MANGROVE COVER-BASED VEGETATION INDICES MAPPING USING PLANETSCOPE DATA IN TIEN YEN DISTRICT QUANG NINH PROVINCE

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https://doi.org/10.55250/jo.vnuf.2023.15.127-138

ABSTRACT

This study focused on mangrove cover mapping by using vegetation indices in Tien Yen district. Mangrove ecosystems play a vital role in many coastal regions, protecting against erosion and storm surges, providing nursery habitats of aquatic organisms, and offering livelihoods to local communities. Besides, this study aims to evaluate the use of PlanetScope data based on vegetation indices for mapping mangrove cover. This study collected and analyzed high-resolution PlanetScope satellite imagery (3m x 3m) to calculate eight different vegetation indices, including CMRI, NDVI, NDWI, GNDVI, BNDVI, SAVI, IPVI, and EVI2. These indices were used to map the mangrove cover in Tien Yen District and to evaluate the accuracy of each vegetation index. The results showed that among all of the indices used, NDVI had the highest accuracy of 96.3% in mapping the mangrove cover in Tien Yen district, followed by CMRI. Besides, the study emphasizes the importance of utilizing remote sensing techniques in supporting conservation efforts and establish sustainable management practices for mangrove forests in Tien Yen district. Additionally, the study presents an overview of the current situation and policy recommendations for the integrated management of mangrove forests, and provides information on sustainable mangrove ecosystem management in the context of climate change adaptation and mitigation in Tien Yen district, Quang Ninh province.

Keywords: mangroves, PlanetScope, Tien Yen, vegetation indices.

1. INTRODUCTION

In tropical and subtropical coasts around the world, mangrove forests have been known as a highly productive ecosystem that is essential to both nature and human life [1]. Mangrove forests are a highly bio-diverse ecosystem with typical products of tropical and subtropical coastal areas [1]. They also make a significant contribution to a variety of processes, including regulating the climate, cleaning the marine environment by capturing and degrading pollutants, reducing soil erosion, securing alluvial soils, and fostering the conditions for alluvial deposits to expand into the sea and form new lands [2].

In Vietnam, mangrove forests are widespread along the coastline, with the largest areas located in the south and north [3]. These forests provide valuable ecosystem services, such as acting as a natural barrier against erosion and typhoons, as well as providing goods and services such as wood for fuel and energy, pollution filtration, and habitat for a wide range of coastal and marine species [4, 5]. Moreover, Vietnam's fishing industry relies heavily on mangroves for seed, feed, and rearing grounds, as 82% of marine products in Vietnam are from inshore areas [6]. Vietnamese mangroves also support the livelihoods of local rural communities by providing enormous resources of some important food sources, namely shrimp, crab, and fish [7-9]. Additionally, mangroves in Vietnam provide crucial ecosystem services, including habitat for fish and biodiversity, fuel wood, raw materials, coastal protection, carbon storage, and salt production [10-17]. Vietnam has more than 8 million people who are protected from flooding thanks to the shield of mangrove forests [18]. They play an important role in providing livelihoods and a living environment for many local people in Tien Yen district, Quang Ninh province [19, 20]. However, human activities, such as

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deforestation, coastal land clearance, land reclamation, and processing and exploitation activities are adversely affecting the mangrove ecosystems in the area, thus causing habitat loss for many species of animals and plants living in the mangrove forests, thus leading to a change in biodiversity. Similarly, the mangrove forests in the Tien Yen district are also facing several threats. One of them is the increasing fragmentation of these forests, which makes them weaker against coastal processes like currents, waves, and semi-exposed coastlines. Inadequate recognition of the value of mangrove forests, weak management, and little protection have also contributed to deforestation and degradation of the mangroves over time. This, in turn, has resulted in a loss of essential resources and ecosystem services that the mangroves provide, which endangers the livelihoods of coastal communities and makes them more vulnerable to storm surges during severe storms and typhoons. Several studies have identified these issues [21-23].

