

Land Use Change and Its Impact of Ecosystem Service Value in Yarlung Zangbo River Basin in Southern of Qinghai-Tibet Plateau

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Abstract

Scientific determination of ecosystem service values (ESVs) is the basis and premise of realizing sustainable management of the regional ecosystem. Therefore, it is of great significance to explore the dynamic evolution of ESV in Qinghai-Tibet Plateau (QTP) to maintain the plateau landscape diversity and ecological environment protection. This paper constructed a comprehensive basin analysis perspective of horizontal distribution, vertical distribution, and basin gradient to analyze the dynamic evolution of ESV in the Yarlung Zangbo River Basin (YZRB). The results showed that: The total ESVs of YZRB increased from 1980 to 2015, in which the ESVs of grassland and water decreased, and ESVs of other sites increased. The changes in ESVs in different land-use types had obvious differences in basin gradients. In general, ESVs presented a stepwise distribution pattern of “upper < middle < lower”. In terms of vertical differentiation, the lower ESVs areas were concentrated at 2000 - 6400 m, the medium ESVs areas were distributed below 5000 m, and the high ESVs areas can only present from 3800 to 4800 m. The areas of grassland and water were decreasing, which was the main cause of ESVs loss. The ESVs' benefits were greater than the losses, so the ESVs in the whole basin were improved. This paper completed the research of ESVs from change analysis to flow tracking and perfected the regularity study of the integrated process of basin ESV from static evaluation to dynamic evolution to conversion.

Keywords

Ecosystem Service Value, Land-Use Change, Spatial Planning, Yarlung Zangbo River Basin, Qinghai-Tibet Plateau

1. Introduction

Ecosystem services are direct or indirect products and services produced by ecosystems through their functions (Costanza et al., 1997; Daily, 1997), which have an impact on human well-being and natural capital flows, and their changes affect human activities on the surface of the earth (Millennium Ecosystem Assessment (MEA), 2005; Costanza et al., 2014). Ecosystem services are highly related to land use/land cover. The changes in land use types and landscape patterns directly affect the supply of ecosystem services (Gao, et al., 2017), and can also change the allocation of energy flow, material flow and information flow of natural capital, indirectly disturb the functional structure of the ecosystem, thus affect the ecosystem services value (ESV). Especially in high-altitude, ecologically sensitive and ecologically fragile areas, the value of ecosystem services in land-use change is more sensitive. The Qinghai-Tibet Plateau (QTP) is the world's roof and the Asian water tower. It is the third pole of the earth with ecological safety barriers and strategic resource reserve functions, which plays an important role in the human living environment and sustainable development (Yao, et al., 2017). Dramatic changes will have a greater impact on its ecological environment and human activities (Fu, et al., 2017). Therefore, quantitatively identifying the ESV of the QTP will help improve the natural capital management of the region and improve the supply and demand allocation of various ecosystem services. Its implementation will support the policy formulation of the Qinghai-Tibet Plateau ecological protection and ecological restoration project (Liu, 2010). Then, it can provide a reference for formulating a rational plateau development plan, biodiversity protection, and ecological compensation scheme.

Ecosystem services are currently a hot topic in international ecology and environmental management research (Bateman, 2013). Many scholars pay more attention to the classification, function monitoring, value assessment of ecosystem services, etc. Among them, the estimation of ESV has received extensive attention. The method for estimating ESV is to convert the quality of ecosystem services into value, which can be divided into two categories: original value assessment and transfer value estimation (Zhou, et al., 2019). The first method collects the field data and calculates the value of the research area through the process, functional mechanism of the ecosystem, and its interaction with humans, mainly including direct market method, display preference method (such as market value method and travel expense method), statement preference method (such as conditional value method and selection experiment method) (Arowolo, 2018). The method of transfer value is to assess the service value of similar areas to be evaluated using value information of one or more assessed areas. For example, Costanza et al. (1997) firstly used this method to evaluate the monetary value of the service functions of 16 ecological landscape sites around the world. The evaluation of ESV and its spatial and temporal differences at different scales are gradually becoming the entry point of ecosystem services, including different ecosystems such as forests, grasslands, farmland, oceans, wet-

lands, and cities (He, et al., 2019; Lin, et al., 2019). The scale covers global, national, regional, provincial, municipal, county, river basin, lake and nature reserves, etc. (Xie, et al., 2017; Yu, et al., 2018; Lei, et al., 2019; Li, 2019).

Related researches mainly focused on the grassland ecosystem, laying a foundation for the researches on the ecosystem services of the QTP. However, there are still some deficiencies. For example, most of the researches focused on the spatial and temporal changes of ESVs and took the land-use change as the independent variable of ESVs change. As a result, there were few links between nature and social economy and many other factors in the study areas, and it was not sufficiently discussed that the driving factors may be intricately linked. From the perspective of researches, the changes of ESVs were mainly analyzed from the whole regions and did not make a fine-scale division of complete high-altitude regions to explore spatial differences and gradient laws within the basin scale. Moreover, systematic analysis of plateau areas with less human disturbance was rarely carried out. Therefore, we are prepared to proceed from the perspective of comprehensive basin management including horizontal differentiation, vertical differentiation, and basin gradient to analyze the dynamic evolution of ESVs of YZRB and depict laws of the benefits and losses of ESVs flows. It is expected to make up for the measurement of ESVs in the plateau basin, and provide decision-making references for the scientific implementation of ecological compensation, deepens the comprehensive ecological environment management and ensures the coordinated development of ecological security pattern on QTP.

