Analysis of the Coupling Coordination and Obstacle Factors between Sustainable Development and Ecosystem Service Value in Yunnan Province, China: A Perspective Based on the Production-Living-Ecological Functions

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Abstract: The relationship and obstacles between sustainable development (SD) and ecosystem services (ESs) are crucial factors for SD decision-making and ecological conservation strategies. The production-living-ecological (PLE) functional perspective provides a new research entry point to analyze the interrelationship between the SD of human society and ESs. In view of this, based on the Sustainable Development Goals (SDGs), this study established an SD localization evaluation framework from the perspective of the PLE functions and subsequently evaluated the SD levels of 16 cities in Yunnan Province from 2005 to 2020. Furthermore, changes in the ecosystem service value (ESV) were explored by combining the PLE land classification and dynamic equivalence methods. The relationship between SD and ESV was then analyzed using the modified coupling coordination degree (CCD) model. Finally, the obstacle degree model was introduced to identify the main factors affecting the CCD level of the two systems. The results revealed the SD level in Yunnan Province to be high in the central region and low in other areas. From 2005 to 2020, the province’s SD level increased from 0.146 to 0.341. Furthermore, the main contribution of ESV originated from ecological land (over 90%). The ESV was higher in the southwest of Yunnan Province compared to that in the northeast. From 2005 to 2020, the ESV decreased by 2.231 billion CNY and was dominated by the regulation services. The CCD level increased significantly from 2005 to 2020. The CCD subcategory changed from SD lag to ESV lag and ESV-SD balanced type. Moreover, the dominant obstacle factors did not change significantly during the study period. The ESV and SD systems were dominated by regulation services and sustainable production subsystems, respectively. The research results have important guiding significance for further optimization of regional development strategies and ecological protection measures.

Keywords: production-living-ecological functions; sustainable development; ecosystem service value; coupling coordination; obstacle factors

1. Introduction

In order to promote the sustainable development (SD) of human society, the United Nations (UN) proposed Transforming our World: The 2030 Agenda for Sustainable Development based on the Millennium Development Goals in 2015 [1]. The agenda provides all-sided Sustainable Development Goals (SDGs) and a comprehensive indicator evaluation framework, including 17 main goals, 169 sub-goals and more than 300 specific indicators from the three dimensions of economy, society and environment [2]. However, due to
regional differences, SDGs are difficult to measure, and SDG indicators generated at the international level often cannot be directly used for regional SD evaluations [3]. In addition, SD issues and their corresponding foci vary by region or country, which makes it a challenge to scientifically evaluate the progress of SDGs [4]. Therefore, SD localization evaluation has become a hotspot of extensive research [5–7]. For example, Allen et al. selected 86 SDGs and 144 corresponding indicators through expert consultation based on the actual situation of Australia and evaluated the progress of these indicators [8]. Phillis et al. selected 46 environmental and socio-economic indicators and employed the fuzzy logic method to measure and rank the SD of 106 cities around the world [9]. Based on the SDG report, several scholars have designed and investigated index systems for the assessment of China’s SD [10,11].

Studies have shown that good ecosystem services (ESs) provide an important basis for the realization of SD and contribute to the accomplishment of multiple SDGs [12–14]. However, the development of human society has led to a series of problems in the ecosystem which limit the achievement process of SDGs [15,16]. This requires us to pay attention to the ESs closely related to the protection of human welfare while also considering strategies for the SD of human society [17–19]. The size of ecosystem service capabilities can be quantified by calculating the ecosystem service value (ESV) [20]. However, the number of ESVs is limited, which restricts the SD of human society [21]. Therefore, exploring the interaction between SD and ESV is of great significance for SD planning and ecological protection strategies.

At present, coupled coordination models are often used to investigate the degree of relevance between ESs and human social development [22]. Zhu et al. measured and analyzed the coupling coordination relationship between the two by calculating the ESV in Tangshan City, China and constructing an evaluation system at the urban development level [23]. Yang et al. studied the spatiotemporal heterogeneity of the coupling and coordination between four ecosystem services functions and the sustainable development at the county level in Shanxi Province, China [24]. These studies are excellent cases for enriching the theoretical basis of coordination and interaction between SD and ESs, but most of them only stay at the level of revealing the spatio-temporal variation characteristics of coupling coordination and do not deeply analyze the influencing factors that lead to changes in coupling coordination [25]. However, identifying the main obstacle factors is beneficial to provide useful information for optimizing the coordination relationship. Therefore, obstacle factor judgment and identification should be paid more attention to.

In 2012, in order to rationally plan future land use and ensure the stable and coordinated development of the social economy, the Chinese government proposed the goal of building “Efficient production space, suitable living space and beautiful ecological space” [26]. The essence behind this goal is the overall coordinated development of production-living-ecological (PLE) functions [27]. On the one hand, the realization of SDGs requires the overall sustainability of the economy, society and environment, which is strongly related to the comprehensive coordination of PLE functions [28]. However, in most existing studies, there is a general lack of connection between the comprehensive assessment of PLE functions and SDGs, which limits effective decision-making based on the perspective of PLE functions to maintain SD [29–31]. On the other hand, the land use-based PLE functional classification method can link the evolution of ESs from the perspective of production-living-ecological land changes of a region [32–34]. Hence, the production-living-ecological functions perspective provides a new research entry point to analyze the relationship between human social SD and ESs. In recent years, the urbanization level of Yunnan Province in China has continuously improved. Moreover, the transformation of land use has led to unprecedented changes in the ecosystem, which has consequently caused obvious changes in the type and value of ecosystem services [35–37]. However, due to the large population, special geographical environment, backward economic development level and many other factors in Yunnan Province, the PLE functions of various cities are becoming increasingly uncoordinated, seriously threatening regional SD [38,39]. Therefore, there is an urgent
need to investigate the coupling coordination and obstacle factors between SD and ESV in Yunnan Province from the perspective of PLE functions.

Based on the aforementioned issues, the objectives of this paper are as follows: (1) to evaluate SD level in Yunnan Province from the perspective of PLE functions by combining the actual situation of the province and the SDG requirements; (2) to analyze the spatial and temporal variation characteristics of ESV via the PLE land classification and the dynamic equivalent methods; (3) to explore the coupling and coordination relationship between SD and ESV in each city of Yunnan Province; and (4) to analyze the system obstacle factors and identify the key factors affecting the coupling coordination level of the two systems in Yunnan Province. This study will provide a new perspective for SD localization evaluation and exploration of the interaction between ESs and SD. The purpose of this paper is to provide a reference for SD decision-making and ecological protection strategies in Yunnan Province.