In the last decades, remote sensing has become a valuable tool for quantifying mangrove extents due to its ability to provide quantitative and qualitative assessments of ground conditions over large and inaccessible areas [24]. Satellite imageries combined with vegetation indices have been widely used to create maps of mangrove forests and vegetation, with various methods including pixel-based, object-based, manual, and unsupervised methods [25, 26]. Multispectral sensors on satellite platforms, such as Synthetic Aperture Radar (SAR), Landsat, SPOT, Sentinels, PlanetScope, and Rapid-eyes, have been used to mangrove cover monitoring and mapping. Based on its high spatial resolution (3m x 3m), PlanetScope data has been proved to be an effective tool for mangrove monitoring and assessment, including biophysical properties, mangrove cover, thus offering a suitable option for studies and applications related to mangrove conservation and management [19, 20, 27, 28]. To achieve high accuracy in land cover classification, using multiple vegetation indices is seen as an important approach [27]. In addition, Diaz and Blackburn [29] conducted a research project that explored the remote sensing of mangrove biophysical properties, in which various vegetation indices were analyzed using PlanetScope data (3m x 3m) in a laboratory simulation that examined the possible effects of background variation on spectral vegetation indices. Likewise, in a study by Hai-Hoa [30], PlanetScope (3m x 3m) along with Landsat (30mx 30m) and Sentinel-2 (10mx 10m) was used to estimate mangrove cover in Thanh Hoa province, estimating mangrove cover from 2005 to 2018. That study tested various approaches, including Supervised Classification, Unsupervised classification, NDVI, SAVI, MSAVI, IPVI, DVI, GNDV, BNDV, OSAVI, TVI, and EVI, and selected the most suitable classification method for the study sites based on accuracy assessments to construct thematic maps. Based on the studies by Diaz and Blackburn [29] and Hai-Hoa [30], it can be concluded that using PlanetScope imagery combined with spectral vegetation indices is a suitable and effective method for estimating mangrove cover and constructing thematic maps with high levels of accuracy.

As a result, with the application of PlanetScope data, this study aims to test and select the most suitable vegetation index for assessing and mapping mangrove forests in Tien Yen. This method was based on the ability of vegetation indices to measure the ratio of reflected light from mangrove forests and the ground, and to assess the accuracy of each vegetation index including NDVI, NDWI, CMRI, IPVI, GNDVI, BNDVI, EVI2, SAVI, as well as the area covered by mangrove forests. The findings intend to provide coastal authorities with the effective tool for mangrove monitoring and evaluation, thereby supporting the decision-making process of mangrove conservation.

2. RESEARCH METHODOLOGY

2.1. Study site

Tien Yen is a coastal district located in the northeast of Quang Ninh province, Vietnam. This district is situated between the Gulf of Tonkin to the east and China to the north. The main economic activities in Tien Yen are agriculture and fishing. Moreover, local people are also dependent on mangrove forests for additional livelihoods. There are a total of 16 communes in Tien Yen district, but only 5 of them, including Hai Lang, Dong Ngu, Dong Hai, Dong Rui, and Tien Lang, have mangrove forests.

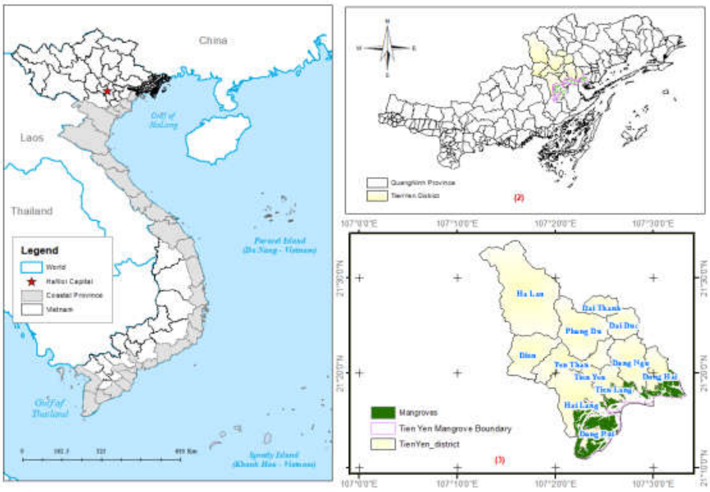

Fig. 1. Study site: (a) Geographical location of Quang Ninh province in Vietnam, (b) Mangrove forests distributed along the coast of Tien Yen district

2.2. Study methods

The PlanetScope data used in this study were refined through a process of geo-referencing and geometric correction. This was necessary to ensure that the images were accurately positioned and consistent for change analysis. To achieve this, the data was checked to make sure it all aligned with the WGS 1984 UTM Zone 48N projection. Adjacent images were then combined using the Mosaic to New Raster tool in ArcMap 10.4.1, creating a cover image of the Tien Yen district study area, which was then clipped along the boundary using the Clip. To distinguish the mangrove cover extent from other land covers, we used a band combination approach, including the true color imagery (RED, BLUE, and GREEN), and (RED, GREEN, and NIR) as described in previous studies [28, 30]. This visual interpretation was involved with the process of observing the presence or absence of mangrove forests and was carried out in accordance with Asrat [31]. This enabled us to identify the target areas effectively.

