

Geographical Analysis on Land Use and Land Cover Changes in Pathein Township

Moh Moh Khaing¹, Thin Thin Myat², Myo Ma Ma Wai³

Abstract

This geographical study is an attempt to analyze the changes of land use and land cover change in Pathein Township. The change of land use types are obtained from Department of Agriculture and Land Records Department of Pathein Township. Based on those data spatial changes of agricultural lands, forest lands, settlement lands, transportation lands, mining and industrial lands, institutional lands and other lands are calculated. Land cover is analyzed by using satellite imagery and Geographic Information System (GIS). The study area has changed in four types of land cover (2000-2015) due to the pressure of growing population. The changes of the land use and land cover are interrelated and consequently these two factors have exerted an impact on the economy of the study area. This research will also be partially helpful for the future development planning of Pathein Township.

Keywords: Landcover, Landuse, Socio-Economic condition

Introduction

Land use and land cover change occurs slowly or abruptly partly due to natural forces and greatly to man induced activities. Land is the basic need for many life support systems. Natural environment and human-induced environmental changes are of concern today because of deterioration of environment and human health. The study of land use and land cover changes is very important to have proper planning and utilization of natural resources and their management. Remote sensing and GIS have covered wide range of applications in the fields of agriculture, environments and integrated eco-environment assessment. Present study area witnessed rapid development during past decades in terms of urbanization, industrialization, and also population increase substantially.

Research Problems

Land use and land cover changed in Pathein Township during last decades. Those changes are different in spatial and temporal scale. Therefore, this study focuses on the controlling factor over the land use and land cover changes, essentially man-induced activities.

Aim

The main aims of research are to analyze the land use and land cover of the study area and to provide feasible suggestions for future development.

Objectives

The main objectives are:

- To examine the geographical bases encouraging land use and land cover changes,
- To study the categories of land use and land cover, and
- To analyze the land use and land cover in the study area.

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Sources of Data and Methodology

Primary Data Sources

Primary data are obtained from the field observation for change of land use and land cover condition and questionnaire survey and structured interviews.

Secondary data Sources

Secondary data Sources were collected from libraries and Department. Elevation, drainage, soil and vegetation data are extracted from DEM (Digital Elevation Model) and Landsat TM7 Image (2000 and 2015).

Methodology

Land use changes were analyzed for 15 years from 2000 to 2015. Type of land cover were studied based on Landsat TM 133-48 satellite data acquired in 2000 and 2015 with the field survey and Geographic Information System (GIS) techniques to analyze the land cover.

Location, Size, Shape and Boundaries

Pathein Township occupies the western part of Ayeyarwady Region located in the western part of Myanmar. It lies between North latitudes $16^{\circ} 34' 50''$ and $16^{\circ} 59' 39''$ and between East longitudes $94^{\circ} 42' 45''$ and $95^{\circ} 02' 55''$. The township is bounded by Thabaung Township 25.75 kilometres (16 miles) on the north, Kangyidaunt Township 24.14 kilometres (15 miles) on the east, Ngaputaw Township 32.19 kilometres (20 miles) on the south and the Bay of Bengal on the west.

The area of Pathein Township is 1670.2 square kilometres (644.88 square miles), sharing 4.77 percent of Ayeyarwady Region. The township comprises Ngwe Hsaung Sub-Township, Shwe Thaung Yan Sub-Township, 15 wards and 53 village tracts made up of 272 villages. Generally the shape is slightly elongated tapering towards the north (Moh Moh Khaing, 2012).

