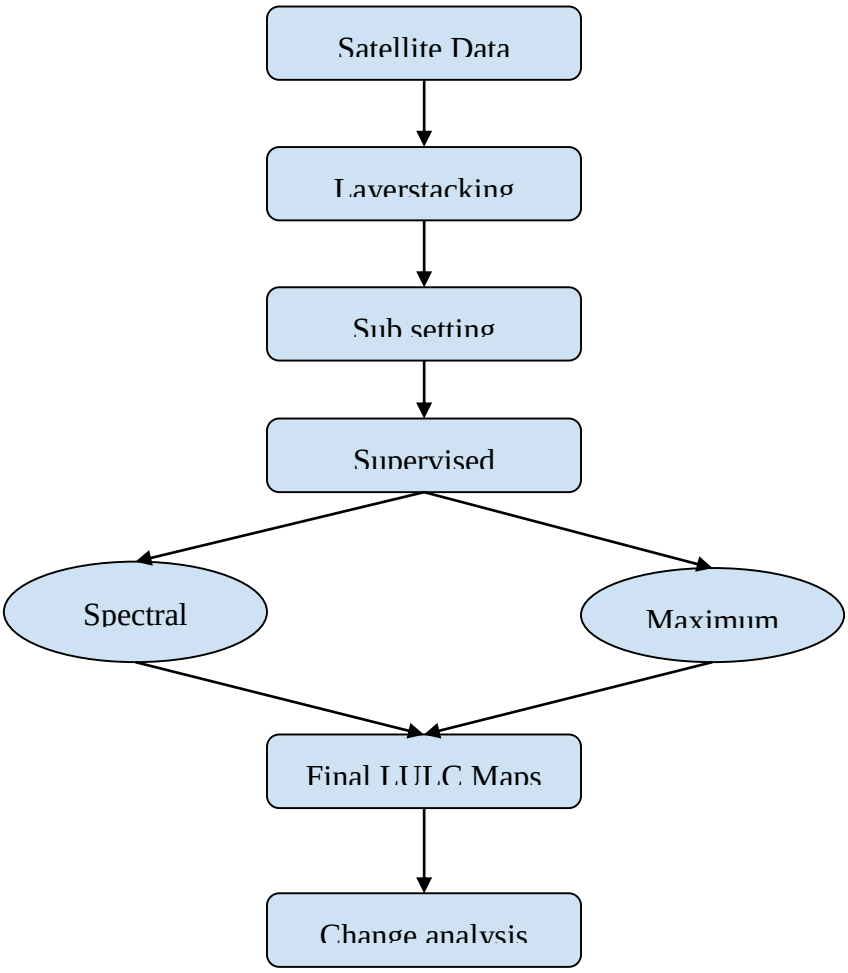

Fig. 1. Flowchart methodology of present study

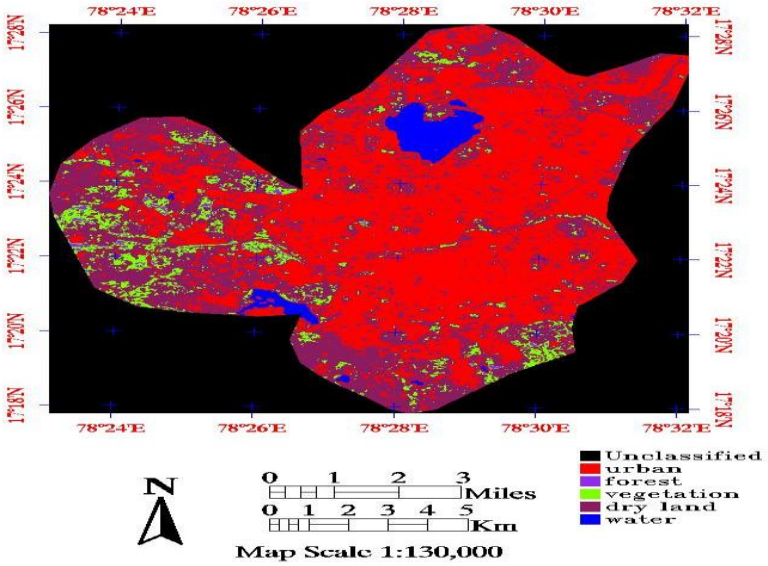

Fig. 2. Classified image of the study region using SAM classifier for the year 2001

