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Land-Use Classifying and Identification of the Production-Living-Ecological Space of Island Villages—A Case Study of Islands in the Western Sea Area of Guangdong Province

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Abstract: Accurately identifying the rural production-living-ecological space (PLES) of different islands can help reveal their distinct natural resources and land-use situations, which is significant for the sorted management, subarea utilization, and protection of islands. At present, studies on the PLES of island villages are deficient. For instance, the existing land-use classification system is incomplete; the PLES is poorly identified; and the dominant function of multiple land-use types based on different island geomorphology types is insufficiently investigated. Therefore, a case study was conducted on the island villages of the western sea area of Guangdong Province, based on remote sensing, spatial analysis, and land classification, with field research and the relevant data. In this study, before establishing the PLES system, the islands were classified, including six bedrock islands, 10 sedimentary islands, and one volcanic island. When the PLES system of the island villages was classified, the ecological and utilized areas of the intertidal zone and neritic region should be combined with the island–continent part, and the distinct industrial types should be emphasized, before forming 22 secondary types of PLES. Furthermore, it is found that each island generally has its own dominant space and land-use type. Ecological space (ES) dominates the bedrock islands, and production space (PS) is prominent for sedimentary islands and volcanic islands. Forestland, aquaculture pond, and dryland are the prominent land-use types for bedrock islands, sedimentary islands, and volcanic islands, respectively. The rural residential lands are the main component of living space (LS) in all islands, and the most urban residential lands are distributed on the bedrock islands. The main driving factors for the formation and distribution of island rural PLES are the altitudinal gradient and geomorphic characteristics. The research shows that the main problems of PLES are that the intertidal zones are threatened by aquaculture ponds at various levels, and the development of LS in these islands is generally backward.

Keywords: production-living-ecological space; identification; island exploitation; perspective of geomorphology

Citation: Bai, R.; Shi, Y.; Pan, Y. Land-Use Classifying and Identification of the Production-Living-Ecological Space of Island Villages—A Case Study of Islands in the Western Sea Area of Guangdong Province. *Land* **2022**, *11*, 705. https://doi.org/10.3390/land11050705

Academic Editor: Dong Jiang

Received: 6 April 2022
Accepted: 6 May 2022
Published: 8 May 2022

1. Introduction

The dense population and rapid economic development in coastal zones in China cause frequent changes in land-use structures of offshore islands and intensify the conflicts among the production space, living space, and ecological space [1,2]. In order to achieve sustainable development of geographical space, in 2012, the Chinese government proposed the principle of the national territorial space development: optimizing the allocation of natural and socioeconomic resources for high-efficiency and intensive production, comfortable living, and eco-friendly territorial space [3–6]. With the discussion and popularization of the concept of production-living-ecological space (PLES) [7,8], the identification of PLES [9,10], the evolution of PLES [11,12], and PLES functionality [13,14] have become research hotspots in the fields of landscape planning and urban planning.

Current studies on the identification of PLES mainly focus on the national land space [15], provincial spaces [16,17], and urban spaces [18,19]. However, PLES identification was rarely conducted in rural spaces, especially in island villages. With the increasing anthropogenic activities, the ecology of the islands has been experiencing critical deterioration. Moreover, the island ecosystem, characterized by a small area, low ecological diversity, and low self-regulating and restoring capacity, is fragile and challenging to repair [20–23]. Therefore, island land planning and management should be carried out from an integrative research perspective. PLES covers the ecological, production, and living spaces, and the classification of PLES is a comprehensive land spatial zoning [24]. PLES identification on island villages could help to find out the conflict and contradiction among the production space (PS), living space (LS), and ecological space (ES), with achieving co-ordinated developments.

Generally, the identification and division of rural PLES can be achieved by two mainstream methods: (1) the evaluation index system (EIS); (2) land-use classification (LUC) [25–27]. The method of EIS is usually used to divide the PLES by evaluating the function and suitability of each administrative unit [28,29]. However, it cannot be used to identify the PLES within the village because of the difficulty in obtaining the socioeconomic statistics at the village level. The method of LUC can identify rural PLES by classifying land-use types with the same dominant function and can be used to identify the multispatial characteristics of rural PLES within the village [30]. For example, Duan et al. [24] identified the multispatial rural PLES in Ertai Town of Zhangjiakou from the perspective of the villagers' behavior.

The existing LUC-related studies on PLES mainly used Chinese "Land-use status classification" (GB/T21010-2017) for spatial identification [31]. Nevertheless, the surface features of island areas cannot be highlighted by using this taxonomy. In this case, scholars who participated in the Special Project for Comprehensive Investigation and Evaluation of China's Offshore Ocean (908 Special Project) formulated an LUC system of islands [2], which can emphasize the surface features of the island–continent part. However, each island contains the island–continent part, island intertidal zone, and neritic region [32]. Thus, it is essential to combine the ecology and the utilized spaces of the intertidal zone and neritic region while classifying the land-use of islands. Furthermore, rural spaces in different islands have distinct resource combinations and utilization characteristics. Consequently, in order to find out the advantages and limitations of resources and utilization in various islands, island classification is necessary.

With the increasing exploitation, the island villages in the western sea area of Guangdong Province are commonly confronted with the following issues: (1) development and utilization behaviors such as reclamation and arbitrary quarrying which changed the topography and geomorphology of some islands; (2) severe destruction of the ecological environment; and (3) extensive utilization of natural resources. With a narrow economic base, restricting the protection and management of the islands. Previous studies in this area mainly focused on qualitative planning strategies, the islands' intertidal zones and neritic regions were rarely considered in the LUC-related studies, and research from a geomorphological perspective is scarce. Hence, the present study aims to fill these knowledge gaps using a remote sensing-based approach. The specific objectives of this study are to: (1) establish a PLES system for the island villages; (2) map the spatial distribution of secondary types of PLES; (3) explain the formation mechanism from the geographical perspective; and (4) figure out the conflict among the PLES and propose space-optimization strategies.

2. Materials and Methods

2.1. Study Area

The study area covers 17 populated offshore islands (within approximately 30 nautical miles) in the western sea area of Guangdong Province (Figure 1). The largest island in the study area is Donghai Island, with an area of 286 km^2, and the smallest island is Gonggang Island, with a mere area of 1.26 km^2, and all the islands are located at a distance of about 0.4 km~18 km from the coastline. The study area belongs to the subtropical climate. Compared with the coastwise mainland, the islands have an oceanic climate, with an annual temperature of 1~1.5 °C lower than that of the adjacent mainland; the number of days with at least Level-8 gale on annual average is 3~8 times that of the adjacent mainland; the annual amount of evaporation is 20~200 mm higher than that of the adjacent mainland [33].

