Sustainable Development Level in Rural China Based on Osculating Value Method

LU Bing-fu*, HAN Wei-ping
Institute for Agricultural Economy and Rural Development, Heilongjiang University, Harbin 150080, China

Abstract This paper expounds the theoretical basis of rural sustainable development, sets up evaluation index system for rural sustainable development level in China, and uses the osculating value method to evaluate the rural sustainable development in cities, autonomous regions and provinces of China. They are divided into 3 grades of A, B and C according to the evaluation result. Finally, we analyze the causation of the differences of rural sustainable development among cities, autonomous regions and provinces in rural China.

Key words Rural sustainable development; Osculating value; Evaluation; Empirical analysis, China

Sustainable development in rural areas is an important component of China's social and economic sustainable development; it is also an inevitable choice for rural development in China in the 21st century. Since the reform and opening up, economic strength in rural areas has improved significantly; agricultural production and technology have advanced significantly; agricultural mechanization and agricultural chemicals have developed rapidly. However, there is a lack of coordination between the development and utilization of rural resources and the environmental protection, which leads to the deterioration of the ecological environment in rural areas, and makes the rural sustainable development under the pressure of unprecedented resources and environment. China has too many people but less land along with the relative shortage of per capita resources, unbalanced regional development, and relatively weak economic and technological foundation. All these basic national conditions determine that China must follow the sustainable development path of resource saving, environment friendly, intensive and highly efficient production, and harmony between man and nature.

1 Rural sustainable development theory
Mankind's understanding of rural sustainable development has gone through a tortuous and complex process. "Den Bosch Declaration" is regarded as a watershed of this process. Before it, researches on agricultural sustainable development were limited to the field of agricultural production, and focused on agricultural technology, environment and output; situation has changed dramatically after the declaration. Due to the advancing of the concepts of sustainable agriculture (SAD) and rural development (SRD), they were combined together organically. Thus research on rural sustainable development strategies came into a new era.

Agriculture is the ultimate provider of human food. It is a production sector of the close combination of natural reproduction, economic reproduction and social reproduction, which makes agriculture play an important and special role in the theory and practice of sustainable development. Basic concept of rural sustainable development includes fairness, continuity, commonality and harmony. Sustainable development of rural economy has long-term dependence on the natural environment and natural resources. The generally recognized principles of sustainable development in rural areas should be the sustained economic growth in rural areas, the continued progress in rural society, the sustainable support of rural resources, and the virtuous circle of rural ecological environment.

2 Index system establishment for the evaluation on rural sustainable development level
When implementing the sustainable development in rural areas, we should firstly ensure the evaluation index according to the rural sustainable development system, and then construct the evaluation index system on the basis of each index. Index is a portrait, description and measurement of the objective world, it is a kind of yardstick or standard, which reflects the quantity concept and specific numerical value of system elements or phenomena. It includes both of index name and index numerical value. Some of the indices constituting the measurement index system are the basic indices directly from original data and the deep-level indices obtained through data mining, which are used for reflecting the characteristics of subsystem. Others are composite indices for the abstraction, synthesis and summary of basic index, which can explain the links between the various subsystems and the overall characteristics of rural sustainable development system. Index system of rural sustainable development is in fact an assemblage composed of a number of indices reflecting the capability of rural sustainable development with index as the basic element.

Rural sustainable development is a three-dimensional composite system, which consists of three subsystems of rural eco-
nomic system, rural social system and rural resources and environment system\(^3\). We establish the measurement index system suitable for the rural sustainable development in China according to the system structure of rural sustainable development. It can not only adequately reflect the implementation degree of rural sustainable development goals, but also can be quantified in order to compare with different areas. Moreover, it can not only reflect the economic, ecological and social benefits of agriculture, but also can realize the combination of static analysis and dynamic analysis. We can adopt analytic hierarchy process to evaluate each hierarchy; meanwhile, we can explore the whole development process. Table 1 shows the integrated measurement index system designed in this paper. This index system has consulted to the research result of agriculture and rural sustainable development by different scholars after screening and integration. It is composed of 3 primary indices, 9 secondary indices and 20 tertiary indices of rural economy, rural society and rural resources and environment.

