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Assessment of Land Cover Changes and the Causes of Mangrove Degradation(A Case Study in Pyindaye Reserved Forest Pyapon Township)

Yan Naing Phyo , Range Officer

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ဖျာပုံမြို့နယ်အတွင်း ပြင်ဒရယ်ကြိုးဝိုင်းအတွင်းရှိ ဒီရေတောဧရိယာများတွင် အခြားမြေ အသုံးချမှုများအဖြစ် ပြောင်းလဲသွားခြင်းနှင့် ဒီရေတောများ အတန်းအစား ကျဆင်းလာခြင်း အခြေအနေများကိုလေ့လာခြင်း

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စာတမ်းအကျဉ်း

ဧရာဝတီတိုင်းဒေသကြီး၊ ဖျာပုံမြို့နယ်၊ ပြင်ဒရယ်ကြိုးဝိုင်းအတွင်းရှိ ဒီရေတောများသည် နှစ်စဉ်သစ်တောထွက်ပစ္စည်းများအလွန်အကျွံထုတ်ယူသုံးစွဲခြင်း၊ စီးပွားဖြစ် ပုဇွန်ကန်၊ ငါးကန် များ မွေးမြူခြင်းကြောင့် နှစ်ကာလအပိုင်းအခြားတွင် အခြားမြေများအဖြစ် မြေအသုံးချမှုများပြောင်းလဲ သွားခြင်းကြောင့် ဒီရေတောများ တဖြည်းဖြည်း ပြုန်တီးလာနေပါသည်။ ကျေးလက်နေပြည်သူများ ၏ လူမှုရေး၊ သဘာဝပတ်ဝန်းကျင်နှင့် စီပွားရေးအခြေအနေများ အထောက်အကူ ပြုနေသော ဒီရေ တောများ ရေရှည်တည်တံ့စေရန် မြေအသုံးချမှုပုံစံများနှင့် လူမှုစီးပွားရေး အခြေအနေများကို လေ့လာဆန်းစစ်ရန် လိုအပ်ပါသည်။ ဒီရေတောများမှ အခြားမြေအသုံးချမှု ပြောင်း လဲသွားခြင်းကို သိရှိနိုင်ရန်အတွက် RS/GIS နည်းပညာဖြင့် Landsat 5,7 and 8 ဂြိုလ်တု ဓါတ်ပုံများကိုအသုံးပြု၍ ၂၀၀၀ ခုနှစ်မှ ၂၀၁၉ ခုနှစ်အတွင်း စိုက်ပျိုးမြေအပါအဝင်၊ အခြားမြေ အသုံးချမှုများအဖြစ် ပြောင်းလဲ သွားခြင်းကို နှစ်စဉ်ပြောင်းလဲသည့် ရာခိုင်နှုန်းအလိုက် တွက်ချက်ပြီး အမျိုး အစား ခွဲခြား ခဲ့ပါသည်။ လူမှုစီးပွားရေးအခြေအနေများကို အခြေခံ၍နောက်မီးကျေးရွာနှင့် အရှေ့ဖျား ကျေးရွာအတွင်း စုစုပေါင်း အိမ်ထောင်စု(၁၁၈)စုကို စာရင်းကောက်ယူခဲ့သည်။ စာရင်း ကောက်ယူခဲ့သော ကျေးရွာ များ ၏ အဓိက အသက်မွေးဝမ်း ကျောင်းဖြစ်သည့် စီးပွားဖြစ် ပုဇွန်ကန်မွေးမြူရေး လုပ်ငန်းကန် ပိုင်ရှင်များနှင့်(Aquaculture Pond Owners)နှင့် အင်္ဂလန် ဖောင် ခေါ် ငါး/ပုဇွန် ဖမ်းစက် လှေပိုင်ရှင် (Bamboo Rack Owners)များကို ၎င်းတို့၏ ထင်းသုံး စွဲမှုနှင့် ပတ်သက်သည့် သုတေသနမေးခွန်း များမေးပြီး ပုဇွန်ခြောက်ပြုတ်ရာတွင် ထင်းလောင်စာ သုံးစွဲမှုနှင့်ပတ်သက်သည့် အချက်အလက် များ စာရင်းကောက် ယူခဲ့ပါသည်။ ဒီရေတော အတန်း အစား ကျဆင်းလာမှုကို ကာကွယ်ရန်နှင့် ရေရှည်တည်တံ့ရန် ကျေးလက်နေပြည်သူများက ဒီရေတောထိန်းသိမ်းခြင်း လုပ်ငန်းများ၊ ပြန်လည် စိုက်ပျိုးခြင်း လုပ်ငန်းများနှင့် ပြုစုပျိုး ထောင်ခြင်း လုပ်ငန်းများ တိုးမြှင့် ဆောင်ရွက် နိုင်ရန်အတွက် ဌာနဆိုင်ရာအဖွဲ့အစည်းများနှင့် ပူးပေါင်းပြီးလိုအပ်သော မူဝါဒများနှင့်ဥပဒေစနစ်များကို အထောက် အကူပြုသော နည်းစနစ် များ ထောက်ပံ့ပေးရန် လိုအပ်လျက်ရှိပါသည်။