Figure 1. Distribution map of island in the western sea area of Guangdong Province.

2.2. Data Processing and Classification Method

This study uses satellite images and auxiliary data, and employs a hybrid classification approach for image classification. The auxiliary data includes those from field investigation, yearbooks, local chronicles, Google images, and the land use/land cover maps of the Resource and Environment Science and Data Center (https://www.resdc.cn (accessed on 13 December 2021)). The auxiliary data were mainly used to identify training samples for image classification, testing samples for accuracy evaluation, and visually modified classified images. A hybrid classification method, which was developed for image classification, was found to be an effective approach to enhancing the accuracy of image classification [34]. This method includes automatic classification (random forest) and visual modification. The classification process is shown in Figure 2. See the following steps for details.

2.2.1. Data Processing and Classification Method

This study adopts the physical boundary of islands as the division, including the ecological and utilized areas of the islands' intertidal zones and neritic regions. The Geospatial Data Cloud (http://www.gscloud.cn/ (accessed on 15 December 2021)) server was used to download Landsat 8 Operational Land Imager (OLI), and Thermal Infrared Sensor (TIRS) database was used for the images of the 2014s and 2015s. All images used in this study are from the dry season period (November–January), during which zero cloud cover allowed for high image quality. The raw images have a spatial resolution of 30 m.

Preprocessing is an essential step to correct atmospheric effects and minimize geometric and radiometric errors before image classification. This study used the ENVI software to undertake the radiometric calibration and atmospheric correction of all the images. A fusion or pan-sharpened multispectral (MS) image provides an improved image of high spatial resolution and can also improve the classification results [35,36]. Therefore, the panchromatic (PAN) band with a resolution of 15 m and MS images were adopted to be fused by the Gram–Schmidt (GS) method in this study. Subsequently, four pan-sharpened MS images with a spatial resolution of 15 m of the studied area were generated.

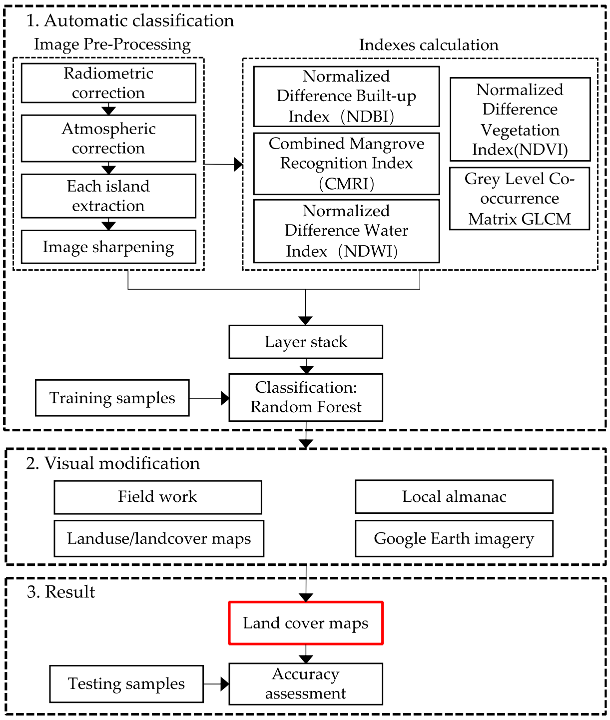


Figure 2. Flow chart of island land-use classification in the study area.

2.2.2. Island Classification

Referring to the 908 Special Project and "Law of the People's Republic of China on the Protection of Islands", according to their results of the classification of islands by geological composition, the islands were classified into three types: bedrock islands, volcanic islands, and sedimentary islands (Table 1). Furthermore, while classified, two or more islands connected via aquaculture pond(s) were deemed as one island.

Table 1. Island classification and image characteristics (Data resources: *Google Earth*).

Primary Classification	Secondary Classification	Image Characteristics	Descriptions
	Bedrock island		The island consists of bedrocks.
Island	Volcanic island (High Island)		The island consists of volcanic ejecta (lava and volcanic ash).
	Sedimentary island		The island consists of incompact substances (mud and sand).

2.2.3. Island PLES System Construction

The identification of a rural place or village varies in different countries. The term in this paper is identified as a region that is outside the urban built-up area and is a system of the territorial complex with natural, social, and economic functions [37,38].

Based on the island land-use classification formulated by the 908 Special Project (Table 2), the primary industries were emphasized and the ecological and utilized area of the intertidal zones and neritic regions were supplemented. Meanwhile, to allow for the resolution of remote sensing (RS) images, some microscale land-use types that were difficult to acquire from the images were merged and adjusted. The islands' PLES-classification-system fit for the studied area was formulated afterward (Table 3).

Table 2. Island land-use classification of study area.

First-Level Land-Use Type	Second-Level Land-Use Type
Arable land	Paddy field
	Dryland
Garden	Orchard
	Tea garden
Forestland	Forestland
	Mangrove forest
Industrial and mining storage land	Industrial land
	Salt pan
Residential land	-
Transportation land	Highway land
	Rural road
Water area and water conservancy facilities land	Harbor land
	Reservoir
	Pond
	Ditch
Other lands	Aquaculture pond
	Mudflat aquaculture
	Sandy land
	Bare land

The production space (PS) refers to the space dominated by the production functions. The PS includes paddy field, dryland, orchard land, and aquaculture pond, which supports agriculture and marine production. The reservoirs and ponds of the islands in the studied area mainly serve agricultural production and hence are classified as PS.

The living space (LS) refers to the space guaranteeing the survival of humankind and carrying human culture. Many time-honored villages on the islands in the studied area have historical, cultural, scientific, artistic, social, and economic value [39]. Thus, in this classification, the rural residential land was separated from the urban residential land by considering the further assessment and preservation of the traditional villages, and was classified into LS alongside land for the harbor and wharf.