Pathein Township is one of the 26 townships of Ayeyarwady Region and it is flanked by the Bay of Bengal in the west. It is easily accessible by roads to Monywa, Yangon and other towns and also by railroad along Pathein-Hinthada-Kyangin, in addition to waterway. Thus, it has comparatively locational advantage. As it occupies the fertile alluvial land of delta, agriculture is well developed. (Figs. 1, 2 & 3)

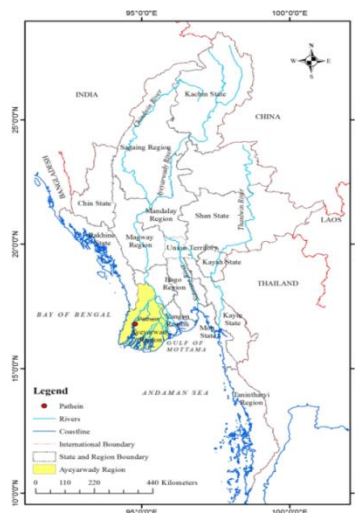


Figure (1) Location of Ayeyarwady Region the Republic of the Union of Myanmar. (Source: Survey Department, Yangon)

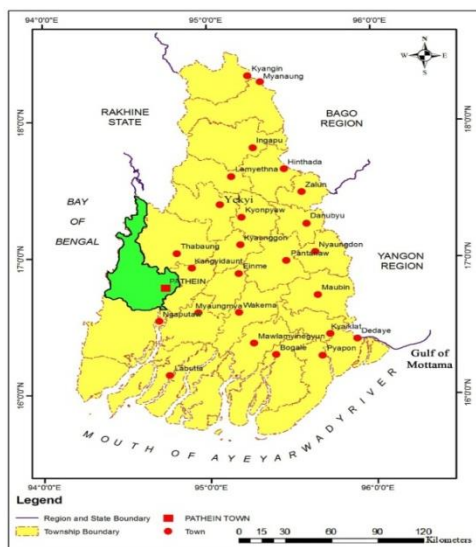


Figure (2) Location of Patheingyi Township of Ayeyarwady Region. (Source: Survey Department, Patheingyi)

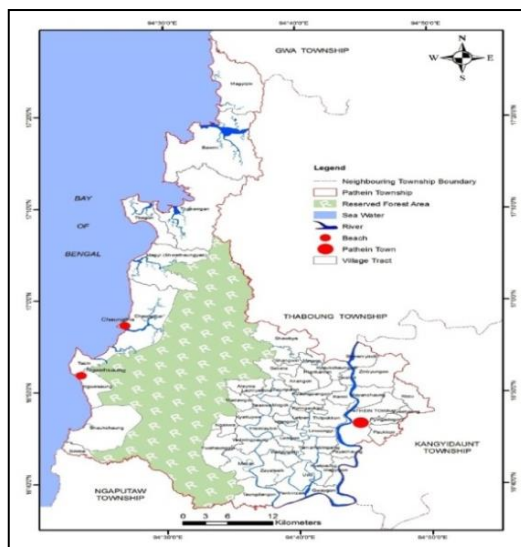


Figure (3) Location of Village Tracts in Patheingyi Township. (Source: Survey Department, Patheingyi)

Relief and Drainage

Although Patheingyi is located in the Ayeyarwady deltaic region, the relief of the entire township is not flat, owing to the southern continuation of mountain spurs, low hill and ridges of Rakhine Yoma and ranges (Hla Tun Aung, 2003). Physiographically it can be divided into three parts as follows: (Fig. 4).

- (1) The Delta and River Plains
- (2) Mountain Spurs of Rakhine Yoma
- (3) The Western Narrow Intermontane Valleys

(1) The Delta and River Plains

This part of the township is manifested by the Ayeyarwady deltaic conditions and river valleys. Generally the land is low and flat, but a few low hills with less than 30.48 metres or 100 feet in height are sporadically found. The low land is fairly extensive to the east of the Ngawun River (Patheingyi River) essentially built by the Ngawun River and its tributaries. Being fertile alluvial land, it is favourable for successful growing of a variety of crops. These plain areas are moderately populated, engaging in farmwork.

(2) Mountain Spurs of Rakhine Yoma

The mountain spurs of Rakhine Yoma continue southward until Mortin Point. In the north, the elevation is about 121.92 metres or 400 feet, but the spurs rise somewhat higher towards the south. This elevated area occupies the western part of the township and is covered with thick forests. Therefore, the extraction of forest products from the reserved forests is one of the important economic activities of the township.