Satellite Data Collection

In this study, we used PlanetScope data in 2023 to estimate mangrove cover (Table 1). Atmospherically corrected images are available at https://www.planet .com/explorer.

Table 1. Remotely sensed PlanetScope used in the Tien Yen district in 2023

Image codes	Date	Resolution	Remarks
20230130_024551_06_225a_3B_AnalyticMS	30 Jan 2023	3 x 3	PlanetScope
20230130_024548_87_225a_3B_AnalyticMS	30 Jan 2023	3 x 3	PlanetScope

Source: http://planetscope.com

Vegetation indices: To determine mangrove cover in 2023, mangrove cover classification was carried out based on eight vegetation indices, including NDVI, NDWI, CMRI, SAVI, BNDVI, GNDVI, EVI2, and IPVI as shown in Table 2.

Table 2. Equations of vegetation indices used for mangrove cover mapping

ID	Vegetation indices	Equations	Range of values	References
1	Normalized Difference Vegetation Index (**NDVI**)	$\frac{(\text{Band}_{NIR} \quad \text{Band}_{RED})}{(\text{Band}_{NIR} + \text{Band}_{RED})}$	-1.0 ÷ 1.0	Rouse [32, 33]
2	Normalized Difference Water Index (**NDWI**)	$\frac{(\text{Band}_{GREEN} \quad \text{Band}_{NIR})}{(\text{Band}_{GREEN} + \text{Band}_{NIR})}$	-1.0 ÷ 1.0	Du [34, 35]
3	Combined Mangrove Recognition Index, (**CMRI**)	(NDVI–NDWI)	-1.0 ÷ 1.0	Gupta [36, 37]
4	Soil Adjusted Vegetation Index (**SAVI**)	$\frac{(\text{Band}_{NIR} \quad \text{Band}_{RED})}{(\text{Band}_{NIR} + \text{Band}_{RED} + \text{L})}(1 + \text{L})$	-1.0 ÷ 1.0	Huete [38]
5	Blue Normalised Difference Vegetation Index (**BNDVI**)	$\frac{(\text{Band}_{NIR} \quad \text{Band}_{BLUE})}{(\text{Band}_{NIR} + \text{Band}_{BLUE})}$	-1.0 ÷ 1.0	Wang [39]
6	Green Normalised Difference Vegetation Index (**GNDVI**)	$\frac{(\text{Band}_{NIR} \quad \text{Band}_{GREEN})}{(\text{Band}_{NIR} + \text{Band}_{GREEN})}$	-1.0 ÷ 1.0	Rouse [40]
7	Enhanced Vegetation Index (**EVI2**)	$2.5 \frac{(\text{Band}_{NIR} \quad \text{Band}_{RED})}{(\text{Band}_{NIR} + 2.4 \quad \text{Band}_{RED} + 1)}$	-1.0 ÷ 1.0	Jiang [41]
8	Infrared Percentage Vegetation Index (**IPVI**)	$\frac{\text{Band}_{NIR}}{(\text{Band}_{NIR} + \text{Band}_{RED})}$	0.0 ÷ 1.0	Crippen [42]

Where: Band_{NIR} is Near Infrared Band (Band 4); Band_{RED} is RED Band (Band 3); Band_{GREEN} is GREEN Band (Band 2); Band_{GREEN} is BLUE Band (Band 1).

Image classification: In ArcGIS 10.4.1, there are various tools available to support the estimation of mangrove forest area from each different vegetation index. In the Spatial Analyst Tools, *Raster Calculator* tool was used for calculating each index in **Table 2** and the *Reclassify* tool was then used with the defined thresholds indicated in **Table 3** for three main classes, including Mangrove forests (closed and open canopies), Non-mangrove forests (abandoned aquaculture ponds, fallow land, and residential areas), and Water bodies (mudflats and water areas).

