Transforming a resource-based city into a sustainable development city: the case of Jiyuan, China

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Abstract: The National People Congress in 2013 stated the need to provide impulse and guidance for a transformation of the Chinese resource-based cities into sustainable cities. This paper considers the transformation path realized in a small Chinese resource-based city in China. The city of Jiyuan has been designated as a priority city to explore different models of sustainable development and has been upgraded to National Sustainable Development Experimental Zone. The study aims to assess its transformation path to a new status of sustainability by using an indicator especially designed for resource-based cities and inspired by the Urban sustainability index. We provide a quantitative analysis of sustainability's drive for a five-year period that covers a pre 2013 situation and a post 2013 period.

Keywords: China, indicator, Jiyuan, resource-based cities, sustainability.

Introduction

Environmental protection is a longstanding concern for Chinese decision-makers as the sixth-five-year plan (1981-1985) objective to strengthen environmental protection firstly demonstrates [1]. Chinese government's willingness to improve environmental conditions have been expressed in many other cases such as the aim of achieving energy efficiency and an environmental-friendly society defined in the eleventh five-year plan (2006-2010) [2] or the necessity of maintaining and monitoring of growth by improving the environment stated in the last five-year plan (2016-2010) [3]. However, reducing environmental impacts while maintaining growth remains a big challenge.

Cities' transformations and urbanization processes could be regarded as relevant tools to analyze the impacts of growth on environment. Even though the rapid development of the Chinese economy has brought benefits for both national and local levels, cities have played a key-role in this development. In 2010, the proportionate contribution to China's GDP from prefecture-level cities and larger cities reached 61% and more than 18% of Chinese cities have adopted a resource-based development due to their natural endowment [4]. Those urban territories, called resource-based cities (RBC), have importantly contributed to growth [5] as resource extraction and processing have sustained economic activity. Nevertheless, a past lack of a sustainable resources management is the root of a foreseeable scarcity being the reason of an unsustainable development. RBC now have to cope with critical resource-use and environmental issues.

Challenges of resource-based cities became apparent in the 1990's. At that time, most of researchers were focusing on their contribution to macroeconomic development without considering possible drawbacks [6,7]. Chinese economic development then set in motion transformation processes in those cities that were investigated by analyzing industrial sectors evolution [8,9,10,11,12,13]. Those studies were widely based on economic factors neglecting sociological or ecological perspectives. So far, the methods most commonly used have been both descriptive and qualitative and few quantitative studies exist. In 1995, the World Resources Institute has described urban sustainability indicators as tools ensuring a systematic monitoring or urban environmental changes [14]. According to this goal, in 2014, an indicator to assess the sustainability's drive for Chinese resource-based cities during only one year, has been offered but there has been no specific application of it for several years [15]. Consequently, the scope of results relied on a one-year period but not on a short-term perspective. It focused on a yearly comparison of several cities but not on some city's transformation process during a short period.

The study aims to assess the transformation path of a Chinese resource-based city to a new status of sustainability. We use an indicator especially designed for resource-based cities and inspired by the Urban

sustainability index as this framework has been created according to Chinese cities specificities [16]. In order to accurately fit with RBC common characteristics, we have modified and extended the USI approach. We provide a quantitative analysis of sustainability's drive for a five-year period that covers a pre 2013 situation and a post 2013 period. The city chosen for the research, Jiyuan, has been designated as a priority city to explore different models of sustainable development and has been upgraded to National Sustainable Development Experimental Zone. Therefore, the research aims to give a quantitative analysis of the short-term state of sustainability in Jiyuan and analyze Jiyuan's local strategy and measures.

2. Methods

2.1. Methodology

The methodological approach consists in applying a modified USI approach in designing a proper indicator to measure sustainability in the case of resource-based cities and compute it for the prefecture-level city of Jiyuan for 2009, 2010, 2012, 2013 and 2014.

2.2. Data

The set of data used have been extracted from the standard local yearbooks provided by Jiyuan local representatives [17,18,19,20,21]. Due to uncertainties or inconsistence, two of the one hundred and five values selected had to be computed by taking the previous and the following values median value. We have selected the five following years 2009, 2010, 2012, 2013 and 2014 for several reasons: (a) data availability (b) 2009 being a turning point for Jiyuan policy-making as an important number of children have revealed lead blood levels way above the standards [22].