2. Data and Methods

2.1. Study Area

The Yarlung Zangbo River Basin is located at 27°80'N - 31°02'N, 81°09'E - 97°10'E, originating from the southeastern part of the QTP and the Gemma YangZong Glacier in Northern Himalayas. The source of YZRB is about 5590 m, which is the highest river in the world (**Figure 1**). The elevation is quite different. The upper reaches region is the plateau cold temperate semi-arid climate. The middle reaches region is the plateau temperate semi-arid climate, and the downstream is the mountain subtropical and tropical climate, spanning four climatic zones. It is a typical plateau monsoon temperate semi-arid climate. The annual average temperature is low, about 4.7°C - 8.3°C, and the precipitation is 251.7 - 580.0 mm. 80% of the precipitation in the area is mainly concentrated in May and September, forming an extremely dry season and wet season. The basin traverses the entire southern part of the QTP from west to east. It is the center of politics, economy, and culture of the Tibet Autonomous Region, with a population accounting for 36% of the entire region. It is rich in natural resources such as land, light, heat, water, and biological resources, and is an important commercial grain base in Tibet autonomous region. The ecosystem is fragile due to its unique geographical location, topographical features, and complex plateau climate.

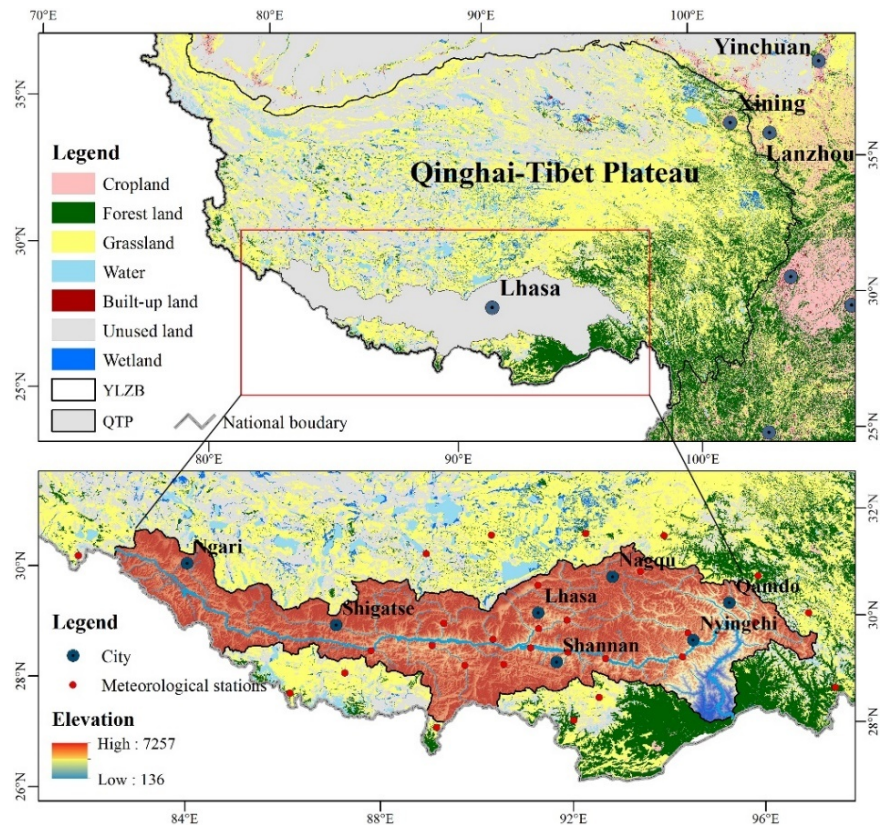


Figure 1. Map of the study area.

2.2. Data Sources

The research data in this paper includes four aspects: 1) Land use data. Land-use data for the YZRB from 1980, 1995, 2005 and 2015, at a resolution of 30 m, were obtained from the Institute of Remote Sensing and Digital Earth at the Chinese Academy of Sciences (Liu et al., 2003). Referring to the national classification criteria for land use status (GB/T21010-2007), combined with the land use characteristics of ecological function areas in the plateau area, the study area is divided into six types of the first-class land: cultivated land, forest land, grassland, water, construction land, and unused land. Class; 2) Digital elevation model (DEM) data. STRM3-DEM, at a resolution of 30 m, from the International Scientific Data Mirroring Website of the Computer Network Information Center of the Chinese Academy of Sciences (<http://www.gscloud.cn>); 3) Meteorological data. Meteorological data including temperature and precipitation are taken from the China Meteorological Science Data Sharing Service Network (<http://dara.cma.cn>), and a total of 30 meteorological sites near the YZRB are used to form a new data set, the spatial distribution is shown in **Figure 1**; 4) Basic geographic data, the baseline map is from the Tibet Autonomous Region Surveying and Mapping Bureau (<http://www.xzbsm.gov.cn/>), and the drawing number is Tibetan S (2017) No. 015. The basin boundary is based on the research of the predecessors. The water system of the YZRB is generated by combining the hydrological analysis module in ArcGIS.