<table>
<thead>
<tr>
<th>Primary index</th>
<th>Secondary index</th>
<th>Tertiary index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural economy</td>
<td>Rural economic growth ability</td>
<td>Per capita agricultural output value/ yuan</td>
</tr>
<tr>
<td></td>
<td>Agricultural production capacity</td>
<td>Per capita food production/ kg</td>
</tr>
<tr>
<td></td>
<td>Agricultural mechanization level</td>
<td>Total power of agricultural machinery per unit arable land/ kW/ hm(^2)</td>
</tr>
<tr>
<td></td>
<td>Peasants' income and consumption level</td>
<td>Degree of agricultural mechanization/ %</td>
</tr>
<tr>
<td>Rural society</td>
<td>Rural social welfare</td>
<td>Proportion of the number of rural old-age welfare in rural population/ %</td>
</tr>
<tr>
<td></td>
<td>Rural education level and proportion of the population engaged in agriculture</td>
<td>Proportion of the total employees of primary industry in the social workers/ %</td>
</tr>
<tr>
<td></td>
<td>Resources level</td>
<td>Proportion of the rural labor force with middle school education and higher/ %</td>
</tr>
<tr>
<td>Rural resources and environment</td>
<td>Environmental degradation level</td>
<td>Per capita arable land area/ hm(^2)</td>
</tr>
<tr>
<td></td>
<td>Environmental protection level</td>
<td>Per capita share of water resources/ m(^3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fertilizer use intensity/ kg/ hm(^2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pesticide use intensity/ kg/ hm(^2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use intensity of plastic film/ kg/ hm(^2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Forest coverage/ %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of wetland area/ %</td>
</tr>
</tbody>
</table>

### 3 Overall osculating value model of the measurement of rural sustainable development level

Measurement of rural sustainable development level is a multi-index comprehensive evaluation problem. And we can carry out measurement by principal component analysis, fuzzy comprehensive evaluation and so on. Rural sustainable development is a continuous process. It is difficult to quantify the contribution degree of each index. The determination of index weight has characteristics of strong subjectivity. Osculating value is a multi-objective decision-making optimization method, which can use the cross-section data to describe the overall regional differences. Its main advantage is no need of weight determination, therefore the subjective inaccuracy can be avoided, and scientific quantization tools are offered for the measurement of rural sustainable development level in different areas\(^4\).\(^5\).

#### 3.1 Rural sustainable development model

It is found from the construction of index system that the evaluation on rural sustainable development and ecological environment in China is multi-level and multifaceted. Therefore, basis for quantitative analysis is required in order to correctly understand the sustainable development of rural economy, rural society and rural resources and environment. This paper sets up the comprehensive evaluation model in accordance with the principles of math. Mathematical model can be used to quantify the indices, which not only fully reflects the capacity level of rural sustainable development in China, but also can conduct comparison among different areas.

Assuming that there are \( n \) variable indices and \( m \) regions in the evaluation analysis, a initial matrix \( D \) is constructed. \( d_j(i = 1, 2, \ldots, m; j = 1, 2, \ldots, n) \) stands for the value of index \( j \) in region \( i \). Hence, we have \( D = (d_{ij})_{m \times n} \). Complex relationships exist among the indices in the initial matrix \( D \). There are positive index (the higher index, the stronger sustainable development capability) and negative index (the higher index, the worse sustainable development capability), and the dimensions of indices are different. We carry out dimensionless standardization treatment on matrix \( D \) for the convenience of comparison:

\[
x_j = \left( \sum_{i=1}^{m} d_{ij} \right)^{1/2} (j = 1, 2, \ldots, n)
\]

