Spatio-Temporal Analysis of Mangrove Extents in Hai Phong City, Vietnam

Amena Easmin[1]*, Ned Horning[2]

[1]*Institute of Forestry Research and Development, Thai Nguyen University of Agriculture and Forestry, Vietnam*
[2]*Applied Biodiversity Informatic, American Museum of Natural History, USA*

Abstract: **The comprehension of mangrove status is based on the ability to separate plant, land and water objects in remotely sensed data in the view of the reflectivity or radiation of the object. The application of GIS and remote sensing technology to analyze mangrove fluctuations has been widely used in the world. High population growth and migration into coastal areas are found to be one of the most extensive land use changes in recent decades and could result in the destructive of the coastal areas of Hai Phong, Vietnam. Coastal areas are at risk of climate change impact and the future trend of this land use could cause coastal erosion, and land degradation. This study provides an assessment of spatiotemporal changes of mangrove extent using remotely sensed data and identifies the drivers. In this study, Landsat and Sentinel-2 data were utilized to quantify the spatiotemporal changes in land use and land cover (LULCC). The study focused on the periods of 1994-2001, 2001-2010, 2010-2015 and 2015-2018, and decadal changes. Unsupervised classification was selected to determine the land use and land cover. Error-matrix based accuracy assessment was accomplished after ground truthing. Comparing two case study sites, Tien Lang district was found to be the most vulnerable to socio-economic development and natural disaster. This paper demonstrates the congruous development of relevant key drivers of coastal mangrove change, with an emphasis on land use change drivers. This study will be helpful for future research but also illustrates an applicable plan for sustainable mangrove management.**

Keywords: **Remote Sensing, Spatial resolution, Sentinel-2, Sustainable mangrove management, Mangroves extents, Land use land cover change.**

I. INTRODUCTION

Mangroves are the beating heart of the Earth surface, providing numerous ecosystem services for humans such as protection from natural disasters as tsunamis and tropical cyclones are broadly used for timber extraction, fisheries, and fodder collection [1], [2], [3]. Without a doubt, mangroves play a vital role in maintaining both regional and global ecological integrity. Simulation results show that mangroves ecosystems are defenseless from pollution such as residual wastes from mining activities, oil spillage from marine transport, heavy metals pollution from sunken ships and other industrial activities such as construction of dams, barrage and embankments for water diversions upstream [4], [5], [6], [7]. Such vulnerability may be due to the mangrove ecosystems' biogeochemistry. As a result, aquatic and terrestrial flora and fauna have an oppressive effect [8].

Experts revealed that mangroves destruction took place very fast over the past 50 years and continues to decline. For example, since mangrove is an unproductive area, people often clear the forest for agricultural practices, human settlements, tourism areas as well as for firewood, construction wood, wood chips, pulp production, and charcoal production [9], [10], [11].

In recent years, rapid changes of shrimp farming are the greatest threat to mangrove ecology; thus, it is essential to upgrade the estimates of the farming area to determine the current extents, the frequency of changes [12]. In addition, remotely sensed data have been broadly used over two decades for mangrove mapping and monitoring to better understand mangrove ecology [3], [13], [14]. Uses of GIS and remote sensing techniques for decades is widely known, monitoring urban growth through land use and land cover change detection help to design and implement various policies to achieve economic, environmental, and social objectives in the process of sustainable rural development [15], [16], [17].

The concentration of this study is to analyze LULCC using Spatio-temporal remotely sensed data to detect following purposes; what is the current status of mangroves in Haiphong, Vietnam? How much mangrove vegetation has changed in selected years and where are spatial hotspots of mangrove changes?

II. MATERIALS AND METHODS

Study Area

HaiPhong is located in the northern Vietnam between zone I and II of the four mangrove zones of Vietnam [18]. HaiPhong is the third largest city in Vietnam with total population of 1,884,685 inhabitants. It also serves as the most important port in northern Vietnam with its deep-water anchorage and large maritime facilities [19]. This study is located in HaiPhong's Bang La, Dai Hop and Tien Lang District (20°37' to 20°41'N, 106°38' to 106°42'E) [20]. Recently the city has been affected by sea level rise and several natural disasters [12].