2.3. Methods

2.3.1. The Calculation of Ecosystem Service Value

XIE, et al. (2017) revised the value of ecosystem service per unit area and obtained the ecosystem services value unit area of Chinese terrestrial ecosystem. The table defined the economic value of natural grain yield per year for cropland with an average yield of 1 ha. On this basis, the value of the ecosystem service per unit area of the QTP has revised again (Wang, et al., 2014). The ESVs in the YZRB is calculated as:

$$ESV = \sum A_k \Delta VC_k \quad (1)$$

$$ESV_f = \sum A_k \Delta VC_{fk}$$

where ESV is the value of ecosystem service; A_k is the distribution area (ha) of land use type k in the research area. VC is the ecosystem value coefficient (yuan·ha⁻¹·a⁻¹); ESV_f is the ecosystem service function value of item f ; VC_{fk} is the value coefficient of service function (yuan·ha⁻¹·a⁻¹) of item f of land use type k . The single unit ecosystem service value in QTP is shown in **Table 1**.

2.3.2. Flow of Ecosystem Service Value

The conversion data of different land-use types are used to calculate the benefits and losses of ESV and analyze the impact of land-use change on ESV. The benefits and losses flows of ESVs are calculated as:

$$PL_{ij} = (VC_j - VC_i) \times A_{ij} \quad (2)$$

Table 1. The single unit ecosystem service value in Qinghai-Tibet plateau (unit: yuan/hm²).

Type	Sub-type	Forest land	Grassland	Cropland	Wetland	Water	Other
Supply services	FP	62.9	188.6	628.6	188.6	62.9	6.3
	RMP	1634.4	31.4	6.3	44	6.3	0
	WC	2011.5	502.9	377.2	9743.3	12,823.4	18.9
	subtotal	3708.8	722.9	1012.1	9975.9	12,892.6	25.2
Regulation services	GR	2200.1	502.9	314.3	1131.5	0	0
	CR	1697.2	565.7	559.5	10749.1	289.2	0
	subtotal	3897.3	1068.6	873.8	11880.6	289.2	0
Support services	SFC	2451.5	1225.8	917.8	1074.9	6.3	12.6
	WT	823.5	823.5	1030.9	11428	11,440.5	6.3
	BP	2049.2	685.2	446.3	1571.5	1565.2	213.7
	subtotal	5324.2	2734.5	2395	14,074.4	13012	232.6
Cultural services	EC	804.6	25.1	6.3	3488.7	2728.1	6.3
Total ESV	Total	13,734.9	4551.1	4287.2	39,419.6	28,921.9	264.1

Abbreviations: FP—food production; RMP—raw material production; WC—water conservation; GR—gas regulation; CR—climate regulation; SFC—Soil formation and conservation; WT—waste treatment; BP—biodiversity protection; EC—entertainment culture.

where PL_{ij} refers to the benefits and losses of ESV after the transformation of type i land use to type j land use type; VC_i and VC_j are the coefficients of ESV of category i land use type and category j land-use type respectively. A_{ij} refers to the area of land use type i converted into land-use type j .

2.3.3. The Dynamic Attitude of LUCC

A single dynamic attitude of land use is used to represent the change rate of a certain land-use type in a certain period in the study area. The expression is:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \quad (3)$$

where K is the dynamic attitude of a certain land-use type during the research period; U_a and U_b are the areas of certain land-use types in the early and late stages respectively. T is the period. When T is set as a year, K represents the annual change rate of a certain land-use type during the research period.

Comprehensive land-use dynamic attitude is used to represent the change rate of the overall land-use type within a certain period in the study area, and the expression is:

$$LC = \left[\frac{\sum_{i=1}^n \Delta LU_{i-j}}{2 \sum_{i=1}^n LU_i} \right] \times \frac{1}{T} \times 100\% \quad (4)$$

where LC is the dynamic attitude of comprehensive land-use during the research period; LU_i is the area of the first-class i land-use type; ΔLU_{ij} as the research period of the first-class i land-use types can be converted into other land-use types the absolute value of area; N is the number of land-use types. When the period of T is set as a year, LC is the annual change rate of land-use in the study area.








