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Assessing Ecosystem Service Value Dynamics in Japan's National Park Based on Land-Use and Land-Cover Changes from a Tourism Promotion Perspective

Huixin Wang, Yilan Xie, Duy Thong Ta, Jing Zhang and Katsunori Furuya *

Graduate School of Horticulture, Chiba University, Chiba 271-8510, Japan; cefa5056@chiba-u.jp (H.W.)
* Correspondence: k.furuya@faculty.chiba-u.jp

Abstract: Understanding the changes in land use and land cover (LULC) in national parks and their corresponding ecosystem service value (ESV) shifts is crucial for shaping future management policies and directions. However, comprehensive analyses in this research area that integrate tourism development perspectives are lacking. Therefore, this interdisciplinary study considers Akan-Mashu National Park in Japan as a case study. Using remote sensing data, LULC maps for the past 10 years were generated using the Google Earth Engine. The benefit transfer method was employed to calculate the corresponding ESV for each year, followed by a qualitative analysis of local tourism policy documents to explore how the park ecosystem has changed in the context of promoting tourism development. The results showed that LULC changes in Akan-Mashu National Park have been relatively stable over the past decade, with the most noticeable changes occurring in built-up areas. The results also confirm that tourism development has not had a significant negative impact on the ESV of the Akan-Mashu National Park. The recommendations proposed in this study can also be applied to other similar national parks or protected areas worldwide to achieve a dynamic balance between environmental protection and tourism development.

Keywords: ecosystem services; land use; land cover; national park; sustainable tourism; recreation

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1. Introduction

Ecosystem services (ES) refer to the benefits to human society obtained directly or indirectly from nature [1]. ES are fundamental to sustaining life and promoting human well-being, providing critical benefits, such as air and water purification, climate regulation, and biodiversity support [1,2]. Natural resources can enhance human well-being; however, some human activities can also affect the natural environment [3]. This interaction is particularly pronounced in protected areas such as national parks, which serve as key reservoirs of biodiversity and natural habitats. Palomo et al. [4] have demonstrated that national parks and their buffer zones offer a diverse array of ecosystem services that benefit the surrounding lands. These areas support an ecological balance and offer recreational, cultural, and spiritual benefits to society.

Japan is renowned for its diverse and picturesque natural landscapes and hosts a network of national parks that are pivotal to its ecological conservation efforts. Japan's national park system was established in 1931 through the passage of the National Park Law. Japan's national parks are "regional" (*chiikisei*) parks that can be designated by setting areas regardless of land ownership, and within the designated areas, various actions that alter the natural environment are regulated as actions that require permission or notification [5]. In addition, various facilities have been developed as places to interact with nature. The Ministry of the Environment (MoE) has set up branch offices to handle various management tasks, including issuing permits and licenses. These parks play a dual role in preserving biodiversity and supporting substantial tourism. The ecological value of Japan's national parks is immense, as they provide critical ecosystem services that contribute to environmental stability and resilience.

Economically, these parks are significant tourism destinations that attract millions of visitors annually and contribute to local and national economies. The Japanese government is working on the "Tourism Vision to Support Japan's Future," which aims to increase the number of foreign visitors to Japan to 60 million by 2030. National parks are positioned as one of the pillars of the "Tourism Vision to Support Japan's Future," which was compiled by the government in March 2016, and the "Project to Fully Enjoy National Parks" has been promoted (https://www.env.go.jp/en/nature/enjoy-project/index.html, accessed on 15 January 2025). This project targeted the branding of Japan's national parks as world-class national parks and initially focused on eight selected national parks (the "Priority Eight Parks") to implement pioneering and intensive initiatives. Nevertheless, an increase in visitor numbers can exacerbate ecological pressures, leading to issues such as increased waste in the community, habitat destruction, pollution, and a decline in biodiversity, ultimately impacting the provision of ecosystem services [6,7].

Quantifying ecosystem service value (ESV) and monitoring its changes are crucial for assessing the effectiveness of conservation efforts [8]. One of the efficient methods for this purpose is the benefit transfer method (BTM) is an efficient method for this purpose. The BTM is used to estimate the value of ES in one location or context by applying valuation data from a similar location or study. In a pioneering valuation study, Costanza et al. [8] combined the unit area values of 17 ecosystem services across 16 ecosystem types with global distribution data to first attempt to estimate the global value of ecosystem services and natural capital. De Groot et al. [9] updated the 1997 valuation by incorporating data from the Economics of Ecosystems and Biodiversity (TEEB) Initiative. Costanza et al. [10] estimated losses and gains in ecosystem services from 1997 to 2011. Therefore, these studies established favorable conditions for utilizing BTM to assess ESV. Changes in land use and land cover (LULC), driven by various factors, significantly influence ecosystem services [11]. Based on these foundations, the value coefficients and adjusted coefficients combined with LULC change analysis are widely used in the value transfer method when estimating the ESV [12–15].

Remote sensing has been widely used in LULC classification, enabling the analysis of land-cover changes over time [16,17]. Previous studies have employed remote sensing to map LULC classifications at the national park scale, providing evidence for further analysis of ESV changes in these areas [18–21].

Some studies have demonstrated how tourism can alter LULC and affect landscape and ecosystem functions. Research has indicated that the rise in tourism in Nepal's national parks may be linked to observed LULC changes, such as the expansion of built-up areas and a decline in forest cover [22]. A study conducted in Bali found that tourism growth drove changes in LULC, and an increase in visitors encouraged the construction of tourism-related buildings [23]. Vijay et al. [24] found that areas with rapid tourism growth also experienced a rapid expansion of built-up land, confirming the impact of tourism pressure on LULC. Despite advancements in assessing ESV dynamics based on LULC changes, a gap still exists in integrating the tourism context with ESV change analysis, particularly from a policy-driven perspective. As the "Project to Fully Enjoy National Parks" has been implemented in selected national parks in Japan, these policy-driven tourism initiatives may have influenced land use and, in turn, affected ecosystem services. However, current research frequently neglects the intersection of policy-driven tourism initiatives and environmental conservation strategies for ecosystem services. Addressing this gap is vital to developing comprehensive strategies that balance ecological preservation with socioeconomic development in Japan's national parks and similar environments.

This interdisciplinary study aims to bridge these gaps by examining the interplay between tourism development, LULC changes, and ecosystem service values, providing a nuanced understanding of the socio-ecological dynamics within Japan's national parks. Specifically, the research objectives of this study are: first, to map the LULC of Akan-Mashu National Park (one of the "Priority Eight Parks") from 2014 to 2023 through remote sensing technology; second, to calculate the ESV for each year from 2014 to 2023 using the benefit transfer method; third, to explore the changes in LULC and ESV of Akan-Mashu National Park from the perspective of promoting tourism development in combination with the qualitative analysis of tourism planning policy documents; and fourth, to propose future national parks management recommendations based on the research results. As a baseline study, our research aims to verify the effectiveness of the policy and provide a scientific basis for the long-term monitoring and policy optimization of protected areas such as national parks.

