SPATIAL ANALYSIS OF LAND USE AND LAND COVER CHANGE: A CASE STUDY IN THE SURROUNDINGS OF KALADAN RIVER, RAKHINE STATE

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ABSTRACT: Spatial analysis is a locational analysis which seeks to explain the patterns of human behavior that occurs over time. The paper studies spatial distribution of land use and land cover patterns using remote sensing and geospatial techniques in the surroundings of Kaladan watershed in the Northern part of Rakhine State. Kaladan River flows through Kyauktaw, Ponnakyun and Sittway townships and emptying into the Bay of Bengal at Sittway Township. Approximately one million people live in the townships along the river. The aim of the paper is to analyze the changes in land use and land cover (LULC) patterns in the surroundings of Kaladan River over the period of 2000-2020. The objectives of the paper are to detect LULC categories by using Satellite data, 2000 image and 2020 image and to calculate the change detection statistics among classified Landsat scenes. Supervised classification - minimum distance algorithm is used to identify LULC categories of 2000 and 2020 images. A post-classification comparison is generated to detect LULC changes. Then, land use land cover patterns of 2000 and 2020 in the downstream of Kaladan are determined. It is validated by the confusion matrix with a Kappa index. The study can provide suggestions as a basis for urban and rural development planning along Kaladan River from Kyauktaw to Sittway.

1. INTRODUCTION

Spatial analysis is a geographical analysis which tries to describe the distribution patterns of human behavior and its processes in terms of Geographical Information System (GIS) and Remote Sensing (RS).

LULC is the study of land surface change. Land use is the human use of land such as built-up area, and land cover is the natural characteristics of land surface such as rivers and forest. Land cover may affect land use and vice versa.
The paper presents land use and land cover (LULC) changes of the region situated in the surroundings of Kaladen River. The river and its tributaries pass through the study area. Many streams and lakes are found in this area. The area can access these water resources for many cultivated lands.

The researchers are interested in the influence of the river on LULC changes. It is one of the major rivers in Rakhine State. Its LULC changes are studied in two periods – year 2000 and 2020. To study LULC changes in 20 years, Landsat images are classified and ground truth points are used to compare the classified data.

The aim of the paper is to analyze LULC changes along Kaladan River in Rakhine State.

The objectives are to classify LULC patterns and to calculate LULC change detection statistics among classified Landsat images.

The paper is divided into five parts to implement the aim and objectives of the research. The first section is introduction, the second is literature review, the third is materials and methods, the fourth section is results and discussion, and the last one is conclusion.

2. LITERATURE REVIEW

Many scholars have studied LULC changes in many study areas. Research on LULC deals with many fields of study – RS and GIS, geography, climatology and environmental field of study. LULC research is relatively more technical, centering on remote sensing data and techniques of RS and GIS.

- Fichera, R. C., and Modica, G., Land Cover classification and change-detection analysis using multi-temporal remote sensed imagery and landscape metrics, European Journal of Remote Sensing, 2012.

This article begins with the quantification and assessment of land use and land cover changes are a challenge to scientists. It states that human activities are a fundamental role in LULC patterns. It highlights the importance of RS and GIS in assessing and analyzing LULC changes. The controlling factors for the changes are population pressure, climate and terrain. Two case studies are performed; one is geospatial LULC change modeling and another is agent based LULC change modeling.

- Qingqing, Z., Hailaing, X., Jingyi, F., Spatial analysis of land use and land cover change in recent 30 years in Manas River Basin, 2010.

The paper studies LULC changes in Manas River Basin which is the major part of the economic belt on the Northern slope of Tianshan Mountains. Four images are used for 1976, 1987, 1998 and 2006 and analyzed by ArcGis and FragStats. Cultivated land has increased with a rate of 121. 39 km2/a. This is due to the reclamation of wasteland and natural grassland. The researchers' findings state that area of residential land and industrial land increased gradually. Unused land is a stable land-use type. The authors point out that the natural environment of Manas River Valley is needed to improve for sustainable development.

- Mallupattu, K., P., and Reddy, S., Analysis of Land Use/Land Cover Changes Using Remote Sensing Data and GIS at an Urban Area, Tirupati, India, 2013.

This research outlines the use of the survey of India topographic map and remote sensing data. Eight categories of LULC are classified on the basis of primary and secondary data. The comparison of toposheet for 1976 and satellite imagery for 2003 are used. Finding of the analysis is that four classifications are significantly increased, namely built-up area, open forest, plantation and other lands. On the other hand, agriculture land, water spread area and dense forest areas are diminished. In this study, urbanization can be seen according to the classification results.