The ecological space (ES) refers to the natural space which can maintain regional ecological security [40]. The mangrove forest is a critical ecological space in the study area, listed in the list of Ramsar Convention wetlands of international importance. Besides, wetlands, sandy beaches, and mudflats in the intertidal zones were highlighted in the PLES classification system. Due to the weak capacity of the islands to withstand natural disasters, this classification also stresses the shelterbelts, which defend against natural disasters, protect production, and maintain ecological balance, so as to highlight the particular ecosystem of the subtropical islands.

Table 3. PLES classification and image features (Data resources: *Google Earth*).

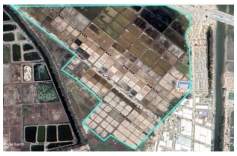
PLES	Secondary Types of PLES	Interpretation Signal	Description
Production space	Paddy field		Cultivated land for aquatic crops such as rice. Including the areas that rotated by aquatic and xerophytic crop.
	Dryland		Cultivated land for xerophilous crops with no irrigation facilities, and the cultivation mainly relies on natural precipitation.
	Tea garden		Site for tea production.
	Salt pan		Salt production sites mainly use the evaporation method, including mixed land-use by fish-farming and salt production.
	Aquaculture pond		The site for aquaculture includes its ancillary facilities, which are located above the shoreline or in the intertidal zones.
	Industrial land		Site for industrial production.
	Reservoir		Site for water storage by artificial intercept (area > 1×10^4 m^2), including its ancillary facilities.
	Pond		Site ponding area or bottomland (area < 1×10^4 m^2), the aquaculture pond is not included.
	Ditch		Site for the channels (width $\geq$ 1 m) used for drainage and irrigation, including ditches, embankments, and surrounding shelterbelt.

Table 3. *Cont.*

PLES	Secondary Types of PLES	Interpretation Signal	Description
Ecological space	Forestland		Site for the forest with canopy density ≥ 0.2.
	Stream		A stream is formed naturally or excavated artificially.
	Shelterbelt		Site for shelterbelt that is distributed on the coastal zone.
	Mangrove forest land		Site for the semimangrove or mangrove forest.
	Wetland		Site for the herb growth in the inland swamp.
	Beach		The dry shoal consists of gravel or sand.
	Rock foreshore		The dry shoal consists of rock.
	Mudflat		The dry shoal consists of sand or mudflat.

Table 3. *Cont.*

PLES	Secondary Types of PLES	Interpretation Signal	Description
Living space	Rural residential land		Villages' house.
	Urban residential land		Urban residential community.
	Harbor land		Site for berthing ships and storage of goods, including the ancillary buildings.
	Highway land		Site for national roads, provincial roads, county roads, and township roads.
	Bare land		Areas with no dominant vegetation cover on at least 90% of the area or areas covered by lichens/moss.

2.2.4. Imagery Feature Extraction

The construction of the categorical dataset requires the spectral signature, index feature calculation, gray-level co-occurrence matrix extraction, and feature fusion [41]. The spectral signature is the foremost feature in remote-sensing image classification [42], while the index feature can effectively enhance image classification accuracy. Index features include Normalized Difference Vegetation Index (NDVI) [43], Normalized Difference Water Index (NDWI) [44], and Normalized Difference Built-up Index (NDBI) [45,46]. Besides, this study adopts the Combined Mangrove Recognition Index (CMRI), which can enhance the discrimination between mangrove forests and nonmangrove vegetations [47] (Table 4).

The existing studies suggest that the gray-level co-occurrence matrix (GLCM) can effectively enhance the classification accuracy of various land-use types and diminish the classification errors due to similar spectral signatures [48]. Combined with the test, the study sets the window size of statistical pixels as 9×9 while extracting textures and selects the value of grayscale quantization level as 32 to calculate six textural features of images using the GLCM (Table 4).

After the calculations above, this step adopted the integrating the multifeatures method [49], including spectral features, texture features (GLCM), and index features. Each feature obtained in this study corresponds to a layer, and the method of layer-overlay is used for feature fusion (Figure 3). The integrating multifeatures method can significantly enrich the information content of remote sensing data, and one of the most commonly used methods to quantify the importance of features is decision trees.

Table 4. The characteristic attributes involved in classification.

Index Features	Normalized Difference Vegetation Index (NDVI)	$NDVI = \frac{NIR-Red}{NIR+Red}$
	Normalized Difference Water Index (NDWI)	$NDWI = \frac{Green-NIR}{Green+NIR}$
	Normalized Difference Built-up Index (NDBI)	$NDBI = \frac{MIR-NIR}{MIR+NIR}$
	Combined Mangrove Recognition Index (CMRI)	$CMRI = NDVI - NDWI$
Gray-Level Co-Occurrence Matrix (GLCM)	GLCM Homogeneity	$\sum_{i=1}^{k}\sum_{j=1}^{k}\frac{P(i,j)}{1+(i+j)^2}$
	GLCM Contrast	$\sum_{n=0}^{k-1} n^2 \sum_{\lvert i-j\rvert=1} P(i,j)$
	GLCM Dissimilarity	$\sum_{i=1}^{k}\sum_{j=1}^{k}\lvert i-j\rvert P(i,j)$
	GLCM Entropy	$-\sum_{i=1}^{k}\sum_{j=1}^{k} P(i,j)\log[P(i,j)]$
	GLCM Mean	$\sum_{i=1}^{k}\sum_{j=1}^{k}\frac{\sum_{i=1}^{k}\sum_{j=1}^{k}P(i,j)}{n^2}$
	GLCM Std. Dev.	$\sum_{i=1}^{k}\sum_{j=1}^{k}[P(i,j)-\mu_{n*n}]^2$

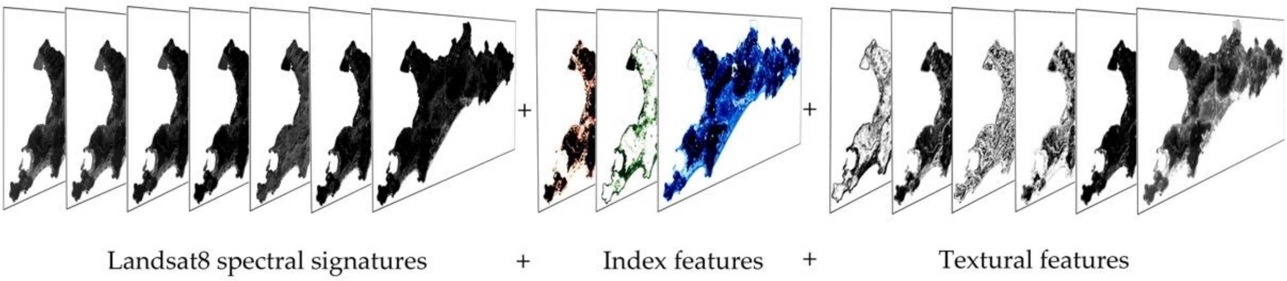


Figure 3. Multifeature fusion diagram (take Hailing Island as an example).