2. Materials and Methods
2.1. Study Area

Yunnan Province is located in the southwest of China, between 21°08′–29°15′ N and 97°31′–106°11′ E, as shown in Figure 1. Yunnan Province is a large agricultural province in China, which is represented by modern agriculture with plateau characteristics. In 2021, the total sown area of grain crops in the province was 419,137 km², with a total output of 19.303 million tons. As of 2021, the major land use types in Yunnan were forest land and cropland, with areas of 24.969 million and 5.396 million hectares, respectively. In 2021, Yunnan Province achieved a gross regional product (GDP) of 2714.676 billion CNY, ranking 19th among all Chinese provinces. The added value of the primary, secondary and tertiary industries was 387.017 billion CNY, 958.937 billion CNY and 1368.722 billion CNY, respectively. In addition, constructing transportation links in Yunnan is difficult due to the mountainous areas and distance between cities [40].

![Figure 1. Geographical location of the study area. (a) shows the geographical location of Yunnan Province in China; (b) shows the land use pattern in Yunnan Province in 2020.](image)

Yunnan Province was previously known to have the most poverty-stricken counties in China. In particular, by the end of 2012, 88 out of 129 counties in Yunnan Province were national-level poverty-stricken counties, with more than 8.8 million people living in
poverty, and the poverty incidence rate of the province exceeded 20 percent. Although Yunnan Province eliminated absolute poverty by the end of 2020, its poverty level is affected by numerous factors such as historic and natural conditions. Thus, the poverty remains widespread and deep. Therefore, there is an urgent need to further consolidate the achievements of poverty alleviation and to prevent poverty. More specifically, the population’s production and lifestyle must be improved, and importance to environmental protection should be a key focus for the enhancement of regional SD levels. Furthermore, Yunnan Province includes more than 30 ecosystem types (classified by China) and is an important ecological security barrier [41]. The Chinese government is deeply concerned about the construction of ecological civilization and ecological environment maintenance in Yunnan Province. Unfortunately, Yunnan Province is essentially a mountainous terrain, and its ecological environment is extremely fragile [42]. With the development of human economy and society, the ecosystem functions of Yunnan Province have been destroyed to a great extent. At present, the province is facing the conflict between the SD of human society and ecological protection and management [43].

2.2. Data Source and Processing

Land use remote sensing monitoring data (30 m spatial resolution), DEM data (90 m spatial resolution) and soil type spatial distribution data (1000 m spatial resolution) of Yunnan Province from 2005 to 2020 were obtained from the Data Center for Resources and Environmental Sciences and Chinese Academy of Sciences (http://www.resdc.cn, accessed on 22 July 2022). Net primary productivity (NPP) data (500 m spatial resolution) of Yunnan Province from 2005 to 2020 were obtained from NASA (https://www.nasa.gov/, accessed on 30 June 2022). Precipitation data (1000 m spatial resolution) of Yunnan Province from 2005 to 2020 were obtained from the National Earth System Science Data Sharing Service Platform (http://www.geodata.cn/, accessed on 17 March 2022). Socio-economic and environmental indicator data were obtained from the Yunnan Statistical Yearbook. A few missing indicators are supplemented from the statistical yearbooks and statistical bulletins of the corresponding municipalities (https://data.cnki.net/, accessed on 26 September 2022). Among them, the land use data were divided into six primary categories and 25 specific secondary categories. The overall accuracy rates of primary and secondary land use types were 94.3% and 91.2%, respectively [44,45], which met the requirements of this study. The maps in this study were processed and plotted by ArcGIS 10.8. The charts were plotted using Origin 2019b and the R package [46].

2.3. Methods

2.3.1. SD Evaluation System Based on PLE Functions

The ultimate goal of both the plan and the optimization of PLE functions is to achieve the targets of China’s SDGs and “Beautiful China” [32,47]. Therefore, in this paper, sustainable development is divided into three levels: production sustainability, living sustainability and ecological sustainability. A total of 33 indicators were selected to construct a sustainable development measurement evaluation system in this study (Table 1). This selection was based on previous studies on localized design indicators for SDGs in China [10,11] and the comprehensive sustainability evaluation of PLE functions [29,31], as well as consultation with experts while considering the specific situation of the study area and data availability. The focus of production sustainability is to reflect regional production capacity and select appropriate indicators related to economic development level, agricultural production and non-agricultural production [48]. In terms of living sustainability, regional living standards and service levels are considered to reflect the degree of suitability and security of life. An ecological sustainability assessment selects indicators related to environmental remediation and ecological maintenance to reflect the pollution degree, improvement level and maintenance ability of the ecological environment. The sustainable development evaluation index selects “human-centered” as the starting point and “production-living-ecological” comprehensive sustainability as the ultimate goal.
<table>
<thead>
<tr>
<th>Target Layer</th>
<th>Criterion Layer</th>
<th>Indicator Layer</th>
<th>Unit</th>
<th>Owned SDGs</th>
<th>Nature of Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td>Per capita cultivated area (S1)</td>
<td>mu/person</td>
<td>SDG2</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Per capita grain output (S2)</td>
<td>kg/person</td>
<td>SDG2</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Per capita gross output value of agriculture, forestry, animal husbandry, and fishery (S3)</td>
<td>CNY/person</td>
<td>SDG8</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of secondary industry (S4)</td>
<td>%</td>
<td>SDG8</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of third industry (S5)</td>
<td>%</td>
<td>SDG8</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total labor productivity (S6)</td>
<td>10^4</td>
<td>SDG8</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sustainable</strong></td>
<td></td>
<td>Number of scientific and technical personnel (S7)</td>
<td>person</td>
<td>SDG9</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Density of economy (S8)</td>
<td>10^8 CNY/km^2</td>
<td>SDG8</td>
<td>+</td>
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<tr>
<td></td>
<td></td>
<td>Financial contribution rate (S9)</td>
<td>10^4 CNY/km^2</td>
<td>SDG8</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total import and export trade (S10)</td>
<td>10^8 dollars</td>
<td>SDG8</td>
<td>+</td>
</tr>
<tr>
<td><strong>development</strong></td>
<td><strong>Living</strong></td>
<td>Per capita total retail sales of consumer goods (S16)</td>
<td>10^8 CNY/10^4 people</td>
<td>SDG2</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population mortality rate (S17)</td>
<td>%</td>
<td>SDG3</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of hospital beds per 10,000 people (S18)</td>
<td>Per 10,000 people</td>
<td>SDG3</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average wage of working staff (S19)</td>
<td>CNY</td>
<td>SDG8</td>
<td>+</td>
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<tr>
<td></td>
<td></td>
<td>Urban registered unemployment rate (S20)</td>
<td>%</td>
<td>SDG8</td>
<td>–</td>
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<tr>
<td></td>
<td></td>
<td>Gas penetration rate (S21)</td>
<td>%</td>
<td>SDG9</td>
<td>+</td>
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<tr>
<td></td>
<td></td>
<td>Per capita park green area (S22)</td>
<td>m^2/person</td>
<td>SDG11</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of full-time teachers in primary schools (S23)</td>
<td>person</td>
<td>SDG4</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of full-time teachers in secondary schools (S24)</td>
<td>person</td>
<td>SDG4</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Industrial exhaust emissions (S25)</td>
<td>Ten thousand cubic meter</td>
<td>SDG12</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulfur dioxide emission level (S26)</td>
<td>Ten thousand tons</td>
<td>SDG12</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fertilizer application rate (S27)</td>
<td>Ten thousand tons</td>
<td>SDG2</td>
<td>–</td>
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<tr>
<td></td>
<td></td>
<td>Industrial wastewater discharge (S28)</td>
<td>Ten thousand tons</td>
<td>SDG12</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centralized treatment rate of sewage treatment plant (S29)</td>
<td>%</td>
<td>SDG6</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Harmless disposal rate of household garbage (S30)</td>
<td>%</td>
<td>SDG11</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>General industrial solid waste comprehensive utilization rate (S31)</td>
<td>%</td>
<td>SDG12</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Forest coverage rate (S32)</td>
<td>%</td>
<td>SDG15</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water resources per capita (S33)</td>
<td>m^3/person</td>
<td>SDG6</td>
<td>+</td>
</tr>
</tbody>
</table>

