Assessing the Development Level of China's National Sustainable Communities at County Level

Leigang Shi [a],Huarui Wu[b],Yuli Lin[c],Xiang Sun[d],Heju Huai[e]and Cunjun Li[f,]*

[1]Beijing Research Center of Intelligent Equipment in Agriculture, Beijing 100097,China

[a]shilg@nercita.org.cn, [b]Wuhr@nercita.org.cn, [c]939188082@qq.com, [d]sunx@nercita.org.cn, [e]huaihj@nercita.org.cn, [f]licj@nercita.org.cn

* the corresponding author

Keywords: county-level city; coordination index; sustainable development; cluster analysis

Abstract. In this paper the sustainable development level of 77 China national sustainable communities at county level was assessed. An assessment indicator system was designed composing of 3 first-level indicators and 14 second-level indicators. The entropy method was employed to calculate the development index and sustainable development level of selected cities. Based on cluster analysis results, the studied cities were categorized into three patterns, i.e. highly coordinated, moderately coordinated and low coordinated. The coordination index was 0.69±0.08, 0.48±0.05 and 0.32±0.05, taking up 9.09%, 51.95% and 38.96% of the total respectively. The three kinds of sustainable development pattern were then compared in terms of their economic, social and environmental development level, so as to set directions for raising the sustainable development level of county-level cities.

Introduction

The coordinated development of economy, society and environment is the guarantee of humanity's sustainable development, of which the urban sustainable development reckoned as the key part. Domestic and overseas researchers have conducted researches about the urban sustainable development theory and assessment indicators. They also have assessed the sustainable development level of various cities, analyzed influential factors and put forward suggestions on urban sustainable development at economic, social and environmental fields [1,2]. China has been positively promoting urban sustainable development and establishing national sustainable communities selected from typical cities, counties and metropolitan areas. Until March 2014, China had established 157 national sustainable communities and more than 180 provincial sustainable communities in over 90% of the country's provinces, municipal cities and autonomous regions.

China has explored new patterns for urban sustainable development at economic, social and environmental fields through practices [3,4]. Since the differences in city types and assessment indicators, the assessment results are distinct. This led to the difficulty for cities to learn from each other [1,5]. Therefore, a consistent assessment method is urgently needed to evaluate urban sustainable development level for cities of the same type. In this study, entropy method was employed to assess the sustainable development level of economic, social and environmental subsystems and overall performance for selected typical county-level cities. It aims to overview the situation of urban sustainable development for county-level cities and provide references for the sustainable development of county-level cities.

Method and Data

Description of study areas. According to *China 21st Century Agenda*, China has established numerous national sustainable communities, which can be categorized into four types, i.e. big city, medium and small-sized city, county-level city/county, and village. In this study, 77 typical county-level cites were studied (Figure 1).

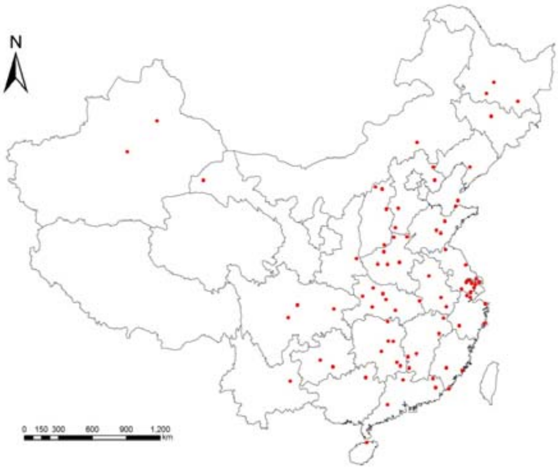
Fig. 1 Location of the study area

Indicator selection and data source. The authors took into account the component of city system and regional sustainable development assessment theory, principle of completeness, comparability, and data accessibility, and employed the method of theory analysis and expert consultation. An assessment system for sustainable development level of county-level city consisting of 14 indicators was built up from the view of economic development, social harmony and environmental sustainability(Table 1). Data were sourced from 77 statistic year books and calibrated by local experts.

Table 1 Indicator system for assessing urban sustainable development

First-level indicator	Second-level indicator	Weight
Economic subsystem	GDP per capita (yuan)	0.0849
	GDP growth rate (%)	0.0141
	Newly registered enterprises per 10 thousand person	0.1408
Social subsystem	Death rate of new born children (%)	0.0651
	Registered unemployment rate for urban residents (%)	0.0309
	Production safety accidents per 0.1 billion GDP	0.27
	Disposable income of urban residents (yuan per capita)	0.0734
	Net income of rural residents (yuan per capita)	0.0506
	Urban and rural income ratio	0.0461
	Growth rate of net income of rural residents (%)	0.0222
	Percentage of urban residents(%)	0.0384
Environmental subsystem	Energy consumption per unit GDP (ton standard coal/10 thousand yuan)	0.1274
	Decline rate of energy consumption per unit GDP(%)	0.0283
	Percentage of days with air quality above second level in a year (%)	0.0079

Assessment method. In this paper, entropy method was used to determine the sustainable development level of urban economic, social, environmental subsystems and as a whole.