Accuracy assessments of classified images: The primary objective of this study was to assess the effectiveness of various vegetation indices in accurately mapping mangrove forest cover. To accomplish this, the research constructed a thematic map of mangrove forest cover by using PlanetScope imagery for each index. The study then collected GPS (GPS Garmin 78s) points through field surveys and combined them with randomly generated points representing 100 locations in mangrove forests, consisting of 60 locations in non-mangrove forests, and 40 locations in water bodies. Afterwards, these points were compared with corresponding data images provided by the Google Earth. To assess the accuracy of mangrove forest cover classified, the study used both visual interpretation and the statistical matrix-based analysis approach for each vegetation index. Through this process, the study evaluated the accuracy of mangrove forest cover classified by PlanetScope, determined and selected the most reliable vegetation index for mangrove cover mapping in Tien Yen district, Quang Ninh province.

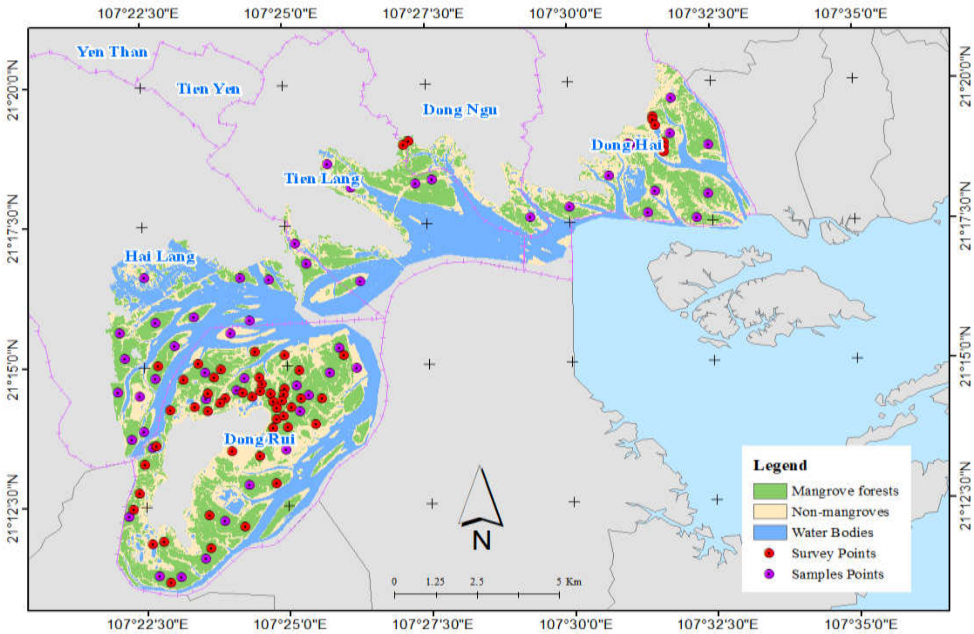

Fig. 2. Location of accuracy points of sample points and survey points in Tien Yen district

For accurate statistical analysis, the study utilized independent test samples to generate a computational matrix and measured the consistency between observed and reference data using the Kappa coefficient. To be more specific, a Kappa coefficient value of 0 ÷ 0.4 indicates inconsistency, 0.41 ÷ 0.6 indicates moderate consistency, 0.61 ÷ 0.8 indicates remarkable homogeneity and 0.81 ÷ 1.0 indicates almost perfect homogeneity [43, 44]. To ensure data accuracy, a minimum interpretation accuracy of 85.0% was established, which is consistent with previous studies by Foody on coastal land cover and mangrove cover maps [45].

3. RESULTS AND DISCUSSION

3.1. Accuracy assessments

Accuracy assessments of land cover and mangrove cover mapping:

As indicated in Table 3, there are eight different vegetation indices. With a value range of -1 to 1 for six indices, the threshold values of calculated vegetation indices for the year 2023 in Tien Yen district are given.

Table 3. Threshold values of vegetation indices determined in 2023 in Tien Yen district

Indices	CMRI	NDVI	NDWI	SAVI	IPVI	BNDVI	GNDVI	EVI2
Range of values	-0.03÷0.62	-0.04÷0.34	-0.34÷0.14	-0.003÷0.5	0.49÷0.64	-0.12÷0.39	-0.15÷0.33	-0.11÷0.72
Thresholds for mangrove cover	0.62	0.34	-0.34	0.5	0.64	0.39	0.33	0.72

The values of indices greater than 0 indicate the presence of a vegetated land area, while NDWI and IPVI have the opposite threshold values. With an EVI2 index range from -0.11 to 0.72, it has the highest vegetation threshold value compared to the remaining 7 indices. Conversely, GNDVI and NDVI have vegetation threshold values of 0.33 and 0.34, respectively, which rank in the last place.

