ASSESSING THE IMPACT OF LAND-USE/LAND-COVER CHANGE ON PROVISIONING ECOSYSTEM SERVICES IN THE LONG XUYEN QUADRANGLE FROM 2000 TO 2021

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Abstract

Changes in land use/land cover (LULC) have a significant impact on the changes in ecosystem service values. This study aims to assess the impacts of LULC changes on provisioning ecosystem services (pES) in the Long Xuyen Quadrangle region (LXQ) from 2000 to 2021. Using Landsat 5 TM and Landsat 8 OLI imagery, this study analyzes the normalized difference vegetation index (NDVI) time series using MODIS imagery to monitor and evaluate the impacts of LULC changes in the LXQ region. Additionally, interviews with farmers were conducted to estimate the ecosystem service values of different rice cultivation models. The research results in the creation of LULC maps for the LXQ in 2000 and 2021, with relatively high reliability, including overall accuracy (OA) of 83.18% (K = 0.772) and 94.26% (K = 0.9284), respectively. The main LULC change observed in the LXQ region from 2000 to 2021 is the conversion from wetlands to double-cropped rice and triple-cropped rice systems. The study identified an area of 54,667.722 ha (26.24%) where wetlands were converted to double-cropped rice, and an area of 36,779.633 ha (17.65%) where wetlands were converted to triple-cropped rice. Furthermore, the estimated ecosystem service values after the conversion from wetlands to triple-cropped rice were approximately 122,504,931 VND/ha/year, and for double-cropped rice, it was approximately 87,772,604.88 VND/ha/year. The research findings indicate that wetland agriculturalization, including double-cropped rice and triple-cropped rice, has affected the ecosystem service provision in the LXQ region. These research results provide significant considerations for future comprehensive valuation of ecosystem service values in the LXQ, Vietnamese MD.

Keywords: *Ecosystem services, land use/land cover change, rice cropping, remote sensing, Vietnamese Mekong Delta, wetlands.*

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ĐÁNH GIÁ ẢNH HƯỞNG CỦA THAY ĐỔI SỬ DỤNG ĐẤT/LỚP PHỦ BỀ MẶT ĐẤT ĐẾN GIÁ TRỊ DỊCH VỤ CUNG CẤP HỆ SINH THÁI VÙNG TỨ GIÁC LONG XUYÊN GIAI ĐOẠN 2000-2021

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Tóm tắt

Những thay đổi về sử dụng đất/lớp phủ đất (SDĐ/LPĐ) có tác động đáng kể đến những thay đổi về giá trị dịch vụ cung cấp hệ sinh thái. Nghiên cứu này nhằm đánh giá tác động của thay đổi SDĐ/LPĐ đến dịch vụ cung cấp hệ sinh thái vùng Tứ Giác Long Xuyên (TGLX) giai đoạn 2000 đến 2021. Nghiên cứu áp dụng phương pháp phân loại có giám sát sử dụng bộ dữ liệu ảnh Landsat 5 TM, Landsat 8 OLI, và phân tích chuỗi ảnh chỉ số thực vật (NDVI) sử dụng ảnh MODIS để theo dõi và đánh giá tác động của sự thay đổi SDĐ/LPĐ vùng TGLX, đồng thời kết hợp với điều tra phỏng vấn nông hộ ước tính giá trị dịch vụ cung cấp hệ sinh thái các mô hình canh tác lúa. Kết quả nghiên cứu thành lập bản đồ hiện trạng SDĐ/LPĐ tại vùng TGLX năm 2000 và năm 2021 với độ tin cậy khá cao lần lượt gồm độ chính xác toàn cục (T) 83,18% (K = 0.772) và 94,26% (K = 0.9284). Biến động hiện trạng SDĐ/LPĐ từ loại hình đất ngập nước sang mô hình canh tác lúa hai vụ và lúa ba vụ là đặc trưng nhất trong giai đoạn 2000 và 2021 tại khu vực TGLX. Nghiên cứu đã phân tách được vùng đất ngập nước chuyển sang đất lúa hai vụ với diện tích 54,667.722 ha (26,24%) và đất ngập nước chuyển sang đất lúa ba vụ với diện tích 36,779.633 ha (17,65%). Đồng thời, giá trị dịch vụ cung cấp hệ sinh thái được ước tính sau khi chuyển đổi mô hình từ đất ngập nước sang mô hình lúa ba vụ trung bình khoảng 122.504.931 VNĐ/ha/năm và mô hình lúa hai vụ trung bình khoảng 87.772.604,88 VNĐ/ha/năm. Kết quả của nghiên cứu này đã cung cấp các giá trị ước tính ban đầu – là cơ sở quan trọng cho việc lượng giá đầy đủ các giá trị dịch vụ hệ sinh thái vùng TGLX trong tương lai.

