Evaluation of regional sustainable development based on ecological footprint model—take Luzhou city as an example

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Abstract. To clearly understand the ecological status and future sustainable development of Luzhou City, based on the ecological footprint model, this paper quantitatively studies the sustainability of Luzhou city's development in 2006-2016, and forecasts the sustainable status of Luzhou City in 2017-2026 by using the grey system prediction model. The results showed that Luzhou city was in the state of ecological deficit from 2006 to 2016, but showed a decreasing trend year by year. Luzhou city's ecological economy is in a weak and unsustainable state, and the structure and function of the ecological economic system are being optimized and adjusted. Therefore, to realize the sustainable development of Luzhou ecological economy, it is necessary to adjust the industrial structure, reduce energy consumption and promote the sustainable development of the region.

1. Introduction

1.1. Research background
In the late 1980s, the World Commission for environment and development (WCED) pointed out the concept of sustainable development in "our common future", which defined sustainable development as "development that can meet the needs of contemporary people and does not harm the ability of future generations to meet their needs [1]." The action of sustainable development was officially launched in 1992, sustainable development is the basic strategic policy of our country, which requires the comprehensive coordination and sustainability of all aspects of agriculture, forestry, animal husbandry and fisheries. While building the economy, we should pay attention to the protection of the ecological environment. The concept of "beautiful scenery and green hills and clear hills" is the basic idea of Xi Jinping's ecological civilization.

1.2. Research purpose and significance
With the development and utilization of resources and the necessity of eco agriculture rural construction, the relationship between ecological environment and resources is tense. In order to realize the diversity of ecological functions, realize the sustainable development of the region, correctly understand the type of dependence of economic development on resource consumption in Luzhou City, scientifically measure the capacity of ecological sustainable development, to make a theoretical basis for green development and the establishment of ecological livable and sustainable development cities.

2. Journals reviewed
Ecological footprint is to express the relationship between human consumption and the earth's carrying capacity. The concept of ecological footprint (EF) in the early 1980s was proposed and developed by Professor Wiliamless, an ecological economist, and his students professor Wackernagel and Dr. Wada [2]. In the application of ecological footprint, scholars later put forward six hypotheses. Its basic calculation includes ecological footprint, ecological carrying capacity and ecological carrying capacity balance. Then the relevant indicators are extended. Foreign scholars first calculated the global per capita ecological footprint and per capita carrying capacity, and finally got the per capita ecological footprint of 2.0hm² and per capita ecological carrying capacity of 2.2hm² (deducting 12% of the ecological productive area). In 1997, Wackernagel applied the ecological footprint method to calculate the ecological footprint of 52 countries and regions in the world, and the results showed that 35 countries and regions had ecological deficits [3]. Since 2000, with the deepening of the concept of sustainable development, WWF has published a report on ecological footprint every two years. The report shows that the global ecological footprint has increased year by year. So far, the research level of ecological footprint has been carried out from the global, national, regional and micro scale [4].