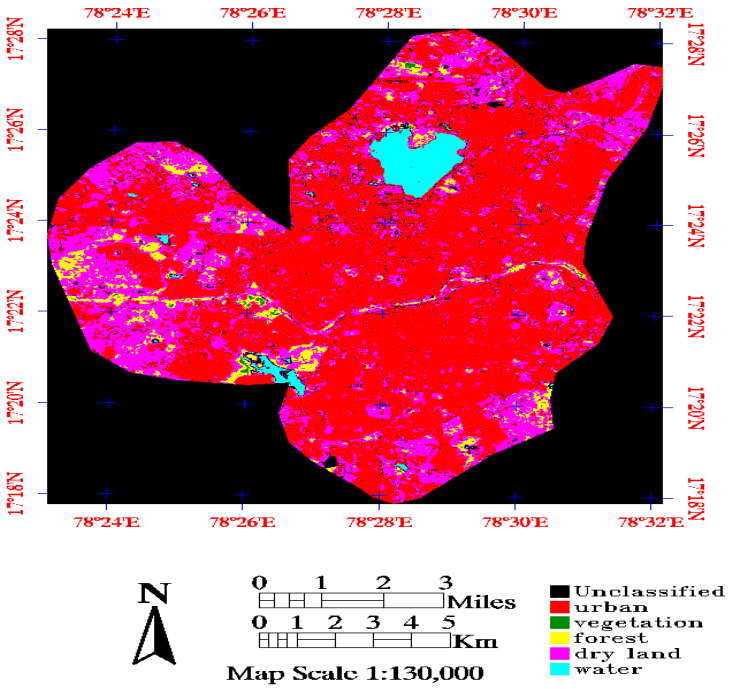

Fig. 3. Classified image of the study region using SAM classifier for the year 2011

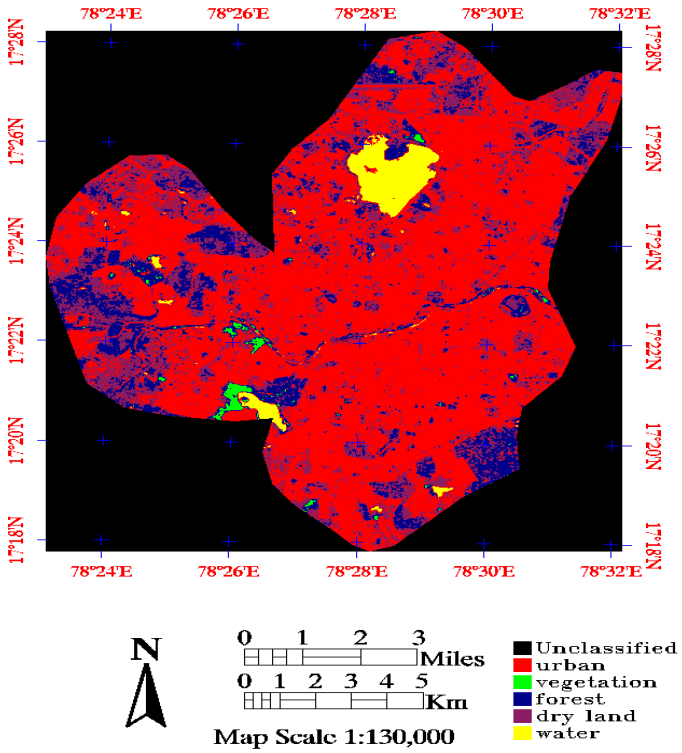

Fig. 4. Classified image of the study region using SAM classifier for the year 2021