(3) The Western Narrow Intermontane Valleys

The narrow intermontane valleys are formed between the Bay of Bengal and the mountain spurs of Rakhine Yoma. The land is rocky with rugged terrain due to the intrusion of the mountain spurs towards the coast. Sand beaches form the dominant landscape in the coastal area, and narrow alluvial plains formed by the deposition of streams rushing down the steep slopes occupy the places. These plain areas are moderately populated, engaging in farmwork. The coast is highly indented with small bays and islets with attractive natural scenic views,

enhancing the development of tourism. The rocky sea-cliff and sand islands are found along the coast. There are white sands useful for making glasses in the Thepyu Island.

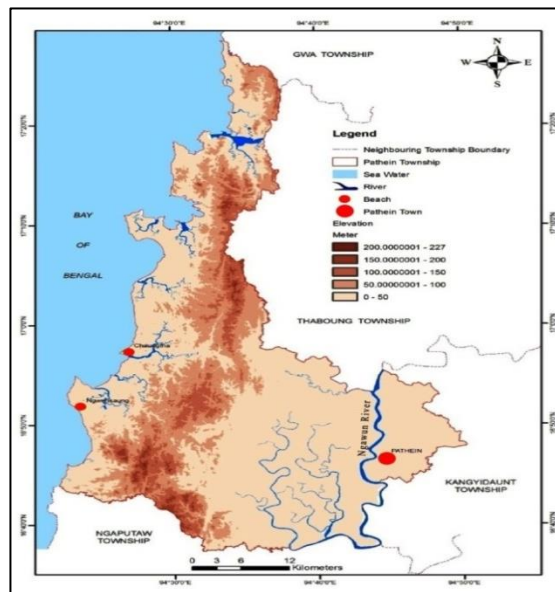


Figure (4) Physical Features and Drainage Pattern in Pathein Township. (Source: Land Records Department, Pathein)

Drainage

Being part of the deltaic area, the streams are criss-crossing, forming a complex channel network. The Ngawun River and its tributaries have the appearance of dendritic pattern. The river which flows from north to south with a length of about 322 kilometres (200 miles) before entering the sea is the most important river in the study area. A number of small streams flowing into the river of which the Thandwe River, Byaingphyu and Kyaukchaungkye Creeks are more useful. The Thandwe River is 40.23 kilometres (25 miles) long into which Yankyaw, Thalathwar and Maezali creeks flow. The Byaingphyu Creek flows from north to south about 4.82 kilometres (3 miles) to the west of the confluence of Byaingphyu Creek and Thandwe River.

Natural Vegetation

Natural vegetation largely depends on relief and drainage, climate and soils. Although the study area was once covered with thick forests in response to high temperature and abundant rainfall, the forest area has been much reduced owing to land clearing for agriculture, settlement, infrastructures and beach resorts. The most dominant forest types found in Pathein Township are tropical evergreen, mixed deciduous and tidal (mangrove) forest.

Social Factors

Such social factors as population growth, density and distribution and institutional factor influence the economy of the township directly or indirectly (Clarke, 1981).

Population Growth and Density

Under the British colonial regions, the vast alluvial land, covered with reeds, raw grasses and bushes, was converted into agricultural land for commercial rice production. As the reclaimed lands were given ownership right to the farmers, people from different parts of the country came and settled in the deltaic region including the study area.

According to the 1921 census, Pathein Township had a total population of 76752 persons and the population increased to 85937 persons in 1931. The average growth rate in the 10-year period from 1921 to 1931 was 1.14 percent per annual. A complete population census was taken in 1973 and Pathein, according to the census, had 196924 persons. The increase from 1931 to 1973 was more than two-fold. When the second population census was taken in 1983, the number of population in Pathein Township increased to 236409 and thus the average annual growth rate in the 1973-1983 period was 1.84 percent. In the 1983-1993 period and 1993-2003 periods, the growth rates were 1.85 percent and 2.00 percent respectively. The estimated number of population was 373113 persons and the average growth rate in the 2009-2010 periods was 1.07 percent per year. In 2014 the number of population was 380985 persons and the average growth 1.01 percent per year.