The concept of ecological footprint was introduced to China by Yang Kaizhong and Zhang Zhiqiang (1999), who first summarized the overseas studies of ecological footprint and calculated the ecological footprint of Gansu Province in 1998 [5]. Zhang Zhiqiang (2000) and others elaborated the concept and calculation model of ecological footprint, and systematically introduced the ecological footprint model into China [6]. Although the application of ecological footprint in China started late, many achievements have been made in the research methods and application fields, and the research methods of ecological footprint have been continuously improved [7]. Combined with other disciplines and models, the ecological footprint model is modified. The analysis methods mainly include comprehensive method, input-output method and component method [8]. Zhang Fangyi put forward the theory of Ecological Footprint Based on emergy analysis. Taking Jiangsu Province as an example, the per capita ecological load is 0.2997hm²/person, and the ecological footprint is 4.7228hm²/person, which is consistent with the calculation results of the traditional ecological footprint model, but more truly reflects the environmental situation of the ecological economic system [9]. We can also take different regional scales as research objects, Fu Kai et al. Analyzed the ecological footprint of Guangdong Province from 2000 to 2012, and predicted the change of ecological footprint using ARIMA model. The results showed that the per capita ecological footprint increased [10]. Gu Xiaowei analyzed the ecological footprint of the university campus, taking Northeastern University and Shenyang University as examples to study the ecological efficiency of Higher Education [11]; Song thought studied the ecological footprint of the consumption of urban and rural residents in Linfen, showing the utilization of resources and environment by residents [12]. According to the research of comprehensive scholars, most of the ecological footprints are about large-scale areas, but little about micro areas. In addition, the research of ecological footprint method is extended to other fields, which links ecological footprint with optimization of regional industrial structure, adjusts industrial structure from the direction of eliminating ecological deficit [13], Jiang Tao analyzes the ecological footprint of the evaluation of the coordination degree of eco-tourism consumption and tourism development in western provinces, regions and cities, constructs three evaluation indexes, and establishes four levels of coordination Degree [14]. Based on the calculation of three models of ecological footprint, ecological carrying capacity and ecological carrying capacity, the ecological footprint method continues to expand. Its research level is broad from the global, national, provincial, state, city and county aspects, but the scope of research is suitable for large regions, and the research on Township and micro level is less, because micro level data is difficult to collect, lack of authenticity and credibility. However, the method of ecological footprint has been applied in different spatial scales, showing good universality. However, from the perspective of urban districts, cities and counties, there are few literatures on the analysis of the two dimensions of ecological footprint in time and space. From the perspective of space, there are relatively few studies on the differences of internal dynamic changes.

3. Research content
The research object is Luzhou City, which is located in the southwest of Sichuan Province. It is divided into four counties and three districts, with a total area of 12236.2 square kilometers, rich in natural resources. Luzhou city is a national health city and a national civilized city with civilized and green development. In 2018, the city's regional GDP totaled 169.5 billion yuan, with the primary, secondary and tertiary industries all increasing over the previous year. With rapid economic growth and upgrading of industrial structure, it has become a Sichuan Free Trade Zone.

This study uses the ecological footprint component method to calculate the ecological footprint of Luzhou City from 2006 to 2016. The grey system prediction model GM (1,1) is used to predict the changes of ecological footprint and ecological carrying capacity of Luzhou City in the next ten years from 2017 to 2026. In the calculation of ecological footprint and the calculation of ecological footprint is divided into two parts: the biological resources part and the energy account part. In this paper, the "net primary production" method is adopted to calculate the equilibrium factors and yield factors in Sichuan Province \[15\]. The equilibrium factors of water area, construction land, fossil energy land, cultivated land, forest land, grassland are 0.47, 1.13, 0.88, 1.13, 0.18 and 0.59 respectively; the yield factors of water area, construction land, fossil energy land, cultivated land, forest land, grassland are 2.15, 1.04, 0.00, 1.04, 1.00 and 2.15 \([16]\)-\([17]\).

The data of this study are from Luzhou Statistical Yearbook (2007-2017), Sichuan Statistical Yearbook (2007-2017), Sichuan national economic and social development statistical bulletin (2007-2017), world food and Agricultural Organization database.

