Research on Public Security Evaluation System in Small Towns Based on Principal Component Analysis: A Case Study of Bin County China

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Abstract

Rural public security issue becomes the focus and difficulty of attention from all walks of life. With Fishbone Diagram Analysis (FDA), the paper introduces environmental carrying capacity into researches of public security in small towns. Under the help of Statistical Program for Social Sciences (SPSS) software and Principal Component Analysis (PCA), the paper selects 17 villages in Bin County China, establishes 4 first-class indicators and 18 second-class indicators, sets up rural public security system with Fishbone method, and finds out the main factors affecting rural public security. The result shows that there are big differences in the risk level of public security among these areas; the components of infrastructure and land carrying capacity are the most important risk factors affecting rural public security, and thus increasing investment in infrastructure & effective use of idle lands can better improve the ecological carrying capacity in terms of rural public security.

Keywords: Rural public security, Environmental carrying capacity, Evaluation system, Fishbone Diagram, PCA.

1. INTRODUCTION

Nowadays, the world faces a complex and multiple trend with the natural and man-made disasters. Mountain torrent disasters such as collapses, landslides and debris flow are still at higher risk. Rural public security has been the focus of many scholars at home and abroad (Zhao et al., 2015). Shapiro analyzed about the public security situation of Los Angeles area at that time with the stock direction model, and considered that distribution of goods and materials, rural characteristics and ethnic composition were important factors of regional public security (Shapiro et al., 2009). Liu Ying analyzed factors affecting rural public security and expounded suggestions and countermeasures to build the rural public security system (Liu, 2010). Liu Chengshui built the rural public security evaluation index system, and through factor analysis and fuzzy neural network, analyzed Beijing municipal public security situation (Liu, 2010). Xu Zhisheng presented rural public security indicators based on sustainable development, but didn’t verify the applicability of the model (Xu, 2004).

In recent years, China has been in an important period of accelerating the economic transformation and socialist modernization, and also in a critical period of urbanization development. Because of increasing rural infrastructure-carrying load, serious natural disasters, weak ecological environment carrying capacity and lower public security prevention and control in small towns have been seriously hindering their healthy and rapid development. Since the development in rural areas is relative lag, rural residents are less able to withstand disasters, rural public security has become been one of the important factors that influence the county’s economic and social development. However, the researches on rural public security system are fewer in China, far behind integrated evaluation system (Guo et al., 2009). Current scholars mainly focus on the environmental bearing capacity factors (Wang et al., 2005), and seldom involved in the case study of environmental bearing capacity of small towns, this just become a short slab of public security system between urban and rural areas. Therefore, the establishment of the evaluation system of rural public security is an inevitable trend of future development (Wei, 2015).

The paper selects 17 villages and towns of Bin County as examples, through the establishment rural public security evaluation system, obtains evaluation results of public security environment bearing capacity, puts forward the corresponding planning countermeasures, and improves rural public security carrying capacity.

2. OVERVIEW

Bin County is located in Harbin City, with an area of 3 844.7 km2. Binzhou Town covers an area of 8.02 km2.
and is the economic, cultural, scientific research, and natural scenery tourist center of the county (HSY, 2003-2013). Bin County is rich in agricultural resources. Grain and animal husbandry is an important provincial and national production base. Situated in the juncture area between Zhangguangcai Mountains and Songnen Plain, Bin County boasts the mountainous area accounting for 37.2% of its total area, mainly distributed in the eastern and southern, which easily develop landslides and debris flow in summer. The annual average temperature is 2.4-6.1 °C and the coldest month is in January with the average temperature of -18.6 °C, for which it’s easy to form the snow and the frost damage; Songhua River runs through the whole city from west to east, and in case of continuous heavy rain there are often floods. Bin County enjoys good ecological environment. However, given priority to extensive economic growth mode, it’s necessary to improve production efficiency.

Figure 1 shows the location between Bin County and Township.