Từ khóa: *Đất ngập nước, đồng bằng sông Cửu Long, giá trị dịch vụ hệ sinh thái, sản xuất lúa, thay đổi lớp phủ/sử dụng đất, viễn thám.*

1. Introduction

Land use and land cover are two terms commonly used to describe the surface characteristics of the Earth where humans live. Land use/land cover changes (LULCC) occur due to human interaction with the environment, leading to alterations in the Earth's surface features through the conversion to a new type of land use/land cover (LULC) or the expansion of existing ones (Lambin & Geist, 2006). The impacts of natural, social, and environmental conditions, such as demographic factors, economy, and climate change, have contributed to increasing LULCC in many regions around the world (Lambin et al., 2001). Therefore, monitoring LULCC plays a crucial role in supporting planners and policymakers in devising land use plans that are in alignment with local realities to achieve sustainable development goals. Nowadays, remote sensing technology is regarded as a prominent method for detecting LULCC over large areas, typically through multi-temporal Landsat and MODIS optical imagery based on the analysis of changes in the spectral reflectance values of the Earth's surface. This method has also been widely used for classifying the LULC stutus quo and observing changes in LULC in Vietnam as well as in the Mekong Delta (MD) region (Binh et al., 2021; Nguyen et al., 2020; Nguyen, Pham, et al., 2022; Vu, Tran et al., 2022; Vu, Vu et al., 2022).

The status of LULC is closely related to ecosystem services through the interactions between humans and the environment (De Groot et al., 2002). The benefits that humans receive from ecosystems, either directly or indirectly, including provisioning, regulating, supporting, and cultural services as well as intangible benefits, are collectively referred to as ecosystem services (ES) (Millennium Ecosystem Assessment, 2005). LULCC results from human activities and changes in the natural environment, simultaneously altering the structure and function of ecosystems, thereby affecting the potential and value of ecosystem services (Hasan et al., 2020). According to Foley (2005), unsustainable land use plans can trade short-term benefits (increased food production, economic development) at the expense of long-term losses in ecosystem services. This is because exploiting land resources to meet human needs often causes environmental changes. In the context of increasing land use changes and ecosystem services at both local and global levels, a study on the impact of changes in the current state of LULCC on ecosystem services is essential for developing policies aimed at sustainable development (Tolessa et al., 2017).