3. Results

3.1. Dynamics in Ecosystem Service Values from 1980-2015

3.1.1. Overall Characteristics of ESV

The ESV of the YZRB between 1980 and 2015 showed significant temporal and spatial dynamics (Table 2). Forest land and grassland contribute the most to the total ESV in the whole basin. The total contribution of the two types of land types is about 75%, followed by water and wetlands, accounting for 23%. The contribution of cropland, built-up land, and unused land is small. In terms of temporal evolution, the total ESV present an “N” type change trend, which increased from $15,957 \times 10^8$ yuan in 1980 to $17,463 \times 10^8$ yuan in 2015, an increase of 1506×10^8 yuan, an average annual increase of 0.27%. From 1980 to 1995, total ESV increased by 251×10^8 yuan with a dynamic degree of 0.1%; The total ESV decreased from 1995 to 2005, with a dynamics of -0.2%; From 2005 to 2015, the total ESV increased significantly, with an increase of 1514×10^8 yuan and a dynamics of 0.9%. Among its, the change of ESV in grassland and water showed an inverted “N” type. Their dynamic degree is -0.6% and -0.9%

Table 2. Changes in ecosystem service value (ESV) in YZRB from 1980 to 2015.

Land-use types	ESV/ (10 ⁸ yuan)				Variation trend	Dynamic degree			
	1980	1995	2005	2015		1980-1995	1995-2005	2005-2015	1980-2015
Cropland	145	101	145	174		-2.0%	4.4%	2.1%	0.6%
Forest land	4873	5589	4891	7227		1.0%	-1.2%	4.8%	1.4%
Grassland	7249	6659	7244	5607		-0.5%	0.9%	-2.3%	-0.6%
Water	3073	3220	3084	2133		0.3%	-0.4%	-3.1%	-0.9%
Wetland	495	495	465	2154		0.0%	-0.6%	36.3%	9.6%
Other	122	145	122	168		1.3%	-1.6%	3.7%	1.1%
Total ESV	15,957	16,208	15,950	17,464		0.1%	-0.2%	0.9%	0.3%

respectively, which was less than 0, indicating that the ESV showed a decreasing trend respectively. It was reduced from 7249×10^8 yuan and 3073×10^8 yuan in 1980 to 5607×10^8 yuan and 2133×10^8 yuan in 2015.

The ESV of different land types shows a trend of “five increase and two decreases”, which can be roughly divided into four types of changes: “V”, “N”, inverted “V” and inverted “N” (**Table 2**). The changes of ESV in grassland and water show an inverted “N” type. The dynamics are -0.6% and -0.9% , which is less than 0, indicating that the ESV shows a decreasing trend. It was reduced from 7249×10^8 yuan and 3073×10^8 yuan in 1980 to 5607×10^8 yuan and 2133×10^8 yuan in 2015. ESV of forest land and unused land show an “N”-type change trend, with dynamic degrees of 1.4% and 1.1% respectively, and the ESV was improved. During the study period, In the cultivated land and wetland, the ESV increased first and then decreased in 1980-2015, showing a “V” change. The cultivated land ESV increased from 145×10^8 yuan in 1980 to 174×10^8 yuan in 2015, and the dynamic change was 0.6% .

3.1.2. Basin Gradient of ESV

The changes of ESVs in different land-use types have obvious differences in basin gradients, and present a stepped distribution pattern of “upper < middle < lower” (**Figure 2**). Wetlands have been the main contributors to ESVs in the whole basin. The ESVs provided by grasslands in the upper and middle reaches is second, accounting for 34.9% and 25.5% . Due to the continuous reduction of grassland in the upper reaches, the proportion of ESV provided is gradually decreasing, while in the middle reaches regions is relatively stable. The forest land in the lower reaches provides the largest ESV, reaching 32.1% . The areas of forest land are increasing, and the ESVs have increased from $30,553.2 \times 10^8$ yuan to $35,815.1 \times 10^8$ yuan from 1980 to 2015, an increase of 17.2% . The proportion of ESVs of water in different reaches is relatively stable, while the proportion of ESVs provides by other land types is small.

The ESV distribution of the whole basin has significant spatial heterogeneity (**Figure 3**). The higher ESV areas are mainly distributed in the lower reaches of the YZRB, and more in Linzhi and Qamdo. The forest land and water in these

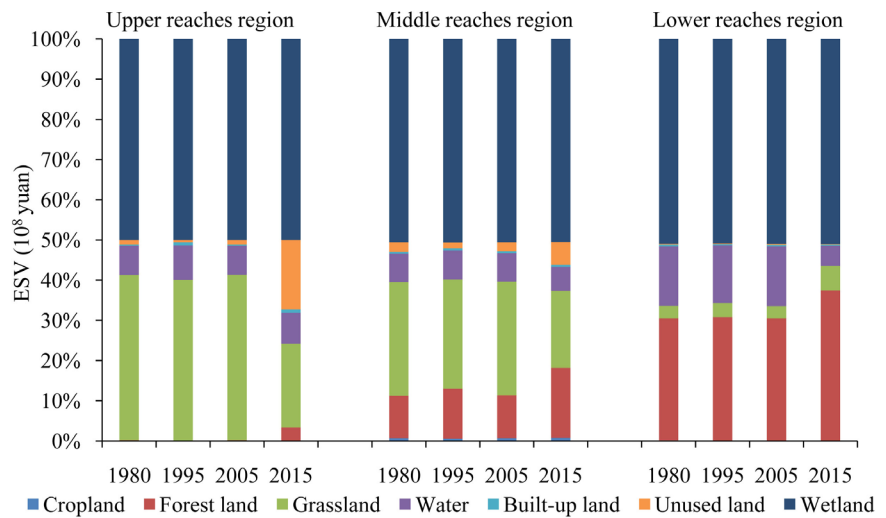


Figure 2. The temporal changes of ESV in different stages of YZRB from 1980 to 2015.