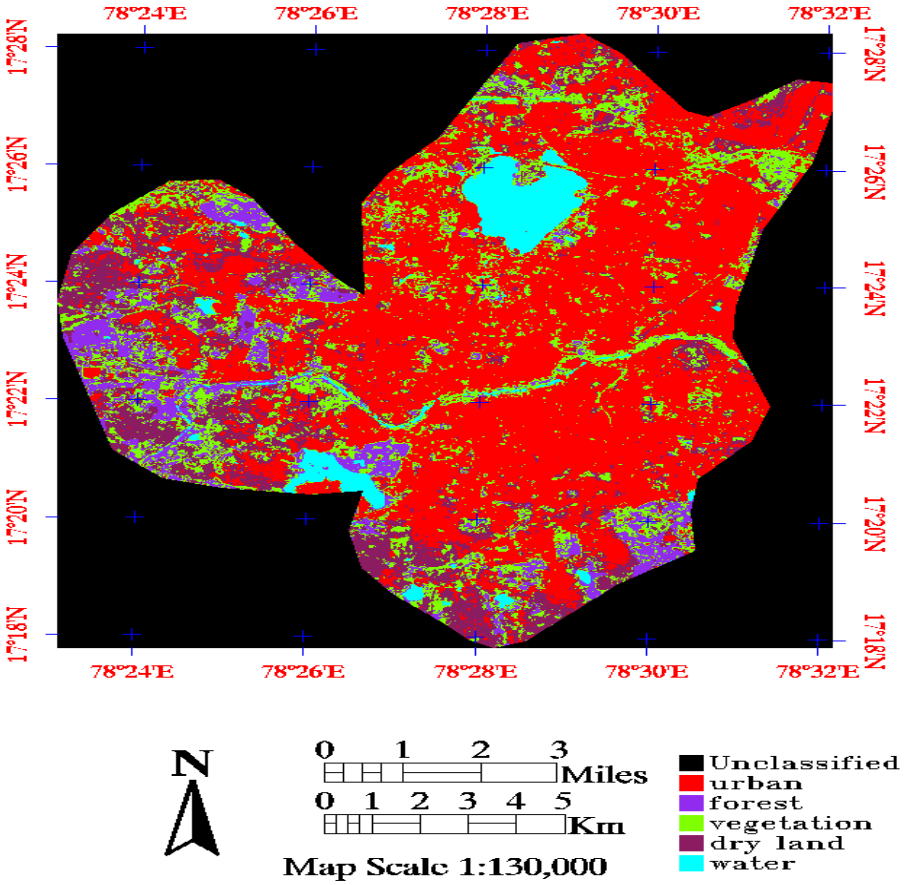

Fig. 5. Classified image of the study region using MLC classifier for the year 2001

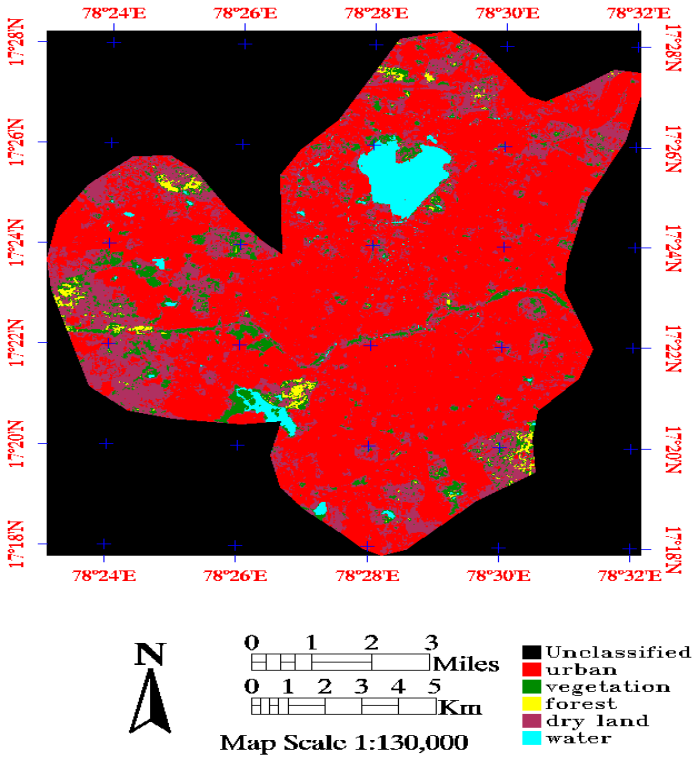

Fig. 6. Classified image of the study region using MLC classifier for the year 2011