4. Results and analysis

4.1. Luzhou's ecological footprint in 2006-2016

4.1.1. Biological resources

Table 1. Ecological Footprint biological account 2016

| Land type      | Average product (kg/hm²) | Biomass consumption (10000 t) | total ecological footprint (10000 Hm²) | after equilibrium(10000 Hm²) | Per capita ecological footprint (hm² / person) | after equilibrium (hm²/pers on) | Land type      |
|----------------|--------------------------|-------------------------------|--------------------------------------|-------------------------------|-----------------------------------------------|-------------------------------|----------------|
| Grain          | 2744                     | 172.64                        | 62.9160                              | 71.0951                       | 0.1461                                        | 0.1651                        | cultivated land |
| Rice           | 2744                     | 121.33                        | 44.2165                              | 49.9646                       | 0.1027                                        | 0.1160                        | cultivated land |
| Wheat          | 2744                     | 9.01                          | 3.2835                               | 3.7104                        | 0.0076                                        | 0.0086                        | cultivated land |
| Corn           | 2744                     | 26.77                         | 9.7558                               | 11.0241                       | 0.0227                                        | 0.0256                        | cultivated land |
| Beans          | 1856                     | 3.17                          | 1.7080                               | 1.9300                        | 0.0040                                        | 0.0045                        | cultivated land |
| Potato         | 12607                    | 29.78                         | 2.3622                               | 2.6693                        | 0.0055                                        | 0.0062                        | cultivated land |
| Oil            | 1856                     | 4.93                          | 2.6579                               | 3.0034                        | 0.0062                                        | 0.0070                        | cultivated land |
| Sugar cane     | 18000                    | 7.30                          | 0.4056                               | 0.4583                        | 0.0009                                        | 0.0011                        | cultivated land |
| Raw hemp       | 1500                     | 0.01                          | 0.0093                               | 0.0105                        | 0.0000                                        | 0.0000                        | cultivated land |
| Product Type               | Total Consumption | Low Calorific Value | Total Ecological Footprint | After Equilibrium | Per Capita Consumption | Per Capita Ecological Footprint | After Equilibrium |
|---------------------------|-------------------|---------------------|---------------------------|-------------------|------------------------|---------------------------------|-------------------|
| Tobacco leaf              | 1548              | 1.27                | 0.8204                    | 0.9271            | 0.0019                 | 0.0022                          | cultivate land    |
| Vegetables and edible fungi | 18000            | 244.15              | 13.5639                   | 15.3272           | 0.0315                 | 0.0356                          | cultivate land    |
| Pork                      | 74                | 25.14               | 339.697                   | 200.4214          | 0.7888                 | 0.4654                          | grassland         |
| Beef                      | 33                | 0.95                | 28.7758                   | 16.9777           | 0.0668                 | 0.0394                          | grassland         |
| Mutton                    | 33                | 0.77                | 23.3848                   | 13.7971           | 0.0543                 | 0.0320                          | grassland         |
| Poultry meat              | 457               | 4.30                | 9.4136                    | 10.6373           | 0.0219                 | 0.0247                          | cultivate land    |
| Rabbit meat               | 33                | 1.34                | 40.4667                   | 23.8753           | 0.0940                 | 0.0554                          | grassland         |
| Milk                      | 502               | 0.85                | 1.6876                    | 1.9070            | 0.0039                 | 0.0044                          | cultivate land    |
| Eggs                      | 400               | 4.32                | 10.8075                   | 12.2125           | 0.0251                 | 0.0284                          | grassland         |
| Tea                       | 566               | 1.21                | 2.1345                    | 2.4119            | 0.0050                 | 0.0056                          | grassland         |
| Garden fruit              | 3500              | 18.76               | 5.3604                    | 0.9649            | 0.0124                 | 0.0022                          | water area        |
| Aquatic products          | 2744              | 11.86               | 4.3206                    | 2.0307            | 0.0102                 | 0.0048                          | woodland          |
| Timber                    | 1.99              | 10147.00            | 0.5099                    | 0.0918            | 0.0012                 | 0.0002                          | woodland          |

4.1.2. See Table 2 for energy account (2016)

**Table 2.** Ecological footprint energy account 2016

| Energy Classification | Total Consumption | Low Calorific Value | Total Ecological Footprint | After Equilibrium | Per Capita Consumption | Per Capita Ecological Footprint | After Equilibrium |
|-----------------------|-------------------|---------------------|---------------------------|-------------------|------------------------|---------------------------------|-------------------|
| Coal                  | 414.9870          | 20.9340             | 157.9516                  | 138.9974          | 20.1731                | 0.3668                          | 0.3228            |
| Natural gas           | 14.9528           | 38.9780             | 6.2670                    | 5.51500           | 1.3534                 | 0.0146                          | 0.0128            |
| Crude oil             | 54.4931           | 41.8680             | 24.5324                   | 21.58850          | 5.2980                 | 0.0570                          | 0.0501            |
| Gasoline              | 0.3020            | 43.1240             | 0.1400                    | 0.1232            | 0.0302                 | 0.0003                          | 0.0003            |
| Kerosene              | 0.0044            | 43.1240             | 0.0020                    | 0.0018            | 0.0004                 | 0.0001                          | 0.0001            |
| Diesel oil            | 1.0244            | 42.7050             | 0.4704                    | 0.4140            | 0.1016                 | 0.0011                          | 0.0010            |
| Power                 | 45.6446           | 83.1100             | 3.7935                    | 4.2867            | 8.8090                 | 0.0088                          | 0.0100            |