Assessment of Land Cover Changes and the Causes of Mangrove Degradation In Pyindaye Reserved Forest, Ayeyarwady Delta, Myanmar

Yan Naing Phyo [2]* *Le Xuan Truong [1]*

[1]Associate Professor, Dean of Faculty of Silviculture, Vietnam National University of Forestry, Hanoi
[2]M.Sc Candidate, Vietnam National University of Forestry, Hanoi

3 Abstract

Mangrove degradation is a serious problem in Myanmar. Addressing the problem of mangrove will not only be to implement effective reforestation programs but also to understand the local people's dependence on the forests and other socioeconomic conditions. This study analyzed the land use changes during 2000-2019 by using multi-temporal land sat of unsupervised classification and the influencing factors on the key drivers of mangrove degradation (especially fuel wood consumption) in the study area and investigated how the mangrove forest conservation practices and policy are going there and their potential impacts for sustainable mangrove forest management in Myanmar. This study employed both qualitative and quantitative methods including interviews with 118 participants through questionnaire surveys and focus group discussion. The results revealed both increase and decrease of different land cover change (LCC) from 2000 through 2019. Significant shifts from some classes to other were also observed. Drivers of the observed changes ranged from climatic factors such as natural disasters to socio-economic factors. Regression analysis results showed that the key drivers of mangrove degradation (especially fuel wood consumption and aquaculture) have strongly and positively significant influenced on the mangrove degradation. This study notes that to a large extent the growth of wood consumption by households and other traders especially bamboo-racks owners for their commercial dry shrimp producing activities is influenced by the lack of other fuel sources and higher price of available sources in the study areas. Thus, unless other fuel sources such as electricity is available by households and bamboo-racks owner to replace the fuel wood, the growth of this fuel wood consumption is increasingly posing more pressure on the mangrove forest and woodland resources in Myanmar especially coastal areas. Then, aquaculture has become as another cause of loss of mangrove areas in Ayeyarwady Delta including the study areas due to overexploitation to develop the commercial shrimp farms. Shrimp farming has been promoted to boost national economies as a potential source of income for local communities with its high economic return and as a mean of poverty alleviation. Awareness of the importance of the biodiversity of the coastal ecosystem and its endangered situation has led to the implementation of measures to ensure sustainable development and conservation. Thus, mangrove degradation is one of the most important environmental problems that the government needs to address and set up the policy, rules and regulations in order to meet the sustainable development target of the country.

Keywords: Mangrove degradation, Land cover change, Fuel wood consumption, Aquaculture, Sustainable development, Ayeyarwady Delta, Myanmar

Assessment of Land Cover Changes and the Causes of Mangrove Degradation In Pyindaye Reserved Forest, Ayeyarwady Delta, Myanmar

4 1. Introduction

Mangroves are a major source on which large communities have been dependent for both subsistence and income generation long time ago. Mangrove plays an important in the life and livelihood of coastal regions (Spalding & Blasco, 1997). The main products of mangrove forest are timber, fuel wood, poles, thatching material, grass, honey, wax, industrial raw materials, and marine and fishery resources (Bandaranayake, 1998). The harvest and utilization of mangrove tree species for both domestic uses as well as commercial purpose has been practiced for several centuries.

Mangroves are found between the latitudes of 32º N and 38º S of the globe and in the mouths of estuaries and in inner tidal areas. Approximately one fourth of the world coastline comprises mangrove ecosystems which are estimated to extend along an area of between 167,000 km^2 and 181,000 km^2 in 112 countries (Kathiresan & Bingham, 2001). According to census 2014, the population of Myanmar is 51.5 million and 25% in poverty. Myanmar's rural population is around 70 % of the total and most depend strongly on forest resources for their livelihoods. The country agricultural sector employs 64% of labor force and it responsible for 46% of the GDP (MIMU, 2014). Our country has one of the highest rates of forest loss among ASEAN countries; especially the Ayeyarwady Delta has seen the worst devastation of mangrove forests. The Ayeyarwady Delta has been managed as a conservation area since the beginning of the twentieth century. However, the mangrove forest cover has been decreasing due to lawless development (e.g. Firewood, Agricultural Expansion, Aquaculture and Inflow of population) (Spalding, 2008).On the other hand, Cyclone Nargis struck in May 2008, having a serious impact on resident's daily lives and livelihoods, with a huge death toll and missing persons. Although approximately 38,000 ha of mangrove of coastal areas was devastated by the cyclone.

Myanmar ranks among the countries most at risk from the main climate change threats identified by the World Bank: droughts, floods, storms, cyclones, sea level rise and impacts on agriculture. According to the most recent (Global Climate Risk Index (CRI), 2016) published by German watch, Myanmar remain the one of the most climate affected country over the past 20 years. Food security and freshwater availability will be reduced by impacts caused by less predictable weather, high temperature and saltwater intrusion into agricultural land. Myanmar has one of the largest areas of mangrove forest remaining in the world: the country ranks 7^{th} with about 485,000 hectares according to a global estimate by (Giri, C et al, 2010). The mangrove forests are also rich in biodiversity with 34 out of the global total around 70 mangrove tree species occurring in Myanmar.