(1)

\[
x_j = \left( \sum_{i=1}^{m} d_{ij} \right)^{1/2} (j = 1, 2, \ldots, n)
\]

(2)

The matrix after standardization is written as

\[
X = (x_{ij})_{m \times n}.
\]

(3)

#### 3.2 Determination of the optimum and worst point sets in the matrix

Let

\[
x_j^* = \max(x_j) \quad (j = 1, 2, \ldots, n),
\]

(4)

the optimum point set is

\[
N^* = (x_1^*, x_2^*, \ldots, x_n^*).
\]

(5)
And the worst point set is
\[ N^* = (x_i^*, y_i^*, \ldots, z_i^*). \] (6)

Regions, which are closer to \( N^* \) and farther to \( N^- \), have higher capacity of sustainable development in rural areas, and vice versa. Thus the areas with optimum sustainable development capacity are the concentrated regions farthest to worst point set and closest to optimum point set.

3.3 Calculation of regional osculating value

Osculating value \( C_i \) reflects the approach degree of each region from the extreme points. We have
\[ C_i = \frac{d_i^* - d_i^{-}}{d_i^{+} - d_i^{-}} (i = 1, 2, \ldots, m), \] (7)

where
\[ d_i^{+} = \left[ \frac{\sum j \left( x_j - x_i \right)^2}{\sum j \left( x_j - x_i \right)^2} \right]^{1/2}, \] (8)
\[ d_i^{-} = \left[ \frac{\sum j \left( x_j - x_i \right)^2}{\sum j \left( x_j - x_i \right)^2} \right]^{1/2}, \] (9)
\[ d_i^{+} = \min \left\{ d_i^{+} \right\}, \] (10)
\[ d_i^{-} = \max \left\{ d_i^{-} \right\}, \] (11)

\( d_i^{+} \) is the Euclidean distances between \( N \) and the area with strongest capacity of rural sustainable development \( N^* \), \( d_i^{-} \) is the Euclidean distances between \( N \) and the area with weakest capacity of rural sustainable development \( N^- \), \( d_i^{-} \) is the minimum value of \( n \) optimum point distances, \( d_i^{+} \) is the maximum value of \( n \) worst point distances. Osculating value can turn the multiple indices into single index, which can overall measure the sustainable development capacity in rural areas.

4 Empirical analysis of the measurement of rural sustainable development level in China

4.1 Determination of the optimum and worst point sets

Combining with the measurement index system of rural sustainable development level and the overall osculating value model, we sort out the related data from the China Statistical Yearbook 2006, Chinese Agricultural Yearbook, and the Monitoring Report on Building a Well-off Countryside in China. After obtaining the original data of measurement of rural sustainable development level in China, we establish the initial matrix \( D \). Standardized treatment is carried out on the initial matrix according to equations (1) and (2), and then the standardized matrix \( X \) is obtained.

According to equations (5) and (6), the optimum point set is \( N^* = \{ 0.363, 0.390, 0.505, 0.341, 0.368, 0.357, 0.384, 0.440, 0.263, 0.883, 0.495, -0.026, 0.214, 0.485, 0.623, -0.009, -0.018, -0.042, 0.362, 0.827 \} \). The worst point set is \( N^- = \{ 0.352, 0.059, 0.047, 0.059, 0.055, 0.011, 0.087, 0.093, 0.066, 0.005, 0.016, -0.267, 0.034, 0.040, 0.003, -0.605, -0.427, -0.356, 0.016, 0.006 \} \).

4.2 Calculation on the osculating value of innovation capability of rural sustainable development

According to equations (8) and (9), we have \( d_i^{+} = 11.483, 1.482, 1.610, 1.663, 1.495, 1.435, 1.417, 1.393, 1.278, 1.495, 1.514, 1.617, 1.670, 1.654, 1.536, 1.648, 1.530, 1.588, 1.567, 1.620, 1.522, 1.651, 1.638, 1.742, 1.673, 1.534, 1.684, 1.714, 1.482, 1.624, 1.619 \), \( d_i^{-} = 0.877, 0.892, 0.768, 0.812, 1.057, 1.873, 1.048, 1.117, 1.374, 0.809, 0.893, 0.711, 0.856, 0.795, 0.696, 0.741, 0.709, 0.687, 0.759, 0.756, 0.864, 0.719, 0.733, 0.784, 0.781, 0.136, 0.813, 0.740, 1.056, 1.837, 0.864 \).