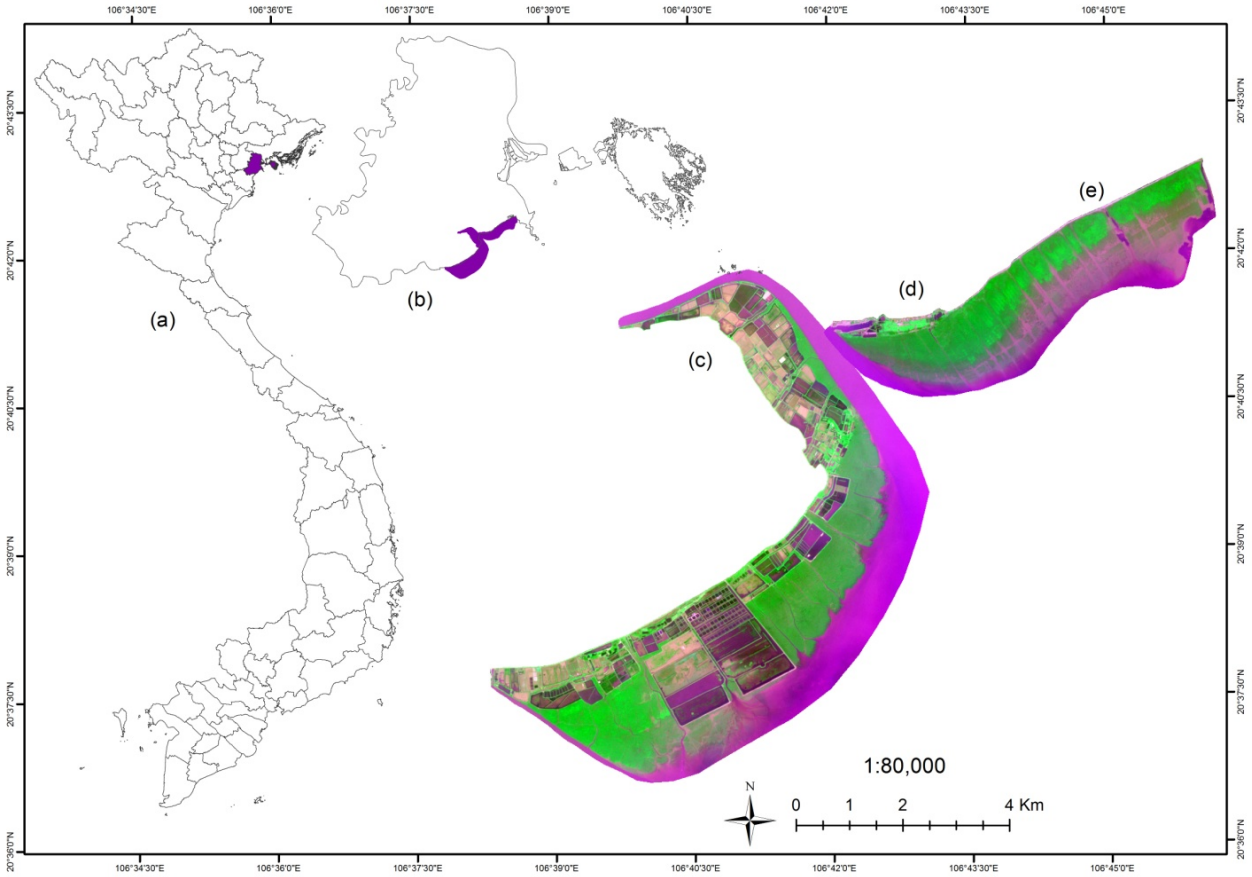


Fig. 1 Geographic map of the study areas; (a) Vietnam Provinces map, (b) HaiPhong Province and (c) Study sites: Tien Lang, (d) Dai Hop, and (e) Bang La.

Data and Preprocessing

Historical Landsat 7 and Landsat 5, Sentinel 2A/B data were analyzed (see Table 1) to detect changes in coastal land use cover in general and changes in mangrove area.

Table 1: Remotely Sensed data used in the study

No	Image codes	Date	Spatial Resolution (m)	Path/ Row
1	LT51260461994357BKT00	24/11/1994	30	126/45-46
2	LE71260462001320SGS00	16/11/2001	30	126/45-46
3	LT51260462006102BJC00	12/04/2006	30	126/45-46
4	LT51260462010337BJC00	12/03/2010	30	126/45-46
5	S2A_OPER_MSI_L1C_TL_EPA__20150810T033949_20160909T110117_A000687_T48QXH_N02_04_02	10/08/2015	10	Sentinel
6	L1C_T48QXH_A005435_20180322T032727	22/03/2018	10	Sentinel

Source: *Earthexplorer.usgs.gov, Glovis.usgs.gov*

Investigation of the status of mangrove spatial distribution

In order to investigate the status of mangrove spatial distribution in broader context, a study of secondary data and mangrove management activities conducted by central and local governments is also necessary. Historical maps of mangroves and remote sensing data were also used for mapping status of mangrove spatial distribution (see Table1). As a result, a map was developed for the assessment of mangrove status within the study area.

TA three weeks field surveys were carried out in May-June 2018 as part of the image classification process. 200 meters perpendicular plot was placed every 500m using Google Earth Pro; 20 plots were placed in both Bang La and Tien Lang. GPS coordinates were recorded at each corner of every plot.

Cloud-free images from Landsat 5, Landsat 7 and Sentinel-2A were used to distinguish changes of mangrove extent to determine key drivers of coastal mangrove changes during the selected periods (1994-2001, 2001- 2006, 2006-2010, 2010-2015 and 2015-2018).

Mapping was done using ArcGIS 10.3.1 after image classification to improve the image quality and to carry out better classification accuracy.

After performing IsoCluster unsupervised classification, based on land use, the raster was reclassified into four classes to determine the existence of the correlation between the features and land use cover changes, including coastal mangroves, water, agriculture, aquacultures, and others category is included to households, roads, others plants and bare lands. In Bang la and Dai Hop area have four class, Mangroves, water, agricultures, and others, others include households, roads, others plants and bare lands. Where, Tien Lang do not have agricultures but aquacultures. All these works were done by ArcGIS 10.3 software.