Figure 1. Bin County & Township Location Diagram

3. INDEX SYSTEM OF RURAL PUBLIC SECURITY BASED ON FDA

FDA is developed by the Japanese management master Ishikawa (Zheng, 2001). The FDA is a method to find root causes of the problems, and also be called cause and effect diagram. It is widely applied in the quality management and security system. Based on rural and regional disaster carrying capacity (Guo, 2009), the comprehensive bearing capacity evaluation index system (Zhang, 2003) and public security evaluation index (Zhu et al., 2006), the paper considers factors of influencing the regional environmental bearing capacity, in combination with the development & regional characteristics of Bin County, the maneuverability and the representativeness, and selects indicators from the land, infrastructure, and social and agricultural bearing capacity, finally builds 4 first-class indicators and 18 second-class indicators.

Figure 2 shows that the Fishbone Diagram Method can be applied to show the public security environment carrying capacity system of Bin County.

Figure 2. Public Security Environment Bearing Capacity System

4. PRINCIPAL COMPONENT ANALYSIS OF RURAL PUBLIC SECURITY RISK

4.1 Index standardization

PCA is a recombination index method by using the ideas of dimension reduction, under the premise of keeping
primary index information unchanged (Shiralia et al., 2013; Fei et al., 2015). The paper combines field investigation and SPSS statistical software, puts forward 18 primary index values, and obtains processing results about index standardization, with reference to text and graphic files such as Harbin Statistical Yearbook (HSY, 2003-2013), Bin County City Yearbook (BCCY, 2003-2013), Bin County Statistical Yearbook (BCSY, 2003-2013), and Bin County Master Plan (BCMP, 2006-2020) et al.

\[ z_y = \frac{x_y - \bar{x}_j}{s_j}, i = 1, 2, \ldots, n; j = 1, 2, \ldots, p \]  

(1)

\[ \bar{x}_j = \frac{1}{n} \sum_{j=1}^{n} x_{ij}, x_j = \sqrt{\frac{1}{n-1} \sum (x_{ij} - \bar{x}_j)^2} \]  

(2)

4.2 Factor analysis

Factor analysis is based on SPSS factor process. The KMO value is close to 1, which means the strength of the correlation between variables and original variables is more suitable for factor analysis. If the value of Bartlett’s Test of Sphericity is less than 0.05, which is significant there is relationship between variables (Sun, 2011).

The results can meet the requirements of factor analysis, and further complete the principal component analysis. Table 1 shows total variance explained.

<table>
<thead>
<tr>
<th>Component</th>
<th>The initial eigenvalue</th>
<th>Extraction squares sum</th>
<th>Rotate the squares sum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>%</td>
<td>Variance Accumulation</td>
</tr>
<tr>
<td>1</td>
<td>5.434</td>
<td>30.191</td>
<td>30.191</td>
</tr>
<tr>
<td>2</td>
<td>2.392</td>
<td>13.288</td>
<td>43.479</td>
</tr>
<tr>
<td>3</td>
<td>2.063</td>
<td>11.460</td>
<td>54.939</td>
</tr>
<tr>
<td>4</td>
<td>1.683</td>
<td>9.352</td>
<td>64.291</td>
</tr>
<tr>
<td>6</td>
<td>1.281</td>
<td>7.117</td>
<td>80.570</td>
</tr>
<tr>
<td>7</td>
<td>1.183</td>
<td>6.573</td>
<td>87.144</td>
</tr>
</tbody>
</table>

Table 1 shows that the first seven initial characteristic roots are greater than 1 and the cumulative percentage is above 85%. Because the variables in table 1 are not missing, and the extracted principal component number is \( m = 7 \), it obtains the initial characteristic roots: \( \lambda_1 = 5.434, \lambda_2 = 2.392, \lambda_3 = 2.063, \lambda_4 = 1.683, \lambda_5 = 1.649, \lambda_6 = 1.281, \) and \( \lambda_7 = 1.183 \). Principal component contribution rate: \( r_1 = 0.3019, r_2 = 0.1329, r_3 = 0.1146, r_4 = 0.0935, r_5 = 0.0916, r_6 = 0.0712, \) and \( r_7 = 0.0657 \). Selection of 7 principal components is more appropriate.