Note: The “mu” is a common unit of land measurement in China and is equivalent to 666.7 m^2.

2.3.2. PLE Land Classification

Land has multiple functions, and the functional attributes of each land type have a primary and secondary distinction. In this paper, according to the Classification of Land Use Status (GB/T21010-2017) [49], while referring to the existing PLE land classification studies [32,50,51], and combined with the actual situation of Yunnan Province, the scoring guidelines for the correspondence between PLE land and land use types were established based on the primary and secondary relationships between different land use types in production, living and ecological functions (Table S1). The function scores corresponding to the land were divided into four levels from high to low: 5 (high), 3 (medium), 1 (low) and 0 (none).

2.3.3. Dynamic Evaluation of ESV

The ESV dynamic equivalent method can comprehensively estimate the changes in ecosystem services [52]. We employed the basic equivalent data of ecosystem service value summarized by predecessors [53,54] (Table S2). First, NPP, precipitation and soil
conservation data were used to calculate the adjustment coefficient, so as to dynamically adjust the basic equivalent of ESV in time and space. Second, the sown area and yield of three major crops (rice, wheat and corn) from 2005 to 2020 and the average price of three crops in the last 15 years were selected as the basic data. The average economic value of an ESV equivalent factor in Yunnan Province from 2005 to 2020 was determined as 1597.23 CNY/ha. Finally, combined with the land use/cover data, the ESV of Yunnan Province was calculated. For more details on the dynamic equivalent method of ESV, please refer to [52,54,55] and the supporting materials.

2.3.4. Weight Setting and Comprehensive Evaluation

In order to eliminate the impact caused by the different dimensions of the index data, we initially processed the index data using the range standardization method. For specific details and the formula of this method please refer to [56]. Following this, the entropy method was employed to calculate the indicator weights, so as to eliminate subjective factors in determining the weights [57]. Finally, the comprehensive values of SD and ESV were obtained as follows [57]:

\[ e_i = -k \sum_{i=1}^{n} Q_{ij} \ln Q_{ij}; \quad k = \frac{1}{\ln m}; \quad Q_{ij} = \frac{X_{ij}}{\sum X_{ij}} \]  

(1)

\[ h_i = 1 - e_i \]  

(2)

\[ W_i = h_i / \sum_{i=1}^{n} h_i \]  

(3)

\[ Z_j = \sum_{i=1}^{n} W_i \cdot X_{ij} \]  

(4)

where \( e_i \) is the information entropy of the evaluation index; \( Q_{ij} \) is the proportion of the \( j \) unit index value of the \( i \) index; \( X_{ij} \) is the standardized value of the SD or ESV system evaluation index; \( n \) is the number of research units; \( h_i \) is the information utility value of the system index; \( W_i \) is the weight of the system index; and \( Z_j \) is the comprehensive value of SD or ESV for unit \( j \).

2.3.5. Modifying the Coupling Coordination Degree Model

The coupled coordination model can be used to measure the degree of collaboration and coordination between two or more subsystems in a complex system. As the interpretation of the coupling degree (CD) depends on its interval distribution, the coupling degree value calculated by the traditional coupling model may have an uneven distribution phenomenon, which reduces its validity. Therefore, in order to ensure that the coupling degree was evenly distributed within the range of \([0, 1]\), this paper referred to Wang et al. [58] and established the modified coupling model as follows:

\[ U_{SD} > U_{ESV}, C = \sqrt{\frac{1 - [U_{SD} - U_{ESV}]}{U_{SD}}} \times \frac{U_{ESV}}{U_{SD}}, \]  

(5)

\[ U_{SD} < U_{ESV}, C = \sqrt{1 - [U_{ESV} - U_{SD}]} \times \frac{U_{SD}}{U_{ESV}}, \]  

(6)

where \( U_{SD} \) and \( U_{ESV} \) represent the SD level and ESV, respectively, and \( C \) represents the coupling degree value. The larger the value, the stronger the interaction between the two systems. In particular, when \( U_{SD} = U_{ESV}, C \) is equal to 1. The coupling degree can only reveal the degree of interaction between the two systems, and cannot identify the
coordination level of between ESV and SD. In order to overcome this, we introduced the coupling coordination degree model [58]:

\[ D = \sqrt{C \times T}, \] (7)

\[ T = aU_{SD} + \beta U_{ESV} \] (8)

where \( T \) is the comprehensive level of the SD and ESV values; and \( D \) is the coupling coordination degree (CCD) of the two systems. As sustainable development and ecosystem services are equally important [24], we adopted \( \alpha = 0.5 \) and \( \beta = 0.5 \).