- Saharan, A. M., and Vyas, N., Classification and assessment of the land use – land cover changes in Jodhpur city using Remote Sensing Technologies, 2018.

This research presents the assessment of land use-land cover changes over the period 1990 to 2018. Five LULC categories are used. Accuracy assessment is also calculated. Urban area and vegetated area have increased and rock outcrops, mining area, water bodies have decreased. The highest percentage of change is in urban area. This article could be used as a reference for proper land planning with required infrastructure in each land development area of the city.

3. STUDY AREA

Study area is the surrounding areas of Kaladen River including three urban areas. They are Sittway city, Kyauktaw and Ponnagyun towns located in the northern part of Rakhine State. The spatial location of the study area is between $20^{\circ}\ 4'\ 12.47''$ and $21^{\circ}\ 2'$

6.7″ N Lat. and 92° 43′ 25.56″ and 93° 12′ 9.57″ E Long. It has an area of 5311 sq km (Figure 1). The study area for 2000 image and 2020 image are shown in Figure 2.

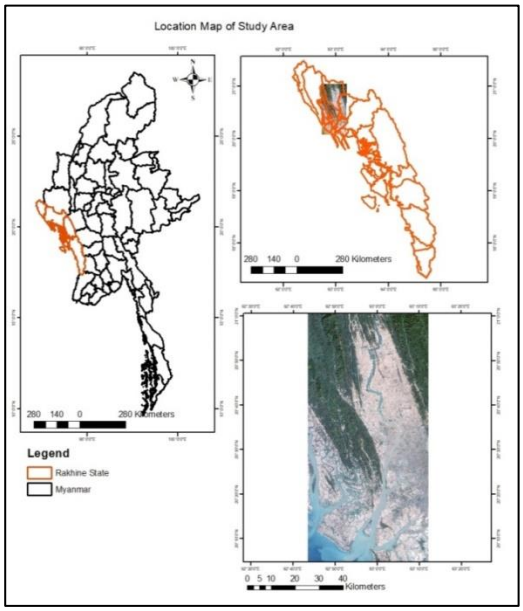

Figure 1. Location Map of Study Area in Rakhine State

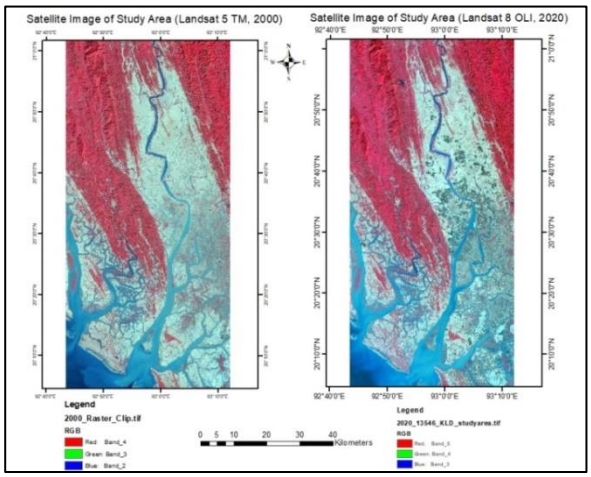

Figure 2. Satellite Images of the Study Area (Landsat 5 TM, 2000) and (Landsat 8 OLI, 2020)

4. MATERIALS AND METHODS

Landsat images for 2000 and 2020 are used in this research. Landsat 5 TM for image 2000 and Landsat 8 for 2020 are acquired from USGS Earth Explorer. Characteristics of the satellite data used in the study are shown in Table 1. Definitions of the five classes are described in Table 2. Ground Truth data are recorded in the form of location points for five classes to verify LULC classification and to assess the classification accuracy.

Table 1. Characteristics of satellite data

Satellites	Path/ Row	Acquisition Date	Resolut -ion	RGB Composite
Landsat 5 TM	135/46	2000-01-21	30m	432
Landsat 8 OLI	135/46	2020-01-28	30m	543

Table 2. Description of LULC Classification

Class	LULC Classes	Definitions
1	Built-up area	Areas include residential and recreational land, industrial and commercial land, land for transportation and religious purposes
2	Cultivated land	Arable land is worked by plowing sowing and raising crops
3	Water body	Areas cover with open water, river, stream, lakes and ponds
4	Vegetation	Areas with forest, trees, shrubs and grass
5	Bare land	It is a type of fallow land with no crops at all

Source: Eurostat, Glossary, Sept, 2019

Remote sensing techniques are used to analyze the land use and land cover changing patterns and monitor the environmental landscape with the context of GIS.