4.3 PC score analysis

As shown in 7 columns of data in the initial factor loading matrix, the research obtained eigenvector matrix. In combination of standardized data, eigenvector principal component values \( Z_i \) (i=1,2,3,4,) of the villages are concluded.

Table 2 shows public security carrying capacity \( Z \) and sorting of 17 towns in Bin County in 2012.

As shown in Table 2, there are large differences of public security carrying capacity in 17 towns of Bin County. Binzhou Town, where the county is located has the strongest public security carrying. Sanbao Town is located in south-central part of Bin County, with weak carrying capacity. Binzhou Town has highest score of PCA \( Z_1 \), which indicates that the public security infrastructure and health care capacity is stronger, but the score about cultivated land and water resources protection factor is lower. PCA \( Z \) of Chang’an Town and Baidu Town is moderate but the load factor carrying capacity is stronger. As economic powerhouse of connecting Harbin City and Bin County, Binxi Town should strengthen the garbage pollution control and agricultural security while persistently promoting the economic development. Tangfang Town, Wuhe Town and Ningyuan Town have
higher score in ecological and construction load factor, but foundation design ability for social security and public security is lower. Juren Town’s medical and agricultural extension bearing capacity is stronger but the ecological carrying capacity is poor. Pingfang Town has the strong ability of agricultural production. Yonghe, Shengli and Xindian Towns are strong in bearing capacity in terms of social security factor. Minhe Binan and Manjing Town are relatively good in medical and agricultural extension load factor, but other factors are weak. Except the individual factor carrying capacity, other load factors are poorer in Jingjian&Yonghe Town.

Table 2 Public security carrying capacity and sorting of 17 towns in Bin County in 2012