Based on **Table 4** of vegetation indices, it could be deduced that the overall accuracy of these indices is quite high, ranging from 90.0% to 96.3% (Table 4). However, the accuracy of the mangrove cover classification differs from one non-vegetation class to another, depending on the index used. The Kappa coefficient is a measure of agreement between observed and reference data. The Kappa coefficients have showed in the table with range from 0.86 to 0.94, in particular six indices with Kappa values ranging from 0.91 to 0.94 indicated there were a relatively high consistency. Among the vegetation indices evaluated, it can be noted that NDVI has the highest overall accuracy of 96.3%

with a Kappa coefficient of 0.94, indicating the highest level of consistency compared to other indices. This suggests that the NDVI index is the most effective vegetation index for mangrove cover classification. On the contrary, the EVI2 index has the lowest Kappa value compared to other indices, with a value of 0.88, which indicates a different level of accuracy compared to other indices.

Table 4. Summary of accuracy assessments of land cover/mangroves in Tien Yen district

	CMRI	NDVI	NDWI	GNDVI	BNDVI	SAVI	IPVI	EVI2
UA (%) for Man	99.0	99.0	99.0	98.0	99.0	99.0	99.0	96.0
UA (%) for Non-	90.0	90.0	83.3	91.7	75.0	90.0	86.0	88.3
OA (%)	95.5	96.3	91.6	93.2	90.2	93.0	90.0	91.4
KC	0.94	0.94	0.89	0.91	0.86	0.91	0.88	0.88

Where: Man (mangrove forests); Non- (Non-Mangrove forests); UA (User's accuracy), PA (Producer's accuracy), OA (Overall accuracy), KC (Kappa coefficient).

Overall, these vegetation indices could be perceived as promising methods for mangrove classification. However, since different indices have various characteristics and accuracies when classifying different classes, selecting suitable indices therefore is crucial to improve the accuracy of vegetation classification in a particular area.

3.2. Mangrove cover mapping using vegetation indices

Coastal land use and land cover mapping:

Table 5 and **Fig. 3** show the coastal land extent along the Tien Yen coastline with each vegetation index, including the area of mangrove forest (ha) when using each vegetation index. The results illustrate that the area of mangrove forest varies depending on the vegetation index used. Among the different vegetation indices, IPVI produces the largest area of mangrove forest (3848.28 ha), followed by EVI2 (3837.07 ha) and CMRI (3625.13 ha). In contrast, BNDVI is recorded as the lowest, with the area of mangrove being 3784.75 ha. Other vegetation indices studied also show varying results in terms of the area of mangrove forest. Among the different vegetation indices, NDVI has the highest overall accuracy of 96.3%, while that of IPVI is the lowest with the figure standing at 90.2%.

Overall, the results suggest that selecting an appropriate vegetation index for mangrove classification and management is critical to achieve accurate and reliable results. Although IPVI produces the largest area of mangrove forest, its accuracy is the lowest among the different vegetation indices studied. Therefore, NDVI and CMRI are the most reliable and accurate vegetation indices for mangrove classification in the Tien Yen coastline area.

Table 5. Coastal land cover extent along the Tien Yen coastline by each vegetation index

No	Vegetation Index	Mangrove (ha)	Non-mangrove (ha)	Water Bodies (ha)	Accuracy (%)
1	CMRI	3625.1	2932.5	3409.2	95.5
2	NDVI	3368.1	3403.6	3195.1	96.3
3	NDWI	3505.5	3286.8	3174.6	91.6
4	SAVI	3426.2	3086.1	3454.6	93.2
5	IPVI	3848.3	2671.5	3447.1	90.2
6	BNDVI	3784.8	3250.6	2931.5	93.0
7	GNDVI	3643.4	3188.1	3135.3	90.0
8	EVI2	3837.1	2934.9	3194.9	91.4