2.2.5. Random Forest Classification

Random forest (RF) is an integrated learning technology that can generate a large number of decision trees for the training, calculation, and classification of samples. The bagging method is adopted in RF to generate independent, identically distributed training sample sets for each decision tree, and the final classification result of the RF depends on the voting of all decision trees.

The RF algorithm is amplified as follows: (1) obtain N (N is a random positive number) training sample sets from a large number of original samples, by drawing with replacement N times; (2) select m (m is a random positive number) classification features randomly from the total features in each sample set; (3) divide the nodes of the decision trees by complete segmentation methodology, and then build a great number of decision trees. After completing the classification for each decision tree, the classes of new samples are determined by a majority vote according to the classification results of the decision trees [50].

The main idea of using the random forest to measure the importance of features is to evaluate the contribution of each feature in each decision tree, and to calculate the average values. Subsequently, the contribution value of features can be compared.

2.2.6. Visual Modification

This study involves various classification types, with the existence of the phenomenon of "different objects with the same spectrum". This leads to unavoidable ineffectiveness when distinguishing surface features. Therefore, in combination with the auxiliary data, the classification maps generated by RF were visually modified to enhance the classification accuracies.

3. Results

3.1. Classification Accuracy Evaluation

The accuracy assessment gave overall accuracies of 87.06~97.38% for the images of all the islands. Meanwhile, the kappa coefficient was 0.84~0.96. Images of larger islands coincide with higher accuracy, whereas images of smaller islands coincide with lower accuracy. The user and producer accuracies of the various thematic classes were over 81.3%, except for ponds (70.3%), reservoirs (72.7%), and bare lands (71.2%).

3.2. Types and Quantity of PLES Classification of the Islands in the Western Sea Area of Guangdong Province

Through the result of PLES classification, the number of PLES types on a single island range between 6 and 19. The PS types divided from the Landsat images include paddy field, dryland, salt pan, aquaculture pond, industrial land, tea garden, reservoir, pond, and ditch. The ES types include forestland, shelterbelt, mangrove forest land, wetland, beach, rock foreshore, mudflat, and stream. The LS types include rural residential land, urban residential land, harbor land, bare land, and highway land. Some secondary types of PLES are distributed only on certain islands. For example, in the PS, the industrial land and salt pan only appear on the sedimentary islands, a vast majority of irrigation ditches are distributed on the bedrock islands, and tea gardens are distributed only in a small area on the bedrock islands. Most mangrove forests and mudflats in the ES are distributed on the sedimentary islands. Only a few streams are distributed on the bedrock islands, while rock foreshores are mainly distributed in the relatively large area on the volcanic islands (Figures 4–6).

3.3. PLES Distribution Characteristics of the Three Types of Islands in the Western Sea Area of Guangdong Province

Overall, the areas of LS are less than both PS and ES in all types of islands. Rural residential lands are the main component of LS and are distributed dispersedly, while the urban residential land is mainly distributed on the bedrock islands. The aquaculture pond is the dominant land-use type in PS of the intertidal zone in the study area, with various proportion levels.

The bedrock islands are dominated by ES, with an area of 264.24 km^2, or 70.35% of the area of bedrock islands. The ES is mainly composed of forestland, which takes 48.0%~89.4% over the island area, and is concentrated distributed on the island–continent part. The ES of the intertidal zone is made up of rock foreshore, with a small area. The PS occupies a total area of 54.95 km^2, representing 14.63% of the bedrock island. The arable land of the island–continent part in bedrock islands takes up a large proportion, from 1.2% to 16.1%, except for Fengtou Island. The LS area of bedrock islands is 22.52 km^2, accounting for only 6.0% of the bedrock island's total area, and the quantity of the harbor land is more than other islands, as shown in Figure 7 and Table 5.