2. Materials and Methods

2.1. Study Site

Designated in 1934, Akan-Mashu National Park (Figure 1) is one of the oldest national parks in Hokkaido, Japan. It is characterized by extensive natural forests, primarily subarctic mixed coniferous forests. These are among the most primeval forests in Japan's national park system. The park's foundation is shaped by three caldera formations, the Akan, Kussharo, and Mashu calderas, created through volcanic activity associated with the Chishima Volcanic Zone. The proximity of multiple volcanic–lake systems within a relatively compact area enhances the park's national significance and ecological value. There is a strict zoning system in Japan to 'maintain the scenic beauty' of national parks. The national park was divided into special and ordinary zones. Special areas are divided into four categories based on the strictness of the regulations: Special Protection Zone, Class I Special Zone, Class II Special Zone, and Class III Special Zone. Ordinary zone allows certain development, subject to environmental protection standards; Special Protection Zone is the strictest, with almost no human activity allowed; Class I Special Zone restricts construction and land modification, permitting only limited facilities; Class II Special Zone allows moderate development, such as small tourist facilities; and Class III Special Zone allows more construction, but it still requires environmental approval. Based on the MoE data, we determined the areas and proportions of the different zones in Table 1. The ordinary zone accounts for approximately 20% of the national park's total area, whereas the remaining 80% are special zones with restrictive rules.

Table 1. Zoning system in Akan-Mashu National Park.

	Special Zone				Ordinary Zone
	Special Protection Zone	Class I Special Zone	Class II Special Zone	Class III Special Zone	
Area	10,460	20,718	24,299	17,386	18,550
Proportion	11.44%	22.66%	26.58%	19.02%	20.29%

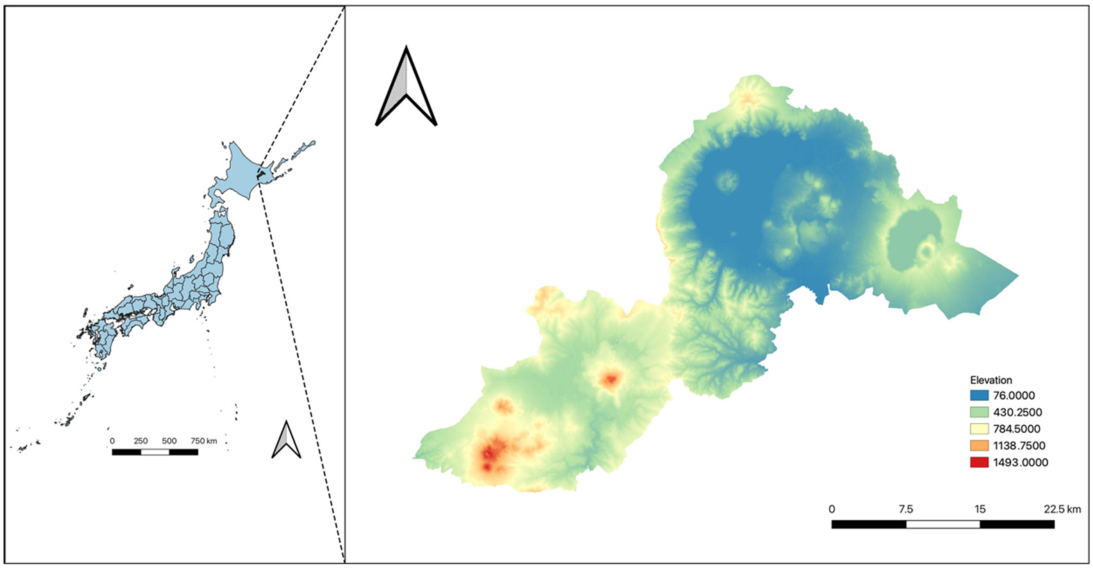

Figure 1. The location of the study site.

2.2. Workflow

The workflow of this study mainly has four steps, as shown in Figure 2: first, use remote sensing to classify the LULC of the study site; second, perform the benefit transfer method to estimate the ESV; third, calculate the percent of annual change and land-use transition ration matrix to analyze the dynamics of LULC, and apply "selected ESV" to validate the result of ESV estimation; and fourth, through qualitative analysis, we finalize a tourism planning policy document that summarizes the operations conducted in Akan-Mashu NP and proposes future tasks based on the "Project to Fully Enjoy National Parks".

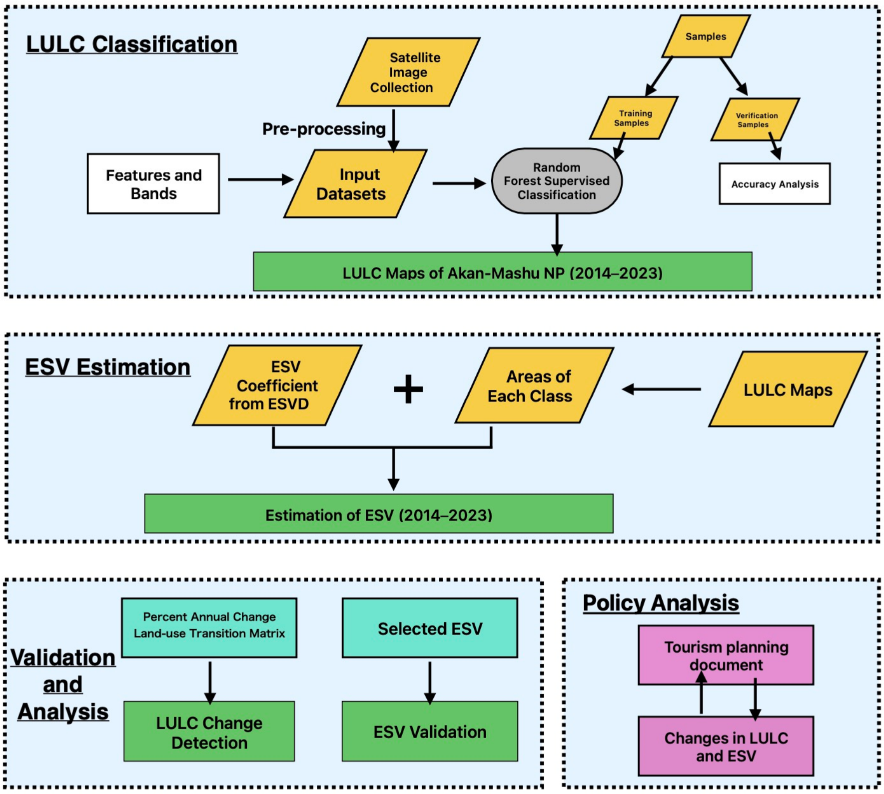

Figure 2. Framework of this study.

There are some existing LULC datasets in Japan, such as GIS-based products from the National Land Numerical Information (NLNI, National Land Information Division, National and Regional Policy Bureau: https://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-L03-b-2021.html, accessed on 15 January 2025) and the Japan Aerospace Exploration Agency, which supports a high-level satellite product. However, these products do not cover all years investigated in this study; therefore, we applied the Google Earth Engine (GEE) to prepare the LULC map from 2014 to 2023. Referring to existing LULC products in Japan, related policy documents, and the classification from the ESVD, we considered six LULC types for the Akan-Mashu NP; detailed descriptions are shown in Table 2.

Table 2. LULC classes in this study.