Myanmar has total coast line about 2,000 km in length and continental shelve of nearly 270,000 km^2 (Sein, C C, 2015).There are three coastal regions in Myanmar, namely Rakhine, Ayeyarwady and Taninthari where mangrove common. Mangrove were found with the coverage of 7,850 km^2 (785,000 ha) of which 32, 00 km^2 (320,000 ha) were designated as reserved forest in 1920s (Forest Department and ITTO, 2011). The Ayeyarwady delta covers an area of 33,670 km^2 (3,367,000 ha) having a large network of creeks, streams and rivers.

The mangrove forests in Ayeyarwady Delta are the largest but also the most affected by human actions (Aung . T, April, 2013). The mangrove area in the Ayeyarwady delta has fallen to about 65,127 ha in 2007, down from approximately 160,735 ha in 1995. The

Ayeyarwady region lost 95,607 ha of mangrove forests within a period of 13 years. The annual rate of deforestation was about 7,350 ha. However, since the 1970s there has been a rapid rate of mangrove clearance and degradation (Giri.C, 2008). This was caused by coastal land conversion, initially to agriculture (rice fields) and later to aquaculture and dry fish and shrimp as well as by timber and fuel wood extraction. According to Ayeyarwady Coastal Region Conservation Association, "coastal land grabbing" has recently become more and more common (ACA, 2015). Therefore, further research is essential not only to assess causes of mangrove forest loss and degradation but also to clarify what are the key drivers of mangrove degradation in study area. Otherwise, there is a significant correlation between people's income sources and sustainable ecosystem of mangrove.

2. Objectives

This study was carried out:

(1) To analyze the land use changes during the selected periods (from 2000 to 2019) by using multi-temporal Land sat of unsupervised classification
(2) To identify the influencing factors on the key drivers of mangrove degradation (especially fuel wood consumption and aquaculture) in study areas

3. Material and Method

A Combination of satellite data (United States Geological survey) by using Land sat 5, 7 and 8 imageries from Pyindaye reserved forest was collected to analyze land use and land cover change in selected periods (from 2000 to 2019). Before the preprocessing and classification of satellite imagery, an extensive field survey was performed throughout the study areas using Global Positioning System (GPS) equipment. This survey was performed in order to obtain accurate location points for each land use included in the classification. The whole process is guided by ground observation and local knowledge. The land use map produced at year from 2000s to 2019 respectively at a scale of 1: 190,000 included six classes (Water body, cultivated land, shrub, forest, settlement and aquaculture) depending on the characteristics and objectives of the study site.

The semi structure questionnaires were used to interview 118 respondents (48 respondents are aquaculture pond owners, 70 respondents are households and the rest are bamboo rack owners producing the dry shrimp) in two selected villages around Nauk Mi and Asha Phya villages to identify the fuel wood consumption by bamboo rack owners for dry shrimp commercial production and fuel wood consumption by households for multi-purposes. Focus group discussion with local stakeholders was conducted to obtain details and additional information related to land use changes and key drivers of mangrove deforestation and degradation in study areas.

4.1 **3.1 Method and technique of data Analysis**

GIS analysis was also conducted to analyze land cover changes in Pyindaye reserved forest by using multi-temporal Land sat 5 , 7 and 8 imagery for land use mapping from 2000s to 2019. The data collected from local stakeholders were analyzed using a descriptive statistics method and multiple regression method with the statistical software package SPSS version 23.

3.2 Model Specification

The multiple regression analysis was used in determining the factors influencing fuel wood consumption of households and bamboo-rack owners in the study areas. The explicit form of the model is presented as

$$Y = \alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cdots \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + \beta_9 X_9 + \beta_{10} X_{10}$$

Where

Y_i = Quantity of fuel wood consumption (bundle/month)

X_1 = Age(year)

X_2 = Family size(number)

X_3 = Level of education (year)

X_4 = Source of fuel wood(1=trader, 0=forest)

X_5 = Access to mangrove in next 5 years (1=yes, 0=no)

X_6 = Mangrove timber collection changes in the past 5 years (1=yes, 0=no)

X_7 = Economic situation within 5 years (1=better off, 2=worse)

X_8 = Type of mangrove species (1= Avicenna officinalis (Thamae), 0=others)

X_9 = Expenditure on fuel wood consumption (kyats/month)

4.3 **4. Result and Discussion**

4.4 **4.1 Change detection in land cover classes (LCC) between 2000-2010**

Generally, over 10 years(2000-2010), the annual changes in areas coverage varied from one land cover class (LCC) to another with aquaculture area experiencing the most increases and forest undergoing the most decrease in area coverage as shown in **Figure 2 and Table 1.**

The forest areas in study area in 2010 has reduced (54.67%) compared to 2000 due to aquaculture area and cultivated land area expansion. Forest covers 22.32% of the state in 2010, down from 47.17% in 2000, forest cover areas reduced 20312 ha. The average annual loss rate of forest was 5.47%. Over 53 ha and 3310 ha of forest have been converted to aquaculture and cultivated land respectively. Over 14987 ha of forest have been degraded due to human actions and Cyclone Nagis in 2008 and then converted to shrub.