Note: the unit is the total consumption of 10000 t average low calorific value GJ / T), the electric power is the construction land, and the rest is the fossil energy land.

4.1.3. Ecological footprint

**Table 3.** Total ecological footprint of Luzhou City from 2006 to 2016

| Year       | Cultivated land | Grassland | Woodland | Water area | Fossil energy land | Construction land | Total ecological footprint |
|------------|-----------------|-----------|----------|------------|--------------------|-------------------|--------------------------|
| 2006-2016  |                 |           |          |            |                    |                   |                          |

4
Table 4. Per capita ecological footprint of Luzhou City from 2006 to 2016

| Year | Cultivated land | Grassland | woodland | Water area | Fossil energy land | Construction land | Total ecological footprint |
|------|-----------------|-----------|----------|------------|-------------------|-------------------|---------------------------|
| 2006 | 0.4846          | 0.5020    | 0.0021   | 0.0025     | 0.4454            | 0.0048            | 1.4413                    |
| 2007 | 0.4554          | 0.5330    | 0.0020   | 0.0027     | 0.5664            | 0.0053            | 1.5649                    |
| 2008 | 0.4884          | 0.4590    | 0.0024   | 0.0031     | 0.5848            | 0.0053            | 1.5430                    |
| 2009 | 0.4730          | 0.7762    | 0.0024   | 0.0035     | 0.8977            | 0.0072            | 2.1600                    |
| 2010 | 0.4517          | 0.8522    | 0.0021   | 0.0039     | 0.9293            | 0.0085            | 2.2476                    |
| 2011 | 0.4474          | 0.8339    | 0.0020   | 0.0040     | 0.6706            | 0.0089            | 1.9668                    |
| 2012 | 0.4586          | 0.8477    | 0.0024   | 0.0043     | 0.4452            | 0.0088            | 1.7671                    |
| 2013 | 0.4291          | 0.5938    | 0.0024   | 0.0044     | 0.6673            | 0.0088            | 1.7058                    |
| 2014 | 0.4290          | 0.6217    | 0.0023   | 0.0028     | 0.4222            | 0.0094            | 1.4874                    |
| 2015 | 0.3871          | 0.6080    | 0.0024   | 0.0047     | 0.3933            | 0.0098            | 1.4053                    |
| 2016 | 0.2698          | 0.5923    | 0.0025   | 0.0048     | 0.3870            | 0.0100            | 1.2663                    |

According to Table 3 and Table 4, since 2010, the changes of per capita ecological footprint and total ecological footprint have the same trend. From 2006 to 2016, the total ecological footprint showed a decreasing trend, and slightly increased from 2010 to 2013. The year with the largest total ecological footprint is 2012, which is 9.7843 million Hm2. The lowest year of total ecological footprint is 2016, 6.2051 million Hm2, with a difference of 3.5792 million Hm2. From 2006 to 2016, the total ecological footprint remained at the level of 6-10 million Hm2, fluctuating up and down in this range. Fossil energy land, grassland and cultivated land contribute the most to the total ecological footprint. From 2006 to 2016, the proportion of cultivated land was between 19% - 28%, that of grassland was between 27% - 30%, and that of fossil energy was between 40% - 50%. The order of the three was fossil energy land > grassland > cultivated land. However, the proportion of forest land, water area and construction land is small, and the proportion of the three is between 0.4% - 1%. The building area is expanding and the demand for it is increasing.