LULC Types	Referred Biome from ESVD	Description
Forests	Temperate forests	Forests in the study area, including plantation and non-plantation forests
Cultivated areas	Cultivated areas	All land used for artificial cultivation and planting, including paddy fields, dry fields, and greenhouse planting areas
Built-up areas	Desert	All artificial construction land, including buildings, parking lots, and some hard paving
Water bodies	Rivers and lakes	Rivers and lakes in the study area
Grassland	Grassland	Grasslands with scattered trees, herbs, and shrubs
Bare land	Desert	Non-vegetated areas dominated by rock outcrops and eroded and degraded lands

2.3. Land Use and Land Cover Classification

2.3.1. Data Collection

We utilized 30 m spatial resolution Landsat 8 Level 2, Collection 2, and Tier 1 surface reflectance data, which are atmospherically corrected products provided by the United States Geological Survey (USGS). We selected the red, green, blue, near-infrared (NIR), and short-wave infrared (SWIR-1 and SWIR-2) spectral bands for the analysis. Boundary data for the three national parks were obtained from an online platform (https://www.geospatial.jp/ckan/organization/biodic, accessed on 15 January 2025). These data were used to extract sections corresponding to the study areas from all Landsat images.

Based on previous studies [25,26], a comprehensive set of spectral indices, topographic attributes, climatic variables, and texture features was derived and integrated into a unified dataset to enhance the accuracy of LULC classification. Spectral indices were calculated using Landsat 8 surface reflectance data to enhance the separability of land cover classes. Topographic variables derived from Shuttle Radar Topography Mission (SRTM) data [27] included elevation, slope, and aspect. The climatic data from the TerraClimate dataset were averaged for the targeted year [28], including soil moisture, runoff, minimum temperature, and vapor pressure, were averaged for the target year [28]. Gray-level co-occurrence matrix (GLCM) texture metrics were derived from a grayscale image created using Landsat 8 bands. These features were selected because of their ability to capture the diverse biophysical and environmental characteristics of the study area. All indices used in this study are summarized in Table 3.

Table 3. Features in the LULC classification.

Features	Description	Data Source
Spectral features	Red, green, blue, near-infrared (NIR), and short-wave infrared (SWIR-1 and SWIR-2) spectral bands	Landsat 8 surface reflectance data
Spectral indices	Modified Normalized Difference Water Index (MNDWI), Normalized Difference Built-up Index (NDBI), Normalized Difference Vegetation Index (NDVI), Green Chlorophyll Index (GCI), Bare Soil Index (BSI), Index-Based Built-up Index (IBI)	Landsat 8 surface reflectance data
Topographic features	Elevation, slope, and aspect	Shuttle Radar Topography Mission (SRTM) digital elevation dataset
Climatic features	Soil moisture, runoff, minimum temperature, and vapor pressure	TerraClimate dataset
Gray-level co-occurrence matrix (GLCM) texture metrics	Mean (SAVG), contrast (CON), correlation (CORR), and variance (VARI)	Landsat 8 bands

2.3.2. Data Processing

The pre-processing steps ensured the generation of a clean, representative image of the study area for each target year. This image served as the base layer for the subsequent feature extraction and classification processes. The cloud and snow masking functions combined with the median composite approach minimized data contamination and improved the reliability of the LULC classification results. For the Akan-Mashu NP, there are records of snowfall in winter, according to the records of the Japan Meteorological Agency. Hence, the cloud- and snow-masking functions were applied to these datasets. The masking process utilizes the QA_PIXEL band to identify and remove pixels affected by clouds and snow.

A manual interpretation method based on existing LULC products was employed to label the reference points. Specifically, authoritative LULC products (ESA LULC dataset and a dataset from the Japan Aerospace Exploration Agency) were selected as references and combined with high-resolution satellite imagery and the actual geographical characteristics of the study area for manual interpretation and verification of each reference point. Furthermore, to avoid classification bias, a series of candidate samples for each land-cover type were randomly generated, manually interpreted, and screened to finalize a reliable reference dataset. This process aimed to provide high-quality reference data for subsequent training and validation of the classification algorithm.

2.3.3. Machine Learning Algorithm

Random Forest (RF) is an ensemble machine learning algorithm that operates by constructing multiple decision trees during training and outputs the mode (classification) or mean (regression) of individual tree predictions [29]. It is widely known for its robustness, ability to handle large datasets, and effectiveness in handling continuous and categorical data. The algorithm selects random subsets of features and samples to build each tree, which improves the accuracy of the model and reduces overfitting. Many studies have shown that RF produces a relatively high accuracy for LULC classification [25,30]. Therefore, in this study, an RF classifier was used for the LULC mapping.

Following a previous study, we used 80% of the training sample points and 20% of the verification sample points to calculate the corresponding confusion matrix [31]. By calculating the confusion matrix, we obtained overall accuracy (OA), kappa coefficient, producer accuracy (PA), and user accuracy (UA) for each year to assess the accuracy of the classification results.

2.3.4. Dynamic Analysis of LULC

To assess the changes in LULC from 2014 to 2023, we applied the land-use transition ration matrix and the percent annual change. Generated in GEE, the land-use transition ration matrix helps standardize the analysis by showing how each land-use type has changed as a proportion of its total area in the baseline year (2014). The percent annual change of land use serves as a quantitative measure for describing the rate of land-use change. It is instrumental in comparing differences in land-use changes and analyzing trends over time [32,33]. The magnitude of a percent annual change reflects the intensity and pace of land-use change. Higher values signify more intense or rapid changes, whereas lower values indicate slower or less significant changes in land use. The formula used is as follows:

$$K = \frac{A_2 - A_1}{A_1} \times \left(\frac{1}{t_2 - t_1}\right) \times 100\%$$

where K represents the rate of LULC change; A_1 and A_2 denote the area of land class A at the start and end of the evaluation period, respectively; and t is the duration of the evaluation in years.

2.4. Estimation of Ecosystem Services Values

This study employed the benefit transfer method to estimate ESV. The benefit transfer method is a practical and efficient tool for estimating ESV when resources or data are limited. It can also be applied across multiple sites, enabling regional- or national-level evaluation of ecosystem services [34].

This study employed value coefficients from the latest 2020 updated Ecosystem Service Valuation Database (ESVD), which is a follow-up to the TEEB [8,9]. The ESVD comprises 4042 value records from 693 case studies spread across six continents, including Asia. As stated in the original document, the selected common currency for ESVD is the international dollar, which reflects the value of the US dollar in the United States based on purchasing power (as of 2020). Therefore, this unit was used to calculate the ESV.

The LULC classes in our study differed slightly from those in the ESVD. For this research, we applied coefficient values for land-use types that were closely aligned with the biomes identified in the ESVD [8]. Specifically, to estimate the ESV for 'forests' and 'water bodies' in our study site, we used the coefficient values for 'temperate forests' and 'rivers and lakes', respectively, as provided in the ESVD (Table 4). For 'built-up areas' and 'bare land', referring to a series of previous studies [19,20] and lacking monetary valuation, we do not include them in value calculations. Although national parks may not directly provide certain services (e.g., water bodies do not directly produce 'food'), they contribute indirectly through regulating services. To avoid underestimating their overall ESV and ensure comparability with previous studies [18,19,21], this study includes all ecosystem service types from the ESVD in the calculation. It is also worth noting that in the ESVD table, not every biome has coefficients for all ecosystem service types. Therefore, we selected ecosystem services (raw materials; climate regulation; regulation of water flows; opportunities for recreation and tourism; inspiration for culture, art, and design) that have consistent values across all biomes in this study to calculate the comparable ESV. Detailed descriptions of the coefficients for each land-use type and the corresponding ecosystem services they offer are presented in Table 4. For the selected coefficients for which consistent values are available across all land-use types, please check Table S3 in Supplementary Materials.