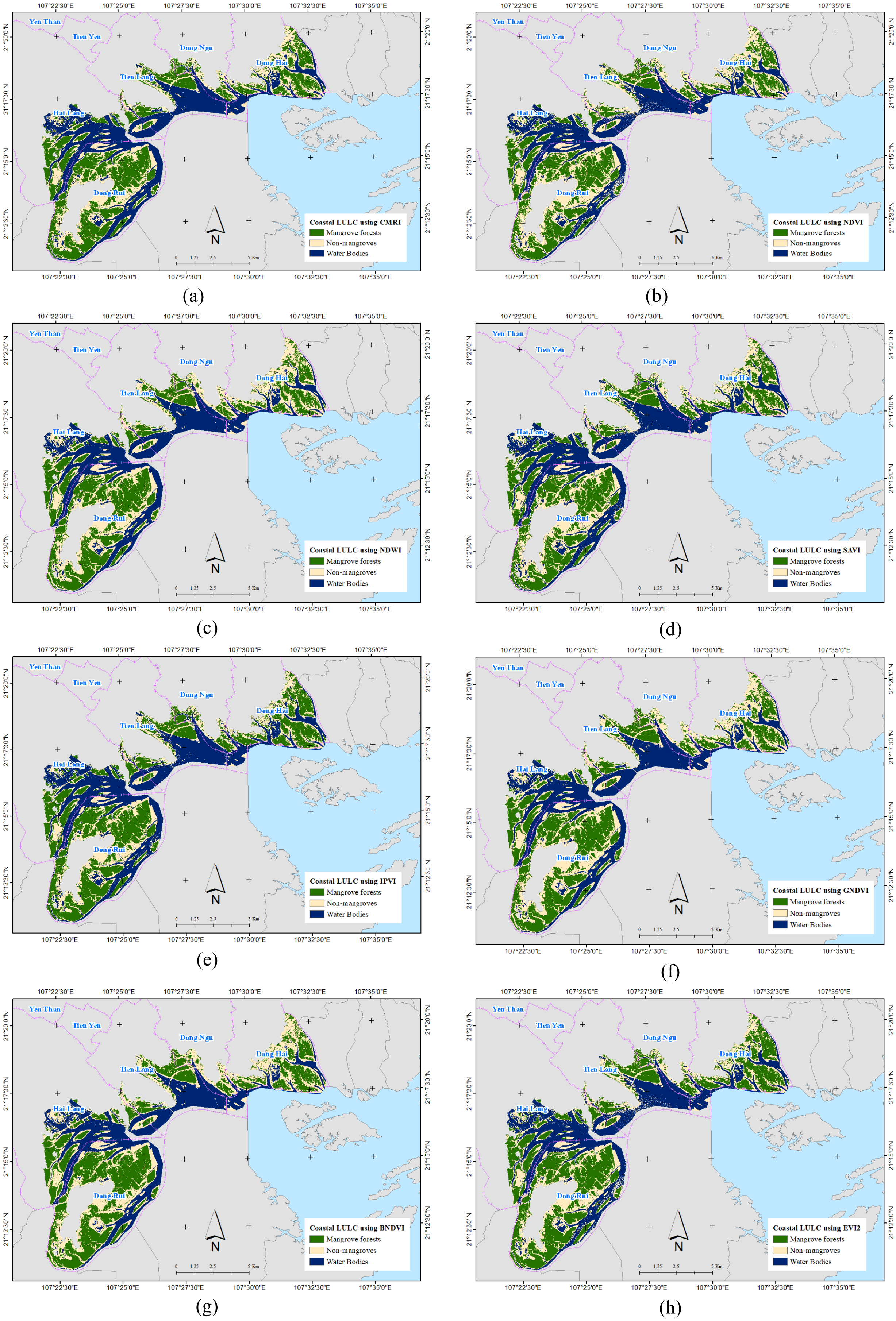

Fig. 3. Mangrove and land cover mapping along the Tien Yen coastline:
(a) CMRI, (b) NDVI; (c) NDWI; (d) SAVI; (e) IPVI; (f) GNDVI; (g) BNDVI; (h) EVI2.