According to the range of \( D \) values, the coupling coordination degree was divided into six categories: level I represents quality coordination, \( D \in (0.8, 1] \); level II is intermediate coordination, \( D \in (0.6, 0.8] \); level III is primary coordination, \( D \in (0.4, 0.5] \); level IV is basic incoordination, \( D \in (0.2, 0.4] \); and level VI is extreme incoordination, \( D \in (0, 0.2] \). Furthermore, according to the relationship between \( U_{SD} \) and \( U_{ESV} \), the types of coupling coordination were subdivided: when \( U_{SD} - U_{ESV} > 0.1 \), the ecosystem services lagged behind; when \( U_{ESV} - U_{SD} > 0.1 \), the SD level lagged behind; and when \( 0 < |U_{SD} - U_{ESV}| < 0.1 \), there was a relative balance between the ecosystem services and SD level [57,59]. See Table S3 for more details.

### 2.3.6. Obstacle Degree Model

The obstacle degree model was adopted to identify the leading obstacle factors affecting the CCD relationship between SD and ESV as follows [60,61]:

\[ I_{ij} = 1 - Y_{ij}, \] (9)

\[ h_j = \left( F_j I_{ij} / \sum_{j=1}^{m} F_j I_{ij} \right) \times 100\%, \] (10)

\[ H_j = \sum h_j \] (11)

where \( Y_{ij} \) is the index standard value; \( I_{ij} \) is the index deviation degree, that is, the difference of the target value of a single index; \( F_j \) is the factor contribution degree, namely the weight of a single index; and \( h_j \) and \( H_j \) are the obstacle degree of the index layer and system layer to CCD, respectively.

### 3. Results

#### 3.1. SD Change Analysis

##### 3.1.1. Time Changes of SD

Figure 2a–d shows the change trends of production sustainability, living sustainability, ecological sustainability and SD, respectively, of 16 cities in Yunnan Province during 2005–2020. From 2005 to 2020, an increase in the level of production sustainability, living sustainability and SD occurred in all cities. Although ecological sustainability in 2020 was slightly higher than that in 2005, its change process fluctuated during the study period. The average value of production sustainability increased from 0.040 in 2005 to 0.116 in 2020 (Figure 2a). The production sustainability growth rate between 2010 and 2015 was faster than that in other periods. Figure 2b shows that the mean value of living sustainability had increased from 0.056 to 0.168. The average value of ecological sustainability was 0.049 in 2005, 0.056 in 2010, 0.051 in 2015 and 0.057 in 2020 (Figure 2c), indicating this variable to initially increase, subsequently decrease and then increase again. Figure 2d demonstrates the average SD value of cities in Yunnan Province increased by 0.195 from 0.146 to 0.341 during 2005–2020.
2020 (Figure 2a). The production sustainability growth rate between 2010 and 2015 was faster than that in other periods. Figure 2b shows that the mean value of living sustainability had increased from 0.056 to 0.168. The average value of ecological sustainability was 0.049 in 2005, 0.056 in 2010, 0.051 in 2015 and 0.057 in 2020 (Figure 2c), indicating this variable to initially increase, subsequently decrease and then increase again. Figure 2d demonstrates the average SD value of cities in Yunnan Province increased by 0.195 from 0.146 to 0.341 during 2005–2020.

Figure 2. Sustainable development trend of Yunnan Province from 2005 to 2020. (a–d) are the changes in production sustainability, living sustainability, ecological sustainability and overall sustainable development level, respectively.

3.1.2. Spatial Changes of SD

Figure 3 reveals an obvious spatial gradient difference in the SD levels of cities in Yunnan Province. There is generally a good agreement between the spatial pattern of production sustainability, living sustainability and SD. In 2005, Kunming exhibited the highest SD, with lower levels for other cities. Thus, the province center had the highest value, while levels were low for the province edges. By 2020, the levels of central and eastern Yunnan were distinctly higher than those of western Yunnan. In contrast, an opposite trend was observed for ecological sustainability, whereby the west was stronger than the east. More specifically, by 2020, the clusters of high-value production sustainability areas were mainly Kunming, Yuxi and Qujing in central and eastern Yunnan, and Dehong, Xishuangbanna and Honghe in the border cities. Dali, Chuxiong, Pu’er and Baoshan belonged to the second highest value level, while Nujiang, Diqing, Lijiang, Lincang, Wenshan and Zhaotong belonged to the third level. Moreover, Kunming, Yuxi and Qujing in central and eastern Yunnan exhibited the highest living sustainability level by 2020, and the Nujiang in northwest Yunnan had the lowest level. The ecological sustainability in western Yunnan was obviously higher than that in eastern Yunnan, and the improvement of urban ecological sustainability in western Yunnan exceeded that in eastern Yunnan. By 2020, the highest levels of ecological sustainability were found in Diqing and Nujiang in northwestern Yunnan, and the lowest in Kunming and Qujing in central and eastern Yunnan. Due to the increasing sustainability level of the three subsystems, the comprehensive SD level of all cities from 2005 to 2020 exhibited an increasing trend. Among them, the change of Kunming was the most prominent (0.46), increasing from 0.31 in 2005 to 0.77 in 2020.
western Yunnan was obviously higher than that in eastern Yunnan, and the improvement of urban ecological sustainability in western Yunnan exceeded that in eastern Yunnan. By 2020, the highest levels of ecological sustainability were found in Diqing and Nujiang in northwestern Yunnan, and the lowest in Kunming and Qujing in central and eastern Yunnan. Due to the increasing sustainability level of the three subsystems, the comprehensive SD level of all cities from 2005 to 2020 exhibited an increasing trend. Among them, the change of Kunming was the most prominent (0.46), increasing from 0.31 in 2005 to 0.77 in 2020.

Figure 3. Spatial pattern changes in the sustainable development in Yunnan Province from 2005 to 2020.

3.2. PLE Land and ESV Change Analysis

3.2.1. Temporal and Spatial Changes of PLE Land

Ecological land is mainly concentrated on the western and southern areas of Yunnan Province, while land for living and production is relatively concentrated on the central and eastern parts of Yunnan Province. From 2005 to 2020, the land for living in central and eastern Yunnan continued to expand, leading to a significant decrease in production land and ecological land (Figure 4a). The proportion (in area) of the three land types in Yunnan Province was determined as follows: ecological land > production land > living land. From 2005 to 2020, production land and ecological land continued to decrease by 1188.131 km² and 1387.270 km², respectively. The area for production land accounted for 0.57% in 2005 and 1.24% in 2020, an increase of 0.67% (Figure 4b). In addition, the land transformation in 2005–2010 and 2015–2020 was greater than that in 2010–2015.