4.2. Luzhou's ecological surplus/deficit in 2006-2010

According to Table 5, the ecological footprint of Luzhou City in 2006-2016 is in the state of ecological deficit. The ecological deficit increased to a lower level. The year with the highest ecological deficit was 2010, reaching -2.1443hm2/person. The year with the lowest ecological deficit was 2016, reaching -1.1619hm2/person. Cultivated land, grassland and fossil energy land are in the state of ecological deficit, and the severity of deficit is different, which is fossil energy land > grassland > cultivated land, consistent with the situation of ecological footprint. Water area, forest land and construction land are in the state of ecological surplus, indicating that the three types of land use are in a good state of sustainable development. In general, the land type in ecological deficit is larger than that in ecological surplus, which leads to the ecological deficit of the whole ecological economic system of Luzhou city.
Table 5. Per capita ecological surplus or ecological deficit of Luzhou City from 2006 to 2016 (hm²/person)

| year | Cultivated land | Grassland | water area | woodland | Construction land | Fossil energy land | total |
|------|-----------------|-----------|------------|----------|-------------------|------------------|-------|
| 2006 | -0.4268         | -0.4952   | 0.0121     | 0.0160   | 0.0113            | -0.4454          | -1.3416 |
| 2007 | -0.3984         | -0.5252   | 0.0123     | 0.0159   | 0.0111            | -0.5664          | -1.4647 |
| 2008 | -0.4313         | -0.4506   | 0.0121     | 0.0151   | 0.0111            | -0.5848          | -1.4421 |
| 2009 | -0.4163         | -0.7669   | 0.0120     | 0.0150   | 0.0097            | -0.8977          | -2.0581 |
| 2010 | -0.3934         | -0.8424   | 0.0121     | 0.0145   | 0.0081            | -0.9293          | -2.1443 |
| 2011 | -0.3891         | -0.8228   | 0.0120     | 0.0144   | 0.0077            | -0.6706          | -1.8625 |
| 2012 | -0.4004         | -0.8391   | 0.0103     | 0.0139   | 0.0077            | -0.4452          | -1.6666 |
| 2013 | -0.3707         | -0.5852   | 0.0102     | 0.0140   | 0.0077            | -0.6673          | -1.6050 |
| 2014 | -0.3164         | -0.6107   | 0.0131     | 0.0145   | 0.0073            | -0.4222          | -1.3351 |
| 2015 | -0.3294         | -0.5970   | 0.0112     | 0.0144   | 0.0070            | -0.3933          | -1.3013 |
| 2016 | -0.2124         | -0.5814   | 0.0110     | 0.0150   | 0.0071            | -0.3870          | -1.1619 |

4.3. Analysis of relevant indicators of Luzhou's ecological footprint in 2006-2016

It can be seen from Table 6 that the GDP of Luzhou city is developing rapidly, and the ecological footprint of ten thousand yuan GDP is decreasing year by year, and the change trend of the two is opposite. Luzhou's ecological footprint diversity index and development capacity increase. The highest ecological footprint diversity index is 1.1185. The ecological footprint diversity index of Sichuan Province is 0.84, which shows that the ecosystem structure and function are strong, which can better meet the needs of economic development.

From 2006 to 2016, the ecological carrying capacity of Luzhou city is gradually increasing, the structure and function of the ecological system are strengthening, the ecological index is in the range of -100% - 0, increasing gradually. As shown in Table 7, this table is the correlation analysis of five indicators related to ecological footprint. The correlation coefficient r between per capita ecological footprint and per capita GDP is -0.328, showing a negative correlation; the correlation between per capita GDP and per capita GDP ecological footprint is obvious, r = -0.978, which shows that Luzhou city's resource investment promotes economic growth. At the same time, the improvement of residents' living standards reflects the economic growth of Sichuan Province. The per capita resource consumption is gradually increasing, and the ecological footprint is increasing.