<table>
<thead>
<tr>
<th>Towns name</th>
<th>Z1</th>
<th>Z2</th>
<th>Z3</th>
<th>Z4</th>
<th>Z5</th>
<th>Z6</th>
<th>Z7</th>
<th>Z</th>
<th>Sorting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binzhou town</td>
<td>7.47</td>
<td>-1.04</td>
<td>-2.39</td>
<td>-0.18</td>
<td>0.04</td>
<td>1.29</td>
<td>0.45</td>
<td>1.95</td>
<td>1</td>
</tr>
<tr>
<td>Changan town</td>
<td>1.69</td>
<td>2.04</td>
<td>3.10</td>
<td>1.63</td>
<td>1.89</td>
<td>1.01</td>
<td>0.23</td>
<td>1.55</td>
<td>2</td>
</tr>
<tr>
<td>Binxix town</td>
<td>2.38</td>
<td>0.52</td>
<td>1.45</td>
<td>0.97</td>
<td>-3.07</td>
<td>-1.36</td>
<td>-1.29</td>
<td>0.58</td>
<td>3</td>
</tr>
<tr>
<td>Baidu town</td>
<td>0.08</td>
<td>0.29</td>
<td>1.22</td>
<td>-0.98</td>
<td>0.19</td>
<td>0.89</td>
<td>0.88</td>
<td>0.25</td>
<td>4</td>
</tr>
<tr>
<td>Tangfang town</td>
<td>-0.59</td>
<td>1.42</td>
<td>-0.25</td>
<td>1.62</td>
<td>0.77</td>
<td>-0.06</td>
<td>0.50</td>
<td>0.23</td>
<td>5</td>
</tr>
<tr>
<td>Juren town</td>
<td>0.11</td>
<td>2.08</td>
<td>0.95</td>
<td>-3.79</td>
<td>-0.61</td>
<td>0.36</td>
<td>-0.43</td>
<td>0.01</td>
<td>6</td>
</tr>
<tr>
<td>Wuhe town</td>
<td>-0.38</td>
<td>0.75</td>
<td>-0.51</td>
<td>0.90</td>
<td>0.04</td>
<td>-0.18</td>
<td>-0.02</td>
<td>0.00</td>
<td>7</td>
</tr>
<tr>
<td>Pingfang town</td>
<td>0.88</td>
<td>-2.67</td>
<td>0.94</td>
<td>-1.23</td>
<td>2.79</td>
<td>-1.92</td>
<td>-1.15</td>
<td>-0.05</td>
<td>8</td>
</tr>
<tr>
<td>Ningyuan town</td>
<td>-0.42</td>
<td>-0.64</td>
<td>0.28</td>
<td>1.00</td>
<td>-0.64</td>
<td>0.07</td>
<td>-1.10</td>
<td>-0.21</td>
<td>9</td>
</tr>
<tr>
<td>Shengli town</td>
<td>-0.31</td>
<td>-2.79</td>
<td>1.92</td>
<td>-0.26</td>
<td>-1.13</td>
<td>-0.62</td>
<td>2.02</td>
<td>-0.29</td>
<td>10</td>
</tr>
<tr>
<td>Minhe town</td>
<td>-1.60</td>
<td>1.19</td>
<td>-1.05</td>
<td>0.13</td>
<td>0.87</td>
<td>-0.18</td>
<td>0.55</td>
<td>-0.33</td>
<td>11</td>
</tr>
<tr>
<td>Binan town</td>
<td>-0.54</td>
<td>0.63</td>
<td>-1.15</td>
<td>0.24</td>
<td>-0.80</td>
<td>-0.90</td>
<td>-0.13</td>
<td>-0.33</td>
<td>12</td>
</tr>
<tr>
<td>Manjing town</td>
<td>-1.34</td>
<td>1.34</td>
<td>-1.24</td>
<td>-0.88</td>
<td>0.18</td>
<td>0.09</td>
<td>0.53</td>
<td>-0.39</td>
<td>13</td>
</tr>
<tr>
<td>Yonghe town</td>
<td>-1.11</td>
<td>-0.26</td>
<td>-1.63</td>
<td>0.77</td>
<td>0.54</td>
<td>-1.55</td>
<td>0.90</td>
<td>-0.49</td>
<td>14</td>
</tr>
<tr>
<td>Xindian town</td>
<td>-1.60</td>
<td>0.10</td>
<td>-0.77</td>
<td>-0.51</td>
<td>-0.76</td>
<td>-0.37</td>
<td>0.83</td>
<td>-0.64</td>
<td>15</td>
</tr>
<tr>
<td>Jindian town</td>
<td>-1.52</td>
<td>-0.37</td>
<td>-0.96</td>
<td>0.07</td>
<td>0.35</td>
<td>0.80</td>
<td>-2.66</td>
<td>-0.70</td>
<td>16</td>
</tr>
<tr>
<td>Sanbao town</td>
<td>-3.20</td>
<td>-2.58</td>
<td>0.09</td>
<td>0.47</td>
<td>-0.64</td>
<td>2.63</td>
<td>-0.10</td>
<td>-1.13</td>
<td>17</td>
</tr>
</tbody>
</table>

5. EVALUATION RESULT ANALYSIS

The first seven principal components rotate element matrix to get Table 3 and improve the seven factors. Especially the first three factors (with public security contribution rate reaching more than 50%) will increase town public security carrying capacity to a large extent.

Table 3 shows that the first seven principal components transform into rotating element matrix.

As shown in Table 3, in PC1, number of physicians per one thousand people gas penetration, emergency evacuation, and cable TV penetration are stronger in carrying capacity and PC1 mainly explain these four indicators, which can be called public security infrastructure and health care capacity factor; calledPC2 mainly explain three indicators: the number of hospital beds per one thousand people, endowment insurance coverage and agricultural technology personnel per one thousand people, which could well be recalled medical and agricultural extension load factor. In PC3, the strongest carrying capacities mainly include cultivated land per capita, the effective irrigation area ratio and water supply coverage, which can be called cultivated land and water resources protection factor. The stronger capacities of PC4 are forest land area per capita and rural bricks rate, namely human settlement factors. PC5 mainly explains garbage treatment rate, net income of farmers per capita and grain productivity per unit area, which can be called life security condition factors. In PC 6, teachers per one hundred middle school students and population density are highlighted factors, which can be called educational security factors. PC7 mainly explains the endowment insurance coverage, which can be called social security factor.
Table 3 Rotating Element Matrix