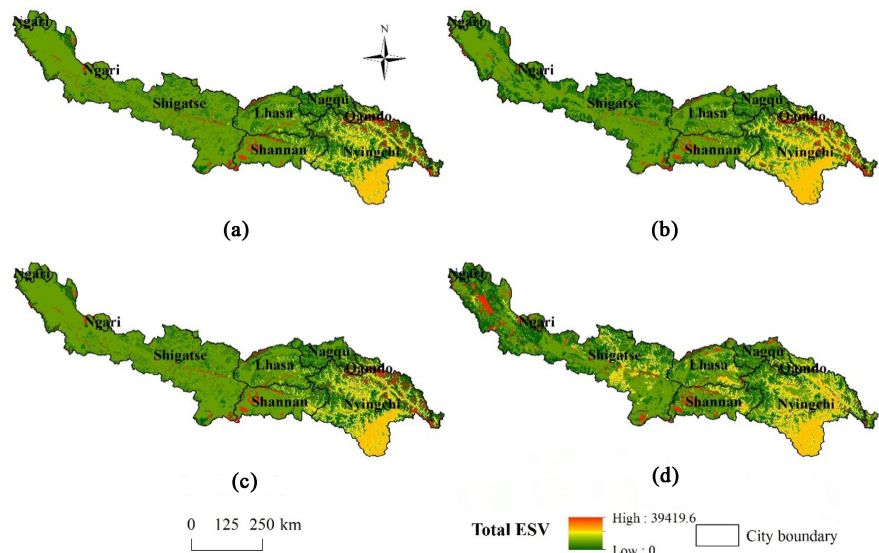


Figure 3. The spatial distribution of ESV in YZRB from 1980 to 2015. (a) 1980; (b) 1995; (c) 2005; (d) 2015.

areas account for a high proportion, which makes the forest and water resources richer. The per unit area ESV of the forest land and water is higher, which has promoted a concentrated area of high ESVs in the lower reaches. Also, the higher ESVs areas are increasing and its spatial distribution is increasingly fragmented. By 2015, except for Medog County in Linzhi, there are more high ES-Vareas in the upper and middle reaches along the tributary area. The change of ESVs Maquan River Basin in Zhongba County, Shigatse City is more obvious. Lower ESV areas are mainly distributed in the upper and middle reaches, where the elevation is high, the vegetation is scarce, the alpine meadows and alpine deserts occupy a large area, the forest vegetation resources are scarce, and the natural environment is poor, resulting in a low ESV. In the middle reaches, the terrain is flat and has better water conservancy facilities. It is suitable for agri-

cultural farming. At the same time, the population density is high, and the degree of disturbance to the natural ecosystem is large. Therefore, ESV has maintained a low level and has not changed significantly. It is worth noting that ESV is always high in lower reaches where there are many forest, while the mixed distribution of middle reaches of cropland land and grassland shows that ESV is at a medium level. The upper reaches are dominated by grassland and unused land, so its ESV is mainly low.

3.1.3. Vertical Differentiation of ESV

In terms of Vertical differentiation of ESV (**Figure 4**), the areas of lower ESV ($(0 - 600) \times 10^6$ yuan) are mainly concentrated in 2000 - 6400 m, showing a “U” trend. When the altitude is less than 2000 m, the areas of lower ESV are less likely to occur. When the altitude exceeds 5400 m, the ESVs of high-altitude vegetation and wetland at higher altitudes are less distributed, so the ecosystem can only provide lower value and the ESV begins to decrease. The areas of medium ESVs ($(600 - 1200) \times 10^6$ yuan) are widely distributed at altitudes below 5000 m. There are a large number of forest land, water, and wetlands at this altitude, and there are many human activities. Engaging in agricultural production also brings a certain ESV, but because of the small value per unit area, the ESV is not high. After the ESVs are greater than 1200×10^6 yuan, only a small amount exists in the interval of 3800 - 4800 m. The terrain factor provides different ecosystem services through the topographic gradient effects of different ecological land. In general, the ESVs of the YZRB present a vertical distribution pattern of “low altitude, low value, and high concentration”.