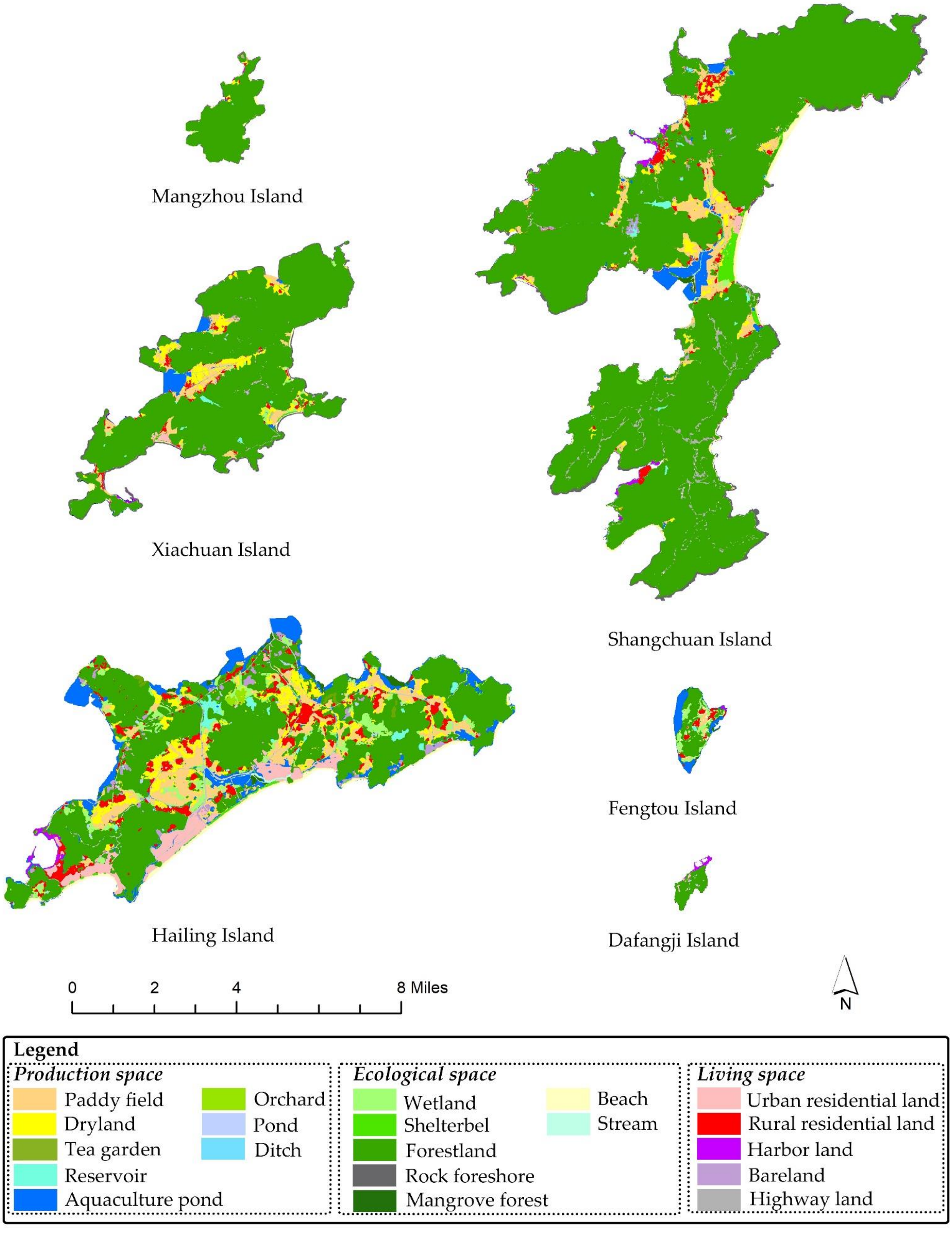


Figure 4. PLES classification of bedrock islands.

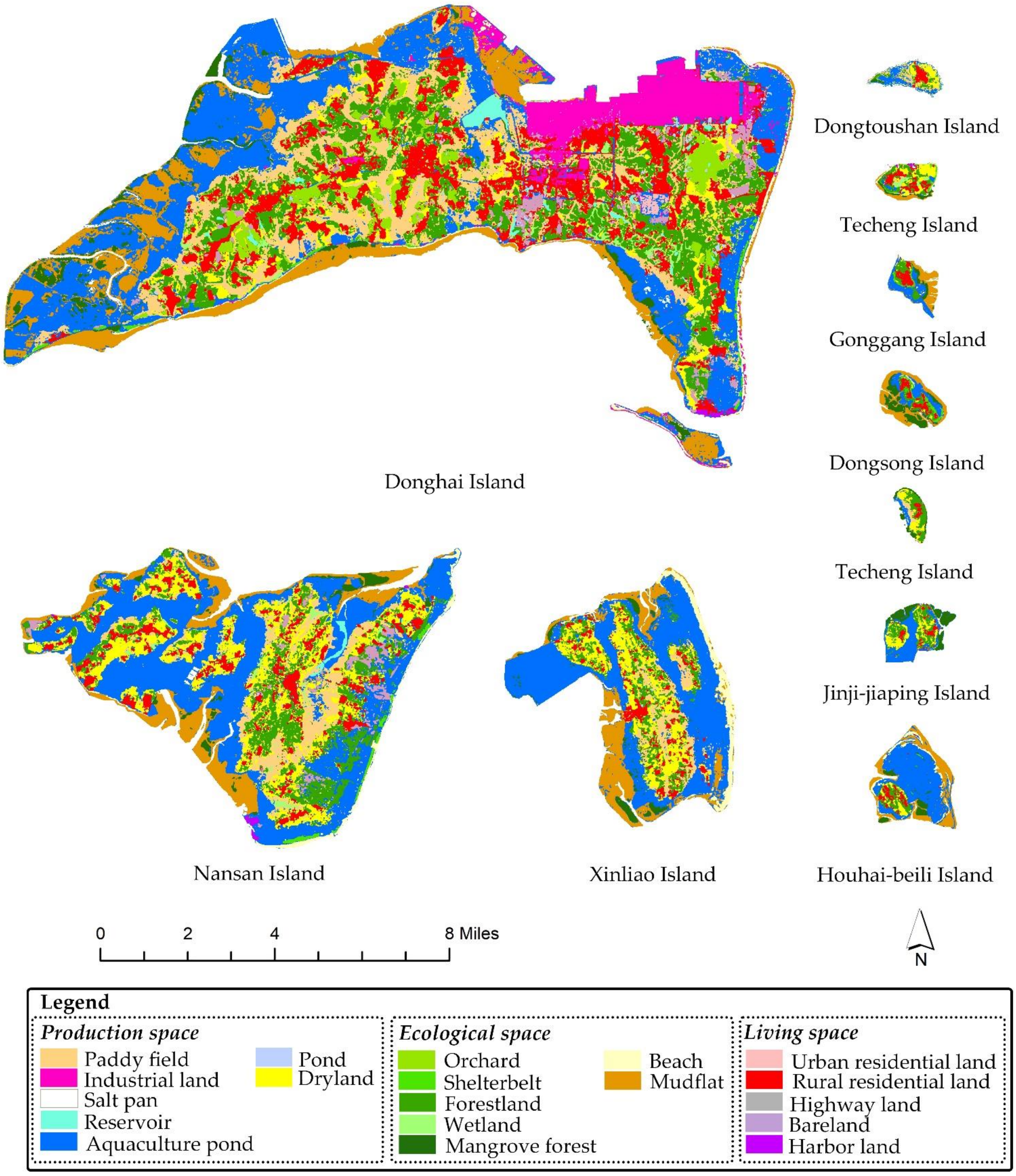


Figure 5. PLES classification of sedimentary island.

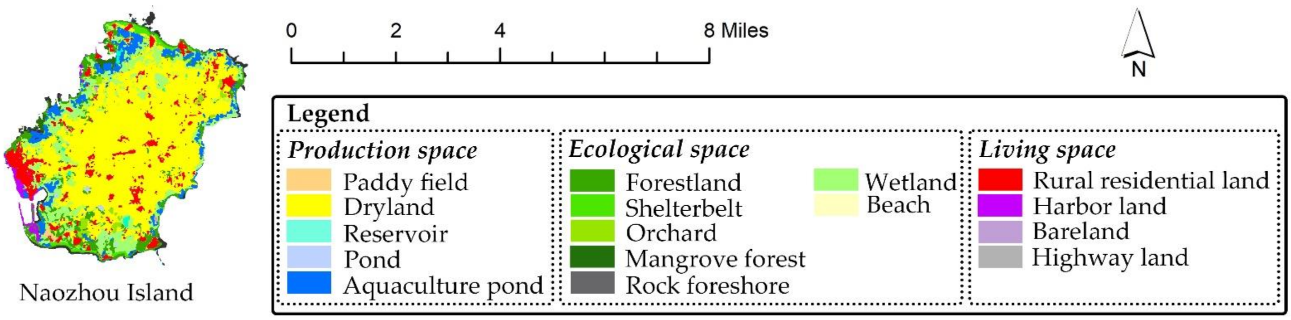


Figure 6. PLES classification of volcanic island.