Table 6. Relevant indicators of ecological footprint

| year | Population | Diversity index | Development capacity | Ecological carrying capacity | ecological footprint index | 10000 yuan GDP ecological footprint | GDP per capita |
|------|------------|-----------------|----------------------|----------------------------|----------------------------|------------------------------------|---------------|
| 2006 | 423.61     | 1.0778          | 1.5534               | 0.0541                     | -0.9459                   | 1.8346                             | 0.7856        |
| 2007 | 429.07     | 1.0858          | 1.6992               | 0.0610                     | -0.9390                   | 1.6454                             | 0.9511        |
| 2008 | 430.40     | 1.1018          | 1.7001               | 0.0713                     | -0.9287                   | 1.2958                             | 1.1908        |
| 2009 | 434.30     | 1.0932          | 2.3613               | 0.0728                     | -0.9272                   | 1.5965                             | 1.3530        |
| 2010 | 421.80     | 1.0938          | 2.4585               | 0.0634                     | -0.9366                   | 1.3263                             | 1.6946        |
| 2011 | 422.50     | 1.1115          | 2.1862               | 0.0581                     | -0.9419                   | 0.9224                             | 2.1322        |
| 2012 | 425.00     | 1.0999          | 1.9435               | 0.0496                     | -0.9504                   | 0.7288                             | 2.4246        |
| 2013 | 424.58     | 1.1335          | 1.9335               | 0.0564                     | -0.9436                   | 0.6350                             | 2.6861        |
| 2014 | 425.00     | 1.1346          | 1.6877               | 0.0801                     | -0.9199                   | 0.5018                             | 2.9641        |
| 2015 | 428.52     | 1.1384          | 1.5998               | 0.1133                     | -0.8867                   | 0.4449                             | 3.1583        |
| 2016 | 430.64     | 1.1185          | 1.4164               | 0.1318                     | -0.8682                   | 0.3680                             | 3.4412        |
Table 7. Correlation analysis

|                           | GDP per capita | Per capita ecological footprint | 10000 yuan GDP ecological footprint | Ecological diversity Index | Ecological footprint development capacity |
|---------------------------|----------------|---------------------------------|-------------------------------------|----------------------------|--------------------------------------------|
| GDP per capita            | 1.000          | -0.328                          | -0.978**                            | 0.872**                    | -0.257                                     |
| Per capita ecological footprint | -0.328        | 1.000                           | 0.360                               | -0.323                     | 0.996**                                    |
| Ecological footprint of 10000 yuan GDP | -0.978**      | 0.360                           | 1.000                               | -0.895**                   | 0.287                                      |
| Ecological diversity footprint | 0.872**       | -0.323                          | -0.895**                            | 1.000                      | -0.238                                     |
| Development capacity of ecological footprint | -0.257         | 0.996**                          | 0.287                               | -0.238                     | 1.000                                      |

Note: * correlation is significant at 0.05, ** correlation is significant at 0.01

4.4. Development trend forecast of ecological footprint and ecological carrying capacity of Luzhou City

Using the per capita ecological footprint of 2011-2016 as the original data, a grey system prediction model was established by using DPS. The model was diagnosed according to the posterior ratio C and the small error probability P. When p > 0.95 and C < 0.35, the model accuracy was good; when p > 0.8 and C < 0.5, the model was qualified; when p > 0.7 and C < 0.65, the model was barely qualified; when p < = 0.7 and P > = 0.65, the model was unqualified. The per capita ecological footprint prediction model C = 0.1349 (good), P = 1.0000 (good), a = 0.031737, b = 0.803174. The prediction equation is x(T+1) = 1.7397. The per capita ecological footprint is decreasing year by year, and the ecological economy is developing well.