Ground truthing

The field survey was accomplished in the study area using the Global Positioning System (GPS) equipment in the Bang La, Dai Hop and Tien Lang for ground truthing.

A total 270 points were collected in the field based on characteristics and location of mangrove. and these points were imported to ArcGIS 10.3.1. Later all coordinates were translated to Universal Transverse Mercator (UTM) projection in zone 48N (WGS_84_UTM_zone_48N) for further analysis.

Accuracy assessments

After classification of mapping, a field survey was required to assess classified map accuracy. This field survey involved group of five students to obtain accurate location for examples of each land use and land cover class included in the classification scheme. Accuracy assessment was therefore needed to identify the actual land cover type (e.g., rice or grassland) of the pixels in question. In order to assess the accuracy of the classified image, the field verification was conducted to sample points using a Garmin GPSMAP 78. 400 points were sampled for Bang La and Dai Hop districts and 400 points for Tien Lang district.

Error matrix-based accuracy assessment was used for the evaluation of change detection results because it shows how many pixels were correctly classified. An overall Kappa test was also applied to measure the extent of classification accuracy, in order to assess consistency between the reference data and the classified images [16], [21], [22].

$$\text{Overall accuracy} = \frac{TCN}{TN} \times 100 (3.1) \quad \ldots. (1)$$

$$\text{Kappa, K} = \frac{(TN \cdot TCN) \quad (RT \cdot CT)}{TN^2 - (RT \cdot CT)} (3.2) \quad \ldots. (2)$$

Where: TN =Total number of ground truth points, TCN = Sum of corrected points, RT = Row total, CT = Column total. Calculation formula (for further information about the formula, [23], [24], [25], [10].

Land use land cover change detection analysis

Unsupervised classification was performed in order to quantify the changes. Overlay method was performed in Analysts Tools in ArcGIS 10.3.1 using raster calculator to examine the difference between multiple data layers. Images were compared to determine the level of change for six time periods (1994-2001, 2001-2006, 2006-2010, 2010-2015 and 2015-2018).

Recommendation for sustainable mangrove management

Based on the finding above, secondary data were reviewed, such as the principles of mangrove forests protection and framework of policy for sustainable management. The study was conducted to propose probable solutions for better management of mangrove forest.

III. RESULTS AND DISCUSSION

Current land cover status

Table 2. Land use land cover status of the study area (ha).

Year	Area	Mangrove	Water	Aquaculture/ Agriculture	Others
1994	Tien Lang	420.12	2037.33	226.26	228.6
	Bang La and Dai Hop	16.92	216.45	0	959.49
2001	Tien Lang	820.89	1374.03	381.42	335.97
	Bang La and Dai Hop	159.84	546.57	35.01	451.44
2006	Tien Lang	965.61	1120.68	460.62	365.40
	Bang La and Dai Hop	323.28	183.78	17.01	668.79
2010	Tien Lang	842.67	940.77	218.07	910.80
	Bang La and Dai Hop	459.99	219.42	25.02	488.43
2015	Tien Lang	1122.48	966.41	732.44	91.32
	Bang La and Dai Hop	539.74	549.35	10.89	93.88
2018	Tien Lang	1139.32	861.16	507.15	405.02
	Bang La and Dai Hop	807.90	200.42	10.14	175.40

Fig. 2 Land cover status in Bang La and Dai Hop, and Tien Lang in 1994 (a), 2001 (b), 2006 (c), 2010 (d), 2015 (e) and 2018 (f)

Our results indicate mangrove forest cover increased as buildup areas were converted into mangroves during 1994-2018. The government of Vietnam and citizens took several steps to develop the mangroves ecosystem. Local communities and the Vietnamese government is trying to increase mangrove area along the coastline of HaiPhong.

Throughout one interview, an employer of a shrimp farm said, the owner of that farm pays local citizens to take care of mangroves in Tien Lang that belongs to him. This means local people are also aware of mangrove protection. As a consequence of this awareness, there is no decline in mangroves but continual growth. However, on the other hand, a citizen of the same area claimed, as there are not many mangrove plants in this area and the current amount is not enough to fight against the natural disaster like storms, tsunami. This person etc. indicated that there is still a long way to go and more plans and implementations are necessary.

Accuracy assessment

The overall accuracy, producer's accuracy and user's accuracy was calculated based on the classified classes. For each land cover class, 30 points were selected for field verification in order to examine the classification accuracy. The overall accuracy for Tien Lang is 82%, Bang La and Dai Hop is 92.5% with the same as equivalent to kappa coefficient results of 0.76 and 0.59, respectively. The producer accuracy result shows the lowest accuracy of water is 63% for Tien Lang, which may be due to the classification administrator who was not able to differentiate between natural water bodies and aquaculture farms in the satellite images. Furthermore, unsupervised classification could not produce precisely defined clusters for each of the land use and land cover classes. The producer's accuracy of mangroves in Bang La and Dai Hop area is 100%, likely due to the high spatial resolution of Sentinel-2B images. The agriculture class accuracy is 80% for the combined areas of Bang La and Dai Hop. The errors for agriculture was likely due to the fact that young mangroves and other plants look similar to agricultural plants in the satellite imagery.

Table 3. Accuracy assessment for the Tien Lang area 2018.