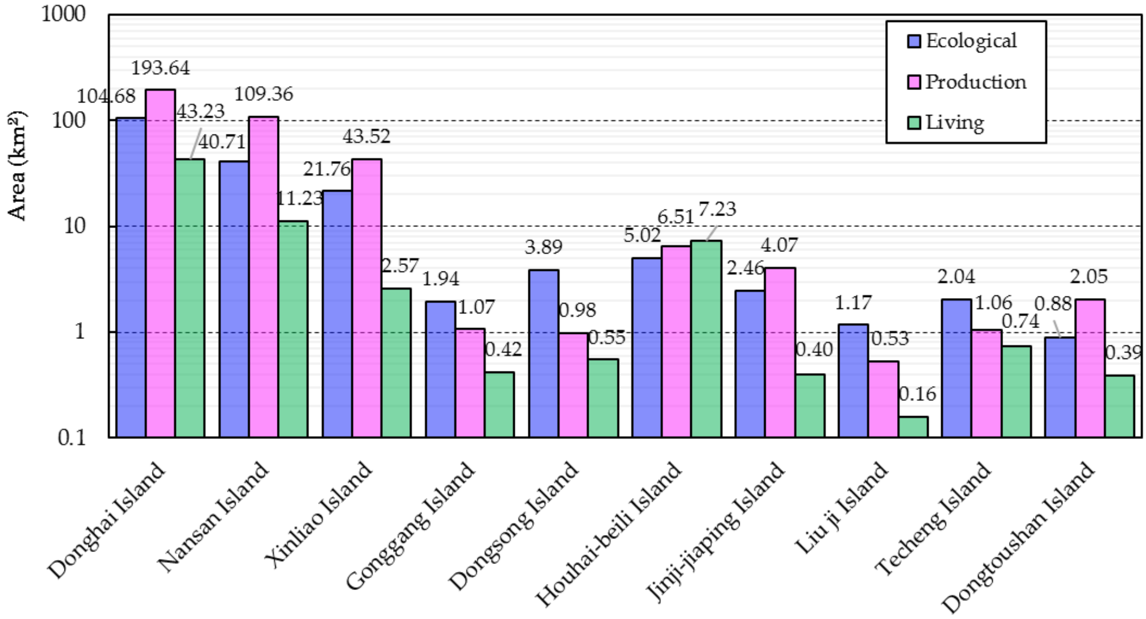


Figure 7. PLES distribution characteristics of sedimentary islands.

Table 5. The PLES pattern and connection between the island sizes and the PLES diversity.

Type of the Islands	Name of the Islands	The Area of the Island (km^2)	The Number of PLES	The Dominant Space of PLES	Dominant Plaque Type of PLES	Percentage of Dominant Patch Types in PLES (of Each Island)	Area of Dominant Patch Types in PLES (km^2)
Volcanic island	Naozhou Island	56.40	16	Production space	Dry farming	53.20%	27.89
Bedrock island	Hailing Island	108.90	19	Ecological space	Forestland	47.00%	51.64
	Shangchuan Island	157.00	18	Ecological space	Forestland	75.30%	103.36
	Xiachuan Island	98.32	13	Ecological space	Forestland	76.25%	63.39
	Mangzhou Island	6.82	9	Ecological space	Forestland	89.40%	5.38
	Fengtou Island	3.67	9	Ecological space	Forestland	41.37%	1.57
	Dafangji Island	1.23	5	Ecological space	Forestland	82.25%	1.06
Sedimentary island	Donghai Island	286.60	18	Production space	Aquafarm	20.27%	70.68
	Techeng Island	3.13	12	Production space	Dry farming	19.97%	0.77
	Nansan Island	123.40	15	Production space	Aquafarm	28.13%	41.26
	Dongtoushan Island	2.91	8	Production space	Aquafarm	27.36%	0.91
	Gonggang Island	1.26	7	Production space	Aquafarm	30.00%	1.02
	Dongsong Island	2.80	8	Ecological space	Mudflat	33.50%	1.81
	Houhai-beili Island	2.76	7	Production space	Aquafarm	50.69%	6.10
	Jinji-jiaping Island	4.54	6	Production space	Aquafarm	33.89%	2.09
	Liuji Island	1.94	6	Ecological space	Forestland	34.57%	0.82
	Xinliao Island	40.70	12	Production space	Aquafarm	33.17%	22.91

The sedimentary islands are dominated by PS, with an area of 362.79 km^2, or 77.26% of the sedimentary islands. In PS, the aquaculture pond is the dominant land-use type and is mainly distributed in the intertidal zone, and the area of aquaculture ponds on some islands even takes up 50%, while the paddy field occupies a large proportion of the island–continent part. The proportion of the intertidal zone of ES occupies an area of 184.55 km^2, or 39.3% of the island's total area, and is formed by mudflats and mangrove forests. In comparison, the ES of the island–continent part is composed of forest and shelterbelt. LS occupies an area of 66.92 km^2 (or 14.25%) of the sedimentary islands, as illustrated in Figure 8 and Table 5.