To analyze LULC changes in a 20-year period of time, two Landsat images are downloaded and image pre-processing is performed by using techniques in GIS and RS. Band composite is completed in ArcMap. Clip the study area and overlay the points and lines to highlight the study area are also accomplished in ArcMap. Then images are resized with the help of resize data parameters. Training samples in ROI are created for five types of LULC. After ROI are created, minimum distance method is used for calculating the probability of a particular pixel assigned to the classes. Minimum distance is used because the class brightness values overlap in the spectral feature space, but not there is any correlation between sample brightness. Methods and procedures

to implement the aim and objectives of the research are shown in Figure 3.

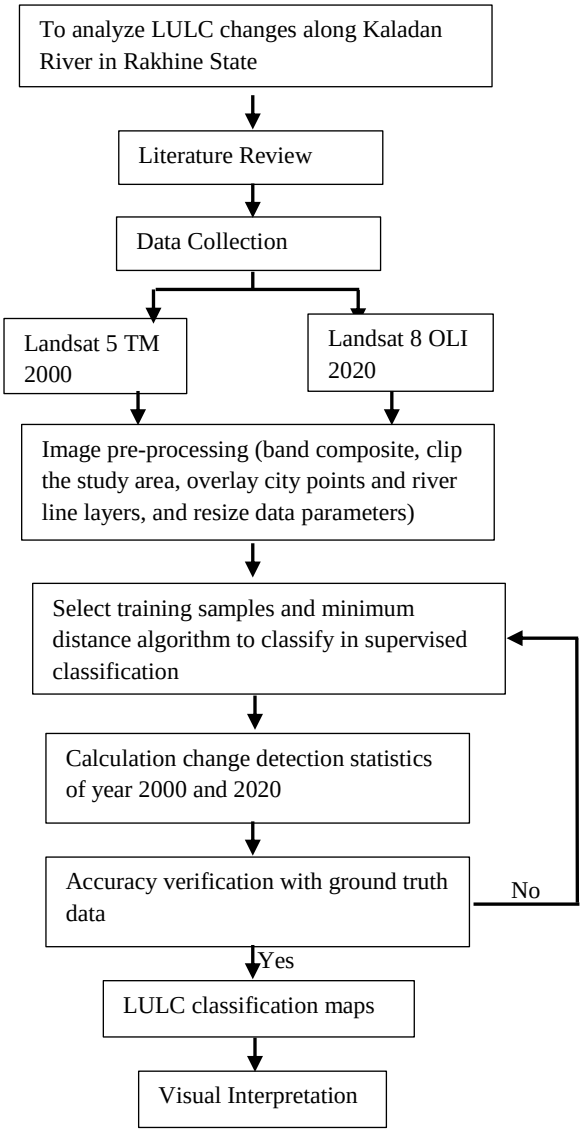

Figure 3. Flow Chart of the Research Framework

5. RESULTS AND DISCUSSION

The study area has five LULC categories to determine LULC patterns of 2000 and 2020 in the downstream of Kaladan. They are bare land, water body, built-up area, vegetation and cultivated land. LULC classification results for 2000 and 2020 are shown in figure 4 and 5. To compare defining areas of interest between images from two different years, change detection is calculated. Change detection matrix for 20 years (2000-2020) is shown in Table 3. In the context of remote sensing, change detection refers to the process of identifying differences in the state of land features by observing them at different times (Jason Karl and Anne Axel, 2014).

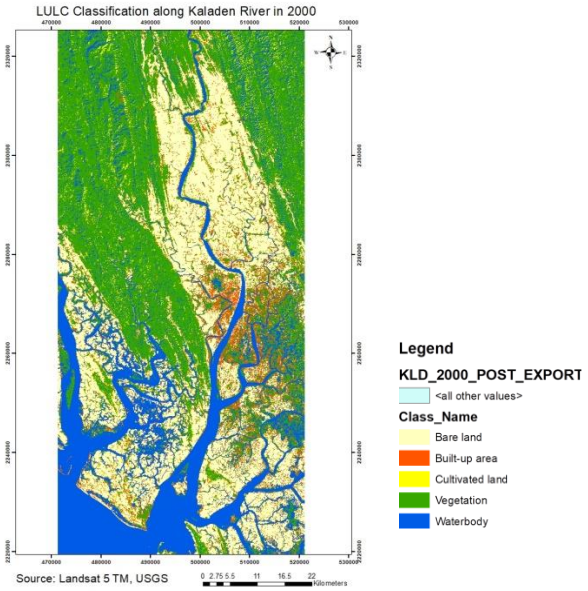

Figure 4. Classified Map (2000)