<table>
<thead>
<tr>
<th>Indicators</th>
<th>PC Z₁</th>
<th>PC Z₂</th>
<th>PC Z₃</th>
<th>PC Z₄</th>
<th>PC Z₅</th>
<th>PC Z₆</th>
<th>PC Z₇</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population density /(people/hm²)</td>
<td>0.1289</td>
<td>0.4027</td>
<td>0.3456</td>
<td>0.5059</td>
<td>0.1274</td>
<td>0.5410</td>
<td>-0.1392</td>
</tr>
<tr>
<td>Per Cultivated Area /(hm²/people)</td>
<td>-0.2738</td>
<td>-0.2998</td>
<td>-0.7770</td>
<td>-0.0826</td>
<td>0.2700</td>
<td>-0.2532</td>
<td>0.1312</td>
</tr>
<tr>
<td>Forest area per capita /(hm²/people)</td>
<td>-0.0883</td>
<td>-0.1107</td>
<td>0.3123</td>
<td>-0.8646</td>
<td>0.0592</td>
<td>-0.1016</td>
<td>-0.0648</td>
</tr>
<tr>
<td>Net income of farmers per capita /(yuan)</td>
<td>0.1554</td>
<td>-0.0410</td>
<td>0.0794</td>
<td>-0.2843</td>
<td>0.7729</td>
<td>0.4648</td>
<td>0.1940</td>
</tr>
<tr>
<td>The effective irrigation area ratio /%</td>
<td>0.3039</td>
<td>-0.0442</td>
<td>-0.6850</td>
<td>0.0700</td>
<td>0.0533</td>
<td>0.0323</td>
<td>-0.4494</td>
</tr>
<tr>
<td>Grain productivity per unit area /%</td>
<td>-0.4258</td>
<td>0.0059</td>
<td>-0.0312</td>
<td>0.1344</td>
<td>0.6089</td>
<td>-0.0908</td>
<td>-0.3176</td>
</tr>
<tr>
<td>Agricultural technology personnel per one thousand people/(people/Per one thousand people)</td>
<td>0.2307</td>
<td>0.8394</td>
<td>0.3500</td>
<td>0.1719</td>
<td>-0.0102</td>
<td>0.2365</td>
<td>-0.1203</td>
</tr>
<tr>
<td>Rural brick rate /%</td>
<td>0.2574</td>
<td>0.1138</td>
<td>0.2786</td>
<td>0.7668</td>
<td>0.1389</td>
<td>0.0516</td>
<td>0.1635</td>
</tr>
<tr>
<td>Water supply coverage /%</td>
<td>0.4829</td>
<td>0.0472</td>
<td>0.7287</td>
<td>-0.0286</td>
<td>-0.0099</td>
<td>-0.1879</td>
<td>-0.0033</td>
</tr>
<tr>
<td>The gas penetration /%</td>
<td>0.8170</td>
<td>0.1319</td>
<td>0.1693</td>
<td>0.0811</td>
<td>-0.1038</td>
<td>0.1846</td>
<td>-0.0020</td>
</tr>
<tr>
<td>Cable TV penetration /%</td>
<td>0.6639</td>
<td>-0.0160</td>
<td>0.0734</td>
<td>0.3807</td>
<td>-0.1097</td>
<td>0.2426</td>
<td>-0.1766</td>
</tr>
<tr>
<td>Emergency evacuation channel/km</td>
<td>0.7704</td>
<td>-0.0631</td>
<td>-0.0261</td>
<td>0.1578</td>
<td>0.2547</td>
<td>-0.2311</td>
<td>0.4361</td>
</tr>
<tr>
<td>Garbage treatment rate /%</td>
<td>0.1153</td>
<td>0.2498</td>
<td>0.3878</td>
<td>-0.2297</td>
<td>-0.7671</td>
<td>0.1965</td>
<td>0.0705</td>
</tr>
<tr>
<td>Number of physicians per thousand people/(people/Per one thousand people)</td>
<td>0.8217</td>
<td>0.4047</td>
<td>0.0190</td>
<td>0.0667</td>
<td>-0.1834</td>
<td>0.0631</td>
<td>-0.2103</td>
</tr>
<tr>
<td>Number of hospital beds per one thousand people /(bed/ Per one thousand people)</td>
<td>0.1337</td>
<td>0.8885</td>
<td>0.2903</td>
<td>0.1307</td>
<td>-0.2093</td>
<td>0.1323</td>
<td>-0.0522</td>
</tr>
<tr>
<td>The basic medical insurance coverage /%</td>
<td>-0.0133</td>
<td>0.8836</td>
<td>-0.2431</td>
<td>0.0177</td>
<td>-0.0139</td>
<td>-0.1519</td>
<td>0.2849</td>
</tr>
<tr>
<td>Endowment insurance coverage /%</td>
<td>-0.0243</td>
<td>0.0601</td>
<td>0.0536</td>
<td>0.1303</td>
<td>-0.0665</td>
<td>0.0689</td>
<td>0.9233</td>
</tr>
<tr>
<td>Teachers per one hundred middle school students/ (people/one hundred people)</td>
<td>-0.1019</td>
<td>-0.0580</td>
<td>0.0591</td>
<td>-0.1342</td>
<td>0.0198</td>
<td>-0.9581</td>
<td>-0.0673</td>
</tr>
</tbody>
</table>