Ground Truth					
Classified	**Mangroves**	**Water**	**Others**	**Aquacultures**	**User's Accuracy (%)**
Mangroves	25	4	2	1	81
Water	1	19	0	0	76
Others	3	1	25	0	74
Aquacultures	1	6	3	29	81
Producer's Accuracy (%)	83	63	83	97	82

Table 4. Accuracy assessment for the Bang La and Dai Hop area 2018.

Ground Truth					
Classified	**Mangroves**	**Water**	**Others**	**Agriculture**	**User's Accuracy (%)**
Mangroves	30	1	1	2	88
Water	0	29	1	0	97
Others	0	0	28	4	88
Agriculture	0	0	0	24	100
Producer's Accuracy (%)	100	97	93	80	92.5

Land cover change detection in selected periods

This study is based on the findings of the various correlation values with the discussion of differences between land use and land cover changes within the period of 2015 to 2018. Resulting Land use and Land cover changes of the year 1994-2001, 2001-2010 and 2010-2015 of the study areas are discussed below:

As seen from the data in **Table 5**, the mangrove vegetation has been constantly growing, which could be a result of proper management. The continuous conversion of water bodies and other areas witnessed a growth rate of expansion in the mangroves vegetation area.

On the contrary, Tien Lang area is still threatened by natural calamities. It is noticeable that aquaculture and others area have been increasing due to the demand for socio-economic development. On the other hand, some parts of the forest are managed by the local government and the rest of the forest is managed by local citizens including aquaculturists. As long as the area is related to income sources, there are always conflicts of interest between the aquaculturists and the community. Moreover, as a tropical region, extreme rainfall or extreme drought could occur in these regions. Low areas are going to submerge in the sea. As a result, environmental risks have increased significantly.

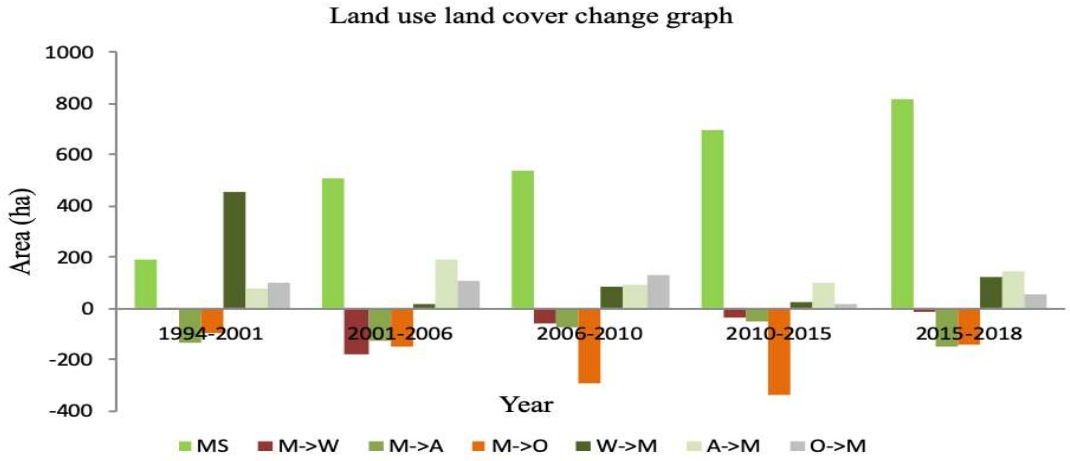


Fig. 3 Land use land cover change graph, Tien Lang.