Table 4. Coefficients for each land-use type (original biome from the ESVD) per ecosystem service biome (Int$/hectare/year; 2020 price levels) [9].

	Forests (Temperate Forests)	Cultivated Areas (Cultivated Areas)	Water Bodies (Rivers and Lakes)	Grassland (Grassland)	Built-Up Areas (Desert)	Bare Land (Desert)
Provisioning						
Food	4	510	2288	-	-	-
Water	-	604	9198	313	-	-
Raw materials	33	6	92	637	-	-
Regulating						
Air quality regulation	1593	10	-	8	-	-
Climate regulation	481	10	251	73	-	-
Moderation of extreme events	6	993	18	-	-	-
Regulation of water flows	68	17	4221	43	-	-
Waste treatment	-	40	50,760	-	-	-
Erosion prevention	6	173	-	-	-	-
Maintenance of soil fertility	117	34	6189	-	-	-
Pollination	-	1498	-	-	-	-
Biological control	-	621	142	-	-	-
Habitat						
Maintenance of species' life cycles (incl. nursery service)	-	-	803	-	-	-
Maintenance of genetic diversity	-	-	17,987	-	-	-
Cultural						
Aesthetic information	35	395	2276	-	-	-
Opportunities for recreation and tourism	281	3101	13,633	92	-	-
Inspiration for culture, art, and design	196	16	310	284	-	-
Spiritual experience	-	-	76	-	-	-
Information for cognitive development	147	-	116	147	-	-
Existence and bequest 'values'	2416	-	-	-	-	-
Sum	5383	8026	108,361	1597	-	-

To compute the ESV of the LULC types, LULC functions, and total ESV, the following equations were applied:

$$ESV_{ft} = \sum_{k=1}^{n} \left(A_{kt} \times VC_{fk} \right)$$

where ESV_{ft} is the estimated ESV of function f at time t, and A_k and VC_k are the area (ha) and the ecosystem service value coefficient of function f (US\$ha^{-1} yr^{-1}) for the LULC type k.

$$ESV_t = \sum_{k=1}^{n} (A_{kt} \times VC_k)$$

where ESV_t is the estimated total ESV at time t, A_{kt} is the area (ha) of LULC type k at time t, and VC_k is the ecosystem services value coefficient (US\$ha^{-1} yr^{-1}) of the LULC type k.

3. Results

3.1. LULC Analysis

3.1.1. Results of LULC

According to the classification conducted on the GEE, we obtained LULC classes from 2014 to 2023 per year in the study areas. The average OA was 89.93%, and the average kappa coefficient was 87.81%. The detailed results of the OA, kappa coefficient, producer accuracy, and user accuracy for 2014 and 2023 are summarized in Table 5. Owing to space limitations, detailed accuracy assessment data for each of the ten years are summarized in Table S1 in the Supplementary Materials.

Table 5. Accuracy assessment results in 2014 and 2023.

Year	2014		2023	
	PA	UA	PA	UA
Forests	93.88%	86.79%	96.55%	80.00%
Cultivated areas	96.88%	83.78%	87.18%	89.47%
Built-up areas	80.00%	96.00%	86.67%	86.67%
Water bodies	96.30%	100.00%	96.00%	96.00%
Grassland	87.10%	96.43%	84.38%	96.43%
Bare land	100.00%	100.00%	96.97%	100.00%
Overall accuracy	92.15%		90.96%	
Kappa coefficient	90.42%		89.12%	

In Akan-Mashu NP, there are six types of LULC: forests, cultivated areas, built-up areas, water bodies, grassland, and bare land (Figure 3). The main water bodies in this park are lakes, and built-up areas mainly converge around the lakes and the northeast. We further analyzed the percentages of different classes in the study areas. According to Figure 4, forests are the land-use type with the largest area, covering more than 70% of the area, followed by water bodies, cultivated areas, grassland, bare land, and built-up areas. The LULC maps at the study site are presented in Figure S1 in the Supplementary Materials.

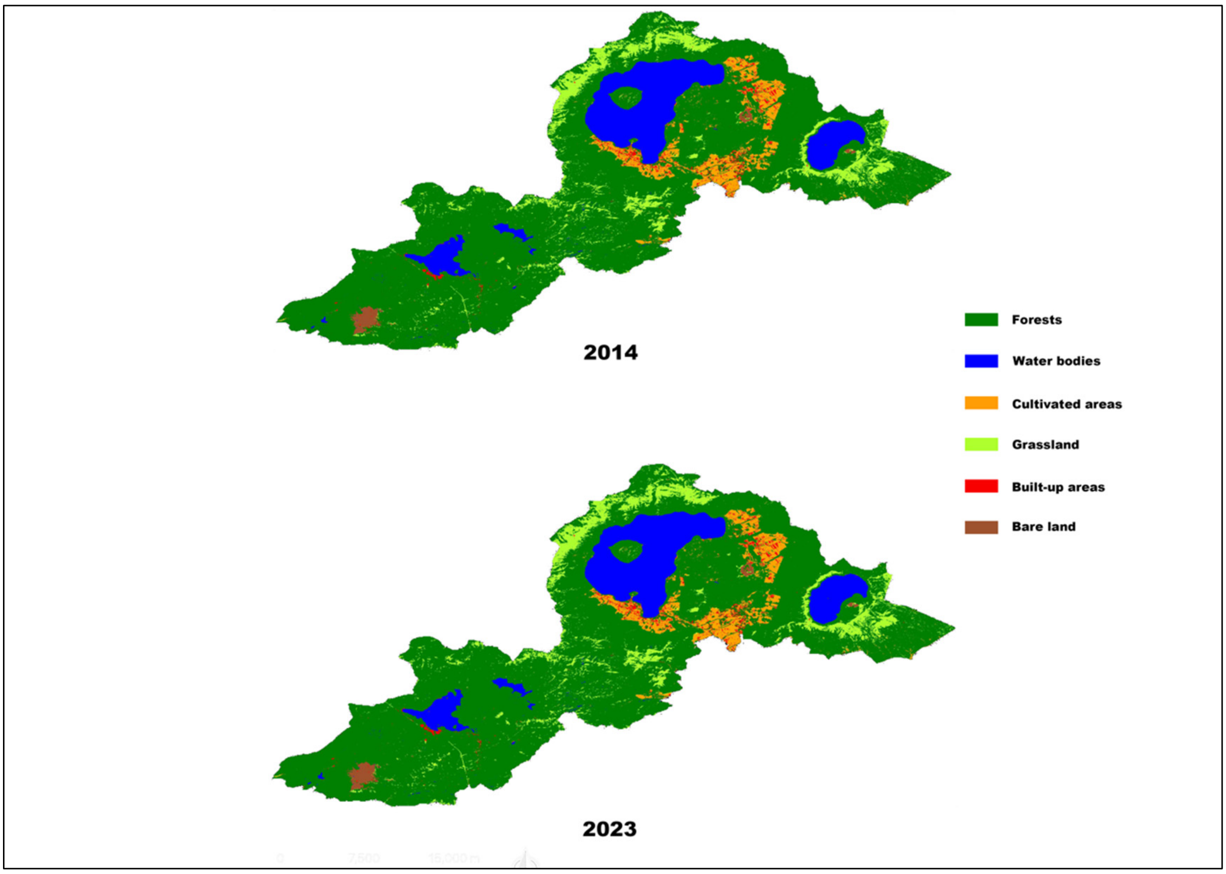

Figure 3. LULC maps of 2014 and 2023.