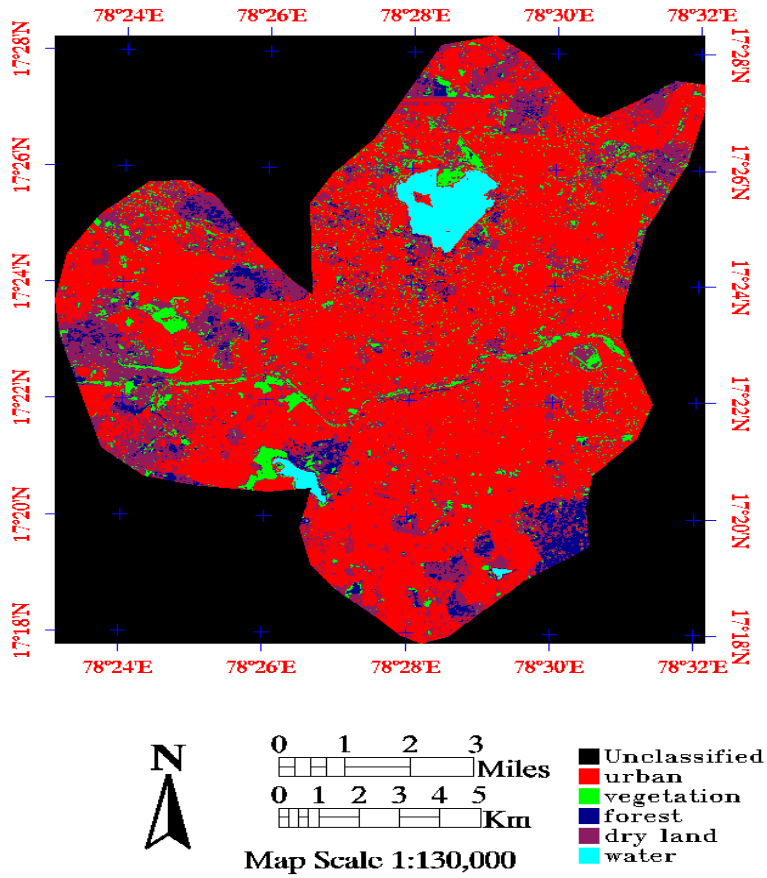

Fig. 7. Classified image of the study region using MLC classifier for the year 2021