According to equations (10) and (11), we have \( d_i^{+} = 1.278, 6 \) and \( d_i^{-} = \max \{ d_i^{-} \} = 1.374, 8 \).

Table 2 reports the regional osculating value obtained according to equation (7).

### Table 2: Measurement result of rural sustainable development level in different areas of China

<table>
<thead>
<tr>
<th>Region</th>
<th>Rank</th>
<th>Osculating value</th>
<th>Region</th>
<th>Rank</th>
<th>Osculating value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shanghai</td>
<td>1</td>
<td>0.000 0</td>
<td>Guangdong</td>
<td>17</td>
<td>0.673 6</td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>2</td>
<td>0.277 5</td>
<td>Hubei</td>
<td>18</td>
<td>0.681 2</td>
</tr>
<tr>
<td>Jilin</td>
<td>3</td>
<td>0.345 9</td>
<td>Shandong</td>
<td>19</td>
<td>0.694 6</td>
</tr>
<tr>
<td>Qinghai</td>
<td>4</td>
<td>0.391 6</td>
<td>Hebei</td>
<td>20</td>
<td>0.700 1</td>
</tr>
<tr>
<td>Inner Mongolia</td>
<td>5</td>
<td>0.402 8</td>
<td>Shanxi</td>
<td>21</td>
<td>0.710 2</td>
</tr>
<tr>
<td>Tibet</td>
<td>6</td>
<td>0.446 9</td>
<td>Guangxi</td>
<td>22</td>
<td>0.717 3</td>
</tr>
<tr>
<td>Liaoning</td>
<td>7</td>
<td>0.487 2</td>
<td>Shanxi</td>
<td>23</td>
<td>0.726 2</td>
</tr>
<tr>
<td>Tianjin</td>
<td>8</td>
<td>0.510 5</td>
<td>Yunnan</td>
<td>24</td>
<td>0.740 4</td>
</tr>
<tr>
<td>Beijing</td>
<td>9</td>
<td>0.521 9</td>
<td>Hunan</td>
<td>25</td>
<td>0.742 2</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>10</td>
<td>0.534 9</td>
<td>Anhu</td>
<td>26</td>
<td>0.747 0</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>11</td>
<td>0.558 9</td>
<td>Shandong</td>
<td>27</td>
<td>0.717 7</td>
</tr>
<tr>
<td>Henan</td>
<td>12</td>
<td>0.562 3</td>
<td>Henan</td>
<td>28</td>
<td>0.750 0</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>13</td>
<td>0.579 8</td>
<td>Shandong</td>
<td>29</td>
<td>0.767 8</td>
</tr>
<tr>
<td>Fujian</td>
<td>14</td>
<td>0.634 1</td>
<td>Guizhou</td>
<td>30</td>
<td>0.791 9</td>
</tr>
<tr>
<td>Xinjiang</td>
<td>15</td>
<td>0.638 3</td>
<td>Gansu</td>
<td>31</td>
<td>0.801 9</td>
</tr>
<tr>
<td>Ningxia</td>
<td>16</td>
<td>0.661 6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Taiwan is not detected due to the lack of data.