The Long Xuyen Quadrangle (LXQ), located in the western MD, spanning the provinces of An Giang, Kien Giang, and Can Tho, covers a natural area of nearly 500,000 ha. LXQ is considered a key region for rice production, freshwater and brackish aquaculture. Moreover, LXQ is known for its high biodiversity, with seasonal floodplain grasslands, natural forests on mountains and limestone hills, coastal wetlands, conserving and supporting various ecosystems such as mangroves, floodplain grasslands, mountain and riverside ecosystems. However, over the past three decades, LXQ has undergone significant changes under the influences of climate change and human intervention, aiming to convert natural ecosystems for different land uses and altering the ecological environment and natural landscape of this region (Funkenberg et al., 2014; Huu Nguyen et al., 2016; Nguyen, Trung, et al., 2022; Tuu et al., 2013). Notably, since the 2000 flood, numerous dykes have been constructed to protect and increase the rice-growing area in the region (Tuu et al., 2013). Based on the 2000 flood levels, the dykes were designed to form enclosed rice production areas (closed dykes) or August dykes (open dykes). As a result, the area of double and triple rice cropping has rapidly increased (Chánh & Trọng Linh, 2021). The results of land use conversion under the influence of the aforementioned dyke system, besides increasing economic values through rice production for the people, have remarkably impacted the values of ecosystem services that have yet to be fully investigated. In this context, valuing ecosystem services is considered necessary to better understand the value of biodiversity and the value of different types of ecosystem services in the LXQ area, as well as in the MD (Dang et al., 2021; Diep et al., 2022; Loc et al., 2017). From there, it positively promotes conservation activities, sustainable exploitation of resources, helping local people improve income and quality of life.

This study was conducted with the aim of detecting significant changes in LULC and valuing the provisioning ecosystem services in the LXQ area.

Through this, the study assesses the relationship of LULCC to the value of ecosystem services in the region over more than two decades (2000-2021). The results of the study could provide useful information for the management, planning, and sustainable use of land resources as well as the ecosystem value of the LXQ region.

2. Study area

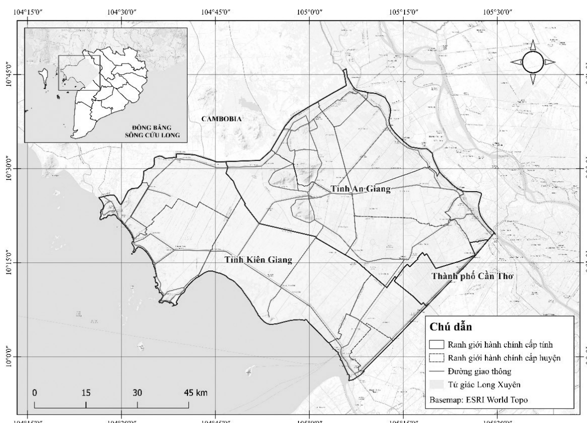

Figure 1. Map of the study area - Long Xuyen Quadrangle, MD

The Long Xuyen Quadrangle (LXQ) is a quadrangular region located in the western part of the MD, spanning the provinces of An Giang, Kien Giang, and the city of Can Tho (Figure 1). The LXQ covers a total natural area of approximately 489,000 hectares. The terrain is low-lying and relatively flat, with absolute elevations ranging from 0.4 to 2 meters. During the flood season, LXQ is submerged under 1 to 2.5 meters of water for 3 to 5 months. Initially a largely barren land, heavily affected by acid sulfate soil and difficult to access for agricultural production, the area has transformed into a key agricultural production region of the MD and the country, thanks to state investment and exploitation policies, currently achieving a total output of about 5-6 million tons of rice per year (Chánh & Trọng Linh, 2021).

3. Data and methods

3.1. Remote sensing data collection

3.1.1. Landsat 5 TM/Landsat 8 OLI Data

The remote sensing datasets of Landsat 5 TM and Landsat 8 OLI, with a spatial resolution of 30m and a 16-day repeat cycle covering the study area, were collected through the open data library on the Google Earth Engine (GEE) platform (code.earthengine.google.com). Specifically, Landsat 5 TM and Landsat 8 OLI imagery were used to classify the LULC status for the years 2000 and 2021, respectively (Table 1).