3.2.2. Temporal and Spatial Changes of ESV

The adjustment coefficients of precipitation, NPP, and soil conservation were high in southwest Yunnan Province and low in northeast Yunnan Province. Moreover, the adjustment coefficient of precipitation varied greatly from year to year, particularly in southern and eastern Yunnan Province. The adjustment coefficient of NPP increased in central and eastern Yunnan Province. However, soil conservation exhibited significant changes only in the western part of Yunnan Province (Figure S1).

The spatial distribution of ESV in Yunnan Province was significantly different, with lower ESV levels in the northeast and northwest regions and higher ESV in the southwest.
The water area exhibited the highest ESV, exceeding 75,000 CNY/ha, while the lowest ESV was observed for construction land, with a negative value. In addition, the distribution range of the second highest value area of ESV density (50,000–75,000 CNY/ha) in Xishuangbanna and Pu’er in southern Yunnan Province presented a significant reduction from 2015 to 2020.

Figure 4. PLE Land change in Yunnan Province from 2005 to 2020. (a) is the change in spatial pattern of PLE land; (b) is the change in the percentage of PLE land area.

Figure 6a presents the changes in primary ecosystem service types (Figure 6a). The total amount of ESV in Yunnan Province exhibited a downward trend during the study period, decreasing from 1036.036 billion CNY in 2005 to 1033.805 billion CNY in 2020. This is a total decrease of 2.231 billion CNY. However, the ESV change process fluctuated under the influence of the dynamic equivalent. More specifically, the total ESV in Yunnan Province decreased from 2005 to 2010, followed by a rapid increase from 2010 to 2015, and a significant decline from 2015 to 2020. The regulation service value occupied the highest proportion among ecosystem services in Yunnan Province. According to the statistics, the value of regulation services reached 690.278 billion CNY in 2020, accounting for 66.77% of the total ESV. Support services were the second most important service type for ESV, accounting for approximately 23.18%. The supply and cultural services exhibited the lowest values, accounting for 5.31% and 4.73%, respectively. Furthermore, the value of the supply, support and cultural services decreased from 57.147, 241.646, and 49.201 billion CNY to 54.992, 239.688, and 48.857 billion CNY, respectively, while the value of regulation services increased from 688.042 to 690.278 billion CNY.
Figure 5. Spatial distribution patterns in ESV density in Yunnan Province during 2005–2020.

Figure 6a presents the changes in primary ecosystem service types (Figure 6a). The total amount of ESV in Yunnan Province exhibited a downward trend during the study period, decreasing from 1036.036 billion CNY in 2005 to 1033.805 billion CNY in 2020. This is a total decrease of 2.231 billion CNY. However, the ESV change process fluctuated under the influence of the dynamic equivalent. More specifically, the total ESV in Yunnan Province decreased from 2005 to 2010, followed by a rapid increase from 2010 to 2015, and a significant decline from 2015 to 2020. The regulation service value occupied the highest proportion among ecosystem services in Yunnan Province. According to the statistics, the value of regulation services reached 690.278 billion CNY in 2020, accounting for 66.77% of the total ESV. Support services were the second most important service type for ESV, accounting for approximately 23.18%. The supply and cultural services exhibited the lowest values, accounting for 5.31% and 4.73%, respectively. Furthermore, the value of the supply, support and cultural services decreased from 57.147, 241.646, and 49.201 billion CNY to 54.992, 239.688, and 48.857 billion CNY, respectively, while the value of regulation services increased from 688.042 to 690.278 billion CNY.

Figure 6b reveals obvious differences in the total ESV among all cities. Pu’er had the highest total ESV, followed by Honghe, while Dehong exhibited the lowest value. From 2005 to 2020, the change trend of total ESV in prefecture-level cities was also different. The total ESV of Baoshan, Chuxiong, Dali, Honghe, Kunming, Lijiang, Qujing, Wenshan, Xishuangbanna and Yuxi presented a downward trend, with Kunming exhibiting the most prominent reduction. This is related to the conversion of a large amount of cultivated and forest land into construction land during the rapid urbanization process. The total ESV of Dehong, Diqing, Lincang, Nujiang, Pu’er and Zhaotong showed an increasing trend, with the largest increase identified for Pu’er, at 1.85 billion CNY.
Figure 6. Changes of different ecosystem service types in Yunnan Province from 2005 to 2020. (a) Value and total ESV changes for primary ecosystem service types; (b) total ESV change for each city in Yunnan; (c,d) are the percentage and change values for secondary ecosystem service types, respectively.

In terms of secondary ecosystem service types (Figure 6c), climate regulation and hydrological regulation services were the main contributors to ESV in Yunnan Province, accounting for approximately 50%. This was followed by soil conservation, biodiversity and gas regulation services, accounting for about 30%. According to the statistical analysis of the value changes in the secondary ecosystem service types (Figure 6d), from 2005 to 2020, only the value of hydrological regulation service increased, while the values of the remaining ecosystem service types decreased. Among them, the values of the gas and climate regulation services decreased by more than two billion CNY. Moreover, hydrological regulation services exhibited a significant increase in its values during 2010–2015 compared to 2005–2010, while a sharp reduction was observed during 2015–2020, which is consistent with the trend of total ESV for the whole province. This can be attributed to the spatio-temporal regulatory factors of precipitation, which are closely related to hydro-
logical regulatory services, and fluctuated greatly in Yunnan Province during 2005–2020 (Figure S1).

The greatest contribution of total ESV in Yunnan Province was from ecological land, accounting for more than 90%. This is followed by production land, accounting for about 5%. The ESV of living land consistently exhibited a loss. In 2020, the ESV of production land, living land and ecological land was 41.757 billion CNY, −8.942 billion CNY and 1000.990 billion CNY, respectively (Figure 7a). The ESV of production land increased continuously from 2005 to 2015, and it decreased from 2015 to 2020. From 2005 to 2020, the ESV of production land increased by 76.002 million CNY, while the ESV of living land continued to decrease from 2005 to 2020, a total decline of 4.893 billion CNY. During the study period, the ESV of ecological land initially decreased, then increased and subsequently decreased again, resulting in a total increase of 2.592 billion CNY (Figure 7b).