Since there existed difference in the dimension of distinct incomparable indicators of the assessment system of urban development, the indicators were made dimensionless at the first step. There were both positive and negative contributions to the system from the indicators. The equations below were employed to conduct data standardization. Each index X_{ij} was converted into relevant dimensionless indicator X'_{ij}.

1) Data standardization

$$X'_{ij} = [X_{ij} - \min(x_j)]/[\max(X_j) - \min(X_j)] \quad (X_{ij} \text{ as a positive indicator})$$

$$X'_{ij} = [\max(X_j) - x_{ij}]/[\max(X_j) - \min(X_j)] \quad (X_{ij} \text{ as a negative indicator})$$

2) The weight of index j for city i

$$Y_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{m} X'_{ij}}$$

3) Indicator information entropy

$$e_j = -k\sum_{i=1}^{m}(Y_{ij} * \ln Y_{ij}) \qquad k = 1/\ln m$$

4) Redundancy rate of information entropy

$$d_j = 1 - e_j$$

5) Indicator weight

$$w_j = d_j \Big/ \sum_{j=1}^{n} d_j$$

6) Assessment score of urban sustainability development

$$SD_i = \sum_{j=1}^{p}(w_j \times X''_{ij})$$

$$S_i = \sum_{j=1}^{n}(w_j \times X''_{ij})$$

X_{ij} represents the assessment result of city i for indicator j. m is the number of cities, n is the value of indicator; $i = 1, 2, ..., m; j = 1, 2, ..., n$; $\max(X_j)$ and $\min(X_j)$ is the maximum value and minimum value of indicator j for all the cities. SD_i is the sustainability assessment score of city i subsystems (economic, social and environmental subsystems). X''_{ij} is subsystem indicator, w_j is the weight of relevant indicator, p was the number of indicators, S_i is the overall sustainability of city i.

Coordination index U represents the coordination level of economic, social and environmental development of study cities.

$$U = (1 - \frac{|S_e - S_s|}{\max(S_e, S_s)}) + (1 - \frac{|S_e - S_r|}{\max(S_e, S_r)}) + (1 - \frac{|S_s - S_r|}{\max(S_s, S_r)})$$

S_e、S_s and S_r represents the sustainable development level of economic, social and environmental subsystem respectively. The bigger the value of U, the more balanced between economic, social and environmental development will be, which indicates higher level of coordination development.

Results

Weights of urban sustainable development assessment indicators. Following the indicator weight determination method in the entropy method, the weights of 14 indicators were determined (Table 1). The weights of the three subsystems were shown in the figure below. As can be seen from the figure below, the weight of social subsystem was biggest, followed by that of economic subsystem and environmental subsystem.

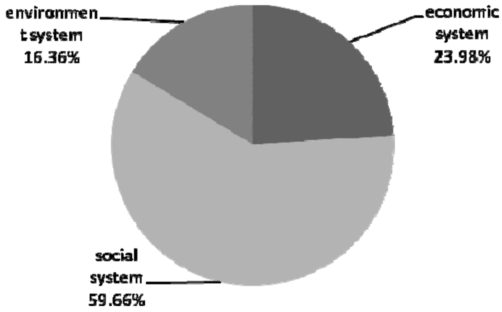

Figure 2 Percentage of the subsystems′ weight

Sustainability analysis of county-level cities. Following the equations above, it was calculated that the sustainablity of economic, social and environmental subsystems of 77 couty-level cities, and also the urban sustainable development coordination index of each city. The city with highest three coordanation index was Zhengding(Henan province), Kunshan(Jiangsu province) and Yinchang(Hubei province), which was 0.80, 0.77 and 0.72 respectively. The city with lowest three coordanation index was Shaodong(Hunan province), Yinshan(Hubei province) and Yiyuan(Shandong province) respectively. There existed 4 fold difference between the highest coordination index and the lowest.