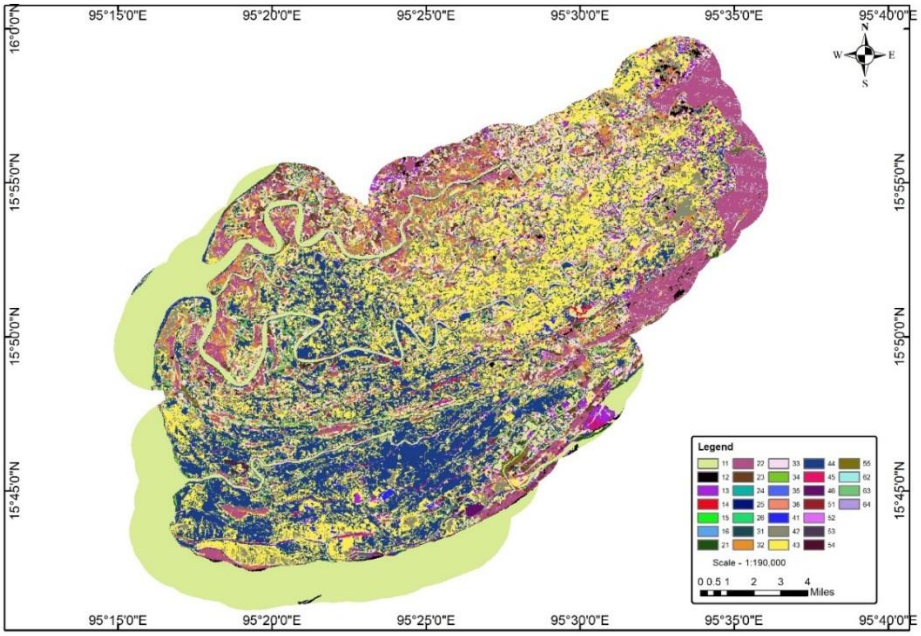
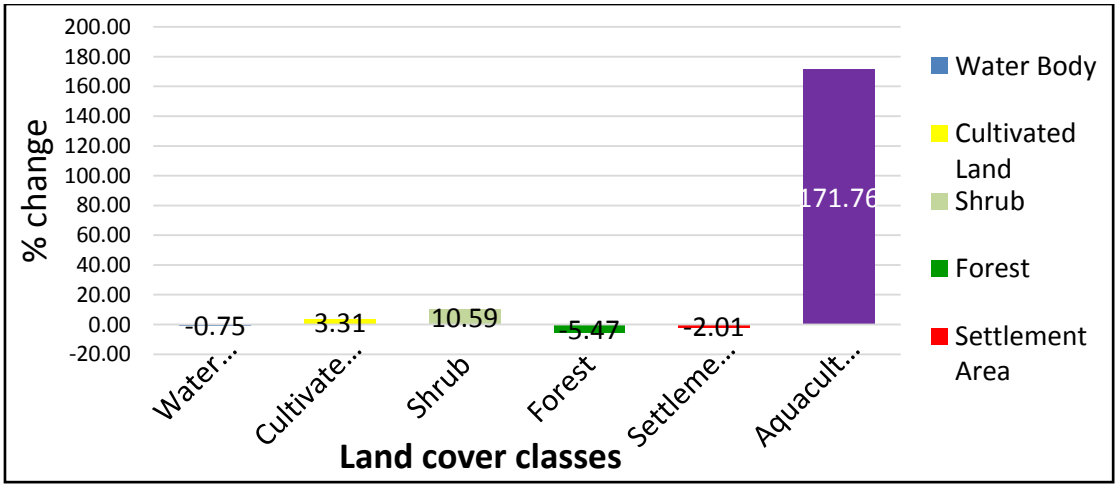


Figure 1. Land cover change detection between 2000-2010 in the study area

4.4.1.1.1 Table 1. Land cover changes by class between 2000-2010 and annual land cover changes (%)

Land cover classes	2000		2010		Land cover changes by class(ha)		Annual land cover changes (%)
	Area (ha)	% of area	Area (ha)	% of area	Area (ha)	Total land cover changes%	
Water Body	17123.4	21.74	15846.84	21.00	-1276.56	-7.46	-0.75
Cultivated Land	9996.84	12.69	13307.22	17.63	3310.38	33.11	3.31
Shrub	14155.47	17.97	29142.27	38.62	14986.80	105.87	10.59
Forest	37157.31	47.17	16845.12	22.32	-20312.19	-54.67	-5.47
Settlement Area	331.38	0.42	264.87	0.35	-66.51	-20.07	-2.01
Aquaculture	3.06	0.004	55.62	0.07	52.56	1717.65	171.76



4.4.1.1.1.1 Figure 2 Annual percentage change in land cover classes from 2000-2010

4.5 4.2 Change detection in land cover classes (LCC) between 2010-2019

Generally, over 9 years(2010-2019), the annual changes in areas coverage varied from one LCC to another with cultivated land, forest, settlement area, aquaculture area experiencing the most increases and shrubs undergoing the most decrease in area coverage as shown in **Table 2 and Figure 4.**

The forest areas in study area in 2019 has increased again (20.94%) compared to 2010 due to reforestation and rehabilitation programs after striking the Cyclone Nagis in 2008. Forest covers 26.75% of the state in 2019, up from 22.32% in 2010. The average annual increase rate of forest was 2.33%. Over 7930 ha of shrub have been converted to forest due to reforestation program in this area. Cultivated land (4967.37 ha), settlement area (91.8 ha) and aquaculture (3.42 ha) has been increased over the years.