The population density is directly related to the number of population. With the increasing number of population, the density has also increased. In 1921 the township had a population density of 53 persons per square kilometer. The density increased from 118 in 1973, 142 in 1983, 170 in 1993, 207 in 2003 to 223 persons in 2010 and 228 persons in 2014. The population density varies from place to place within the study area. As in all other townships, the density is highest in the urban area. In the rural areas people are concentrating more along the streams where accessibility is relatively high with broad village tracts of fertile farmland (Fig. 5).

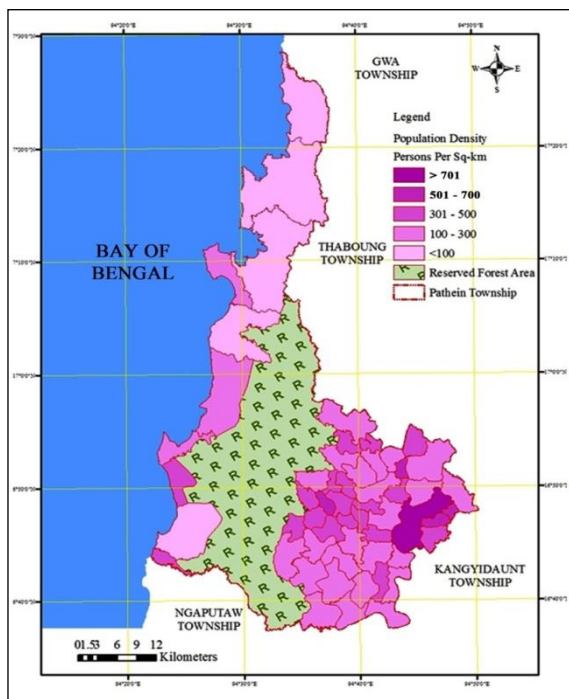


Figure (5) Population Density by Town/Village Tracts within Pathein Township.

Land Use and Land Cover Changes in Pathein Township

General Land Use of Pathein Township

The changes in land use, to some extent, unfold the change in regional development. Pathein Township encompasses a total area of 167027 hectares or 412723.7 acres. The general land use is usually classified as cultivated land, culturable waste land, forest land and uncultivable land, forest land and uncultivable land (Min Min Aye Than, 2011). The

uncultivable land includes lands used for settlements, transportation, industrial building, religious purposed, cemetery, water body and pasture.

In 1999-2000, the township had a cultivated land area of 46308.8 hectares or 114429 acres which accounted for 29.7 percent of the township area and it increased to 65523.9 hectares or 161913 acres represent 39.2 percent of the township area. The increase in the occupied land area was mainly due to the reclamation of culturable waste land in response to the changed economic system and the high demand of agricultural produces.

There were 3695.7 hectares or 9139.48 acres of culturable waste land in 1999-2000 which shared 2.4 percent of the township area. This type of land decreased to 637.38 hectares or 1575 acres in 2014-2015 due to the reclamation of culturable waste land into agricultural land.

The area occupied by forest land was 44488.9 hectares or 109932.07 acres (28.5percent). It has increased to 36969.3 hectares or 91353 areas in 2014-2015.

The area includes uncultivable land an area of 61401.5 hectares or 151723.1 acres (39.4%) in 1999-2000 and it increased to 63892.2 hectares or 157881 acres (38.3 %) in 2014-15.

The increase was on account of the land extension of settlements with the increasing population and the establishment of infrastructural facilities, particularly road construction. The industrial areas expansions are also accounted for the increase of uncultivable land.

Categories of Land Cover in Pathein Township

Land cover is one of the most important elements for description and study of the environment (FAO 2005). Land is observed physical cover on the earth's surface. It includes vegetation and man-made feature as well as bare rock, bare soil and inland water surface (Di Gregorio and Jansen, 2005).

Many classification systems of land cover are being used throughout the world. However, there is no single internationally accepted land cover classification system. Each classification is made to suit the needs of the user, and few uses will be satisfied with inventory that does not meet most of their needs (Lee *et al.*, 2001).