2.3. Indicator

The indicator gives a yearly quantitative baseline of Jiyuan's state of sustainability to understand how the city has been managing its sustainability issues. We have developed an indicator inspired by the USI and composed by four dimensions, twenty components and twenty-one measures. The Jiyuan sustainability indicator's unicity is based on the Resources dimension, which has been especially designed according to Jiyuan leading production (lead) and other relevant measures. For each component, a weight has been given according to the three scenarios (S1, S2, and S3). The sum of the component's weight for each scenario is equal to one.

Table 1: Jiyuan sustainability indicator

Dimension	Subcategory	Components	Measure	Weight (S1)*	Weight (S2)*	Weight (S3)*
Society		Employment	% of urban employment rate	0,050	0,050	0,050
		Doctor resources	Number of doctors	0,050	0,050	0,050
		Education	Middle school students in young population	0,050	0,050	0,050
		Pension	Pension security coverage	0,050	0,050	0,050
		Health care	Health care security coverage	0,050	0,050	0,050
Economy		Income level	Income per household (yuans)	0,083	0,083	0,050
		Reliance on industry	GDP from second sector (yuans)	0,083	0,083	0,050
		Capacity investment	GDP from service industry (yuans)	0,083	0,083	0,050
Environment	Quality	Industrial pollution	Industrial SO_2 discharged (tons)	0,031	0,041	0,050
		Air quality	Air qualified days	0,031	0,041	0,050
		Wastewater	Wastewater discharge per inhabitant	0,031	0,041	0,050
		Agriculture	Fertilizers (tons)	0,031	0,041	0,050
	Urbanization	Urban population	Urban population rate	0,031	0,041	0,050
		Population	Population	0,031	0,041	0,050
		Mass transit usage	Capacity passenger	0,031	0,041	0,050
		Internet access	% of household access to internet in rural areas	0,031	0,041	0,050
Resources		Energy consumption	Volume of energy consumption (tons of coal equivalent)	0,063	0,043	0,050
		Energy production	Volume of energy production (tons of coal equivalent)	0,063	0,043	0,050
		Lead	Volume of lead production (tons)	0,063	0,043	0,050
		Environmental protection	Environmental protection investment (yuans)	0,063	0,043	0,050

*S1, S2, S3 respectively corresponds to Scenario 1, Scenario 2 and Scenario 3.

2.4. Weighted scenarios

We have developed three different weighted scenarios (S1, S2 and S3 in Table 1) to focus on the impacts of the Environment and Resources dimensions. In the first scenario, all the dimensions have the same weight whereas in the second one environment is the most weighted dimension (33%) whereas resources only accounts for 17%. In those two scenarios, Environment and Resources dimensions account for 50% of the indicator, but the resources dimension is more important in the first scenario than in the second one. In the last scenario all

measures are equally weighted and consequently, environmental and resources dimensions accounts for 60% of the value of the indicator. Those scenarios are definitely environment and resources-oriented.

3. Results and discussion

3.1. Indicator values due to different scenarios

For each year considered in the study, there is an indicator variation due to the scenarios' weight. We define a yearly difference rate indicating the rate of difference between the indicator values of two considered scenarios (see Formula 1). The difference rate refers to a difference between two scenarios, therefore a high difference rate means the change of weights have notably impacted the indicator value and consequently the city's state of sustainability.

Formula 1: $$\text{Difference Rate}_{2009 - S1/S2} = \frac{S1 \text{ indicator value in } 2009 - S2 \text{ indicator value in } 2009}{S2 \text{ indicator value in } 2009} \times 100$$

For the scenarios 1 and 2, the lowest difference reaches 1,6% (year 2014) and the highest 8,5% (year 2013). For scenarios 1 and 3, and then scenarios 2 and 3, it respectively reaches 0,8% (year 2014) and 12,6% (year 2012), and then 0,3% (year 2014) and 2,7% (year 2010). The change of weights between scenario 2 and 3 have few impacts, whereas it as important impacts between scenarios 1 one 3. In any case, 2014 is the less sensitive year to changes whereas 2012 is the highest. Indeed, in 2012, lead production peaked and environmental protection investment has been consequent. Consequently, it increases the score of the Resources dimension and so the impact of weight changes. Then, in 2014, the environmental protection investment has been paramount, the reliance on the second industry has significantly decreases and the third sector proportion has increased. Therefore, the impact of weight changes is not significant.