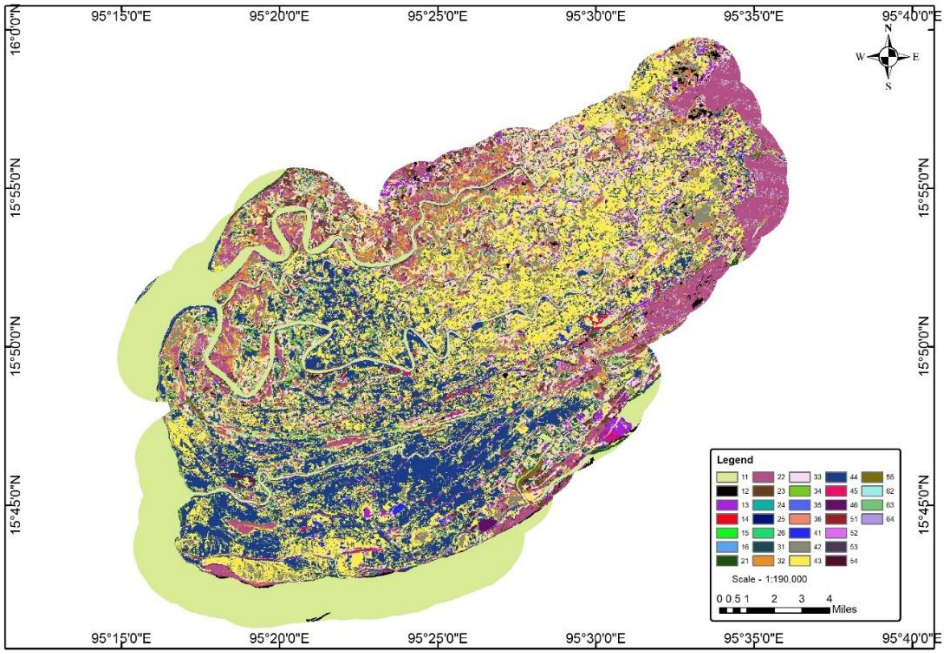
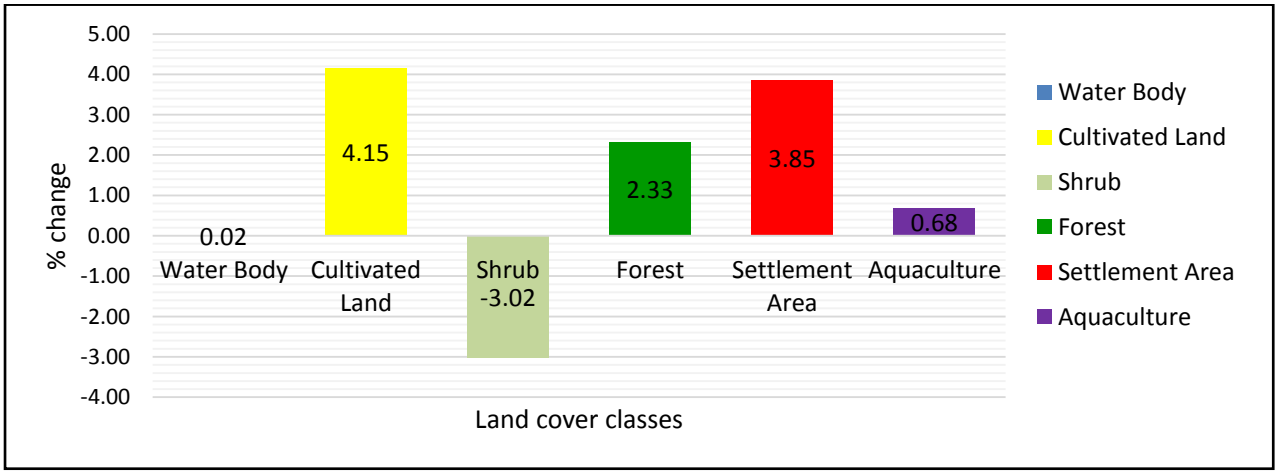


Figure 3. Land cover change detection between 2000-2010 in the study area

4.5.1.1.1 Table 2. Land cover changes by class between 2010-2019 and annual land cover changes (%)

Land cover classes	2010		2019		Land cover changes by class(ha)		Annual land cover changes (%)
	Area (ha)	% of area	Area (ha)	% of area	Area (ha)	Total land cover changes%	
Water Body	15846.84	21.00	15871.05	20.84	24.21	0.15	0.02
Cultivated Land	13307.22	17.63	18274.59	24.00	4967.37	37.33	4.15
Shrub	29142.27	38.62	21211.47	27.86	-7930.8	-27.21	-3.02
Forest	16845.12	22.32	20372.22	26.75	3527.1	20.94	2.33
Settlement Area	264.87	0.35	356.67	0.47	91.8	34.66	3.85
Aquaculture	55.62	0.07	59.04	0.08	3.42	6.15	0.68