5 Measurement result analysis of rural sustainable development level

Table 2 shows the rank of rural sustainable development capability in provinces, cities and autonomous regions of China according to the three indices of rural economy, rural society and rural resources and environment. The measurement results of rural sustainable development levels in provinces, cities and autonomous regions of China are divided into A, B, and C grades. Rank 1–10 belongs to grade A; rank 11–20 is grade B; and rank 21–31 is grade C. In the year 2005, rural sustainable development levels of Shanghai, Heilongjiang, Jilin, Qinghai, Inner Mongolia, Tibet, Liaoning, Tianjin, Beijing and Zhejiang are the strongest and in rank A. Among them, Beijing, Shanghai, Tianjin, Zhejiang and Liaoning are highly developed economic areas, and the proportion of agricultural workers in social workers is relatively low. Their social welfare level is relatively high; the rural per capita income level and per capita agricultural output are relatively high; rural sustainable development ability is relatively high. Environmental damages in Qinghai and Tibet are less with relatively good natural condition due to few population. Therefore, rural areas in these provinces have better sustainable development ability. However, Heilongjiang, Jilin, Inner Mongolia have abundant land resources, high level of agricultural mechanization, strong capacity of com-
prehensive agricultural production. Therefore their rural sustainable development levels rank the top. Rural sustainable development levels of the provinces and autonomous regions in Jiangxi, Hainan, Jiangsu, Fujian, Xinjiang, Ningxia, Guangdong, Hubei, Shandong and Hebei are in the middle and rank B grade. Comprehensive situations of rural sustainable development ability in these provinces and autonomous regions are worse than the cities in grade A. But their rural economic and social development paces are accelerated; their rural resources and environment are paid high attention to; and rural sustainable development ability is strengthened. Rural sustainable development levels of the provinces and autonomous regions in Shanxi, Guangxi, Shaanxi, Yunnan, Hunan, Anhui, Sichuan, Henan, Chongqing, Guizhou and Gansu are relatively low and rank grade C. Most of these regions have relatively poor natural environment along with few per capita land resources and water resources consumption, relatively high proportion of agricultural population and agricultural workers and low rural sustainable development level. There are also few areas in rapid economic development, but their rural sustainable development ability is restricted due to the low per capita share of resources, and the high level of environmental degradation.

6 Conclusion

Rural sustainable development is an important content of the China's Agenda for 21st Century. It is also the important field and fundamental guarantee of the sustainable development of China. After the measurement of the rural sustainable development level in 31 provinces, cities and autonomous regions of China, we comprehended the actual situation of rural sustainable development ability in China. The sustainable development ability in rural China is seriously unbalanced. Therefore, the state should implement preferential policies to western region, increase the intensity of agricultural subsidies, improve peasants‘ income, focus on the protection of land and water resources which is the basis for the survival of agricultural production, and enhance resource utilization ratio in order to achieve the goal of rural sustainable development.

References


基于密切值法的中国农村可持续发展水平的测度

卢秉福,韩卫平
（黑龙江大学农业经济与农村发展研究所,黑龙江省哈尔滨 150080）

摘要 介绍了农村可持续发展的理论基础及其所包含的基本理念与原则,根据农村可持续发展系统的结构,确定了适合中国农村可持续发展的度量指标体系,它由农村经济、农村社会和农村资源环境3个1级指标、9个2级指标和20个3级指标组成。采用密切值法按照数学原理建立了中国农村可持续发展的综合评价模型,该模型可以对各项指标进行量化,从而便于进行地区间农村可持续发展水平的比较。根据测度结果将中国各省、市、自治区农村可持续发展水平划分为A、B、C3个等级,1—10名为A级,11—20名为B级,21—31名为C级。上海、北京、江苏、浙江、天津、广东、云南、北京、山东等10省市自治区为A级,它们由于人均收入水平和人均农业产值高,或自然条件好、农业综合生产能力强,农村可持续发展水平排名靠前；江西、海南、江苏、广东、湖南、贵州等11省市自治区为B级,它的可持续发展能力综合情况不如A级城市,但发展步伐快,能力不断增强；山西、陕西、安徽等11省市自治区为C级,它们大多由于自然条件较差、农业人口比例较低,农村可持续发展水平较低。

关键词 农村可持续发展;密切值;测度;实证分析