3.3. Implications for mangrove mapping-based vegetation indices

***Implications for using vegetation indices**:*

Mangrove forests provide valuable ecological services, including coastal protection, biodiversity conservation, and carbon sequestration. Despite significant goods and services offered by mangrove forests in Tien Yen district, they are still facing various threats, including overexploitation of natural resources, coastal development, and climate change [19, 20, 46]. Therefore, sustainable management of mangrove forests is essential to ensure their ecological and socio-economic values [19, 47]. Moreover, continuous monitoring of the dynamics of mangrove forests is crucial to detect early changes for needed intervention actions [48]. Indeed, remote sensing technology, particularly satellite imagery, has been extensively used to map and monitor mangrove forests due to their ability to provide clear and timely information on large and remote areas [19, 48]. Specifically, vegetation indices derived from satellite images provide valuable indicators of mangrove extent and can be used to differentiate mangrove forests from other land cover types, such as agricultural fields, urban areas or water bodies. These vegetation indices, including NDVI, NDWI, CMRI, SAVI, make it possible to track changes in mangrove extent and distribution based on changes in index values. These indices can quickly and accurately map the extent of mangrove forests from remotely sensed imagery. The use of these indices in mangrove monitoring can help identify areas where mangroves are present or where mangrove cover has declined, assess regeneration potential and determine areas with high conservation value.

Singgalen and Manongga [48] conducted a study titled "Monitoring of mangrove ecotourism area in which they used NDVI, NDWI, and CMRI in Dodola Island, Morotai Island regency, Indonesia to monitor mangrove ecotourism area there. The study spotted a decrease in NDVI and CMRI values in the mangrove ecotourism area, indicating potential threats to the mangrove ecosystem due to infrastructure development. The significant reduction in vegetation indices values from years to years highlights the potential impact of development activities on the mangrove ecosystem.

The study by Gupta [36] developed an index for discrimination of mangroves from non-mangroves using Landsat-8 OLI imagery, they constructed the Combination Mangrove Reflectance Index (CMRI) to distinguish mangroves from non-mangrove vegetation and compared its performance with other established vegetation indices. The study utilized spectral signatures and morphological characteristics of mangroves to generate an improved index to distinguish mangroves from non-mangrove vegetation. Plus, the study also compared the performance of that improved index with other established vegetation indices, including Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Soil-Adjusted Vegetation Index (SAVI), and Simple Ratio (SR), which are all calculated using Landsat-8 OLI imagery. As a result, CMRI has showed the best performance of mangrove cover discrimination among tested indices.

***Mangrove sustainable management approaches**:*

One of the key sustainable management solutions for mangrove forests in Tien Yen is to promote community-based management [49]. This approach empowers local communities to participate in the management and decision-making process, which enhances their engagement, ownership, and responsibility. Community-based management can be achieved through various initiatives, such as community patrols, social forestry, community co-management, and collaborative governance. These initiatives can help increase the effectiveness of mangrove forest protection and restoration, improve livelihoods, and reduce conflicts among stakeholders.

Another sustainable management solution for mangrove forests in Tien Yen is to establish Payment for Ecosystem Services (PES) schemes [19, 50]. (1) PES schemes can be designed to reward forest conservation, restoration, and sustainable use, such as ecotourism and non-timber forest products [51, 52]. (2) PES schemes can provide economic incentives to local communities and forest-dependent households for their contributions to ecological services [46]. (3) PES schemes can be designed to reward those who contributed to forest conservation, forest restoration, and sustainable forest use, including ecotourism and non-timber forest products. Besides, lots of efforts have been made to determine ways to incorporate mangrove forest ecosystems into existing policy frameworks, for example, using mechanisms such as Reducing Emissions from Deforestation and Forest Degradation (REDD) and the United Nations Framework Convention on Climate Change (UNFCCC) [53].

Additionally, promoting alternative livelihoods is also a sustainable management solution that can help reduce pressure on mangrove forests [49]. Alternative livelihoods can provide viable and sustainable income sources to local communities, such as aquaculture, agroforestry, and eco-tourism. These alternatives can help reduce economic dependence on mangrove forests and promote the diversification of income sources.

Finally, strengthening governance and institutional frameworks is another essential measure for the sustainable management of mangrove forests in Tien Yen [49]. To realize this aspiration, it is essential that all relevant stakeholders get involved in the execution of the framework, including local communities, government agencies, the private sector, and civil society organizations. The legal and policy frameworks for mangrove forest management should be reviewed and updated. Moreover, appropriate enforcement and monitoring mechanisms should as well be established. Capacity building and human resource development are also essential to ensure effective management and governance of mangrove forests.