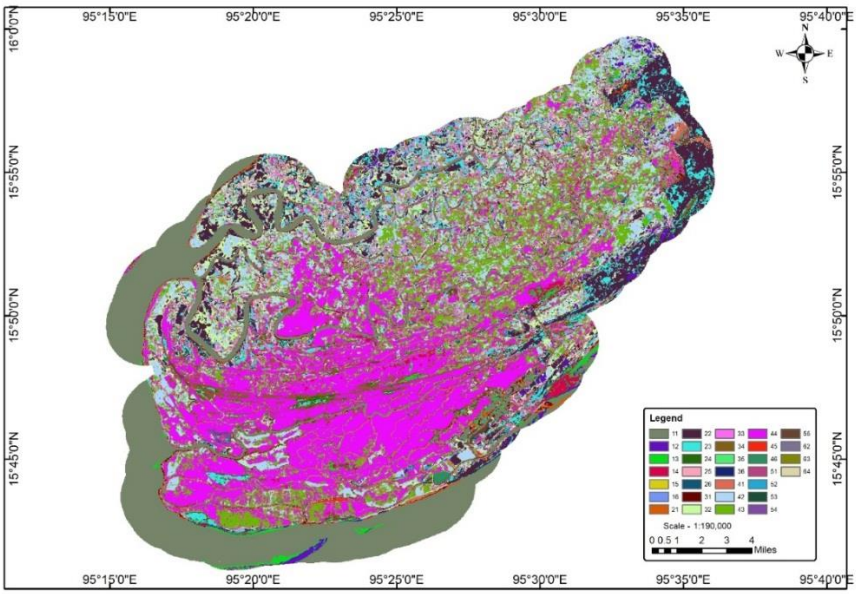
4.5.1.1.1.1 Figure 4 Annual percentage change in land cover classes from 2010-2019

4.6 4.3 Change detection in land cover classes (LCC) between 2000-2019

Generally, over 19 years(2000-2019), the annual changes in areas coverage varied from one land cover class to another with cultivated land, aquaculture area experiencing the most increases and forest undergoing the most decrease in area coverage as shown in **Table 3and Figure 6.**

The forest areas in study area in 2019 has reduced (45.17%) compared to 2000 due to aquaculture area and cultivated land area expansion . Forest covers 26.75% of the state in 2019, down from 47.17% of the state in 2000, forest cover areas haven't been reached to forest areas in 2000 although forest areas have been increased again in 2008 later due to reforestation and rehabilitation programs. The average annual loss rate of forest was 2.38%. Over 55.98 ha and 8277.75 ha of forest have been converted to aquaculture and cultivated land over the years respectively.