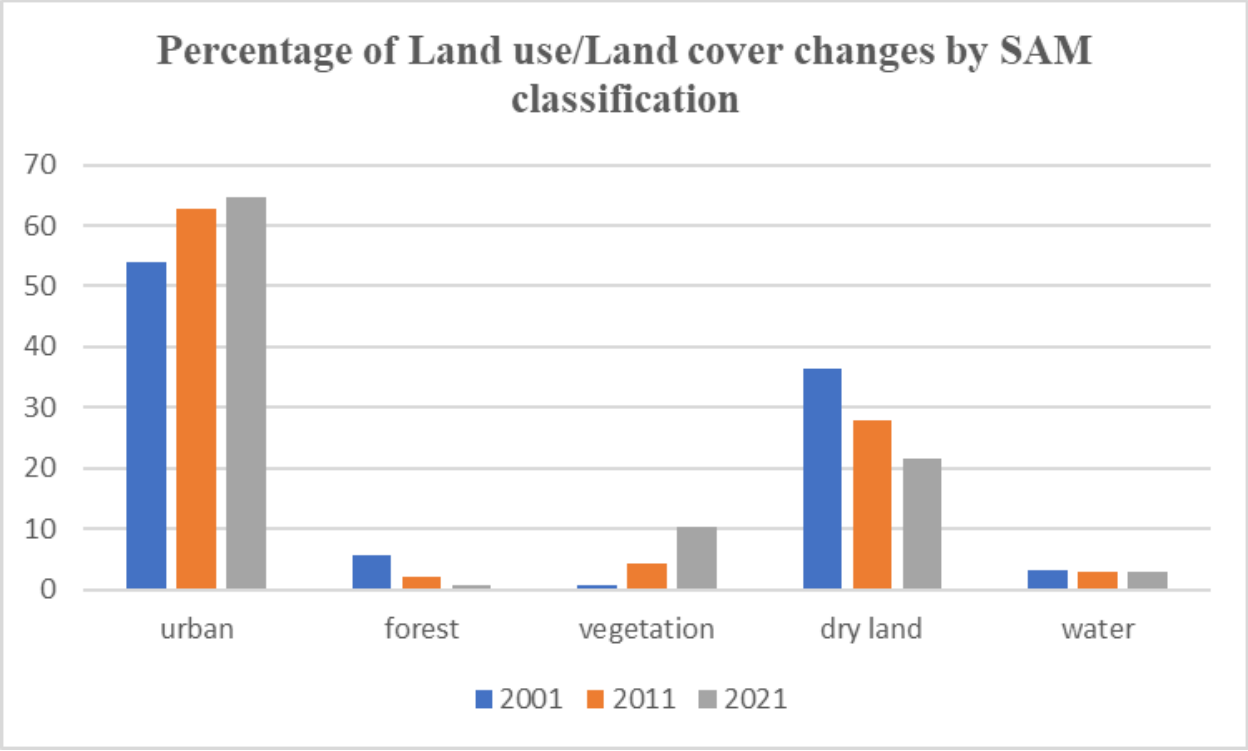

Fig. 8. Percentages of different classes of the study area obtained from SAM classification. X-axis: urban, forest, vegetation, dry land and water classes. Y-axis: percentages of the classes(%)

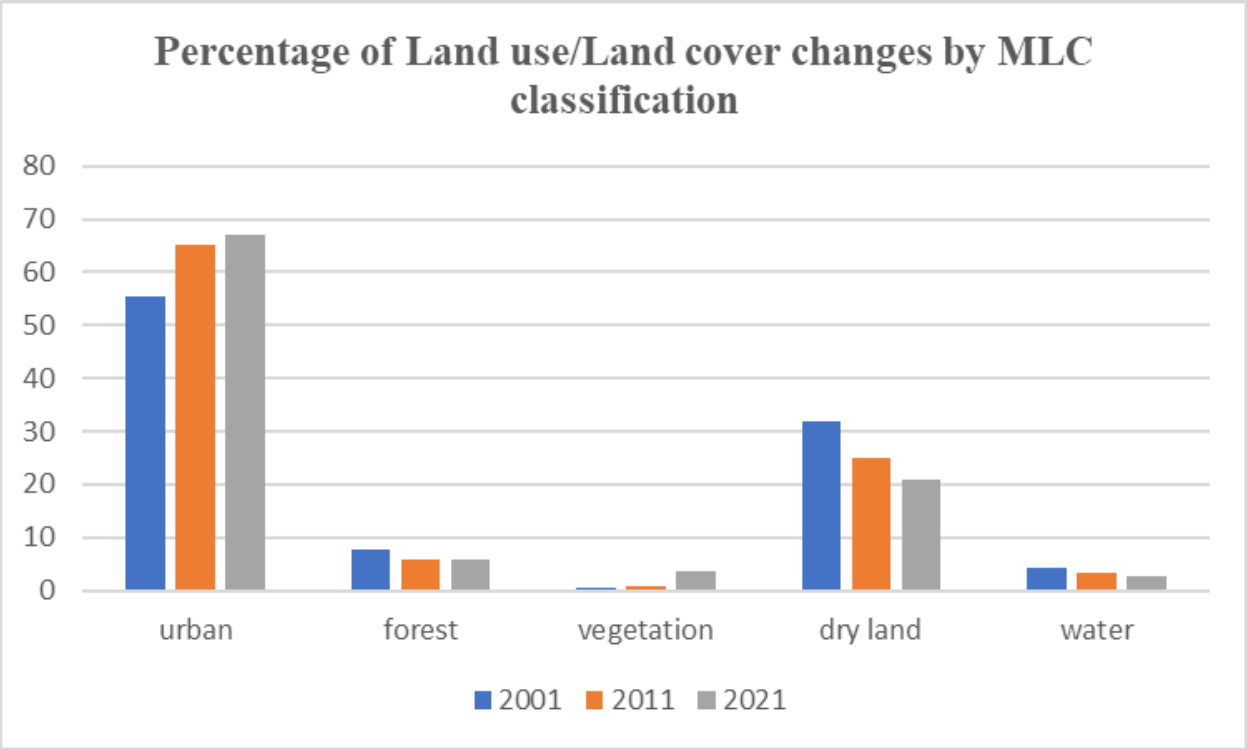

Fig. 9. Percentages of different classes of the study area obtained from MLC classification. X-axis: urban, forest, vegetation, dry land and water classes. Y-axis: percentages of the classes(%)