At the more generalized levels it should meet the principal objective of providing a land cover classification system for use in land use planning and management activities.

In studying the global land use and land cover change, Lambin *et al.*, (2003) used five categories of land cover: crop land, agricultural land, forest land, pasture land urban land. Leper *et at.*, (2005) considered four categories of land cover namely, crop land, forest land, degrading lands in dry zone and urban settlements for the study of global land use and land cover.

Several classification systems are designed for or amenable to use with remote sensing techniques. Remote sensing image-forming devices do not record activity directly. The remote sensor acquires a response which is based on many characteristics of the land surface, including natural or artificial cover. The interpreter uses patterns, tones, textures, shape and site association to drive information about land use activities from what basic information about land cover is obtained.

A land use and land cover classification system which can effectively be employed orbital and high altitude remote sensor data should meet the following criteria (Anderson, 1971):

1. The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensor data should be at least 85 percent.
2. The accuracy of interpretation for the several categories should be about equal.
3. Repeatable or repetitive result should be obtainable from one interpreter to another and from one time of sensing to another.
4. The classification system should be applicable over extensive areas.
5. The categorization should permit vegetation and other types of land cover to be used as surrogates for activity.
6. The classification system should be suitable for use with remote sensor data obtained at different times of the year.
7. Effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensor data should be possible.
8. Aggregation of categories must be possible.
9. Comparison with future land use should be possible.
10. Multiple uses of land should be recognized when possible.

Some of these criteria should apply to land use and land cover classification in general, but some of the criteria apply primarily to land use and land cover data interpreted from remote sensor data.

For the study of land use and land cover changes of Pathein Township, it is required to know the general land use and land cover types in the Township. Moreover, knowledge of the present distribution and area of agricultural, recreational and urban lands, as well as information on their changing proportions, is needed by legislators, planners and the state and local governmental officials to determine better land use policy, to project transportation and utility demand, to identify future development pressure points and areas, and to implement effective plans for regional development. Therefore, land use and land cover classification system of Pathein Township presented in this paper includes only the more generalized one at the first and second levels (Table 1).

Table (1) Land Cover Classification System Pathein Township. (Source: Compiled by Researcher based on USGS Classification System)

No	Level (I)	Level(II)
1	Agricultural Land	“Le” land, “Ya” land, “Kaing-kyun” land, Garden land
2	Forest Land	Reserved Forest Land Closed Forest land
3	Non-agricultural Land	Transportational land Residential land Mining and industrial land Other lands
4	Areas of Water Body	Rivers and Streams Lakes and Ponds Dams and Reservoirs

Table (2) Distribution of Level (I) Land Cover Categories in Pathein Township. (Source: Land Record Department in Pathein Town)

Land Cover Types	2000		2015		Change(+/-) (2000-15)
	Hectare	Township Area (%)	Hectare	Township Area (%)	
Agricultural Land	53675.56	32.14	66161.35	39.61	+6485.7
Forest Land	49680.10	34.46	36969.30	34.60	+207.2
Non-agricultural Land	57566.62	29.74	57773.82	22.13	-12710.8
Areas of Water Body	6100.65	3.65	6118.45	3.66	+17.8
Total	167022.92	100.00	167022.92	100.00	

There are four categories in level (1) cover group. These are agricultural land, forest land, non-agricultural land and area of water body. The level (1) categories can be subdivided into 13 types in level II land cover group. Land cover classification system of study area is shown in Table (1).The distribution of Level (I) Land Cover categories is presented in (Table 2) and (Fig. 6).