Table 1. Information on Landsat and MODIS imagery data

Dataset	Year	Spectral bands	Path - Row	Spatial resolution	Coordinate system
Landsat 5 TM	2000	Blue Green Red Near Infrared Shortwave infrared 1 Shortwave infrared 2	125 - 053	30m	WGS 84 Zone 48N
Landsat 8 OLI	2021				
MODIS 13Q1	2000, 2021	NDVI		250m	

3.1.2. MODIS data

The MODIS imagery dataset, collected on the GEE platform with the dataset ID "MODIS/006/MOD13Q1" and a spatial resolution of 250m for the years 2000 and 2021, was used to analyze the changes in the Normalized Difference Vegetation Index (NDVI) (Table 1).

3.2. Image Preprocessing

Atmospheric Correction: The Landsat datasets were atmospherically corrected for surface reflectance (SR) on GEE using specialized software with the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) algorithm for Landsat 5 TM images and the Land Surface Reflectance Code (LaSRC) for Landsat 8 OLI, as employed by the USGS (Masek et al., 2006).

Image Mosaicking: The Landsat dataset was mosaicked from multiple scenes covering the LXQ area and averaged (mean). The MODIS imagery dataset was mosaicked from various scenes to create a multi-temporal NDVI series for the years 2000 and 2021.

3.3. Image classification method

3.3.1. Landsat image data

Creating training samples

Landsat image data, using the Red, Green, and Blue spectral bands combined into true color images, were used to create training samples representing each type of LULC based on 08 feature interpretation keys including shape, texture, size, tone, shadow, structure, site, and color.

Classification algorithm

Training samples were extracted for pixel values on each spectral band for supervised classification on Landsat images using the Random Forest classification algorithm. Random Forest is a machine learning method for image classification based on the combination of decision trees (Breiman, 2001; Gislason et al., 2006). In this study, the Random Forest algorithm was chosen to classify Landsat images with the number of decision trees (ntree) set to 50 based on the ee.Classifier.smileRandomForest function from the training sample data.

3.3.2. MODIS image data

Unsupervised classification of multi-temporal NDVI data

The multi-temporal NDVI image series extracted from MODIS images were combined and calculated for average values by month. From this, we analyzed NDVI value fluctuations over time associated with specific developmental stages of rice crops throughout the year. NDVI values are low at non-cultivation times (post-harvest soil or plowed land). NDVI values start to increase at the sowing time and reach a maximum during the rice growth stage, then gradually decrease and reach a minimum after harvest. Based on the fluctuation of NDVI values throughout the year, we identified the characteristics of seasonal rice cultivation, such as double and triple cropping, in the study area (see Figure 2).

Rice cropping seasons were classified using the unsupervised classification method with the Kmeans algorithm, with the number of clusters set to 15 and the number of iterations set to 20. The classification results were grouped into 2 categories corresponding to the two cropping structures, including double and triple cropping, through the ee.Image.remap function.

3.4. Accuracy assessment

According to Jensen (2005), accuracy is assessed by calculating the error matrix based on the classification results using two parameters: (1) overall accuracy (OA) and (2) Kappa coefficient (K), thereby evaluating the degree of agreement between the classified image data and the ground survey data.

OA = Sum of diagonal quantities / Total quantities of the row (column) (1)

$$K = \frac{OA-E}{1-E} \qquad (4)$$

Where: OA is the overall accuracy given by the error matrix; E represents the expected quantity of accurate classification.

3.5. Estimating ecosystem service provision value

According to the Millennium Ecosystem Assessment (2005), the value of ecosystem service provision is calculated using formula (3):

$$EPV = P * Y - (VC + FC + OC) \qquad (3)$$

Where: EPV - ecosystem service provision value (VND/ha/year); P (Price) - selling price of agricultural products (VND/kg); Y (Yield) - productivity of agricultural products (kg/ha/year); VC (Variable Costs) – total variable costs (VND/ha/year); FC – fixed costs (Where: V - value of equipment, machinery, and materials used for initial investment in the usage cycle; r - bank interest rate; N - lifespan of equipment, machinery, and materials (usage cycle).

$$VC = \frac{V(1+r)^N}{N} \qquad (5)$$

Where: V - value of equipment, machinery, and materials incurred during the production process; r - bank interest rate; N - lifespan of equipment, machinery, and materials (usage cycle).

$$OC = \frac{V(1+r)^N}{N} \qquad (6)$$

Where: V - value of land lease; r - bank interest rate; N - lease period.