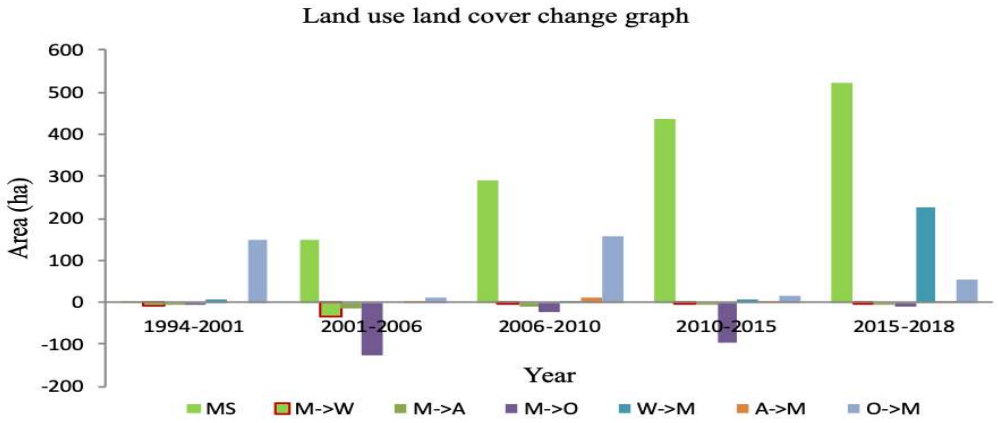
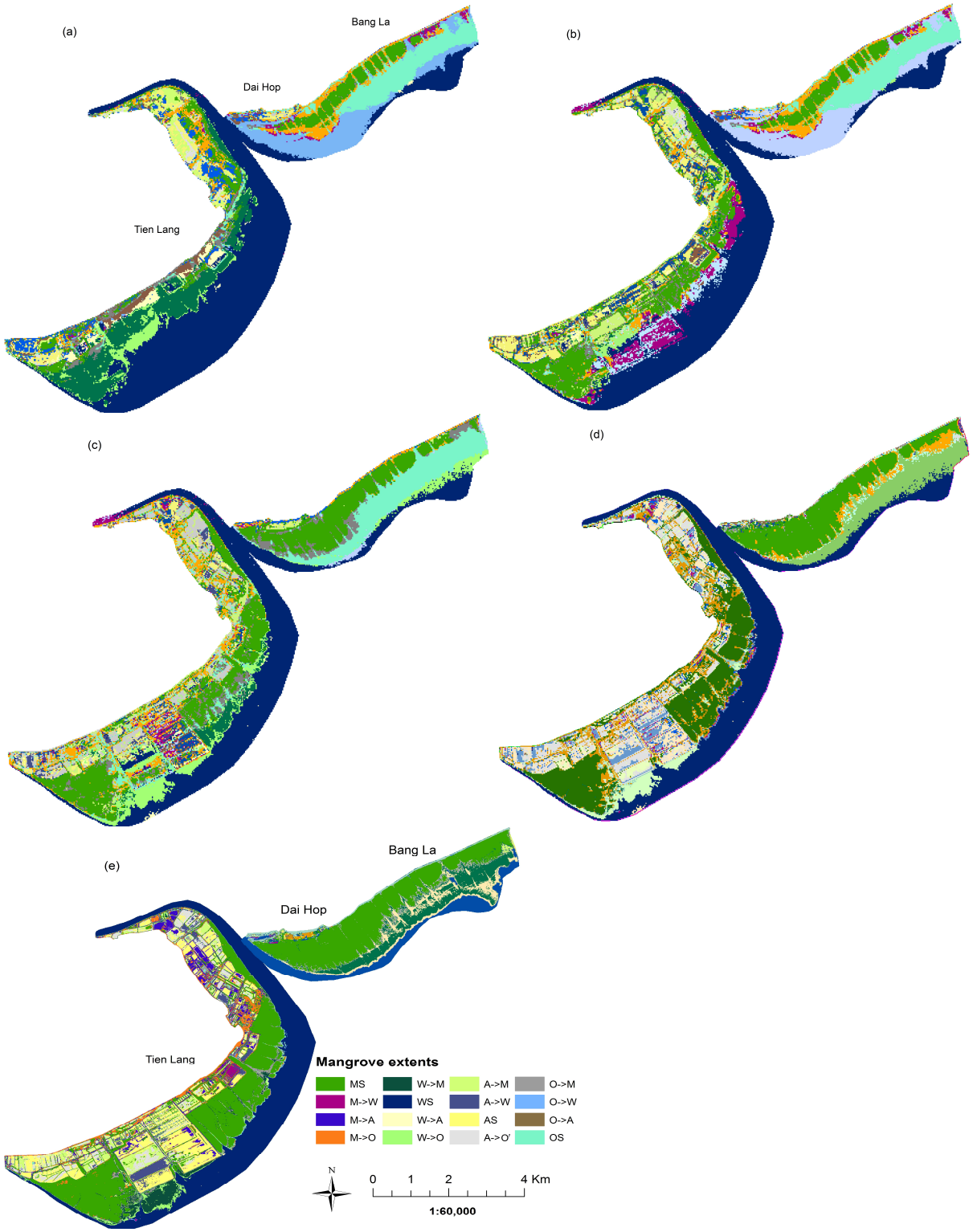


Fig. 4 Land use land cover change graph of Bang La and Dai Hop.

Where: Mangroves (M) stable (S), Mangroves (M)->Water (W), Mangroves (M)-> Aquacultures/ Agricultures (A), Mangroves (M)->Others (O), Water(W)->Mangroves (S), Aquacultures/Agricultures (A)->Mangroves (M), Others (O)->Mangroves (M)

Table 5. Change detection of mangrove extents in Tien Lang (T), Bang La and Dai Hop (B)

Year	1994-2001		2001-2006		2006-2010		2010-2015		2015-2018	
Area	T/L	B/D	T/L	B/D	T/L	B/D	T/L	B/D	T/L	B/D
MS	190.26	3.42	509.31	149.76	536.67	289.71	697.5	437.67	817.01	520.76
M->W	7.02	6.48	182.34	35.01	59.67	0.54	35.46	2.16	11.87	1.46
M->A	130.32	6.39	124.29	12.6	75.69	10.8	51.39	5.94	149.28	7.73
M->O	92.52	0.63	149.67	125.91	293.58	22.23	336.06	93.96	144.32	9.79
W->M	454.14	7.2	18	0	85.77	0.72	23.31	6.21	121.83	227.9
WS	1359.54	184.68	1038.06	180.63	788.67	147.06	755.28	210.42	775.19	195.27
W->A	67.59	8.37	15.93	0.99	28.35	0.18	10.71	0.63	19.64	1.22
W->O	156.06	16.2	48.69	2.16	217.89	35.82	157.23	323.55	49.75	124.96
A->M	79.92	0	188.91	0.09	90.27	11.79	98.73	1.53	146.17	4.65
A->W	2.25	0	23.13	1.8	65.79	0	126.27	2.7	70.28	2.68
AS	98.28	0	177.48	10.71	78.57	3.78	153.09	0.36	323.77	1.36
A->O	45.81	0	71.1	4.41	225.99	1.44	353.16	5.49	190.22	3.56
O->M	96.57	149.22	104.67	9.99	129.9	157.77	14.3	13.95	52.31	54.59
O->W	5.22	355.41	130.5	329.13	26.64	71.82	16.92	3.06	3.82	1.01
O->A	85.23	26.01	63.72	10.71	35.46	10.26	2.88	14.85	14.46	1.19
OS	41.58	428.85	66.51	318.96	173.34	381.69	55.53	62.19	20.73	37.09