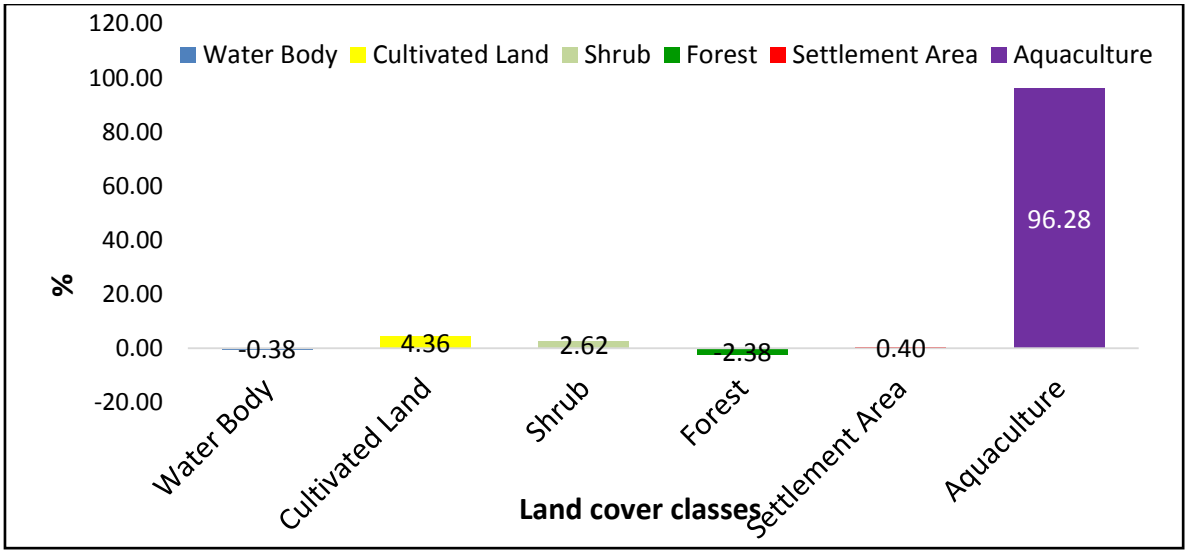
4.6.1.1.1.1



4.6.1.1.1.2 Figure 5. Land cover change detection between 2000-2019 in the study area

4.6.1.1.2 Table 3 Land cover changes by class between 2000-2019 and annual land cover changes (%)

Land cover classes	2000		2019		Land cover changes by class(ha)		Annual land cover changes (%)
	Area (ha)	% of area	Area (ha)	% of area	Area (ha)	Total land cover changes%	
Water Body	17123.4	21.739	15871.05	20.84	-1252.35	-7.31	-0.38
Cultivated Land	9996.84	12.692	18274.59	24.00	8277.75	82.80	4.36
Shrub	14155.47	17.971	21211.47	27.86	7056	49.85	2.62
Forest	37157.31	47.173	20372.22	26.75	-16785.09	-45.17	-2.38
Settlement Area	331.38	0.421	356.67	0.47	25.29	7.63	0.40
Aquaculture	3.06	0.004	59.04	0.08	55.98	1829.41	96.28



4.6.1.1.2.1 Figure 6. Annual percentage change in land cover classes from 2000-2019

4.6.2 4.4 Influencing factors on the fuel wood consumption of households and bamboo-rack owners in the study areas

The results of the multiple regression analysis for households and bamboo-rack owners are presented in **Table 4.** The double logarithm gave the best fit and hence, was selected as the lead equation based on the number of significant variables, plausible magnitude of the regression coefficients, magnitude of the coefficient of determination (r2) and correctness of signs of the coefficients.

The result shows that four of the nine explanatory variables used in the model significantly affected the consumption of fuel wood by households while three of the nine explanatory variables used in the model significantly affected the consumption of fuel wood by bamboo-rack owners. According to the regression result, level of education and access to mangrove in next five years variables negatively influence the consumption of fuel wood by households while family size, level of education, source of fuel wood negatively influence the fuel wood consumption by bamboo-rack owners. In contrast, age, family size, source of fuel wood, mangrove timber collection changes in the past 5 year, economic situation of households within 5 years, type of mangrove species and expenditure on fuel wood consumption variables positively influence the consumption of fuel wood by households but age, access to mangrove in next 5 years, mangrove timber collection changes in the past 5 years, type of mangrove species and expenditure on fuel wood positively influence the consumption of fuel wood by bamboo-rack owners.

The coefficient of access to mangrove in next 5 years was found to inversely effect on quantity of fuel wood consumption in the study areas at a probability level of 0.05. This implies that although household can able to access to mangrove in next 5 years, they might access to alternative fuel sources as well to substitute fuel wood for multiple purposes due to

current local and international organizations development program for their livelihood development activities.

The positive coefficient of mangrove timber collection changes in the past 5 years and its significance at 5% implies that the more the changes of mangrove collection by households the higher the consumption of fuel wood. The coefficient of economic situation of households within five years is positive and statistically significant at 5%. This implies that household's economic situation gradually better off, their fuel wood consumption increases.

Expenditure on fuel wood consumption by households was found to positively affect the quantity of fuel of consumption at a probability level of 0.01. This implies that as expenditure on fuel wood consumption increases, quantity of fuel wood consumption increases. For every 1% increase in expenditure on fuel wood, quantity of fuel wood increases by 1.49%.

Regarding the results of bamboo-rack owners, the coefficient of family size was found to inversely effect on quantity of fuel wood consumption in the study area at a probability level of 0.1. This implies that although the number of family members increases, it would not be affected on the quantity of fuel wood consumption because bamboo-rack owners used fuel wood mainly in dry shrimp commercial production activities.

The positive coefficient of the economic situation of bamboo-rack owners within the 5 years and its significance at 10% implies that the more increases in economic situation by bamboo-rack owners, the higher the consumption of fuel wood because they used a lot of fuel wood in their dry shrimp processing activities.

Expenditure on fuel wood consumption by bamboo-racks owners was found to positively affect the quantity of fuel of consumption at a probability level of 0.01. This implies that as expenditure on fuel wood consumption increases, quantity of fuel wood consumption increases. For every 1% increase in expenditure on fuel wood, quantity of fuelwood increases by 2.49%.

4.6.2.1.1 Table 4. Multiple regression estimates of socio-economic factors influencing fuel wood consumption in study areas

Variables	**Households (n=35)**		**Bamboo-racks owners(n=35)**	
	Coefficients	**t-ratio**	**Coefficients**	**t-ratio**
Constant	2.59	22.23***	7.151	21.613***
Age	0.001	0.159	0.005	1.047
Family size	0.006	0.016	-0.079	-2.491*
Level of education	-0.005	-0.509	-0.012	-0.604
Source of fuel wood	0.003	0.043	-0.014	-0.066
Access to mangrove in next 5 years	-0.141	-3.577**	0.000	0.003
Mangrove timber collection	0.092	2.836**	0.039	0.290

changes in the past 5 year				
Economic situation of households within 5 years	0.132	2.919**	0.282	2.228*
Type of mangrove species	0.051	1.406	0.032	0.343
Expenditure on fuel wood consumption	1.49	12.334***	2.69	6.804***
R^2	0.989		0.963	
Adjusted R^2	0.977		0.928	
F statistic	103.356***		30.717***	

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

4.5 Influencing factors on the aquaculture areas expansion by pond owners in the study areas (n=48)

The results of the multiple regression analysis for pond owners are presented in **Table 5**. The double logarithm gave the best fit and hence, was selected as the lead equation based on the number of significant variables, plausible magnitude of the regression coefficients, magnitude of the coefficient of determination (r2) and correctness of signs of the coefficients.