In this study, we conducted surveys and interviews with 16 households in 06 communes across 03 districts, specifically in Giang Thành district, Hòn Đất district (Kien Giang province), and Tri Tôn district (An Giang province) to estimate the value of ecosystem service provision of specialized rice cultivation land.

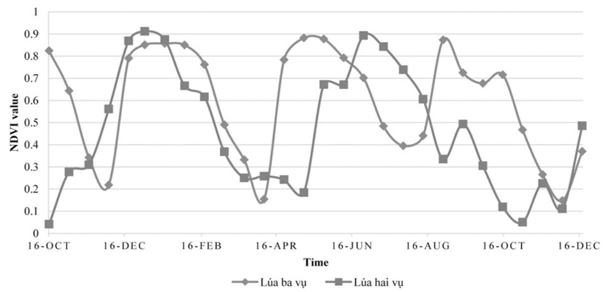

Figure 2. Graph illustrating the change in NDVI over time for double and triple rice cropping in the study area.

4. Results and Discussion

4.1. Accuracy assessment

The accuracy assessment results show that the overall accuracy (OA) and Kappa coefficient (K) for the years 2000 and 2021 were OA = 85.93%, K = 0.77 (year 2000), and OA = 94.26%, K = 0.93 (year 2021), respectively. The classification accuracy for the year 2000 falls within the range of $0.6 \leq K < 0.8$ indicating good accuracy, and for the year 2021 within the range of $0.8 < K < 1.0$ indicating high accuracy. These results obtain the classification accuracy required, and therefore the LULC maps can be used for further analysis.

4.2. LULC classification results for 2000 and 2021

The LULC classification results for the LXQ in 2000 included 07 LULC types, namely: (1) Built-up areas, (2) Double-cropped rice, (3) Forests, (4) Barren land, (5) Wetlands, (6) Aquaculture, and (7) Rivers and streams, as presented in Figure 3. Among them, the double-cropped rice was the dominant LULC, distributed across districts: Thoại Sơn, Tri Tôn, Tịnh Biên, Châu Đốc, Châu Phú, Châu Thành, Long Xuyên city (An Giang province), Vĩnh Thạnh (Can Tho city), Tân Hiệp, Châu Thành, Rạch Giá city, and a part of Hòn Đất district (Kien Giang province).

The double-cropped rice and wetlands covered the highest proportion of the area, accounting for about 75% of the region's natural area, with corresponding areas of 288,164.80 ha for double-cropped rice and 123,337.89 ha for wetlands. Followed by barren land and forests with areas of 65,362.68 ha (accounting for 12.12%) and 33,213.15 ha (accounting for 6.16%), respectively. Other LULC types were distributed with low proportions (below 6%) (Table 2).

Table 2. Area and proportion of different LULC types in the LXQ in 2000

No.	LULC type	Area (ha)	Proportion (%)
1	Double-cropped rice	288.164,80	53,42
2	Wetlands	123.337,89	22,87
3	Barren land	65.362,68	12,12
4	Forest	33.213,15	6,16
5	Built-up areas	20.123,19	3,73
6	Aquaculture	5.166,54	0,95
7	Rivers and streams	4.043,16	0,75
	Total	**539.411,41**	**100**

The results in Figure 4 show that the LULC of the LXQ in 2021 was classified into 08 types: (1) Built-up areas, (2) Perennial crops, (3) Forests, (4) Barren land, (5) Triple-cropped rice, (6) Double-cropped rice, (7) Aquaculture, and (8) Rivers and streams. These results indicate that there was an addition of one LULC type, triple-cropped rice, compared to the year 2000. Among them, the triple-cropped rice was the dominant LULC, distributed across most districts in the region including: Thoại Sơn, Tri Tôn, Tịnh Biên, Châu Đốc, Châu Phú, Châu Thành, Long Xuyên city (An Giang province), Vĩnh Thạnh (Can Tho city), Tân Hiệp, Châu Thành, and a part of Giang Thành district (Kien Giang province).