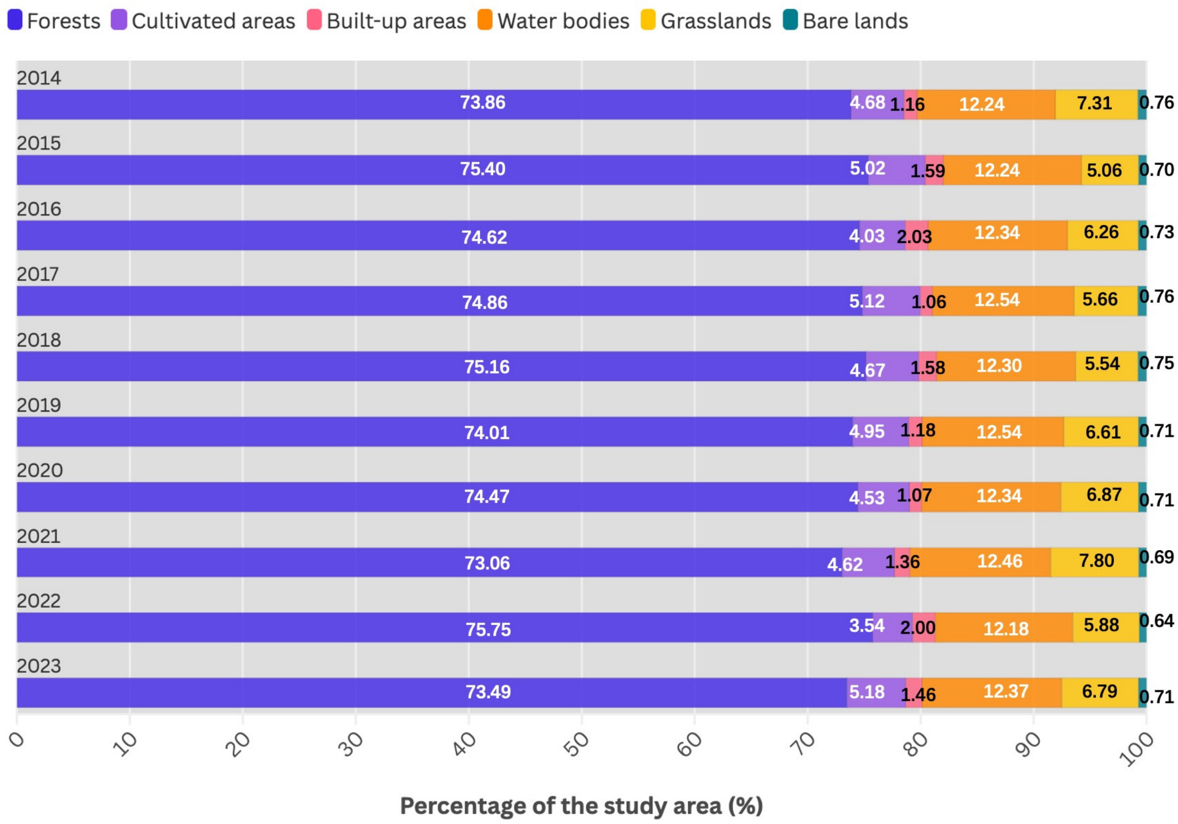

Figure 4. The proportion of land-use types in the total study area.

3.1.2. Dynamic of LULC

We summarized the area of different land-use types (unit: hectare) and their proportion of the total area in each year during the study period, as shown in Table S2 in the Supplementary Materials. Table 6 indicates the LULC transition ratio matrix from 2014 to 2023. This matrix helps standardize the analysis by showing how each land-use type has changed as a proportion of its total area in 2014. This table focuses on the interconversion relationships among different land-use types. During the study period, the proportions of water bodies, forests, and bare land converting to other land-use types were relatively low. Specifically, over 99% of water bodies, approximately 96% of forests, and 85% of bare land remained unchanged. Additionally, 27% of grassland was converted into forest. There was also a bidirectional conversion between cultivated areas and built-up areas, with approximately 14% of cultivated areas transitioning into built-up areas, while around 42% of built-up areas were converted into cultivated areas. The actual land area values are in the Supplementary Materials (Supplementary Materials Table S3). Table 7 shows the area of different land-use types in 2014 and 2023, as well as their corresponding percent annual change. The forest area has hardly changed during the study period, with a percent annual change of −0.06%. Cultivated areas experienced an increase, expanding from 4364.25 hm^2 in 2014 to 4834.85 hm^2 in 2023, with a percent annual change of 1.20%. Following cultivation, built-up areas expanded by 281.48 hm^2, with a percent annual change of 2.89%. The area of the water bodies increased slightly with a percent annual change of 0.11%. Grassland and bare land had a slight decrease, with a percent annual change of −0.79% and −0.66%, respectively.

Table 6. LULC transition ration matrix from 2014 to 2023.

	Land Use in 2023 (Rate %)					
Land Use in 2014 (Rate %)	**Forests**	**Cultivated Areas**	**Built-Up Area**	**Water Bodies**	**Grassland**	**Bare Land**
Forests	**0.96**	0.01	0.00	0.00	0.02	0.00
Cultivated areas	0.09	**0.75**	0.14	0.00	0.02	0.00
Built-up area	0.18	0.42	**0.36**	0.00	0.02	0.01
Water bodies	0.01	0.00	0.00	**0.99**	0.00	0.00
Grassland	0.27	0.01	0.00	0.00	**0.72**	0.00
Bare land	0.08	0.00	0.01	0.01	0.05	**0.85**

Table 7. Coverage of LULC classes and changes in the study periods.

	Area (ha) in 2014	**Area (ha) in 2023**	**Percent Annual Change (2014–2023)**
Forests	68,942.87848	68,598.89781	−0.06%
Cultivated areas	4364.250524	4834.85305	1.20%
Built-up areas	1080.534794	1362.018005	2.89%
Water bodies	11,427.55309	11,544.68741	0.11%
Grassland	6823.193704	6341.036997	−0.79%
Bare land	706.1257991	664.0890898	−0.66%

Figure 5 shows the changing trend in the area of each land-use type during the study period. Forests, water bodies, and bare land are land-use types that changed relatively slowly, whereas grassland, cultivated areas, and built-up areas changed more obviously.