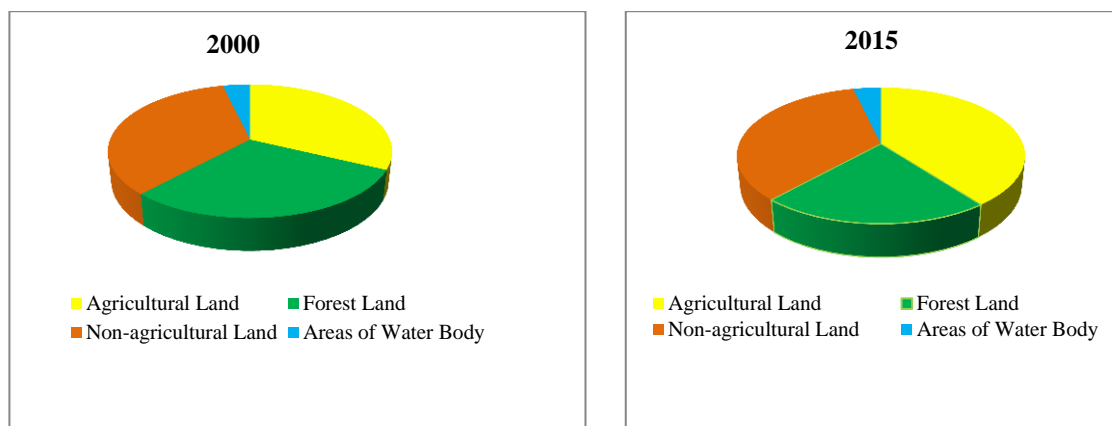


Figure (6) Distribution of Level (I) Land Cover Categories in Pathein Township. (Source: Based on Table 2)

Agriculture Land

Agriculture plays an important role as the basic sector in the main economic production of the study area. Therefore, agricultural lands are found widespread in the study area. The level II categories of agricultural land in Pathein Township are “Le” land, “Ya” land, “Le” land, “Kaing-kyun” land and Garden land. “Le” land is the most distinctive agricultural land type in the study area. “Le” land is more suitable for rice cultivation and sesamum, pules and beans are also grown on this land. According to 2015 data, the study area had 42153.74 hectares of “Le” land which amounted to 25.24 percent of the total area.

“Garden” land was the second largest agricultural land type in the study area. According to 2015 data, “Garden” land off the study area was 22181.26 hectares which covers to 32.82 percent of the study area. “Garden” land is more suitable for “Garden” crops such as rubber, coconut, betel-nut, cashew and mango.

“Kaing-kyun” lands are found on the floodplains of Patheingyi Rivers. This land is a very small area in the study area. Tomato, onion, bean, ladyfinger, pumpkin and vegetable are commonly grown on this land.

The population of the study area increased year by year and so the demand for food is also growing. This demand has to lead an increasing amount of the cultivable land. Therefore, the changes of agricultural land cover are prominent in the study area.

Forest Land

As there are many forest lands, the forest products play an important role in the economy of the study area. The forest products include teak, hardwood, bamboo, cane, charcoal, firewood, honey, bee wax and cutch. During 2015, there were 36969.30 hectares of forest area in the study area which amounted to 34.60 percent of the total area. As the study area occupies part of the mountain spurs of Rakhine Yoma, that part of the land is thickly forested, combined with high temperature and copious rainfall. Some forests are classed as reserved forests. The forest reserves in Patheingyi Township are Chaungtha, Mezali, Thalethkwar, Sinma and Kyaukchaungkyi. In Patheingyi township, deforestation usually takes at the edge of large forest areas and along major transport network. Therefore the conservation and management of natural forests have been carried out in the study area.

Non-agricultural Land

The area under non-agricultural land in the study area was 57773.82 hectares which amounted to 22.13 percent of the areas of the study area. The level II categories of non-agricultural land are transportational land, residential land, mining and industrial land and other lands.

The transportational land of the study area had 805.73 hectares which amounted to 0.48 percent of the total area. In the study area, there are roads, railways and also waterways. Waterways are the chief means of transportation.

Residential lands include towns and villages. During the year 2015, the total residential lands of the study area had 4284 hectares which amounted to 2.56 percent of the study area. Most of the residential lands are found in the rural areas.

In the study area, there are mining and industries are 568.18 hectares which amounted to 0.34 percent of the study area. Private mills and industries are rice mills, saw mills, oil mills and other industries. Rice mills and oil mills are widespread in the study area. The saw mills are located in urban area. Other cottage industries include workshops, food staff factories and other small mills.