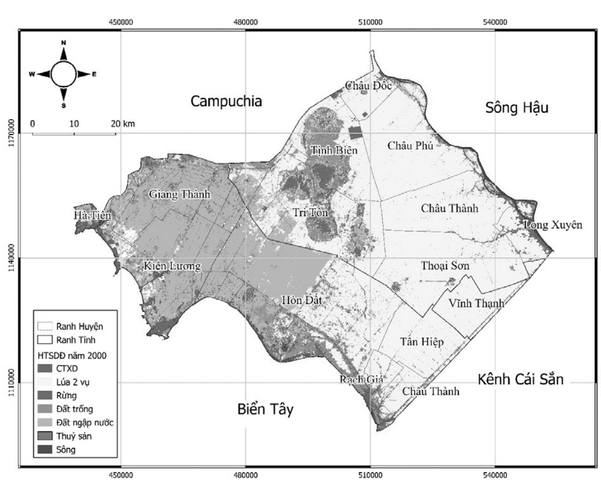

Figure 3. LULC map of the Long Xuyen Quadrangle in 2000

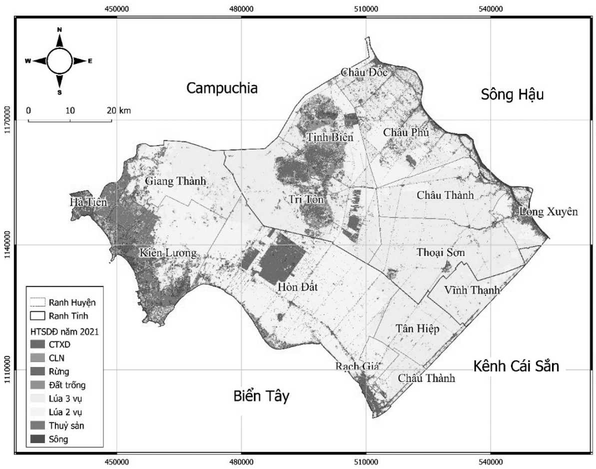

Figure 4. LULC map of the Long Xuyen Quadrangle in 2021

In 2021, the LXQ area had two predominant LULC types accounting for about 77%, consisting of triple-cropped rice and double-cropped rice with areas of 257,545.68 ha (48.16%) and 158,050 ha (29.56%), respectively. Following these, built-up areas, aquaculture, and forests had corresponding areas of 31,963.59 ha (5.98%), 29,717.91 ha (5.96%), and 29,698.83 ha (5.55%). Other LULC types were distributed with lower proportions (below 5%) (Table 3).

Table 3. Area and proportion of different LULC types in the LXQ in 2021

No.	LULC type	Area (ha)	Proportion (%)
1	Triple-cropped rice	257.545,68	48,16
2	Double-cropped rice	158.050,00	29,56
3	Built-up areas	31.963,59	5,98
4	Aquaculture	29.717,91	5,56
5	Forest	29.698,83	5,55
6	Barren land	15.499,44	2,9
7	Perennial crops	10.007,91	1,87
8	Rivers and streams	2.249,55	0,42
	Total	**534.732,91**	**100**