Where, Mangroves (M) stable (S), Mangroves(M) ->Water (W), Mangroves(M) ->Aquacultures/ Agricultures (A), Mangroves(M) ->Others (O), Water(W)->Mangroves (S), Water (W) stable (S), Water(W) -> Aquacultures/Agricultures (A), Water(W) -> Others(W->O), Aquacultures/Agricultures(A) -> Mangroves (M), Aquacultures/Agricultures (A) -> Water (W), Aquacultures/ Agricultures (A) stable(S), Aquacultures/ Agricultures(A) -> Others (O), Others (O) -> Mangroves (M), Others(O) -> Water(W), Others (O) -> Aquacultures/ Agricultures (A), Others(O) stable (S).

Fig. 5 Land use land cover change map of mangrove extents in Tien Lang, Bang La and Dai Hop from 1994-2001, 2001-2006, 2006-2010, 2010-2015 and 2015-2018

Key drivers of changes in mangrove extents

In comparison with the mangrove status of Bang La and Dai Hop, the authority of Tien Lang should focus on mangrove plantation. At the same time, continuous land loss and mismanagement in some fish prone areas have been noticed Hence, this system is comparatively stable. Continuous changes of mangroves to aquacultures were the most dominant change in Tien Lang. The drivers for changes of Tien Lang mangroves area are given below:

Period of 1994-2001

There were 420.12ha of mangroves in 1994, which changed o 130.32ha of aquacultures and 92.52ha of others during 1994-2001. Mangrove forests were degraded here because of private aquaculture. According to the FAO report [26], the main drivers for mangrove loss in Tien Lang area are shrimp farming.

According to Hue and Scott [27], the Prime Minister issued National Decree 773-TTG, which specified that the open coastal areas and water bodies could be used for shrimp farming activities, coupled with the government's encouraging policy of aquaculture and export of marine products. Which encouraged the conversion of coastal lands into aquaculture; Ha et al., [28] stated that 'Decree 02/CP in 1994 that management be handed over from state-owned enterprises (SFEs) at the central and provincial levels to households, villages, and communes for sustainable and long-term use. This indicates that local households also practiced shrimp farming in small areas, possibly be mangrove areas, agricultural and bare lands. According to Hue and Scott [27], between 1995-1999, contractors could record in 'Red Book' to get the land use certificate. Most shrimp farmers extended cultivation towards water bodies and mangrove areas during this period.

On the other hand, there were 16.92ha of mangroves in Bang La and Dai Hop in 1994 which increased to 159.84ha in 2001. Although there was a restoration and plantation program, 'national program 327' was applied, which was not successful until 1997, but there was mangrove plantation program that started with the central Red Cross and Japanese Red Cross Society in 1998. Meanwhile, mangroves management structure improved and got strong, and local citizens started follow them. As Hai Phong Red Cross Society directly managed these areas, hence the vegetation cover there was relatively unchanged [29].

Period of 2001-2006

The greatest mangrove conversion was a change of 124.29ha of mangroves to aquacultures and 149.67ha to others area. The 'Article Nr. 17, Decision 178/2001/QD-TTg' included the limitation of not using more than 30% of land for aquaculture, an allowance to cut no more than 20% of forested area and, most relevant to benefit sharing, entitlement to 80-90% of income after tax for households that receive financial support from the government and 100% for those who invested without support [28].

Although the amount of conversion to mangroves from aquaculture was the highest during this perioddue to low temperatures in Summer and heavy rain in the rainy season, shrimp farming projects failed in Northern Vietnam [30]. Not all mangroves area were decreased the by human activities, but there was a typhoon in 2005 that destroyed mangroves and dikes in Tien Lang. Bang La and Dai Hop mangrove area increased during this period, comparing to the period of 1994-2001. This is due to initiatives of the Vietnamese government and the Japanese Red Cross Society (JRCS), as well as policy, administrative structures and, regulations have been upgraded.

Period of 2006-2010

Though changing of mangroves conversion decreased to half in the comparison of the previous period, still, 75.69ha of mangroves converted to aquacultures and 293.58ha of mangroves converted to others areas.

According to FAO report by Tuan [31], illegal cutting and mangroves intrusion have appeared after stopped funding in 2006. After the typhoon in 2005, local citizens were able to understand the value of mangroves, they took initiative then to plant mangroves and build dikes. Where women played the most active involvement in the implementation, and they built private nurseries at home to plant mangroves. On the other hand, JRCS directly maintained the mangrove forest both commune, Bang La and Dai Hop.