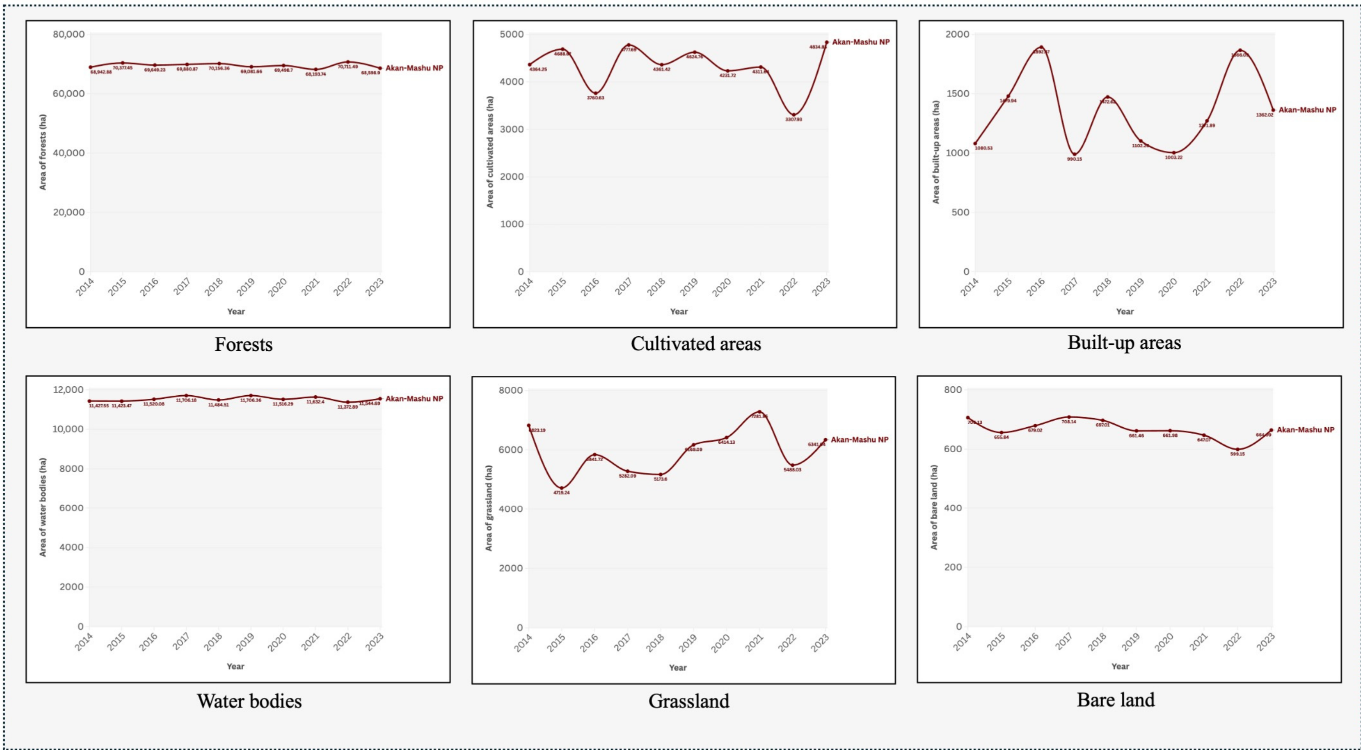

Figure 5. The changing trend of the area of each land-use type in the study period (Note: Here, we used different scales for each land-use type).

3.2. Ecosystem Services Valuation

3.2.1. The Results of ESV

Table 8 shows the annual ESV (unit: million USD) of the study site during the study period and the ESV provided by different land-use types and their proportions. Although water bodies only occupy approximately 12% of the area, they provide more than 70% of the ESV, making them the largest land-use type in the overall ESV, followed by forests, which provide approximately 22% of the ESV, and then cultivated areas and grasslands; these two types of land use only offered little value from the overall perspective. However, it is worth noting that some biomes (e.g., water bodies) have more comprehensive ecosystem service coefficient data in the ESVD table. Therefore, we also calculated a comparable ESV using only the service types for which coefficients are available across all biomes. The results indicate that the proportion of comparable ESV provided by each land-use type is similar to the original findings. Detailed results are presented in Supplementary Materials Table S5.

We also calculated the ESV provided by four ES types—please refer to Figure S2 in the Supplementary Materials. It is noteworthy that due to the insufficient research on certain ecosystem services, particularly non-material services (e.g., Genetic resources), some valuation coefficients are missing. We believe that some types of ecosystem services are undervalued, such as habitat services.

Table 8. ESV provided by different land-use types and their proportions.

Year		Forests	Cultivated Areas	Water Bodies	Grassland	Sum
2014	ESV	371.12	35.03	1238.30	10.90	1655.34
	Proportion	22.42%	2.12%	74.81%	0.66%	
2015	ESV	378.84	37.63	1237.86	7.54	1661.87
	Proportion	22.80%	2.26%	74.49%	0.45%	
2016	ESV	374.92	30.18	1248.33	9.33	1662.76
	Proportion	22.55%	1.82%	75.08%	0.56%	
2017	ESV	376.17	38.35	1268.49	8.44	1691.44
	Proportion	22.24%	2.27%	74.99%	0.50%	
2018	ESV	377.65	35.00	1244.47	8.26	1665.39
	Proportion	22.68%	2.10%	74.73%	0.50%	
2019	ESV	371.87	37.12	1268.51	9.85	1687.35
	Proportion	22.04%	2.20%	75.18%	0.58%	
2020	ESV	374.11	33.96	1247.92	10.24	1666.23
	Proportion	22.45%	2.04%	74.89%	0.61%	
2021	ESV	367.09	34.61	1260.50	11.63	1673.82
	Proportion	21.93%	2.07%	75.31%	0.69%	
2022	ESV	380.64	26.55	1232.38	8.76	1648.33
	Proportion	23.09%	1.61%	74.77%	0.53%	
2023	ESV	369.27	38.80	1250.99	10.13	1669.19
	Proportion	22.12%	2.32%	74.95%	0.61%	

3.2.2. The Temporal Variation of the ESV

Table 9 shows the changes in ESV provided by different land-use types in the study area from 2014 to 2023. In Akan-Mashu NP, the ESV of forests decreased by USD 1.85 million, and that of grasslands decreased by USD 0.77 million, while both cultivated areas and water bodies increased, of which the ESV of water bodies increased by USD 12.69 million, and the value of cultivated areas increased by USD 3.78 million. The total ESV in the study area increased by USD 13.85 million in the last decade. For the results of changes in selected ESV (raw materials; climate regulation; regulation of water flows; opportunities for recreation and tourism; inspiration for culture, art, and design) provided by various land-use types during the study period, we found that the rate of change is consistent with the results in Table 9. For detailed information, please refer to Table S6 in the Supplementary Materials. Our results show that although the current ESVD has missing data for some ecosystem services, the ESV calculated using the original table is comparable to the selected ESV.