Figure 7. ESV changes of PLE land in Yunnan Province during 2005–2020. (a) shows the total ESV of production, living and ecological land; (b) shows the changes in ESV of production, living and ecological land during different period.

3.3. Analysis of Coupling Coordination between SD and ESV

3.3.1. Analysis of Coupling Degree between SD and ESV

Figure 8 presents the spatial distribution of the coupling degree (CD) in each city of Yunnan Province from 2005 to 2020. The CD between SD and ESV exhibited obvious differences in Yunnan Province. However, in general, the coupling relationship gradually improved and by 2020, and the coupling relationship of most cities was maintained at a medium-high level coupling stage (0.6–1). The CD in northwestern Yunnan was higher than that in southeastern Yunnan. The CD was observed to decline in Kunming, Zhaotong, Qujing, Wenshan and Pu’er due to a mismatch between their development levels and ecosystem service supplies. This gap gradually increased, leading to the continuous decrease of CD.
3.3.2. Analysis of Coupling Coordination Degree between SD and ESV

Figure 9 presents the dynamic change of CCD between SD and ESV. Although the CCD of SD and ESV differed among cities, the change trend in the CCD of cities within the same region was consistent. In central Yunnan, Kunming, Yuxi and Chuxiong exhibited the same change trend, with the CCD initially increasing, then decreasing and subsequently increasing again. Note that the change range of Kunming was greater than that of Yuxi and Chuxiong. In eastern Yunnan, the CCD of Qujing and Zhaotong increased from 2005 to 2015 but decreased significantly after 2015. In the west Yunnan region, the CCD of all the cities increased from 2005 to 2020. The CCD in Dali fluctuated significantly from 2005 to 2020. In southern Yunnan, the CCD of Honghe and Xishuangbanna showed an increasing trend, while the CCD of Pu’er and Wenshan increased prior to 2015 and decreased thereafter. In terms of the whole province and study period, the most obvious increase in CCD was observed for Dehong, with an increase of 0.22, followed by Baoshan and Lincang, with an increase of 0.194 and 0.188, respectively. Only Kunming, Qujing, Zhaotong, Wenshan and Pu’er presented a declining CCD, among which Pu’er showed the most obvious decrease of 0.16.
3.3.3. Analysis of Levels and Types of Coupling Coordination between SD and ESV

We divided the levels and types of coupling coordination of cities in different regions of Yunnan Province (Figure 10). For the CCD, from 2005 to 2020, the coordination level between ESV and SD in Diqing, Nujiang, Dehong, Dali, Baoshan, Lincang, Lijiang and Xishuangbanna changed from intermediate incoordination (V) to primary coordination (III). The coordination state of Kunming and Qujing experienced the sequential processes of primary coordination (III), intermediate coordination (II), basic incoordination (IV), and primary coordination (III). The coordination level of Chuxiong, Qujing, Yuxi, Zhaotong, Honghe, Pu’er and Wenshan did not significantly improve, but fluctuated between intermediate incoordination (V) and basic incoordination (IV). In terms of CCD type, in 2005, the coupling coordination type of most regional cities generally lagged behind the level of SD. By 2020, all cities in western Yunnan and Xishuangbanna in southern Yunnan exhibited a relative balance between SD levels and ESV, while other cities presented a lag in ESV.

Figure 10. Levels and types of coupling coordination between SD and ESV in different regions of Yunnan Province during 2005–2020.

3.4. Obstacle Degree Analysis

Formulas (9)–(11) were used to analyze the obstacle degree of the subsystem and index layers of the SD and ESV systems, allowing us to determine the key factors affecting the SD and CCD in Yunnan Province. In terms of the subsystem (Table 2), the leading obstacle factor for the SD subsystem was production sustainability, accounting for more than 50%.
The barrier to ecological sustainability was the lowest, at just 10%. For the ESV system, the obstacle degree of regulation services was the largest, exceeding 30%, while the lowest was observed for cultural services, less than 10%. In addition, the obstacle degree of living sustainability in Yunnan Province was observed to decrease each year. However, that of production and ecological sustainability increased, revealing that the constraints of both on CCD are continuously highlighted.

Table 2. Subsystem layer obstacle factor and obstacle degree.

<table>
<thead>
<tr>
<th>Year</th>
<th>Production Sustainability</th>
<th>Living Sustainability</th>
<th>Ecological Sustainability</th>
<th>Supply Services</th>
<th>Regulation Services</th>
<th>Support Services</th>
<th>Cultural Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>55.50</td>
<td>34.50</td>
<td>10.00</td>
<td>28.61</td>
<td>36.13</td>
<td>26.30</td>
<td>8.95</td>
</tr>
<tr>
<td>2010</td>
<td>56.53</td>
<td>33.36</td>
<td>10.11</td>
<td>27.23</td>
<td>35.34</td>
<td>28.47</td>
<td>8.95</td>
</tr>
<tr>
<td>2015</td>
<td>56.59</td>
<td>31.43</td>
<td>11.99</td>
<td>29.29</td>
<td>34.50</td>
<td>27.06</td>
<td>9.15</td>
</tr>
<tr>
<td>2020</td>
<td>59.19</td>
<td>27.61</td>
<td>13.20</td>
<td>28.69</td>
<td>35.24</td>
<td>27.06</td>
<td>9.01</td>
</tr>
</tbody>
</table>

In order to determine the specific obstacle indicators, the top five obstacle factors affecting the SD and ESV systems of Yunnan Province from 2005 to 2020 were extracted (Figure 11). In the ESV system, the dominant obstacle factors were reflected in different aspects of the subsystem. Food production (E1), soil conservation (E8), gas regulation (E4), raw material production (E2), and climate regulation (E5) were the main factors contributing to CCD differences. They were also observed to progressively increase in terms of the obstacle degree. The constraints in the SD system were generally from production sustainability factors, namely total import and export trade (S10), number of scientific and technical personnel (S7), financial contribution rate (S9) and economic density (S8). This reveals that the production problems in Yunnan Province are mainly related to economic production as well as scientific and technological production. Among them, the obstacle degree of the number of scientific and technological personnel (S7) increased significantly from 2005 to 2020 by 2.76. Furthermore, the obstacle degree of water resources per capita (S33) in terms of ecological sustainability also increased from 6.81% in 2005 to 9.94% in 2020, by 3.12.