Period of 2010-2015

during this period 51.39ha of mangrove converted to aquaculture and 336.06ha of mangrove changed to others areas. According to Jhavery et al., [32] aquaculture farming continued the destruction of mangroves as same as others period and there was additional damage due to typhoons in 2012.

However, the reason for mangrove enhancement that the citizens of these two communes follow policy, the forest department manages it and government staff of these areas are diligent.

Period of 2015-2018

According to head of Dai Hop, 30% of the population are dependent on aquatic products like crabs, shrimps, snails, and fishes. Also, 10% of the local population of the study areas including Bang La, Dai Hop, Tien Lang, and neighboring wards; Tan Trao, Ngu Don, and Lai-Ha are directly involved with the mangrove area. As a result, young plants and fertile seeds get crushed and destroyed by fishermen trampling them and this key fact highlighted during the field survey. Throughout the interview an aquaculturist mentioned, there are some aquatic ponds that they cannot cultivate fishes due to storm and other natural calamities, as a

result, the project remains incomplete and was stable to the bare lands.

It is observed that mangrove management in Tien Lang includes a lack of proper socio-economic development planning for some areas, tin increase in aquaculture, not enough studies and appropriate planning and application of farming for a sustainable management.

Feasible solution for a better management of mangroves

The mangrove tree density of the Bang La and Dai Hop area is very high, providing not only the environs benefit from the mangroves that directly serve human life, but also the indirect values of ecology play an important role in protecting the environment at the seaside.

On the contrary, the Tien Lang is strongly influenced by the storm surge, which is a deterrent to natural mangroves in this sub-zone. For this reason, ecosystems and biodiversity have already suffered extensive damage and which will be continuing. If the mangrove forests increase further, it will play a more effective role in dealing with natural calamities; therefore, proper steps should be taken. It is also necessary to increase the mangrove forest in all regions by determining the most vulnerable zones needed.

Though aquaculture should be banned due to its many disadvantages, it's not possible. There is conflict arising between citizens and the government, somewhat this problem is relatively not considered to be resolved in the reality, but researches; in addition to the financial losses, the natural environment has been threatened. Therefore, mangrove forest restoration on the bare lands areas should be planted instead of aquaculture. For this reason, a model has been designed that could apply for sustainable management including economic, social and environmental practices to improve the mangroves forest ecosystem, aqua culturists and dependent people's livelihood. The advantages of the model are discussed below:

Following the structure of a sustainable management model (Diagram 1) will provide many opportunities and favorable circumstances.

Mangroves plantation and duck farming in the bare lands and abandon aquacultures

Vegetation cover (Fig 5) shows that Tien Lang was more extensive than Bang La and DaiHop in the 1994. As time passed by, vegetation was restored due to the initiative taken by the government, Japanese Red Cross Society and local citizens of Bang La and Dai Hop. Despite the fact that, same projects were applied in Tien Lang, it wasn't as successful as Bang La and Dai Hop. Though the similarities and differences between two places are countless, Bang La and Dai Hop could be a good example to follow. As we can see from Bang La and Dai Hop, it is possible to grow mangroves in the bare land; it is also possible to apply the same method in Tien Lang, but in different way. That is why this model is built to consider nature and the economy. As most of the abundant aquaculture and bare lands are ownership based, it is recommended to plant mangroves in these places, at the same time, duck farming could be a good income source.

Duck farming will allow local citizens to not disturb the mangrove forest and help them to improve their socio-economic condition. At the same time, the developed livelihood will make them responsible for mangroves conservation.

For this reason, in cooperation with local citizens, the duck farming could be started after one year of mangroves plantation, so that, plants can be stabilized in the ground. If duck farming is operated here with the mangroves, there will be less possibility to cutting of mangroves for aquacultures or others activities.

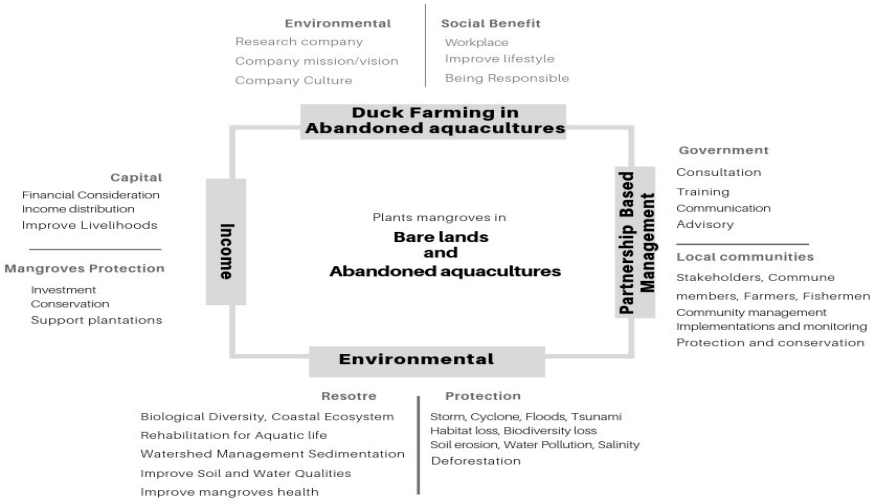


Diagram. 1 Sustainable mangrove management model for Tien Lang

Partnership based management

The harmonious combination of protection and exploitation and uses for the sustainable development of natural resources is a challenge for each country. Hence, investment and protection by the government will be needed for the mangrove plantation in the first stages. Therefore, financial support for the plantation from the investors are necessary here. Partnership with the government and local communities are required for better management of the mangrove forest. That's why together with the authority of the local government and individual owners of the abundant aquaculture and bare lands have to come forward to plant mangroves and begin duck farming in the same place. This will have social and environmental benefits.