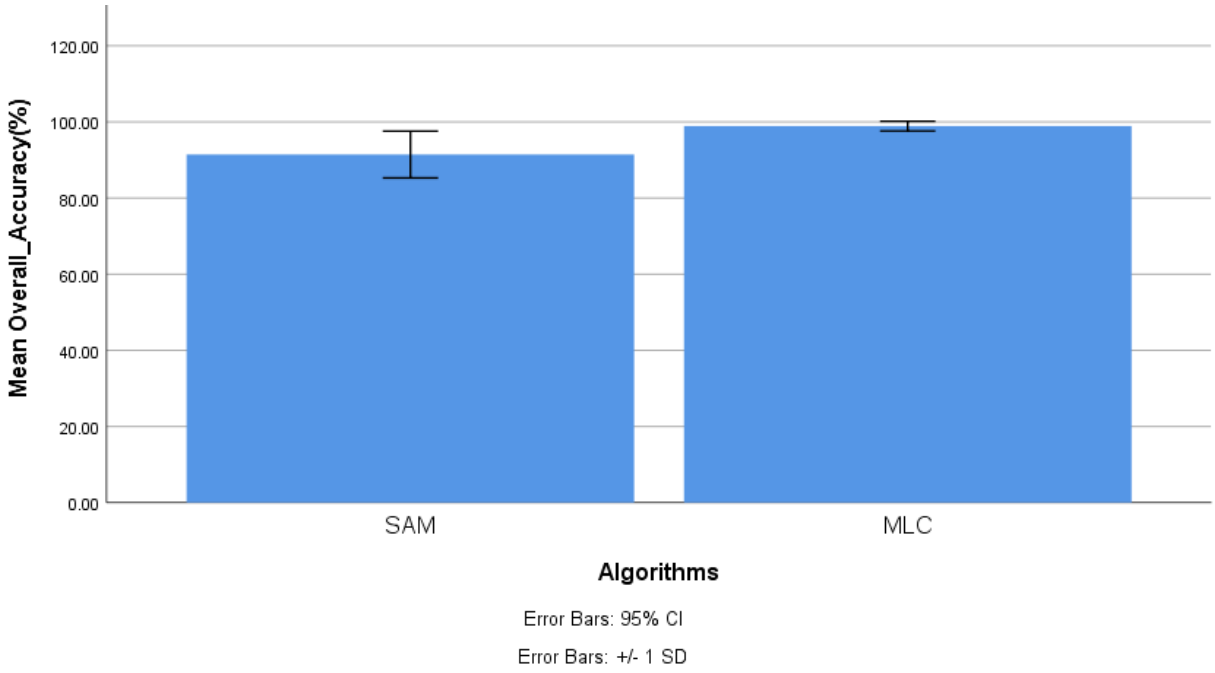

Fig. 10. Bar plot showing the mean accuracy (in %) plotted for the two groups considered, SAM, MLC. The mean accuracy is better for the MLC than the SAM . X-axis: SAM vs MLC and Y-axis:Mean Overall Accuracy ±1 SD