Figure 11. Obstacle factors and the corresponding obstacle degree at the index layer (top five). (a) for the SD system; (b) for the ESV system. See the preceding for the indicator code definitions.
4. Discussion

4.1. PLE Land and ESV Changes

Based on the PLE land classification method, this paper identifies the changes in production, living and ecological land, and it quantifies the ecosystem service capacity of Yunnan Province through the dynamic equivalent method of ESV. We identified obvious and complex transformations between production, living and ecological land use in Yunnan Province from 2005 to 2020 (Figure 4). This is consistent with the characteristics of land use function changes in an agriculture-dominated region during the development process [32,62]. Furthermore, we also noted that during the period from 2010 to 2015, the total amount of land conversion in Yunnan Province decreased, the land was relatively stable, and the growth intensity of construction land was lower than in the other two periods (2005 to 2010 and 2015 to 2020). Tong et al. observed a similar trend in the intensity of land use change for four municipalities directly under the control of the Central Government of China [63]. This can be explained by the impact of government policies on land change. Prior to 2010, China was in a period of rapid urbanization and industrial development, resulting in significant land changes [64]. Following this, China promulgated the National Plan for Key Functional Zones (2010) and the Red Line of 1.8 billion mu for Cultivated Land (2013). Therefore, governments at all levels reconsidered and formulated land use plans, which consequently slowed down the transfer of land during this period. In 2014, the People’s Government of Yunnan Province issued the New Urbanization Plan of Yunnan Province (2014–2020). Under the guidance of this new plan, the land use of Yunnan Province has entered a new stage.

In terms of the spatial distribution of ESV, we determined the ESV values in western Yunnan and southern Yunnan to be higher than those in other regions, which is mutually confirmed by Zong et al. [38]. However, the total amount of ESV in Yunnan from 2005 to 2020 showed a fluctuating trend that initially decreased, then increased and subsequently decreased. This is different from the gradual increase in ESV observed in recent studies [35,65]. However, our results are considered to be reasonable and can be explained. In particular, from 2005 to 2020, the area of grassland, farmland and unused land in Yunnan Province decreased, yet the area of construction land, woodland and water body were increased, which agrees with recent research [35,65]. Under the same land change trend, if only the effects of land transfer on ESV are considered, and the effects of NPP, precipitation and soil conservation factors on the spatial-temporal regulation of ESV are not accounted for, the area of ecological land with high ESV (e.g., as woodland and water body), will increase significantly, and the total amount of ESV within the region will inevitably rise. Nevertheless, the dynamic change of natural factors in the ESV accounting process is affected. Among the influences of meteorological factors, particularly precipitation changes, the influence of ESV is significant [66,67]. The findings of these studies support the results in this paper, whereby the fluctuations in the precipitation regulatory factors during the study period are observed to affect the temporal and spatial differences of ESV and the inter-annual fluctuation changes. The production and ecological land in the study area continued to decrease from 2005 to 2020, resulting in a continuous decline in ESV. Addressing land functional degradation is essential for the achievement of SDGs associated with SDG2, SDG6 and SDG15, as well as for the minimization of losses in ecosystem services [68]. Therefore, there is a need to optimize PLE lands to reduce ESV deficits and ensure the long-term sustainability of ecosystem service provision [69].

4.2. Changes in SD

Much work remains to be performed in order to explore for local assessment of regional sustainable development based on the UN’s SDGs framework. This requires the joint efforts of multiple disciplines, as well as a multi-level, multi-perspective view of the problem [70]. Based on SDGs, this paper makes a localized assessment of the SD level of municipalities and administrative units in Yunnan Province from three levels of production-living-ecological sustainability. Although the SD assessment from the perspective of PLE
functions does not fully cover the 17 aspects of the Sustainable Development Agenda 2030, it provides a new approach for the localized assessment of SD. The work presented here is helpful for decision makers in the creation of relatively specific policy and development plans by focusing on the sustainability evaluation of the PLE functions. In this paper, the comprehensive index of PLE sustainability was calculated to represent the level of SD. However, some scholars consider there to be trade-offs and synergies among production, living and ecology, and comprehensive evaluations are not able to reflect the relationship among the three [48,71]. Therefore, we also implemented the multidimensional functional evaluation model proposed by Wei et al. to calculate the level of SD [72] and found the results (Figures S2 and S3) to essentially be consistent with the study. This indicates the ability of the comprehensive evaluation to reflect the SD of a region from the perspective of PLE functions [73,74], proving the credibility of the results. The gradient difference of SD among Yunnan cities is obvious, with Kunming exhibiting the highest SD and Nujiang the lowest. Although Kunming presents a low level of ecological sustainability, as a provincial capital, its production and living abilities are outstanding, placing it as number one in terms of comprehensive SD [75]. The lowest comprehensive SD level of Nujiang is mainly attributed to its relatively regressive production and living sustainability. By 2020, the high-value areas of production sustainability were concentrated in Kunming and its neighboring cities, which were mainly driven by policies and the geographical environment. Furthermore, the border cities of Dehong, Honghe and Xishuangbanna also exhibited a high level of production sustainability due to the support of foreign trade policies. The sustainability of living is limited by the economic level and geographical factors; with the exception of the high level of cities in central Yunnan, other cities had little difference [76]. The ecological sustainability of the cities in western Yunnan was better than eastern, which was mainly due to the superior ecological environment and lower influence of human activities [43].

4.3. Coupling Coordination between SD and ESV and Obstacle Factors

From 2005 to 2020, the coupling coordination level between SD and ESV increased in most cities (Figures 9 and 10). It is not difficult to determine that the rise of CCD in these parts of the cities was due to the rise of SD, along with the economic and social development. However, from 2015 to 2020, the rising trends of CCD in Wenshan, Qujing, Zhaotong and Pu’er were broken. The decrease in CCD in these cities during this period was mainly due to the continuous increase in SD, but the decrease in the precipitation adjustment coefficient in southern and eastern Yunnan in 2020 compared to 2015 (Figure S1) caused a sharp turnaround in the service value of hydrological regulation (Figure 6d) and eventually led to an abrupt decrease in CCD between SD and ESV in these cities. In addition, we also note that the SD level of cities in central Yunnan has increased more significantly than other regions, but the level of coupled coordination has hardly increased significantly. The reason for this is that, as urbanization progresses, a large amount of productive and ecological land in central Yunnan is continuously encroached upon by living land, leading to a decrease in ESV year by year [35,42]. Even if SD developed significantly for the better, the gap between the two imbalances cannot be obviously improved. This suggests that a unilateral improvement in the level of regional development or ecosystem services has a limited impact on the elevation of the CCD of both [22,23]. This may also be the reason why the CCD between SD and ESV in Yunnan Province has improved but is still or will still be in the primary coordination stage for a long time. The synergistic improvement of ESV and SD is the key for the two to move to a higher level of coordination [24]. Decision makers should pay attention to this result as well as to the changes in ecosystem services for policy and planning, so as to balance the relationship between ecosystem service provision and pressure from various factors brought by regional development [77].