The government has to consult stakeholders and community people about the plantation and conduct training for the farmers, fisherman, and community management. Involving local people and giving them training for the monitoring of the mangroves will raise *awareness* and understanding about the rule of *law* and policy of mangroves conservation, and implementation of them. Monitoring by the local community could be a better approach for the protection and conservation of the mangrove forest. The progress of the plantation should be checked time by time for the better management.

Social Benefit

This management plan will follow the 'win-win theory', where, economic and environmental benefit are assumed to be equally beneficial. Planting mangrove forest will improve the lifestyle and provide income source through creating jobs for unemployed citizens in Tien Lang, who will monitor and take care of the forest. Meanwhile, unemployed citizens in the surrounding area. Additionally, nutrition from duck meat which has a high content of protein can reduce uncertainty of food and malnutrition. Once this plan is in place there will be a nice option for students for the future research and to find more appropriate solutions.

As mangrove forests deliver frequent social benefits such as protection from natural disasters, evening walk or sightseeing for the local people, pollen collection for honey bees, can be a precious option for the community, and will encourage them to be sincere for a better environment and protection.

Income Sources

This sustainable management plan will assist in extensive ways, in terms of minimizing the cost of duck production, increasing plant growth, providing environmental benefits and increasing income of farmers through selling duck meat. If the duck farming is introduced here, it will create a symbiotic relationship between mangroves and ducks yielding mutual benefits to both entities. For example, farmers do not have to supply extra foods for ducks, the droplets will work as a natural fertilizer, meantime, the continuous movement of ducks in the field will provide natural stimulation which will help to oxygenate and increase the availability of necessary nutrients like Nitrogen, Phosphorous and Potash to the mangrove plants. As a result, this project will increase the income of the farmers and make the availability of a nutritious diet. The income from the duck farming will improve the livelihoods and encourage them to be more sincere about the protection of mangroves.

Environmental benefit

While mangrove vegetation will be restored fully, it will provide environmental and social benefits. For example, the dense root systems of mangrove forests trap sediments flowing down rivers and off the land which will help stabilizing the coastline and prevent erosion from waves and storms. Mangrove forest improves water quality, sedimentation, and rehabilitation of marine life. At the same time, there will not be many environmental damages, especially in the disaster pron areas in Tien Lang.

IV. CONCLUSION

This study is based on an unsupervised classification of Landsat and Sentinel data, to investigate spatiotemporal changes of mangrove extent for 1994 to 2018. The overall accuracy assessment of Tien Lang is 82% and Bang La and Dai Hop is 92.5%. Land use and land cover status in 2010 shows that mangrove extent in Tien Lang decreased sharply, due to clear cutting of mangroves that caused by extensive shrimp farming. The major finding is the stability in mangrove extent in each period in Bang La and Dai Hop, due to plantation and conservation by the local citizens with the support of the Japanese Red Cross Society (JRCS) and the Vietnamese government. Among them, forest, bare lands and other areas were identified as a type for the study area while mangroves forest gain occurring.

The study shows that total mangrove cover is Tien Lang status until 2019 is about 1139.32ha, Bang La and in Dai Hop it is 807.90ha. Total mangroves in Tien Lang were 420.12ha in 1994 and 1139.32ha. contrariwise, the total area of mangroves in Bang La and Dai Hop was about 16.92ha in the 1994, which increased to 807.90ha by the 2018. Comparing with different study periods, mangroves areas have been increased respectively. Considering the area of Bang La and Dai Hop, mangroves expansion in Tien Lang should be broaden.

A continual change in aquaculture and mangrove area is conspicuous in the result. Socio-economic drivers are mostly responsible for the decrement of mangrove extent and policy and project development were the positive drivers of mangrove expansion. Not only aquaculture gradually increases by the time because of the socio-economic demand, but mangroves also increased in some areas due to a initiatives of the local government in Tien Lang, while Bang La and Dai Hop mangrove forests are were protected by local citizens and government staff. Build-up area also slightly

increases in both areas. But the bare land cover is declining due to aquaculture practices in Tien Lang.

Proper management of land use and forest cover changes in Tien Lang is required because without proper management, habitat for wild flora and fauna, including threatened, endangered and rare species will soon be lost and will change the ecosystems of the area. If coastal areas are not guaranteed security and reduced environmental pollution through increasing mangrove area and dikes, the impact of the country's overall economy will be affected.

Further study

This study is about the theoretical possibilities of sustainable mangrove management in Tien Lang. There is a lot of possibilities for practical studies. Especially for those research projects, who do studies widely. Where they could add socio-economic developmental in the study area to stop the widely practiced aquacultures. At the same time, A future research project is to implement on reducing the impact of natural disaster in the study area.

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