Other lands include pasture, religious land cemetery, virgin land and other unclassified areas. In the study area, other lands occupied 57773.82 hectares which amounted to 22.13 percent during this year.

Areas of Water Body

River and streams, lakes and ponds, dams and reservoirs are included in level II categories of the area of water body. In 2015, area of water body was 6118.45 hectares which amounted to 3.66 percent during this year.

Analysis of Land Use and Land Cover Changes in Pathein Township

The analysis of land cover changes mainly focuses on four types of land cover in the study area. The period of land cover change analysis covered a 15-year time frame from 2000 to 2015. Landsat image of 2000 and 2015 was processed by 30 meter resolution in Environmental Visualization Image (ENVI 4.7). Besides 2000 Landsat image was processed by Landsat 7 ETM image (133048). In 2015 Landsat image was processed by Landsat 8 ETM image (133048).

Types of Land Cover

The earth's surface is a combination of various elements including vegetation types, soil types, exposed types, water bodies, agricultural and human activities. Land cover types of the area are changing (Fig. 7).

In analyzing the main land cover changes of the township, priority is given to the changes in the main land cover types such as Agricultural Land Cover, Forest Land Cover, Non-Agricultural Land Cover, Forest Land Cover, Bare Land Cover and Water Body. It is found that the areas of the Agricultural Land Cover, Non-Agricultural Land Cover, Bare Land Cover and Water Body had increased. However, the areas of Forest Land Cover had decreased. In order to fulfill the needs for the well-being and welfare of the increasing population of the township, changes in their land uses which had been carried out, had caused the land cover change within the township.

In the study area, during the 15-year period from 2000 to 2015, the area of the agricultural land cover had increased. In Pathein Township, the village tracts were Shankwin, Anankon, Kyaunpankon, Gwogon, Makyekon, Uto, Yaymanaypinkainn, Aleywar, Paukkon, Shwemyindin and Aleywar, Paukkon and Kyetpaun. These village tracts are located in the Pathein River valley. The increase of net sown area in these village tracts was the conversion of the existing fallow land into cultivated land.

The change in non-agricultural land was the change of land use and land cover change during the 15 year period from 2000 to 2015. The increase of non-agricultural land due to the expansion of institutional land in the study area.

The change in forest land was the second largest change of the land use and land cover during the 15-year period from 2000 to 2015. The decrease of forest land was due to the deforestation, the production of charcoal and the expansion of non-agricultural land in Pathein Township.

In includes rivers creek, inn, canal and reservoirs. Water body founded as river and creeks are Pathein River and Creeks. During the 15-year period for 2000 to 2015 the water body area had increased, due to the instruction by dams. Bare land has no vegetation and man-made structures. In Pathein Township patches of bare land are found around the extremity of forestland and some villages of the western part of the township.

Findings and Suggestions

Pathein Township located in the western part of the Ayeyarwady Region occupies forest areas in the western part, used mainly as agriculture land fishing source in the eastern parts. The dominant land use and land cover of study area is Agricultural Land and Non-Agricultural land and Forest land. Regarding the changes of general land use, this study area experienced the increase in paddy land, garden land. It is especially due to conversion of cultivable waste land into "Le" land and garden land.