Table 8. Development trend forecast of per capita ecological footprint

| X (t+1)    | 1.7397 |
|------------|--------|
| X (t+2)    | 1.07835|
| X (t+3)    | 0.99051|
| X (t+4)    | 0.90983|
| X (t+5)    | 0.8063 |
| X (t+6)    | 0.76765|
| X (t+7)    | 0.70512|
| X (t+8)    | 0.64768|
| X (t+9)    | 0.59493|
| X (t+10)   | 0.54647|

GM (1,1) model was established by using the total ecological carrying capacity from 2006 to 2016, C = 0.3154 (good), P = 1.0000 (good), a = -0.011599, b = 0.0983. = 0.11645, The prediction equation is x(t+1) = 8.584926exp(0.011599t) - 8.480626. The change trend of per capita ecological carrying capacity is not obvious, but the per capita ecological footprint is reduced, and the ecological economy is developing in the direction of sustainable development.

Table 9. Development trend forecast of per capita ecological carrying capacity

| X (t+1)    | 0.10613 |
|------------|---------|
| X (t+2)    | 0.10737 |
5. Summary and suggestions

5.1. Summary

In the time series, the ecological footprint of Luzhou City decreased slowly and changed unsteadily. From the perspective of consumption, the per capita ecological footprint from 2006 to 2016 has a trend of increasing to decreasing, and the overall situation is unstable. In the ecological footprint account, the per capita ecological footprint of six kinds of ecological productive land accounts for the largest proportion of cultivated land, which is due to the impact of biological resource account users on food consumption expenditure.

From the perspective of the structure of ecological footprint, all types are changing. In terms of the structure of ecological footprint, the proportion of cultivated land, grassland and fossil energy land is high, showing a downward trend from 2006 to 2016. The construction land is increasing year by year, and the water area and forest land are basically stable. The total ecological footprint fluctuates little, with a range of about 2 million hectares. In recent years, it has gradually decreased, and people's demand is changing.

From 2006 to 2016, Luzhou city was in an ecological deficit situation, with tight supply and demand conflicts, and its ecological economic system was in a weak and unsustainable development state, which will be alleviated in the future. Among the six kinds of ecological productive land, water area, construction land and forest land are ecological surplus with surplus. Cultivated land, grassland and fossil energy land are in deficit state, resulting in the total ecological footprint of Luzhou City in deficit state. Although the contradiction between human and land is tense, the total ecological deficit is decreasing, and the ecology and economy are gradually in accordance with the sustainable development direction.

In the past three years, the per capita ecological footprint has decreased. From 2014 to 2016, the per capita ecological footprint was 1.4874hm\(^2\), 1.4053hm\(^2\), 1.2663hm\(^2\). The per capita ecological carrying capacity increased. From 2014 to 2016, the per capita ecological carrying capacity was 0.1025hm\(^2\), 0.1046hm\(^2\), 0.1044hm\(^2\), and the per capita ecological deficit decreased. From 2014 to 2016, the per capita ecological carrying capacity was 1.3351hm\(^2\), 1.3013hm\(^2\), 1.1619hm\(^2\), and the overall ecological economy was in good condition. According to the forecast, in the future, the per capita ecological footprint will be reduced, the per capita ecological carrying capacity will be increased, and people's pressure on the ecological environment will be relieved, so as to realize the harmonious coexistence of ecology, economy and nature.

5.2. Suggestions

To improve the mechanism of ecological compensation, we can increase the proportion of green GDP on the one hand, and reduce the incidence of various pollution behaviors on the other hand. Improve the level of science and technology, increase research and development, and improve the efficiency of resource utilization. In energy consumption, reduce the loss rate of resources, realize multi-level reuse, realize waste utilization through the coupling of industrial chain, and turn waste into treasure. At the same time, we should develop ecological economy and ecological agriculture to realize the organic
unity of ecological, economic and social benefits. In recent years, the cultivated land in Luzhou City has decreased and the construction land has increased. Reducing the burning of fossil fuels is an important way to reduce the ecological footprint, and also an important way to protect the ecological environment. The government and relevant departments shall establish the Ecological Footprint Assessment and early warning mechanism, change people's travel and lifestyle, save energy, reasonably apply resources to factories and enterprises, develop and innovate new technologies. Luzhou city should also strengthen the development of service industry to improve people's spiritual world. Develop multi-functional agriculture and multi-functional industries, and finally realize the sustainable development of economic ecology.

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