Table 2 Classification of national county-level cites in this study

	High coordinated type	**Moderate coordinated type**	**Low coordinated type**
City	Kunshan Fukang Gucheng Linzhou Yicheng Kuerle Zhengding	Changyang,Ninghai, Zhangjiagang,Longkou, Changdao,Yanling, Qian’an,Changshu, Dafeng,Jinggangshan, Yixing,Duyun,Qingzhen, Youyu,Haimen, Shaoshan,Liangping, Anji,Guixi, Zixing,Dengmai, Zhaodong,Zhangping, Yu,Qingfeng,Donghai, Zhongxiang,Yishui, Nanxiong,Keshiketeng, Mengzhou,She, Chongyi,Maoji,Wuyuan, Dashiqiao,Wuan,Jiaoling, Zezhou,Luliang	Jiangyin,Taicang, Chongming,Hui’an, Tongxiang,Dunhuang, Wenling,Huairen, Suichang,Xiantao, Dongshan,Hailin, Hebi,Yongxing, Guanghan,Xiangxiang, Pingquan,Shennongjia, Danling,Yiyuan, Huarong,Huayin, Taihe,Shaodong, Song,Baofeng, Yun’an,Fengshun, Yingshan,Gongcheng

According to the coordination index of urban sustainable development, the 77 county-level cities were classified into three catagories (Table 2). The percentage of highly coordinated, moderately coordinated and low coordinated cities was 9.09%, 51.95% and 38.96%, with coordination index of 0.69±0.08, 0.48±0.05 and 0.32±0.05 respectively. The average coodination index of highly coordinated cities was about double that of low coordinated cities. In general, the percentage of highly coordinated cities was low.

The sustainability index of economic, social and environmental subsystems of highly coordinated, medium coordinated and low coordinated cities can be seen in Figure 3. The sustainability index of economic, social and environmental subsystems in highly coordinated cites was 0.08±0.03, 0.11±0.05 and 0.07±0.04 respectively. The sustainability index of economic, social and environmental subsystems in medium coordinated cites was 0.05±0.04, 0.12±0.04 and 0.05±0.03 respectively.

The sustainability index of economic, social and environmental subsystems in low coordinated cites was 0.04±0.03, 0.21±0.10 and 0.06±0.04 respectively.

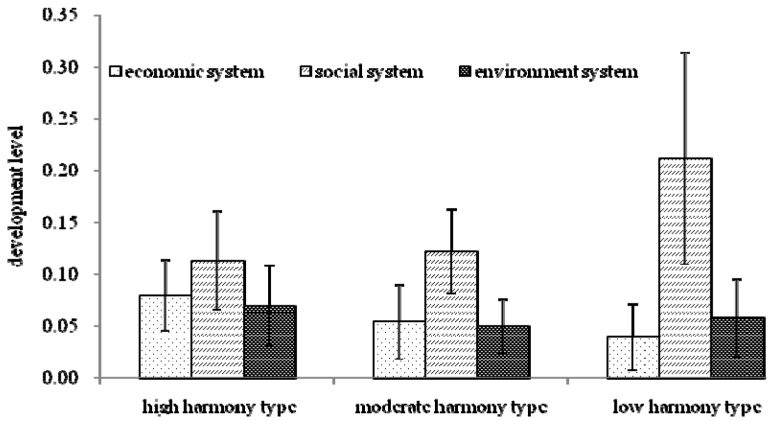

Figure 3 Sustainablility index of subsystems for cities of different type

Conclusion

In this paper, the urban sustainable development level of 77 typical county-level cities was assessed, with significant difference observed. Based on the results of urban sustainable development level, the 77 cities were divided into three categories, i.e. highly coordinated, moderately coordinated and low coordinated. Nearly 10% of the cities were highly coordinated and the majority were moderately coordinated and low coordinated. The low coordination level of urban development was resulted from that the sustainable development level of one single subsystem was too high or too low. In the next step, the authors will try to find out the dominant influential factor for sustainable development of county-level cities and put forward specific measures to raise the urban sustainable development level.

Acknowledgements

This work was financially supported by National Key Technology Support Program(2013BAJ04B04).

References

[1] Singh R K, Murty, H R, Gupta S K, et al. An overview of sustainability assessment methodologies. Ecological Indicators. Vol.15(2012), p. 281-299.

[2] Song YJ. Ecological city and urban sustainable development. Procedia Engineering. Vol.21(2011), p. 142-146.

[3] Chen X, Liu X, Hu D. Assessment of sustainable development: A case study of Wuhan as a pilot city in China. Ecological Indicators. Vol.50(2015), p. 206-214.

[4] Cai C, Shang J. Comprehensive evaluation on urban sustainable development of Harbin city in Northeast China. Chinese Geographical Science, Vol.19 (2009), p. 144-150.

[5] Aldegheishem A.Evaluating the urban sustainable development on the basis of AHP: A case study for Riyadh city. Journal of Sustainable Development, Vol.7 (2014), p. 113-120.