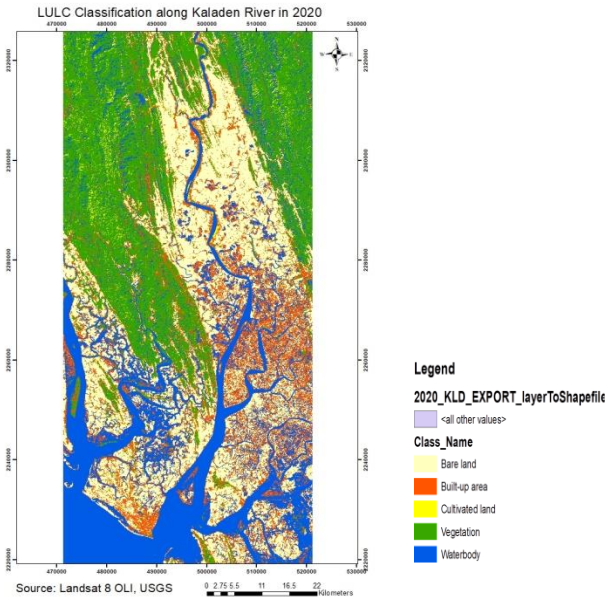

Figure 5. Classified Map (2020)

To verify the classification, accuracy assessment of the classification results is measured using confusion matrix and Kappa coefficient. Overall accuracy is 77.54%. The Kappa value is 0.71. Ground Truth Map for overall accuracy assessment is illustrated in Figure 6.

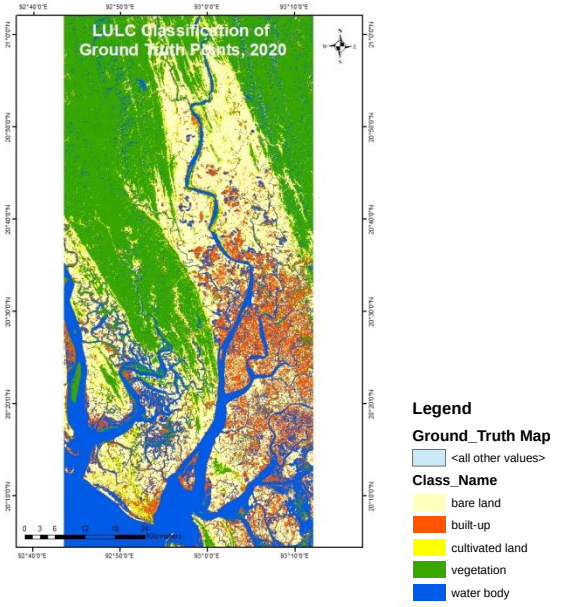

Figure 6. Classified Map of Ground Truth Data (2020)

Total area differences are shown in change detection matrix table. Built-up area and cultivated land area are increased. Areas of bare land, water body and vegetation are decreased.

Figure 5 depicts the changes of LULC during the period 2000 to 2020. In particular, during two decades, built-up area increases from 414188100 sq meters to 562612500 sq meters. The results show that the urban built-up area has increased by 272473200 sq meters and cultivated land by 64957500 sq meters. As a percent built-up area has increased by 65.7% and cultivated land has also increased by 40.5%. It can be clearly seen the urbanization in the study area, and the economy of the area is primary activity. The important reason is the area is situated along Kaladen River and its tributaries and its downstream area where is the most suitable for agricultural lands. Soil for the cultivation is alluvial and fertile soil. Moreover, to expand the settlement units, the study area has one major state city, Sittway and two major towns namely, Ponnagyun and Kyauktaw. As a consequence, bare land, water body and vegetation areas have decreased. Bare land has decreased by 21.4%, water body decreased by 23.3% and vegetation, 48.5% (Table 3).