4.3. LULC change in the period 2000 - 2021

The period from 2000 to 2021 saw 15 types of LULC changes, with a total conversion area of 208,341.43 ha, accounting for 42.6% of the region's area (Figure 5). Meanwhile, areas without change covered 280,658.57 ha, accounting for 57.4%. Four main conversion groups among these changes were of (1) Conversion from wetlands to other types, (2) Conversion from double-cropped rice to other types, (3) Conversion from barren land to double-cropped rice, and (4) Conversion from forests to other types (Table 4). Notably, the conversion from wetlands to rice cultivation (both double and triple cropping) totaled 91,447.35 ha, representing 43.89% of the total LULC conversion area. This result indicates that the LULC change in the study area mainly focused on the conversion from wetlands to rice cultivation. This finding aligns with previous discoveries regarding wetland fluctuations in the LXQ area (Funkenberg et al., 2014; Nguyen, Trung, et al., 2022). It also reflects the outcomes of long-term investments in infrastructure development and flood prevention dykes, as well as the construction of drainage canals (T5 canal) towards the West Sea by the local government in this area (Chánh & Trọng Linh, 2021).

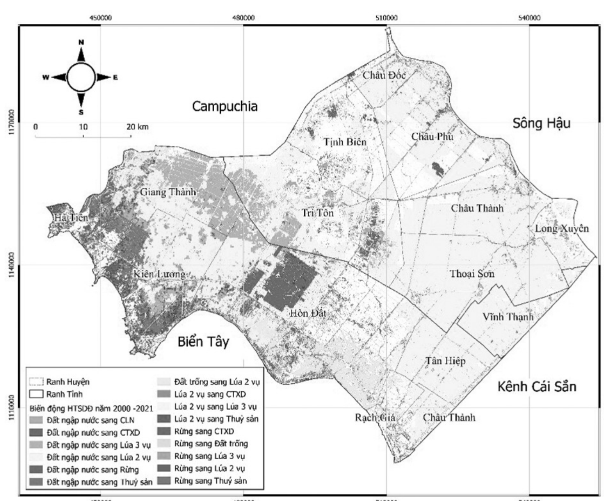

Figure 5. LULC change map for the 2000-2021 period in the LXQ area

Table 4. Area of LULC changes during 2000-2021

No.	LULC change	Area (ha)	Proportion (%)
1	Wetland to perennial crops	4.100,04	1,97
2	Wetland to built-up areas	7.157,07	3,44
3	Wetland to triple-cropped rice	36.779,63	17,65
4	Wetland to double-cropped rice	54.667,72	26,24
5	Wetland to forest	11.768,58	5,65
6	Wetland to aquaculture	15.703,47	7,54
7	Barren land to double-cropped rice	22.696,66	10,89
8	Double-cropped rice to built-up areas	10.195,59	4,89
9	Double-cropped rice to triple-cropped rice	37.421,88	17,96
10	Double-cropped rice to aquaculture	339,87	0,16
11	Forest to built-up area	3.095	1,49
12	Forest to barren land	1.293,39	0,62
13	Forest to triple-cropped rice	413,02	0.2
14	Forest to double-cropped rice	319,02	0,15
15	Forest to aquaculture	2.390,49	1,15
	Total	**208.341,43**	**100**

4.4. Ecosystem service provision value of rice cultivation land in the LXQ area

4.4.1. Total costs

The average total cost for the rice cultivation model in the three surveyed districts is 16,967,713 VND/ha/year. Of these, Lương An Trà commune (Tri Tôn district, An Giang) had the highest total cost (19,411,919 VND/ha/year) due to high seasonal and opportunity costs; Vĩnh Phú commune (Giang Thành district, Kien Giang) had the lowest total cost (13,639,833 VND/ha/year) benefiting from low opportunity costs (Table 5).