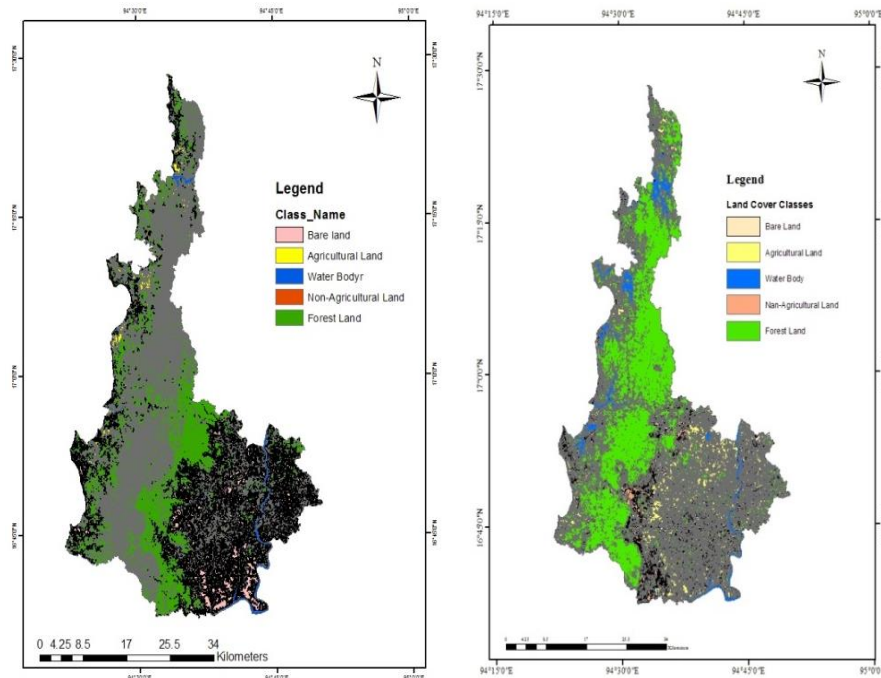


Figure (7) Land Cover Classes of Pathein Township (2000 and 2015). (Source: Based on Landsat TM 133-48 Imagery, 2000 and 2015)

Land cover changes are due to the pressure of growing population, need for agricultural land, expanded demand for charcoal and commercial wood. Agricultural development pointed out the decrease of forest land. Most of the people live in rural areas and their main economy was agriculture.

Assessment on non-agricultural land in the study area revealed that it had notably increased, due to extension of dam and canal system, settlement area, construction of road. Moreover, changes in economic activities include fish and frawn ponds and brick baking industry. Wood, firewood and bamboo cutting were practised by some villagers in the study area. Agriculture development pointed out the decrease of forest land which was due to dams. Infrastructure was promoted to enlarge agricultural land.

The economic growth of the study area depends mainly on the forests and for the improvement of agricultural land, manufacturing sector is still limited. The expanding irrigated farming in the dry season is desirable for the agricultural intensification. Transportation development brought the emergence of many economic activities. Many farmers and traders transported rice to other towns, which become regional exchange centers.

From the land management point of view, the major concerns are decline in quality of soil, erosion and loss of topsoil by wind and water, loss of vegetation cover and salinity. Thus the land management system that must be introduced should be able to restore the lost fertility and increase farmer's income.

Annual decreasing rate of forest area in the study area must be controlled by the systematic ways, especially; expensing of agricultural land area into forest area should be avoided. The knowledge of the forest, which serves as a leading role for the socio-economic development of a region, should be stimulated to the native people.

Finally, in order to reduce conflicts arising from the land use and land cover change in Pathein Township, systematic management plans are necessary.

Conclusion

Pathein Township is located in the western part of Ayeyarwady Region in the southwestern part of Myanmar. It lies between North latitudes 16° 34' 50" and 16° 59' 30" and between East longitudes 94° 42' 45" and 95° 02' 55". The total area of the township was 1670.25 sq km (644.88 sq miles). The township comprises Ngwe Hsaung Sub-Township, Shwe Thaung Yan Sub-Township, 15 wards and 53 village tracts made up of 272 villages.

The mountain spurs of Rakhine Yoma continue southward until Mortin Point. In the north, the elevation is about 121.92 metres or 400 feet, but the spurs rise somewhat higher towards the south. This forest type occupies the western upland region, particularly the reserve forests.

As in all other townships, the density is the highest in the urban area. In the rural areas people are more concentrating along the streams where accessibility is relatively high with broad village tracts of fertile farmland.

Based on Landsat TM Images of 2000 and 2015, five types of land cover were classified for land cover analysis in Pathein Township. The area increase was found agricultural land during the study period.

Land use and land cover change was pronounced in the conversion of cultivable waste land and pasture land into cultivated land, settlement land, water body area and transportation land.

The positive aspect of land cover change is the increase in the agricultural land area. The decrease in the forest land area is not desirable, as it can exert negative impact on the environment.

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