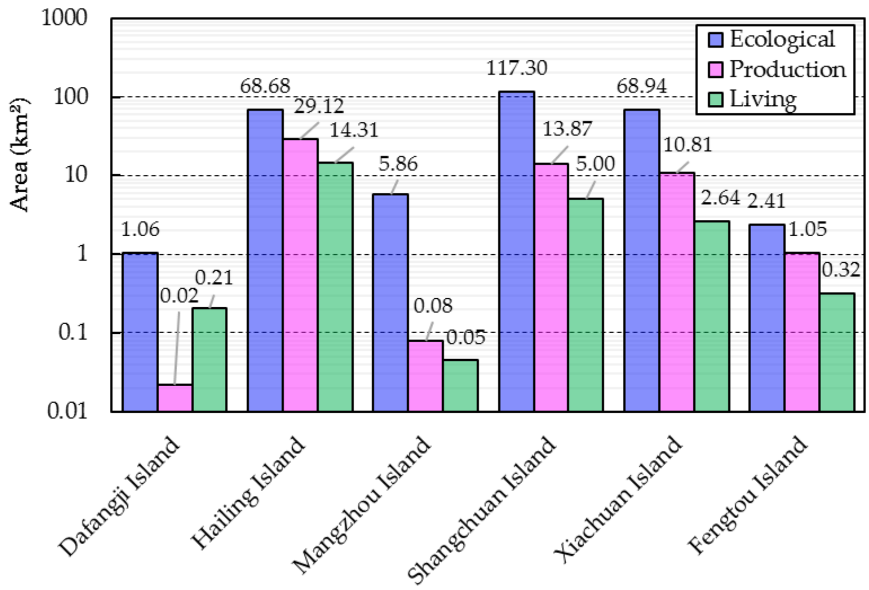


Figure 8. PLES distribution characteristics of bedrock islands.

The number of the volcanic island samples is less than that of other island types. The overall distribution of their PLES is similar to the sedimentary islands. PS takes an area of 32.87 km^2 or 58.69% of the island. The dominant land-use type in PS is day land (53.20%), and the intertidal zone is mainly occupied by aquaculture ponds. The ES on the island–continent part occupies 25.35% of the volcanic island and comprises wetland (13.80%), while rock foreshore takes a large proportion of the intertidal zone. The LS of volcanic islands occupies an area of 9.41% (see Figure 9 and Table 5).

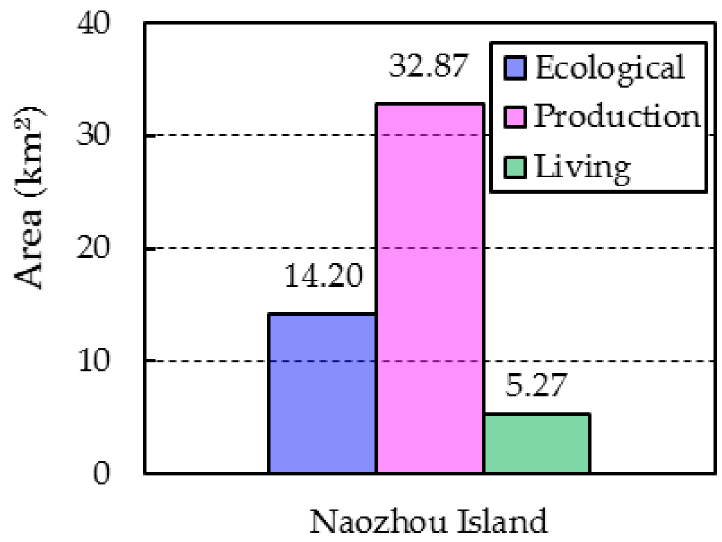


Figure 9. PLES distribution characteristics of volcanic islands.

4. Discussion

4.1. Satellite-Image-Classification-Based Method and Classification Accuracy

In this study, the accuracy of most images can reach a threshold of above 90%. Although some of the user and producer accuracies are lower than 80%, most have an accuracy between 81.3% and 99.5%, and such an accuracy threshold is deemed satisfactory for the studied area with complex and diverse land features categories [51].

4.2. The Formation and Distribution Mechanism of PLES from the Geomorphic Perspective

The PLES diversity in the studied area is closely related to island sizes. Usually, islands with a larger area have relatively complete geomorphic combinations with more developable geomorphic types [52]. This kind of island has more diversified PLES. In contrast, the landform of small islands is unitary. Some small bedrock islands only have hills and sandy beaches. Thus, the exploitation extent is limited, with less PLES (Table 5). Furthermore, the geomorphology of islands also influences the development level, dominant space, and distribution characteristics. According to the concept and method of Geomorphons [53], the geomorphic elements were extracted from DEM data by ArcGIS, and the PLES of different islands was analyzed in this study.

4.2.1. Bedrock Islands

The diversity of PLES in the bedrock islands dominated by hills is lower than that of the islands occupied by platforms. For example, the area of Hailing Island is similar to Xiachuan Island, but the PLES diversity of the former is higher because the platform occupies nearly 50% of the total area.

The hill and platform difference led to the ES and PS/LS dualistic pattern of the bedrock islands. Hills generally account for over 60% of the bedrock islands, and forest land in ES is mainly distributed in hilly areas, with an altitude of 16–517 m and steep slopes. Since hills are not developed on a large scale, a few primary and some secondary forests are preserved, with a large area of the artificial forest planted and the nature reserve established [54], leading to the idea that ES maintenance is better than that of other island types.

Generally, PS and LS are distributed on the platform at an altitude of 0–20 m. The platform area of the bedrock island is usually small; thus, the exploitation of PS and LS is limited. In PS, arable land irrigation mainly relies on reservoirs, resulting in more reservoirs reconstructed from bedrock islands than other islands under a water-scarce situation. In PS of the intertidal zone, since the shoal area is small, the aquaculture ponds cannot be built on a large scale. In LS, the natural environment of the bedrock islands is more suitable for harbor exploitation since they have a jagged coastline, deep near-shore water, and fewer barrier shoals. Thus, the number of harbor land in bedrock islands is more than that of other island types.

4.2.2. Sedimentary Islands

The altitude of the sedimentary island is 0–93 m, with over 95% of areas lower than 16 m, and the flat terrain caused a high level of exploitation indirectly, including small islands with an area of 1 km^2 to 3 km^2. Thus, the proportion of PS and LS in sedimentary islands is large.

The marine depositional plain and mudflat are the main geomorphic types of the sedimentary island, leading to the different dominant land-use types of PS and ES on the island–continent and intertidal zones. Sedimentary islands are formed by the deposition of sediment flow [55], during which more sandy lands are formed, with the low-lying wetlands evolving from tidal creeks on the island–continent. These landscapes are primarily turned into drylands and paddy fields. These islands, with a low vegetation coverage, are susceptible to desertification and storm surge invasion, so many casuarinas are cultivated for wind-breaking and sand-fixation in this area. Furthermore, the intertidal zone of the sedimentary island developed a large area of mudflat, offering the enabling environment for the mangrove forest growth and the aquaculture pond reclamation. Thus, the area and the density of aquaculture ponds far outweigh the other islands under disorderly exploitation.