Identifying the major obstacle factors affecting CCD is essential to further improve the relationship between ESV and SD. Due to regional differences, the level of development and ecological endowment varies from place to place, leading to their different obstacle
factors [75]. For example, the top barriers to SD in the Weihe River Basin of Shaanxi Province, China, revealed by Wang et al. [78], are the number of college students per 10,000, local government revenue, amount of water resource per capita, investment in water conservancy as a percentage to GDP, gross domestic product and urban living area per capita. Cui et al. [79] confirmed that the impediments to the SD of the coastal zone of Zhejiang Province, China, are mainly at the level of ecological functions, with specific factors related to the area of coastal wetlands, forest coverage and the area of marine-type nature reserves. In contrast, the obstacle factors of the SD system in Yunnan province identified in our study were mainly in production sustainability, specifically, in terms of insufficient economic production (S10, S9, S8) and scientific and technological production capacity (S8) (Table 2, Figure 11). This was determined by the unbalanced and insufficient development of Yunnan. Yunnan has only one production pole, and production factors, such as scientific research and capital, are mainly concentrated in the central part of Yunnan. While the northwest, northeast and southeast of Yunnan are relatively lacking in production factors due to rugged terrain, weak industrial base and deep poverty [80,81]. We found that regulation service was the biggest obstacle factor in the ESV system of Yunnan Province, mainly in gas regulation (E4) and climate regulation (E5). On the one hand, Yunnan is located in a low latitude plateau, and its diverse topography and other natural conditions make the climate and hydrological regulation functions vary significantly among regions [65]. In recent years, accelerated urbanization has led to increased disturbance of the regional ecological environment by human activities, which further contributes to the high degree of barriers to regulation services [82]. This means that the protection and development of ecological lands with high-value coefficients, such as forests, water bodies and wetlands, should be strengthened, and their high-quality regulatory services should be brought into play and stabilized [83].

4.4. Limitations and Future Work

This article has the following limitations: (1) In order to explore the SD level from the perspective of PLE functions, this paper selected representative indicators combined with the requirements of SDGs. However, the index system may be flawed in its ability to reflect the SD level comprehensively, which needs to be further explored and improved. Although this method is simple to measure and can reflect certain facts, this method presents linear superposition results of production-living-ecological functional sustainability, which may be insufficient to describe the synergies and tradeoffs between them. Future studies should try to explore more using other models. (2) The coupling coordination model is used to measure the interaction between SD and ESV, but it cannot prove a correlation [24], so this paper does not reveal how ESV changes affect the SD process [84,85]. (3) Our paper only explores the relationship between SD and ESV in prefecture-level cities, yet the evaluation results of small administrative units are often more targeted and have greater practical reference significance for the actions of local governments. Therefore, in the case of future data accessibility, it is necessary to consider the accurate exploration at the county or town level, and even to use high-resolution remote sensing inversion data that can display various indicators. This can better reflect the details of spatial differences, so as to provide a more comprehensive reference for regional management and decision-making.

5. Conclusions

ESs are particularly important to the achievement of SDGs, and understanding the relationship between regional ESs and SD can help local ecological conservation and development decisions. Our study provides a new perspective for SD localization assessment and exploration of the interaction between ESs and SD. It was found that: (1) From 2005 to 2020, the SD level of Yunnan Province gradually improved, and the sustainable level of production and living exhibited an obvious spatial pattern that was high in the center and low at the boundary regions. Moreover, the spatial distribution of ecological sustainability was stronger in the west and weaker in the east. (2) Ecological land contributed to over
90% of ESV in Yunnan Province. The change of total ESV in Yunnan Province exhibited a fluctuated trend that initially decreased, then increased and returned to decrease, resulting in a total decrease of 2.231 billion CNY. (3) The level of coupling coordination improved significantly from 2005 to 2020, with a gradual increase in the initial coordination types and a significant decrease in the intermediate incoordination types. The coupling subcategory changed from SD lagging as dominant to ESV lagging as dominant, and then to a balance between the two. Spatially, CCD showed high levels in the northwest and low levels in the southeast. (4) The production sustainability and regulation services were identified as the main factors restricting the CCD between ESV and SD. Stakeholders and policy makers should not only focus on economic productivity but also ensure the sustainability of the science and technology productivity. Focusing on the cultivation and introduction of scientific and technological talents can help better promote the SD of Yunnan Province. In addition, ecological protection policies are necessary to moderate changes in regulatory services and help balance the relationship between the ESs supply and the pressure of various factors brought about by regional development. Future work is proposed that focuses on exploring how ESs influence the process of SD realization as well as to gain insight into the influence of other factors on the relationship between ESs and specific SDGs in order to provide more appropriate references for policy makers.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su15129664/s1: Table S1: Scoring standard system for Production-living-ecological land. Table S2: Value equivalent factors of ecosystem services per unit area in Yunnan Province. Table S3: Classification of coupling coordination degree and types. Text S1: Dynamic evaluation of ecosystem service value. Figure S1: Spatial distribution of ESV base equivalent adjustment coefficients. Figure S2: Results of the multidimensional functional model of PLE sustainability for cities in Yunnan Province. Figure S3: Results of the multidimensional functional model of the sustainable development level of each city in Yunnan Province. Reference [86] is cited in the supplementary materials.

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

Abbreviations
The following table shows the abbreviations used in this article.

<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>SD</td>
<td>Sustainable Development</td>
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<td>SDGs</td>
<td>Sustainable Development Goals</td>
</tr>
<tr>
<td>ESs</td>
<td>Ecosystem Services</td>
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<td>PLE</td>
<td>Production-Living-Ecological</td>
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<tr>
<td>ESV</td>
<td>Ecosystem Service Value</td>
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<tr>
<td>CCD</td>
<td>Coupling coordination degree</td>
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