3.3. Summary of the Tourism Promotion Policy Document

From the 'Akan-Mashu National Park Enjoyment Project Step-up Program 2025', we mainly summarize the measures to promote tourism by 2020 and plans through a qualitative analysis [35]. In Table 10, we present four main measures that have been conducted, selected cases of each measure, and potential connections between these initiatives and changes in LULC and ESV. Noteworthy, adventure travel (AT) is defined as a trip consisting of two or more of the following three elements: nature, activities, and cross-cultural experiences. According to a survey by the Adventure Travel Trade Association (ATTA), data show that adventure travelers spend approximately 1.7 to 2.5 times more per person than regular travelers. This suggests that AT can contribute to regional revitalization while minimizing environmental impact by attracting fewer but higher-spending visitors [35]. We also summarized seven main measures to promote the future tourism development of this national park. These seven aspects are as follows: (1) responding to the COVID-19 pandemic and the Post-COVID Era, (2) promotion of AT in Eastern Hokkaido, (3) rehabilitation of usage hubs through public–private collaboration, (4) formation of the Akan-Mashu National Park Trail Network, (5) new utilization to enhance the added value of nature, (6) prompt response to simple improvements from the user's perspective, and (7) promotion of sustainable tourism. For a detailed description of each aspect, please refer to Supplementary Materials Table S7.

Table 9. Amount of change of ESV in the study period (unit: million USD).

	2014–2023	Change Rate
Forests	−1.85	−0.50%
Cultivated areas	3.78	10.78%
Built-up area	-	-
Water bodies	12.69	1.03%
Grassland	−0.77	−7.07%
Bare land	-	-
Total	13.85	0.84%

Table 10. Local measures to promote tourism as of 2020 and the potential impact of LULC and ESV [35].

Main Types of Measures	Specific Implementation Measures	Selected Cases Description	The Potential Impact of LULC and ESV
Promoting adventure travel (AT)	AT is positioned as an important target. As a result of aggressive activities to attract visitors, the Adventure Travel World Summit (ATWS) will be held in Hokkaido in 2021.	• The first Adventure Connect event was held in Sapporo in September 2017 to promote networking with people involved in AT • The activity counter opened in a private hotel as a base for AT in the Akan area in 2018	This move may contribute to smooth changes in land use and the protection of ecological values
New use of the national park	The project promoted new utilization of previously unused resources and areas of national parks, considering the conservation of the natural environment.	• From 2020, guided trekking tours will be offered on Atosanupuri, which had been off-limits to hikers, with rules based on the Ecotourism Promotion Act • From June 2019, a guided trail from Uramashu Observatory to Kaminoko-ike Pond will begin • Construction of a new trail (Takiguchi Line) that connects the south shore of Lake Akan to the waterfall (partial section to open in 2020)	Newly opened guided tours and trails may increase the area of construction areas, resulting in a decrease in ESV

Table 10. *Cont.*

Main Types of Measures	Specific Implementation Measures	Selected Cases Description	The Potential Impact of LULC and ESV
Promote private investment through public–private partnerships	The project to fully enjoy the national park has encouraged new private investment from within and outside the region, and efforts to revitalize the region have progressed.	• In 2018 and 2019, trial glamping at Wakin Campground in cooperation with private operators to study effective use of the off-season	
Development of public spaces	Reorganization and multilingual support were promoted to ensure stress-free and comfortable use of public facilities such as visitor centers, park grounds, and restrooms within national parks.	• Reorganization of the boardwalk and installation of camping decks in 2020 • Trees were cut down to ensure a clear view from Lake Mashu No. 1 Observation Deck and the rest house	New facilities for visitor use and the transformation of a range of public spaces may increase the area of built-up areas, leading to a reduction in ESV

Based on the data provided by the MoE [36], we compiled the annual visitor numbers to Akan-Mashu National Park from 2014 to 2022, shown in Figure 6 (as of the time of writing, 2023 data have not been released). During the period from 2014 to 2019, the changes in visitor numbers were small, even showing a slight decline, indicating that the tourist pressure on the park remained relatively stable without significant growth. In 2020, there was a sharp decline due to factors such as the pandemic, but in 2021, the numbers quickly returned to 2019 levels. Even though a series of tourism promotion measures were implemented in the study area (such as the construction of new facilities), there was no significant surge in the number of visitors in the short term. However, this also indicates that there is still substantial room for growth in the number of visitors in the future, which further emphasizes the importance of maintaining a balance between ecological protection and tourism development moving forward.

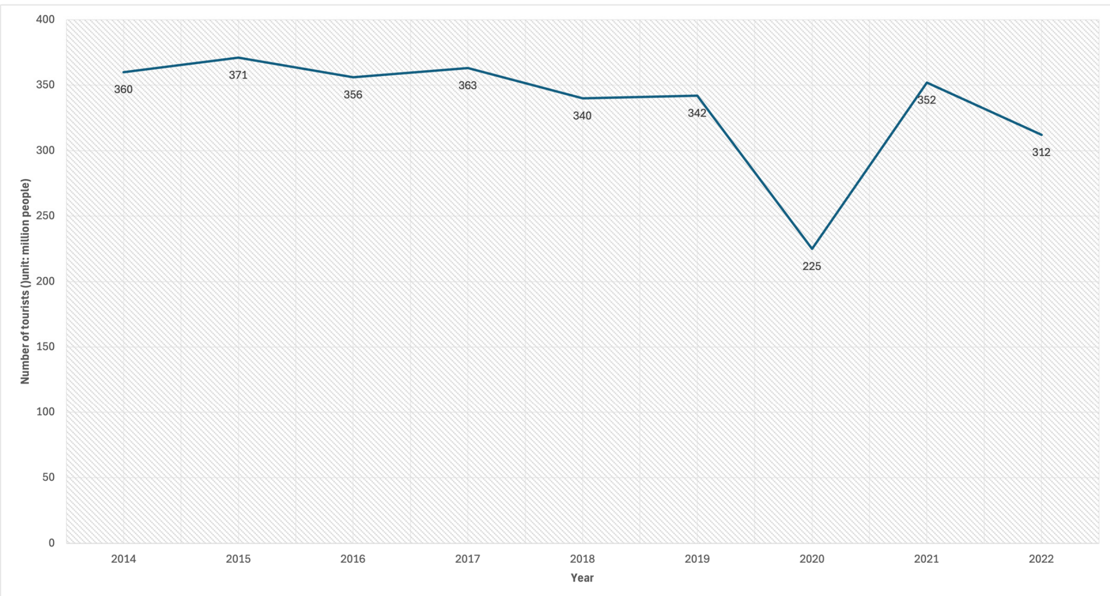

Figure 6. Annual visitor numbers to Akan-Mashu National Park from 2014 to 2022 [36].

4. Discussion

4.1. Changes of LULC

The LULC results of this study revealed that the land-use type in the Akan-Mashu NP was dominated by forests, followed by water bodies and grasslands. Human activities engaged in land-use types: cultivated and built-up areas cover only a small portion of the study area. This result is consistent with the features of the NP, which has a magnificent landscape that weaves volcanoes, forests, and lakes together. Although the percent annual change of forests decreased from 2014 to 2023, the absolute change was 0.06%, indicating almost no significant changes. Similar to forests, changes in water bodies, grasslands, and bare land were slow. The percentage of annual changes in built-up areas (2.89%) and cultivated areas (1.20%) was relatively higher than that of the other land-use types. The LULC transition ration matrix reflects the mutual conversion between these two land-use types. As of 2020, the management department has implemented numerous measures to attract tourists, as summarized in Section 3.3. Among these measures, projects increase the construction area by opening and building new walking trails, viewing platforms, and parking lots (Table 10). We believe that these initiatives to promote tourism are one of the reasons for the increase in built-up areas. On the other hand, previous studies have indicated a marked increase in abandoned farmland in Japan due to the substantial decline and aging of its rural population [37,38]. Our research showed that cultivated land within national parks has developed steadily over the past decade, with a steady increase from 2014 to 2023. This result may be because our study period was in the last decade, and the coverage area was not large enough, which does not reflect the more significant phenomenon of farmland abandonment. Additionally, a study has found that the farmland abandonment rate in Hokkaido is lower than in other regions of Japan [39].