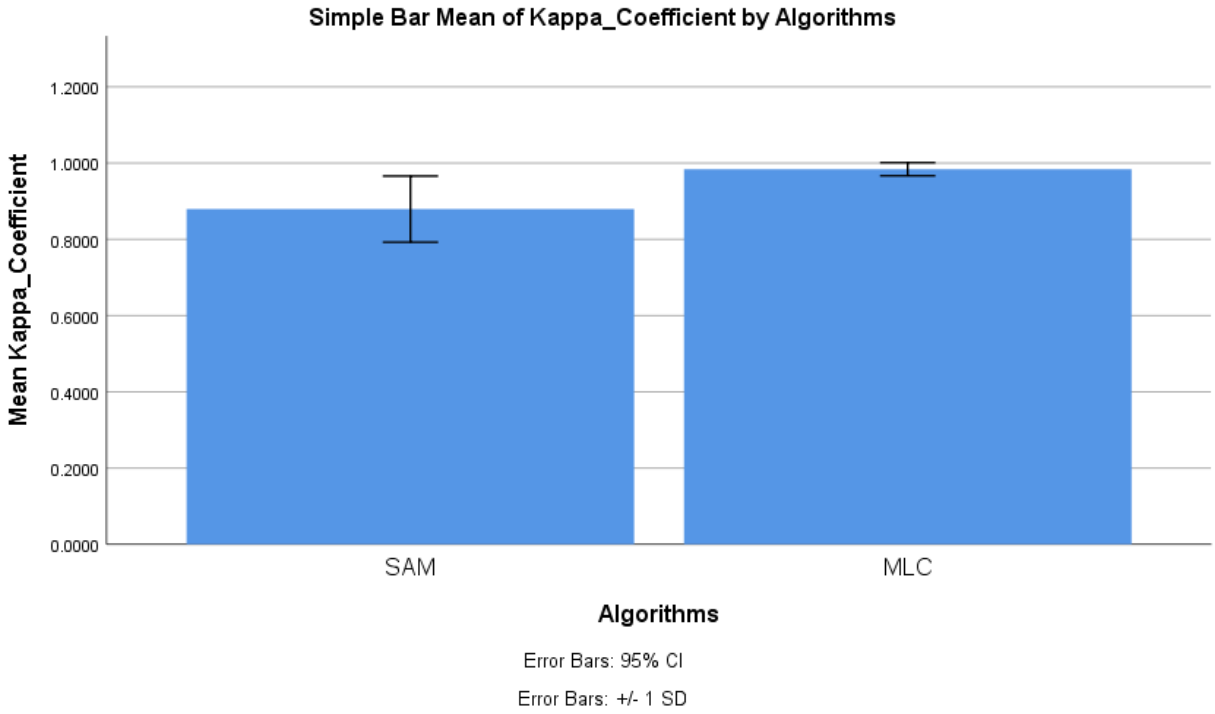

Fig. 11. Bar plot showing the Kappa coefficient (no units) plotted for the two groups considered, SAM,MLC. The mean accuracy is better for the MLC than the SAM . X-axis:SAM vs MLC and Y-axis:Mean Kappa coefficient ±1 SD

Table 1. Accuracy assessment of test results obtained from SAM and MLC classification

Types of classification	2001		2011		2021	
	Overall accuracy	Kappa coefficient	Overall accuracy	Kappa coefficient	Overall accuracy	Kappa coefficient
SAM	87.63%	0.81	88.14%	0.84	98.51%	0.97
MLC	99.29%	0.98	97.47%	0.96	99.91%	0.99

Table 2. Analysis of group statistics in terms of mean, standard deviation and standard error mean for the two groups and 6 samples. Mean accuracy and kappa coefficient is observed to be higher for the MLC classifier than that of the SAM classifier indicating better performance

Group Statistics					
Algorithms		N	Mean	Std. Deviation	Std. Error Mean
Overall_Accuracy	SAM	3	91.42	6.13	3.54
	MLC	3	98.89	1.26	0.73

Kappa_Coefficient	**SAM**	3	0.87	0.08	0.05
	MLC	3	0.98	0.02	0.09

Table 3. Independent sample t-test results carried out for two groups on overall classification accuracy and kappa coefficient for determination of statistical significance. It is observed that on performing t-test, there is statistical significant difference for classification accuracy ($p=0.037, p<0.05$) and significant difference for kappa coefficient also($p=0.046, p<0.05$)

Independent Samples Test										
		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	**Sig. (1-tailed)**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Overall_Accuracy	**Equal variances assumed**	9.48	0.037	-2.06	4.00	0.10	-7.46	3.61	-17.51	2.58
	Equal variances not assumed			-2.06	2.17	0.16	-7.46	3.61	-21.92	6.99
Kappa_Coefficient	**Equal variances assumed**	8.22	0.046	-2.04	4	0.11	-0.10	0.05	-0.24	0.037
	Equal variances not assumed			-2.04	2.15	0.16	-0.10	0.05	-0.30	0.10