6. CONCLUSIONS

(1) Public security environment bearing capacity in Bin County isn’t identical but with bigger differences, so researches on public security planning and design should be strengthened in all the villages and towns, with the formation of town disaster prevention and reduction planning system for Bin County in Harbin. BCMP (2006 Edition) only emphasized formulating public security planning based on fire and environmental protection, while the comprehensive town security planning was not taken seriously. So it is imperative to set up the quantitative research of town public security planning system, which should be based on the environmental carrying capacity in small towns, in combination with computer-aided tools (Sun and Wang, 2014).

(2) Bin County should strengthen the construction of public security emergency command system, establish disaster emergency management system with a unified command, comprehensive coordination, classified management, graded responsibility, and localized management, and improve efficient operational mechanism. All towns, in a serious shortage of security managers and public security product supplies, should adhere to the leadership by county government and participation of residents, establishing and perfecting the disaster relief linkage mechanism. The county should improve the construction of support capability to village disaster relief
emergency, make material reserve planning, expand the coverage of grain depots, enrich materials varieties, and enhance its allocation efficiency (Sun and Yan, 2014; Anders, 2015).

(3) Public security infrastructure, health care and carrying capacity of the cultivated land and water resources are the major factors affecting public security. To improve the regional public security carrying capacity, it’s necessary to formulate special planning on infrastructure and water resources and establish a fully medical insurance system across county.

(4) The FDA could clearly express the town security index evaluation system. The PCA could quantitatively study the various public security environment carrying capacities, conclude the main carrying factors, and provide useful enlightenment for the researches on security future planning.

(5) To strengthen the legalized management of the town security. The town disaster prevention and mitigation shall be legalized and standardized. Since the laws are mandatory, the town security legislation can effectively eliminate the unnecessary artificial behaviors endangering the town security. It will not only have a positive effect on the town public security management, but also have a certain guiding significance in town disaster prevention during construction and development of towns (Liet al., 2012).

It is one of the important measures to keep economic and social stability during the development of small towns. By establishing a quantitative analysis of public security planning management system in small towns and analyzing Bin County’s status in environmental bearing capacity, the paper establishes index evaluation system based on the Fishbone Diagram, makes the principal component analysis and evaluation, analyzes the rural security factor when dealing with the public security events, and puts forward some proposals to improve the ability of small towns to public security events.

However, because of the complexity of the public security environment system and difficulties in the data acquisition, we will continue to improve the index evaluation system and evaluation model in the future (Sun, 2012; Ann et al., 2014).

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