The township administration can be aware of the needs for the increasing urban area and agricultural lands such as basic infrastructures and sufficient irrigation system. The outputs from the analytical results of RS and GIS will be informative for the policy makers and urban planners. Moreover, updated data can also be accessed in land use planning for the study area.

Many shcolars stated the various analytical results. “Fichera, 2012 stated that human activities play vital role in LULC changes and controlling factors for the changes are population pressure. Cultivated land has increased (Qingqing, 2010), and significantly increased in built-up area and plantation (Mallupattu, 2013). Urban area and vegetated area has increased (Saharan, 2018).”

These findings accord with the results of the present paper studying the LULC changes around the Kaladen River – the significantly increase in built-up area and cultivated land.

6. CONCLUSION

This study has two objectives. The first one is to classify LULC patterns by the use of satellite images in the context of GIS. The second one is the calculating change detection statistics among classified Landsat images to analyze the differences of LULC changes along Kaladan River during 20 years. Change detection method in post classification can be used to compare each class and can update the result based on databases.

Results from remote sensing data and techniques provide LULC patterns and have been used in decision making process. The results analyzed from the study indicate that the urbanization has considerably modified the LULC around downstream area of Kaladen River with significant increase of culitvated land.

Kalaken River is one of the major rivers in the State. It has played a fundamental role in the LULC patterns. Settlement areas are intensely found along the banks of the river and small islands in the river. Lands near the water resources such as the Kaladen River and its tributaries, lakes and ponds are devoted to cultivate lands. This is intensely seen in 2020 image. Additionally, the fertile soil in this area contributes to the expansion of settlement patterns, especially in the fast development in the towns and lands near the water sources. More than half of the study area's agricultural land is found along the Kaladen River valleys and plains of the Kyauktaw, Ponnagyun and Sittway townships.

On the other hand, urbanization affects the landscape change, that is, areas of vegetated cover, water body and bare land have decreased. The most striking feature is the change of built-up area, agricultural land and forest area among increasing and decreasing phanomenon. Human activities play a vital role on the change of around the river. The impacts of human activities on the surroundings of the river involve irrigation, reclamation the land, fishery and transportation.

This study can provide a basis for land use planning and environmental planning to monitor the LULC change along the downstream area of Kaladan River including one state city and two major towns.

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Table 3. Change Detection Results in 20 years

Pixel Counts	Bare land	Water body	Built-up area	Vegetation	Cultivated land	Row Total
Unclassified	0	0	0	0	0	0
Bare land	1253834	24397	192615	95063	25294	1591203
Water body	113975	1124515	60980	67253	4256	1370979
Built-up area	194015	58852	157461	188119	26678	625125
Vegetation	14651	256328	30940	1137330	15947	1455196
Cultivated land	18999	2467	18213	721505	105913	867097
Class Total	1595474	1466559	460209	2209270	178088	0
Class Changes	341640	342044	302748	1071940	72175	0
Image Difference	-4271	-95580	164916	-754074	689009	0
Percentages	Bare land	Water body	**Built-up area**	Vegetation	Cultivated land	**Row Total**
Unclassified	0	0	0	0	0	0
Bare land	78.587	1.664	41.854	4.303	14.203	100
Water body	7.144	76.677	13.251	3.044	2.39	100
Built-up area	12.16	4.013	34.215	8.515	14.98	100
Vegetation	0.918	17.478	6.723	51.48	8.955	100
Cultivated land	1.191	0.168	3.958	32.658	59.472	100
Class Total	100	100	100	100	100	0
Class Changes	21.413	23.323	**65.785**	48.52	**40.528**	0
Image Difference	-0.268	-6.517	35.835	-34.132	386.892	0
Area (Square Meters)	Bare land	Water body	**Built-up area**	Vegetation	Cultivated land	Row Total
Unclassified	0	0	0	0	0	0
Bare land	1.128E+09	21957300	173353500	85556700	22764600	1.432E+09
Water body	102577500	1.012E+09	54882000	60527700	3830400	1.234E+09
Built-up area	174613500	52966800	141714900	169307100	24010200	**562612500**
Vegetation	13185900	230695200	27846000	1.024E+09	14352300	1.31E+09
Cultivated land	17099100	2220300	16391700	649354500	95321700	780387300
Class Total	1.436E+09	1.32E+09	**414188100**	1.988E+09	160279200	0
Class Changes	307476000	307839600	272473200	964746000	64957500	0
Image Difference	-3843900	-86022000	148424400	-6.79E+08	620108100	0

Source: Figure 4 and 5