3.2. The Flow of Ecosystem Service Value

3.2.1. Land-Use Change Transfer

Land-use/cover change affects the structure and function of ecosystems, which in turn affects the ecosystem’s ability to sustain its services (Li, et al., 2016). The

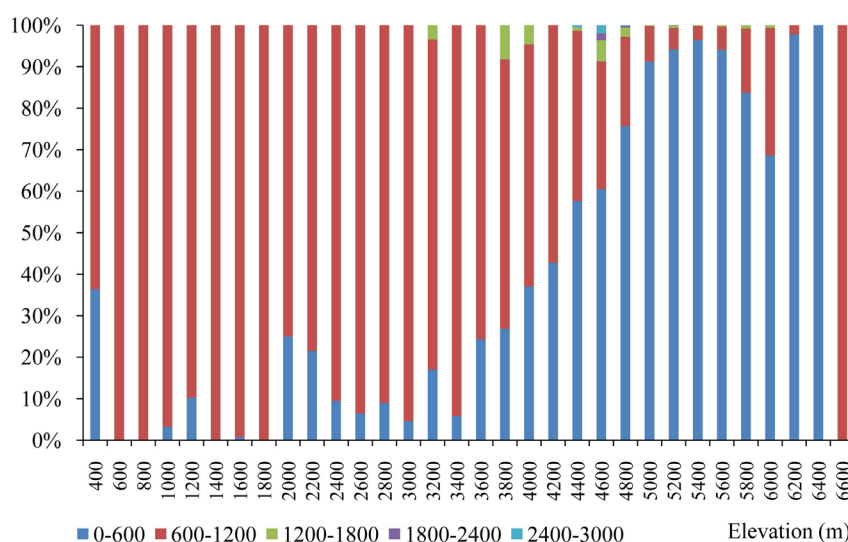


Figure 4. The Vertical heterogeneity of total ecosystem service value in YZRB.

transitions between unused land and grassland were the most dramatic from 1980 to 2015, and grassland degradation and desertification were major ecological problems in YZRB (Table 3). The unused land was converted to the grassland of 350.01×10^4 ha, while the grassland turned to unused land of 157.84×10^4 ha. The second is the conversion of forest land to grassland and grassland to forest land, with an area of 197.08×10^4 ha and 70.68×10^4 ha. Forest land, grassland, and unused land are the main types of land-use change in the YZRB. Unused land transfer area is the largest, with a total of 402.21×10^4 , accounting for 15.69% of the study area. The areas that turned to grassland were the largest, totaling 622.36×10^4 ha, accounting for 24.27% of the total area, followed by unused land, forest land, and water, and other types of land-use were less variable.

3.2.2. Ecosystem Service Value Gains and Losses

Since the wetland area has the highest ESV per unit area, followed by water bodies and forest land, the conversion of land-use types to these three types will result in higher ESV increments, resulting in greater returns, and correspondingly, the reduction in area will also. The overall ecosystem service value is at a loss. The previous analysis shows that the area of grassland and water body in the YZRB is decreasing. The area of cropland, forest land and wetland is increasing. The conversion of forest land to grassland and wetland to grassland has lost the value of ecosystem services by $18,099.7 \times 10^6$ yuan and $14,038.0 \times 10^6$ yuan. The main type of flow causes the loss of ecosystem services value (Table 4). The unused land to the higher ecosystem service equivalents such as

Table 3. Land-use transition matrix of in YZRB from 1980 to 2015.

	Cropland	Forestland	Grassland	Water	Built-upland	Unused land	Wetland
Cropland	148,696.9	32,822.9	196,583.6	3711.0	3439.0	12,634.7	8650.5
Forestland	52,474.7	2,667,503.5	1,970,831.6	50,195.3	456.3	515,603.4	4713.9
Grassland	98,454.8	706,830.6	9,705,708.8	220,335.1	1286.5	1,578,387.2	9887.9
Water	5769.6	19,865.9	147,271.7	366,131.6	130.7	168,085.7	30,139.1
Built-up land	5956.2	403.9	6171.5	125.8	4291.4	636.2	352.7
Unused land	9633.8	117,218.2	3,500,146.2	392,484.3	200.1	2,327,520.8	2438.0
Wetland	17,330.8	2962.5	402,597.3	29,274.1	189.9	24,724.5	69,373.9

Table 4. Ecosystem services value flowing matrix in YZRB from 1980 to 2015.

	Cropland	Forestland	Grassland	Water	Built-up land	Unused land	Wetland
Cropland	0.0	310.1	51.9	91.4	-14.7	-50.8	303.9
Forestland	-495.8	0.0	-18,099.7	762.3	-6.3	-6945.6	121.1
Grassland	-26.0	6491.4	0.0	5369.7	-5.9	-6766.5	344.8
Water	-142.1	-301.7	-3589.1	0.0	-3.8	-4817.0	316.4
Built-up land	25.5	5.5	28.1	3.6	0.0	0.2	13.9
Unused land	38.8	1579.0	15005.1	11247.7	-0.1	0.0	95.5
Wetland	-608.9	-76.1	-14,038.0	-307.3	-7.5	-968.1	0.0

grassland, water body and woodland allowed the overall ESV to increase, with revenues of $15,005.1 \times 10^6$ yuan, $11,247.7 \times 10^6$ yuan and 1579.0×10^6 yuan, respectively. Secondly, the grassland turned to forest land and water body with higher value than its unit ecosystem service, which also benefited ESV, adding 6491.4×10^6 yuan and 5369.74×10^6 yuan respectively. In general, the value of cultivated land, forest land, water body and wetland ecosystem service flows is in a state of income, and the value of construction land, grassland and unused land ecosystem services is in a state of loss, the overall income is greater than the loss, and the value of watershed ecosystem services has increased.