The result shows that six of the eight explanatory variables used in the mode significantly affected the aquaculture areas by ponds owners. According to the regression result, level of education experience in aquaculture, transportation cost, total aquaculture productivity variables positively influence on the aquaculture areas expansions by pond owners while age, access to training, pond owner's difficulties and gross income variables negatively influence on the aquaculture areas expansions.

The coefficient of level of education was found to positively effect on aquaculture area expansion in the study area at a probability level of 0.1. This implies that the higher the pond owner education level, the more increase the aquaculture areas.

The negative coefficient of access to training and its significance at 10% implies that although the pond owners' access to training, aquaculture areas is not increased because they just received the information about how to manage the ponds and to increase the productivity.

The coefficient of experience in aquaculture of pond owners is positive and statistically significant at 5%. This implies that as experience in aquaculture increase, areas expansion increases. For every 1-year increase in experience in aquaculture farm, area expansion by pond owners increases by 0.066%. However, the coefficient of pond owners face difficulties was found to negatively influence on the aquaculture area expansion at a probability level of 0.5.This implies that although they have a community forest certificate to access the mangrove for aquaculture area expansion, they have many strict regulations to get the license for aquaculture farm from department of fisheries.

Transportation cost for aqua-products trading was found to positively affect the aquaculture area expansion at a probability level of 0.1. This implies that although

transportation cost increases, the aquaculture farm areas increase. For every 1% increase in transportation cost, aquaculture farm areas increase by 0.001%.

The positive coefficient of the gross income of aquaculture farm and its significance at 10% implies that the more increases in aquaculture areas, the higher the total aquaculture productivity. For every 1% increase in aquaculture productivity, aquaculture farm areas increase by 0.001%.

4.6.2.1.2 Table 5. Multiple regression estimates of socio-economic factors influencing aquaculture areas in the study areas

Variables	**Pond owners (n=48)**	
	Coefficients	**t-ratio**
Constant	-1.829	-1.111
Age(year)	-0.001	-0.108
Level of Education	0.364	2.491*
Access to Training	-0.574	-1.770*
Experience in aquaculture(year)	0.066	3.007**
Pond owner's difficulties	-1.025	-3.332**
Transportation cost(MMK)	0.001	2.115*
Gross income (MMK)	-2.47	-0.213
Total aquaculture productivity (Kg)	0.001	2.196*
R^2	0.847	
Adjusted R^2	0.718	
F statistic	12.395***	

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

5 5. Conclusion

Land cover change (LCC) is a major issue of concern with regards to change in the global environment. The rapid growth and expansion of urban centers, the need for more production due to the rapid population growth, changing technologies due to the scarcity of land are among the many drivers of LCC in the world today. LCC has become one of the major concerns of researchers and decision makers around the world today. Landsat 5, 7 and 8 satellite images of 2000, 2010 and 2019 were used for the GIS and RS image analysis. The observed changes varied from one land cover category to another with some maintaining a constant change (increase or decrease) over the three analysis periods (2000-2010, 2010-2019 and 2000-2019). Some classes underwent decrease in the first period and an increase in the second and third period and vice versa. This study advocates that multi-temporal satellite data is very useful to detect the changes in land cover comprehensively. The study reveals that the land cover change pattern and its spatial distribution are the major rudiments for the

foundation of a successful land use strategy required for the appropriate development of the any areas

Degradation of natural resources particularly land and forest has become a matter of serious concern in developing countries where most of the rural people rely largely on these resources for their subsistence. The depletion of forest resources and increasing demand for forest products especially of the rural people who depend on forests for livelihoods have widened the gap between the demand and supply of forest products. Recent mangrove changes are due mainly to agricultural and shrimp farming expansion, which is developing in an unplanned way. Agricultural and shrimp farm development and degradation also caused environmental and natural resources problems with socio-economic consequences such as land degradation, environmental pollution, the conflicts among natural resource users and the gap between the rich and poor. The main causes of deforestation in the Ayeyarwady mangrove forests are due to socio-economic problem of the local communities. In these areas, the local people are very poor, and they don't know about the conservation and sustainable use of these invaluable natural resources. The encroachment problems in the study area are exacerbated by low enforcement of the forest law, lack of a national land use policy, and the absence of coordination among the relevant ministries. More active form of management is required to operate the Pyindaye reserved forest and identify alternative livelihood sources for residents.

These above-mentioned problems need to be addressed through the development and implementation of comprehensive land use policies at national and local levels. Effective governance, adaptation and mitigation options for climate change, better planning for rehabilitation of degraded mangroves and creation of awareness to local communities are needed to conserve, protect and restore the valuable mangrove wetland ecosystems. The amelioration of current situation requires the agricultural land , an adequate compensation scheme, and support for other ways to earn and need strong protections for the remaining mangroves and comprehensive national and local land prevent further deforestation in the Pyindaye reserved forest.

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