As summarized in Table 1, most of the zoning in this area is classified as special zoning, which has several restrictions and regulations. Our findings regarding changes in LULC indicate that land use has not shifted significantly over the past decade, demonstrating the success of protection and management strategies.

4.2. Changes of ESV

Our results show that different land-use types contribute to different ESV. Although water bodies account for only approximately 12% of the total area of the national park, they provide more than 70% of the ESV, which shows the importance of this land-use type in the overall ecosystem service. In particular, the three major lakes, Lake Akan, Lake Mashu, and Lake Kussharo, not only have supporting services and regulating services and provide habitat functions for plants and animals but are also important scenic spots. According to the policy documents of the management department, there are artificial facilities, such as observation platforms and campsites, around the lakes. Therefore, we believe that the areas around the three major lakes need to focus on monitoring ecological changes and tourism pressure. The coefficient table (Table 4) shows that cultivated areas can provide objective regulation and cultural service values. However, a study predicts that farmland abandonment is likely to become a widespread issue across Japan in the future [38]. This requires management departments and local town governments to make efforts to balance local agricultural development with national park management.

From the time-series results of the ESV, the changes in the past decade have been very slow, and the overall ESV has increased by USD 13.85 million. Our research results reflect that management planning is very effective, and the plan to promote the development of tourism has not brought too much pressure and impact on the local ecological environment. Although our results showed minor changes in ESV, they do not imply that conservation efforts should be overlooked. Instead, a stable ecological state should promote the ongoing implementation of effective policies to sustain existing ecological service values.

4.3. Management Recommendations

Based on the main findings of this study, we propose several management recommendations for balancing ecological conservation and tourism development in national parks. We hope that these recommendations will not only apply to the subjects of this study—Japan's national parks—but will also provide a reference for managing similar environments worldwide. First, our results suggest that the Japanese national park zoning management system may have contributed to the observed stability in land use and ESV over the past decade. Zoning management systems should continue to be strictly followed in the future to ensure the ecological conservation of national parks. This recommendation is applicable globally, especially in developing countries such as China, which has recently begun to establish national parks. Second, we suggest that abandoned vacant lands or buildings in Akan-Mashu National Park be demolished and replaced with new tourism facilities. This approach would not occupy additional construction land and could enhance the area's appeal and tourism experiences for visitors. Third, by identifying the value share of different types of ecosystem services, we can provide a reference for future tourism planning goals of national parks. Although we acknowledge that the current ESVD may lead to an underestimation of the value that certain ecosystem services can provide, we believe that applying a consistent methodology across different national parks allows us to observe changes in the proportional contribution of different ecosystem types to the overall value. Based on these variations, this analysis can serve as a reference for planning future tourism strategies. For instance, when cultural services have the highest proportion, management can use the local culture as the main feature to attract visitors. Finally, we will propose possible directions for future visitor management. Focusing on the carrying capacity of the national park is one possible approach [40]. For instance, setting seasonal or annual visitor limits could help regulate tourism impact. In addition to fixed numerical limits, there are resilience-based theories such as the Limits of Acceptable Change (LAC), a framework that has been widely applied in the management of national parks [41,42]. Unlike carrying capacity, LAC assumes that environmental changes are inevitable, emphasizing the importance of identifying acceptable levels of change and developing management. We believe that these theories and approaches could be applied to the future visitor management of this national park. Although visitor numbers have remained relatively stable over the past decade, there is significant potential for growth in the future. Therefore, it is essential to establish appropriate strategies to address potential tourist pressure.

4.4. Limitations and Future Research

This study has the following limitations. First, there are constraints related to data sources and accuracy. The temporal and spatial resolutions of remote sensing data may not be sufficient to accurately capture small-scale land-use changes. The ESV coefficients used in this study were based on comprehensive global assessments, which may not fully reflect the ecosystem characteristics of the study area. As noted in a similar study [21], certain land types (e.g., bare land within protected areas) do not entirely lack ecological value but rather lack economic valuation studies. Therefore, when applying the benefit transfer method, we excluded these land types from the valuation. Meanwhile, since the current ESVD contains missing data on certain ecosystem services, our results may underestimate the value that those ecosystem services can provide. Secondly, there were limitations to the timescale. Since this study is an interdisciplinary project focusing on changes in LULC and ESV in Japan's national parks after the implementation of the "To Fully Enjoy National

Parks" project, only data from the past ten years were obtained, rather than a longer period. However, LULC and ESV changes may have been influenced by historical land use and management practices over a longer period. Third, this study did not integrate socioeconomic dimensions. This research mainly focuses on the ecological dimensions of LULC and ESV, potentially overlooking the interrelationship between tourism development and socioeconomic factors.

To address these limitations, we plan to improve future research projects as follows. High-resolution remote-sensing data can be used to improve data accuracy. For ESV evaluation, multi-source data can be integrated to reflect local characteristics, such as ecosystem modeling based on local environmental data, visitor surveys, and crowdsource data. Owing to the limitations of the time scale, future research could extend this period to analyze long-term trends. Additionally, scenario simulations (e.g., InVEST models) can be used to predict the potential impacts of policies on future ESV, compensating for a short time span. To address the third point, future research should expand on these dimensions by incorporating social and economic indicators to establish a more comprehensive analytical framework. For example, the coupled coordination degree model can be used to comprehensively analyze the coordinated development of ecology, socioeconomics, and tourism within national parks. Furthermore, further research could predict future land use, calculate the corresponding changes in ESV based on this framework, and develop an early warning system using other tourism-related indicators.

5. Conclusions

This study analyzed the LULC changes in the Akan-Mashu National Park over the past decade and found that the changes were relatively stable. Similar to the LULC changes, the ESV in the Akan-Mashu National Park also showed steady growth during this period, with an overall increase of USD 13.85 million. These results reveal that tourism development has not substantially harmed the ESV of Akan-Mashu National Park. Beyond providing an empirical assessment of LULC and ESV trends, this study also offers a policy-oriented perspective. By reviewing the tourism development policies implemented in Akan-Mashu National Park up to 2020, we identify key management strategies that have contributed to ecological stability. Despite implementing tourism promotion projects and a series of measures in the region, the number of visitors has not significantly increased over the past decade. This result indicates that this study area still holds substantial potential for future development. Based on these insights, we propose four strategic recommendations to further balance conservation and tourism development, ensuring the park's long-term sustainability. While these recommendations are tailored to the study area, they offer a broader reference for sustainable tourism and land use management in other protected areas worldwide.

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