3.3. Response of EVSs to Climate Change and Human Activities

The change of ecosystem service value is influenced by many factors such as nature and man. The spatial differentiation of ecosystem service value is also the result of the combination of random factors (human activities) and structural factors (natural background). Natural environment changes have a great impact on land and ecological environment, directly affecting land-use types, changing soil and water photothermal conditions, affecting land surface cover growth, and thus indirect effects and ecosystems, and affecting the value of ecosystem services. Basic environmental factors such as temperature and precipitation. The climatic conditions affect the land-use structure change by changing the hydrothermal conditions of the underlying surface, changing the type of surface land cover, and causing the functional change of land-use. This will change the function of the ecosystem, which will cause the ESVs to fluctuate. Therefore, this paper analyzes their relationships based on scatter plots of temperature, precipitation, population, and GDP with ESV (**Figure 5**).

The annual average temperature of the YZRB was 4.7°C , 5.2°C and 5.3°C , showing a significant growth trend. And the annual precipitation decreased from 489.6 mm in 1980 to 397.1 mm in 2015, showing a significant decrease. Climate change causes rising temperatures and reduced precipitation, which leads to the development of warm and dry watersheds. The most direct impact is that the water area shrinks, which will change the local water vapor cycle and have a certain impact on plant growth. The most direct evidence for this is the evidence. It is the continuous reduction of grassland area and the expansion of cultivated land during the study period. Since the water plays an important role in regulating services such as hydrological regulation and waste treatment, and has a very high coefficient of ESV. Therefore, the ESVs of water will decrease as the water areas decrease. As can be seen from the scatter plot distribution, annual average temperature and precipitation show a significant positive correlation with ESV. As the temperature and precipitation increase, the overall centralized distribution trend of ESV increases, but it shows a discrete distribution after reaching a certain threshold. This indicates that climate conditions have a positive effect on ESV, and ESV will increase with the increase of temperature and precipitation in certain hydrothermal conditions. Most studies have shown that changes in vegetation is the main natural factors of precipitation, water