4.2.3. Volcanic Island

Naozhou Island features a volcanic landform, which has the altitude ranging from 0 to 81 m and decreasing outward from the crater center with a gentle slope gradient. Thus, it is intensively exploited. Since loping fields on volcanic islands with a topographic relief gradient between 10–40 m lack surface water, many drought-tolerant crops are planted in this area, such as sweet potatoes, peanuts, and mung beans. Combined with the field research, local literature, and historical satellite maps, it is found that some lagoon and ancient lagoon landforms were developed on the coast and intertidal zone. The formation of harbor lands mainly relies on the lagoon landforms. While the wetlands mostly evolved from ancient lagoons and most reservoirs, paddy fields were exploited on this geomorphic type.

4.3. Problem Analysis of PLES and Exploitation Suggestions

4.3.1. Problem Analysis of PLES

The specialties of the small islands (e.g., low environmental carrying capacity and limited natural resources) restrict the production and living activities of the island. With the different degrees of anthropogenic activities and exploitation in various types of islands, the ecological environment has been affected at different levels: (1) The overall threat to ES in bedrock islands is less than that of other island types. Among them, ES of the island–continent part is less contaminated by agricultural and domestic sewage. The primary pollution risk is concentrated in the intertidal zone, mainly from the harbor lands and aquaculture ponds, especially in Hailing Islands. (2) The contradictions between PS, LS, and ES in the sedimentary island are more prominent. The problems are as follows: most sedimentary islands have no garbage disposal facilities except for the islands with large areas (e.g., Nansan Island and Donghai Island); much domestic and agricultural sewage threatens the ES of the island–continent part after intense exploitation, especially on the natural wetlands; and the mangrove forests and the mudflats in the intertidal zone are threatened by the high-density aquaculture ponds in disordered distribution. (3) According to the field investigation, the water shortage and overuse by tourism and agriculture are the main ecological issues for the volcanic island.

The production activities of the islanders were restricted by the frequent wind disasters and water scarcity of these islands. In order to increase their income, the islanders on the sedimentary and volcanic islands adopted large-scale and high-density aquaculture systems and drought-tolerant economic crop patterns. However, the income of islanders who participated in traditional agriculture is still unstable. This leads to the obvious population loss, farmland abandonment, and homestead hollowing of the agricultural areas. Although the islanders can increase their income by engaging in tourism on the bedrock islands, the islanders who participated in traditional agriculture face the same problems as the sedimentary islands and volcanic islands.

Overall, low exploitation can help to keep the PLES balance of small islands because it can sustain the available natural resources for production and living activities and have fewer threats to the ES. The PLES of bedrock islands maintains the balance through the low exploitation rate and comparatively abundant natural resources. However, the drastic human–land conflict causes a PLES imbalance on the sedimentary and volcanic islands.

4.3.2. Exploitation Suggestions

It is suggested that ecological carrying capacity and self-purification should be emphasized. Additionally, the core and buffer protection zones of the ecology and cultural relics should be established when further developing and planning these islands. To balance the PLES of these islands and meet the needs of the islanders, intensive agriculture, and fisheries, eco-friendly and novel industries with higher technologies can be introduced on these islands. Specifically, the development modes such as ecological tourism are more applicable to the bedrock islands. Ecological restoration should be considered before further exploiting the sedimentary islands. During the volcanic island exploitation, the agricultural planting structure and tourism mode should be fully considered for the sustainable use of water resources. Moreover, attention should be paid to the public infrastructure, such as the schools, transportation facilities, and garbage disposal facilities, to improve the livability of LS in these islands.

5. Conclusions

In the present study, Landsat images were used to identify and analyze the rural PLES of different island types in the western sea area of Guangdong Province, and the PLES distribution characteristics and formation mechanism were explored. The following conclusions can be drawn.

(1) It is found that the ecological and utilized area of the intertidal zone and neritic region should be combined with the island–continent part, and the distinct industrial type should be considered during the establishment of the rural island PLES classification system.
(2) The bedrock islands are dominated by ES, which is composed of forestlands. While the PS is the dominant space of sedimentary islands, and the aquaculture pond is the main land-use type. The dominant type of volcanic island is dryland. The rural residential lands are the main component of LS in all kinds of islands.
(3) Altitudinal gradient and geomorphic characteristics are the main driving factors for the formation and distribution of island rural PLES. In addition, the exploitation level, preference of dominant industries, and PLES contradiction of different island types are clarified from a geomorphology perspective.
(4) A comprehensive and targeted method of land-use classification and PLES establishment of the island is proposed in this study. Thus, this method is more applicable to the island areas, such as the Small Island Developing States, the small islands of other developing countries, or regions with similar natural resources. Moreover, it can be applied on the mesolevel and microlevel of space, as it is difficult to distinguish the boundaries between the cities and villages on the macrolevel. Additionally, this method could divide nonoverlapping boundaries and generate continuous geographical spatial maps with different functions. Therefore, the method is easier to accomplish in regional management and implement in the specific departments when facing practical applications.

This work only qualitatively analyzed the balance of the rural PLES of islands and how the rural PLES meet the needs of the islanders because the village-level social and economic data lacked statistics from the local statistical bureau. Such data is challenging to obtain from fieldwork. Nevertheless, a quantitative analysis of the social and economic data will be conducted in the future.

Author Contributions: Conceptualization, R.B. and Y.P.; methodology, R.B.; software, R.B.; validation, R.B.; formal analysis, R.B. and Y.P.; investigation, R.B. and Y.P.; resources, Y.S.; data curation, R.B., Y.S. and Y.P.; writing—original draft preparation, R.B.; writing—review and editing, R.B., Y.S. and Y.P.; visualization, R.B.; supervision, Y.S. and Y.P.; project administration, Y.S. and Y.P.; funding acquisition, Y.S. and Y.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Natural Science Foundation of China, grant number 51978275.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The supports from Bureaus of Natural Resources in Yangjiang City, Zhanjiang City, and Taishan City, Agricultural Departments and local government offices of the islands in the study area, Local Chronicles Museum are acknowledged. The technological advises from Cheng Jiang from Western Sydney University are well acknowledged.

Conflicts of Interest: The authors declare no conflict of interest.

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