Table 5. Costs for the rice cultivation model

No.	District/commune	Fixed Costs (FC)	Variable Costs (VC)	Opportunity Cost (OC)	Total Cost
	Hòn Đất district				
1	Bình Giang	91.948	2.898.000	11.574.074	14.564.022
	Giang Thành district				
2	Vĩnh Điều	116.413	4.946.888	14.146.090	19.209.391
3	Vĩnh Phú	245.641	4.906.538	8.487.654	13.639.833
	Tri Tôn district				
4	Tân Tuyến	106.666	4.582.500	11.574.074	16.263.240
5	Lương An Trà	337.500	5.571.333	13.503.086	19.411.919
6	Vĩnh Phước	490.111	4.081.675	14.146.090	18.717.876
	Average cost	**231.380**	**4.497.822**	**12.238.511**	**16.967.713**

4.4.2. Total income

Table 6 shows the average total income of the three surveyed districts is 140,101,994 VND/ha/year, with Bình Giang commune (Hòn Đất district) having the lowest income value of 126,968,571 VND/ha/year due to both low productivity and selling price of rice. Meanwhile, Vĩnh Phước commune (Tri Tôn district) had the highest income of 152,726,666 VND/ha/year due to the highest selling price of rice and relatively high rice productivity compared to other communes (Table 6).

Table 6. Total income and Ecosystem Service Provision Value (EPV) of the rice cultivation model

No.	District/commune	Total income (VNĐ/ha/year)	Average EPV (VNĐ/ha/year)
	Hòn Đất district		
1	Bình Giang	126.968.571	112.404.549
	Giang Thành district		
2	Vĩnh Điều	143.650.000	124.440.607
3	Vĩnh Phú	136.769.230	123.129.396
	Tri Tôn district		
4	Lương An Trà	142.737.500	91.618.080
5	Tân Tuyến	137.760.000	121.496.759
6	Vĩnh Phước	152.726.666	134.008.790
	Average	**140.101.994**	**117.849.697**

4.4.3. Ecosystem Service Provision Value (EPV)

The average ecosystem service provision value of the rice cultivation model in the three districts is 117,849,697 VND/ha/year. The lowest ecosystem service value was 91,618,080 VND/ha/year in Lương An Trà commune, Tri Tôn district, which is lower than the average value for the entire surveyed area. This is due to high seasonal costs (5,571,333 VND/ha/year) and high opportunity costs (13,503,086 VND/ha/year), leading to a total income of 142,737,500 VND/ha/year for the surveyed households in this commune. The highest EPV was 134,008,790 VND/ha/year in Vĩnh Phước commune, Tri Tôn district (Table 6). These results indicate a significant variation in the distribution of EPV values across the LXQ region, with the lowest EPV being only 68% of the highest EPV.

Preliminary survey data indicates that the ecosystem service value of wetlands in 2000 brought little economic efficiency. By 2021, most of the area had been converted to rice cultivation models, providing relatively high economic efficiency for farmers. The ecosystem service value for the triple-cropped rice model is 122,504,931 VND/ha/year and for the double-cropped rice model is 87,772,605 VND/ha/year.

5. Conclusion

The study applied Landsat and MODIS remote sensing imagery to establish LULC maps in the Long Xuyen Quadrangle in 2000 with 07 LULC groups and in 2021 with 08 LULC groups, achieving high reliability, where the overall accuracy for 2000 and 2021 was 85.93% and 94.26%, respectively. The results show significant LULC fluctuations during 2000-2021, with wetlands undergoing the most considerable changes, resulting in conversion to 06 different LULC types, including conversion to perennial crops, built-up areas, triple-cropped rice, double-cropped rice, forests, and aquaculture. Notably, the conversion from wetlands to double and triple rice cropping constituted the highest proportion (43.89% of the total LULC change area in the region). The study also preliminarily evaluated the ecosystem service provision value of rice cultivation land in the LXQ, specifically, 122,504,931 VND/ha/year for triple-cropped rice and 87,772,605 VND/ha/year for double-cropped rice. It did identify the service provision value of double and triple rice cropping models for 2021; however, the value of wetlands in 2000 was left unknown due to a lack of data and resources. Therefore, assessing the impact of LULC changes on ecosystem service values in the study area remains limited and necessitates further research in the future. Despite its limitations, the preliminary assessment of ecosystem service values is deemed necessary to better understand the impacts of LULC changes on the value of different types of ecosystem services in the LXQ area.

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