In summary, sustainable management solutions for mangrove forests in Tien Yen require a multi-faceted and integrated approach that involves local communities, government agencies, the private sector, and civil society organizations. By promoting community-based management, establishing PES schemes, promoting alternative livelihoods, and strengthening governance and institutional frameworks, mangrove forests can be sustainably managed, conserved, and restored for the benefits of both the environment and local communities.

4. CONCLUSIONS

Remote sensing technology has become an important tool for monitoring the health and extent of mangrove forests. The use of remote sensing data and indices can help identify areas for conservation and restoration, assess the impacts of human activities and climate change on mangrove ecosystems, and support the sustainable management of these fragile ecosystems.

This research highlighted the importance of choosing the most accurate indices for dividing mangrove forests into different layers. The NDVI index was suggested as the most suitable index for dividing mangrove forests distinguished among other different classes, with an accuracy rate of 96.2%, it is also confirmed from previous studies. This index is based on the difference in the reflection of visible and near-infrared light, which can effectively differentiate mangrove forests from other land covers.

This research also brought up several sustainable solutions for the conservation and management of mangrove forests, including community-based management, payment for ecosystem services, alternative livelihoods, and strengthening governance and institutional frameworks. These solutions require multi-stakeholder collaboration and participation, including local communities, government agencies, and civil society organizations. By implementing these solutions, we can ensure the sustainability of mangrove forests and preserve their ecological and socio-economic values for current and future generations.

Overall, this research emphasized the importance of remote sensing technology and accurate indices in the monitoring and management of mangrove forests. It also provided valuable insights into the sustainable management solutions needed to address the challenges faced by these vital ecosystems. It can be inferred that the continued conservation and restoration of mangrove forests are essential for protecting their numerous ecological and socio-economic benefits and the promotion of the sustainability for our natural environment.

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XÂY DỰNG BẢN ĐỒ LỚP PHỦ RỪNG NGẬP MẶN DỰA VÀO CHỈ SỐ THỰC VẬT TRÊN ẢNH PLANETSCOPE TẠI HUYỆN TIÊN YÊN TỈNH QUẢNG NINH

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TÓM TẮT

Nghiên cứu tập trung xây dựng bản đồ độ lớp phủ rừng ngập mặn dựa vào chỉ số thực vật tại huyện Tiên Yên. Hệ sinh thái rừng ngập mặn đóng vai trò quan trọng trong nhiều vùng ven biển, bảo vệ khỏi sự xói mòn và đợt sóng cơn bão, cung cấp môi trường sống cho các sinh vật thủy sinh học và cung cấp nguồn sinh kế cho cộng đồng người dân địa phương. Nghiên cứu đánh giá việc sử dụng chỉ số thực vật để lập bản đồ độ bao phủ rừng ngập mặn dựa vào dữ liệu PlanetScope. Nghiên cứu đã thu thập và phân tích ảnh vệ tinh PlanetScope có độ phân giải cao (3m x 3m) để tính toán chỉ số thực vật khác nhau, bao gồm CMRI, NDVI, NDWI, GNDVI, BNDVI, SAVI, IPVI, và EVI2. Các chỉ số này đã được sử dụng để lập bản đồ lớp phủ của rừng ngập mặn ở huyện Tiên Yên và xác định độ chính xác cho từng chỉ số. Kết quả cho thấy NDVI có độ chính xác cao nhất (96,3%) so với các chỉ số khác trong việc lập bản đồ lớp phủ rừng ngập mặn, tiếp theo là chỉ số CMRI tại huyện Tiên Yên. Nghiên cứu này nhấn mạnh tầm quan trọng của việc sử dụng tư liệu ảnh viễn thám trong hoạt động giám sát đánh giá rừng ngập mặn cũng như thiết lập các phương án quản lý rừng ngập mặn bền vững tại huyện Tiên Yên. Ngoài ra, nghiên cứu đã gợi mở một số đề xuất về chính sách quản lý tích hợp trong quản lý rừng ngập mặn, cung cấp thông tin về quản lý hệ sinh thái rừng ngập mặn bền vững trong bối cảnh tác động của biến đổi khí hậu tại huyện Tiên Yên, tỉnh Quảng Ninh.

Từ khoá: chỉ số thực vật, dữ liệu ảnh PlanetScope, rừng ngập mặn, Tiên Yên.

Received	**: 24/3/2023**
Revised	**: 28/4/2023**
Accepted	**: 11/5/2023**