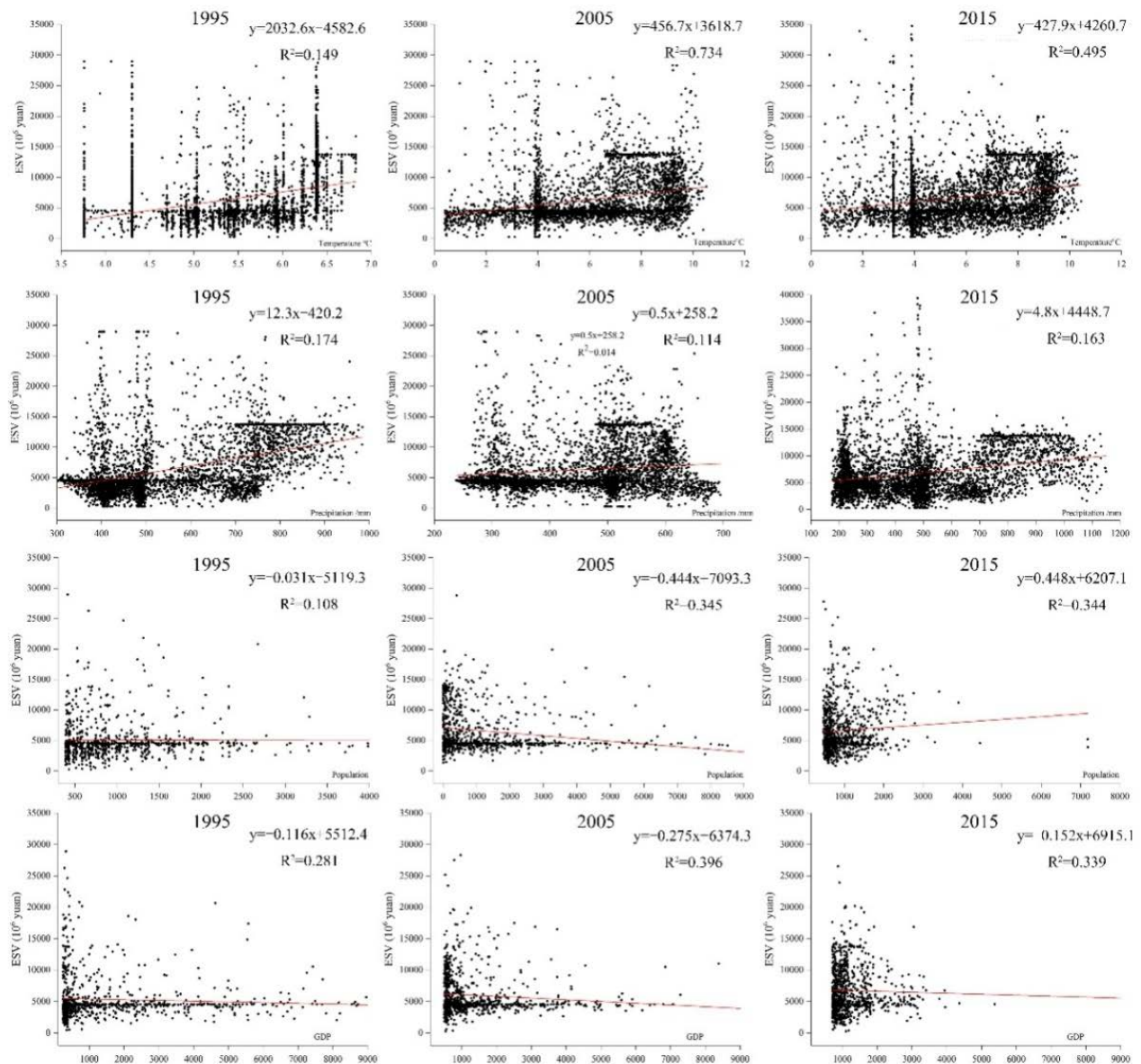


Figure 5. The scatter plots of temperature, precipitation, population and GDP with ESV.

conditions change of vegetation growth environment, for the supply of ecological system, regulation and support services will produce great influence, together with the study area in southern QTP, high altitude, big head, vegetation growth is slow, so that the temperature also become one of the constraint conditions of the vegetation growth. Due to the complex environment, water, poor thermal conditions to cooperate in cold plateau and moist valleys mixed artificial vegetation growth environment of the YZRB valley is impossible, so the ecosystem services value dependence on climate factor is higher, the high and low temperatures and precipitation intensity are existing structural impact on ecosystem services value.

On the other hand, changes in human activities have a certain impact on the land and ecological environment. Population and GDP data are indispensable

indicators of socio-economic factors and can indirectly reflect the random effects of human activities on the natural environment or ecosystem in YZRB. Both population and GDP have a significant negative relationship with ESV. The degree of negative correlation between population and ESV has been expanding with time, indicating that the YZRB in the QTP is increasing with the increasing population, and the damage to the ecosystem is gradually increasing. The population increase makes the plateau ecosystem that is more fragile. Unstable, the ESV provided will naturally decrease. GDP indicates the degree of social and economic development in a region. Compared with other parts of China, the social and economic development of the YZRB is relatively backward. The social development is mostly based on local planting and agriculture and animal husbandry, and its impact on the ecosystem is not significant. However, the ecological ecology of the basin is extremely fragile, the threshold of the ecosystem is low, and serious ecological and environmental problems are prone to occur, and these problems are irreversible in the alpine Qinghai-Tibet Plateau. With the continuous attention of the Chinese government to the ecological environment and the conduct of protective research in the Pan-Earth region, the social economy of the YZRB is maintained in a sustainable state. Although there is a negative relationship between GDP and ESV, its inhibition effect is with continuous reduction, the impact of ecological environment damage caused by the development of human society is gradually decreasing. In the future, under the guidance of the green and sustainable development policies advocated by the Chinese government, the ecological protection work in the QTP will be better and better, and the response of ESV to the random effects of human activities will gradually decrease, and the ecosystem will be more stable.

4. Conclusion

Total ESVs in the whole basin showed a change trend of “N” type, with an overall increase of 1506×10^8 yuan, an average annual growth of 0.27%. During the study period, forest land and grassland contribute the most to ESVs, while the ESVs generated by grassland and water are decreasing, and others are increasing. The areas of higher ESVs are mainly distributed in the lower reaches, and more concentrated in Nyingchi and Qamdo. The ESVs have a stepped distribution pattern of “upper < middle < lower”.

When the altitude is lower than 2000 m, there are less areas of low ESVs. The high-altitude ecosystem services such as vegetation and wetlands at an altitude of more than 4500 m are less distributed, so the ecosystem can only produce lower service value. The areas of medium ESVs are widely distributed below 3800 m. There are only a few areas of higher ESVs in the range of 3800 - 4800 m.

In general, the ESVs of the YZRB present a vertical distribution pattern of “low altitude, low value, and high concentration”. The transition between unused land and grassland is most dramatic. The transitions from unused land to grassland, grassland to unused land and forest land to grassland are the main type of land-use change. Ecological problems such as desertification and degra-

dation of grassland in the basin are more prominent. Changes in land-use types lead to the benefits of ESVs in cropland, forest land, water and wetland, while the ESVs of built-up land, grassland and unused land are in a loss state. The overall income of the basin is greater than the loss, and the ESVs have improved.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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