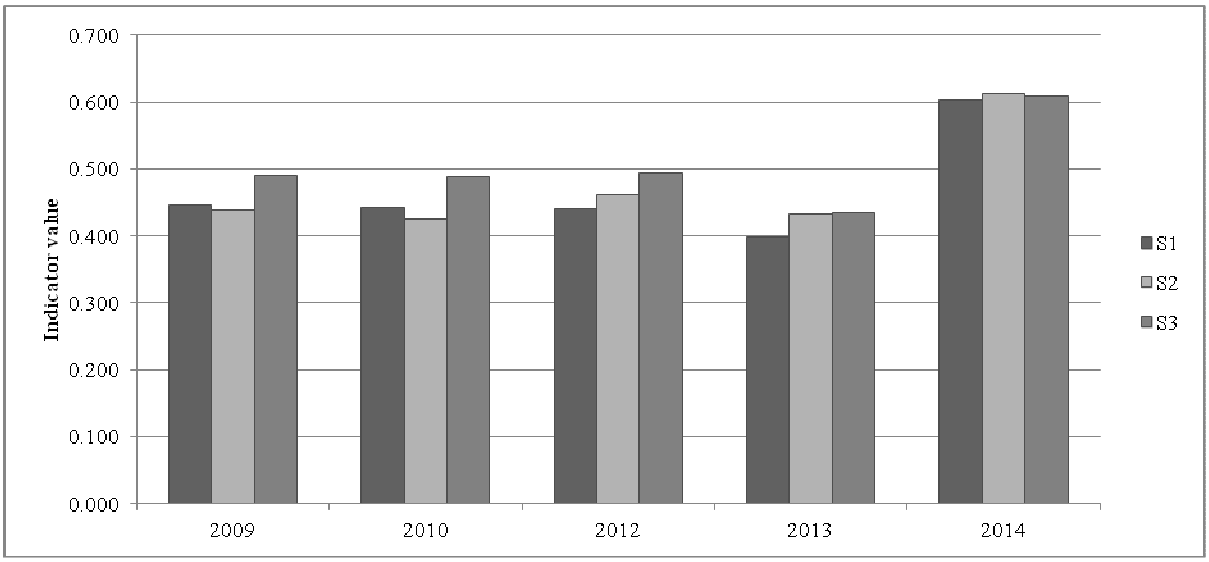

Figure 1: Indicator value according to the three scenarios

Table 2. Yearly difference rate according to the three scenarios

Difference rate	2009	2010	2012	2013	2014
S1/S2	1,7	4,1	-4,9	-8,5	-1,6
S1/S3	-9,5	-10,2	-12,6	-8,9	-0,8
S2/S3	-2,2	-2,7	-1,6	-0,1	0,3

3.2. Indicator trend

The Jiyuan sustainability indicator's trend is similar in the three scenarios considered, so the different weights don't have a noticeable impact. In addition, two periods can be pointed out. Before 2013, the indicator values are approximately steady whereas in 2013 it faces a significant drop. Indeed, the Resources dimension has been impacted by important lead and energy productions. Furthermore the environmental protection investment has not been that important comparing to 2012 and 2014. After 2013, there is an important increase of the indicator value. There are three reasons for this shift: (a) the Society dimension has ranked a good score mainly due to the increase of pension and health care coverage (b) the Economy dimension has been boosted by the decrease of

reliance on second sector of industries and the expansion of the third sector (c) the environmental protection has been paramount with an increase of a factor 16 comparing to 2009 for instance.
The indicator trend reveals two significant periods and supports a shift towards a more sustainable dynamic in 2014 supported by several dimensions.

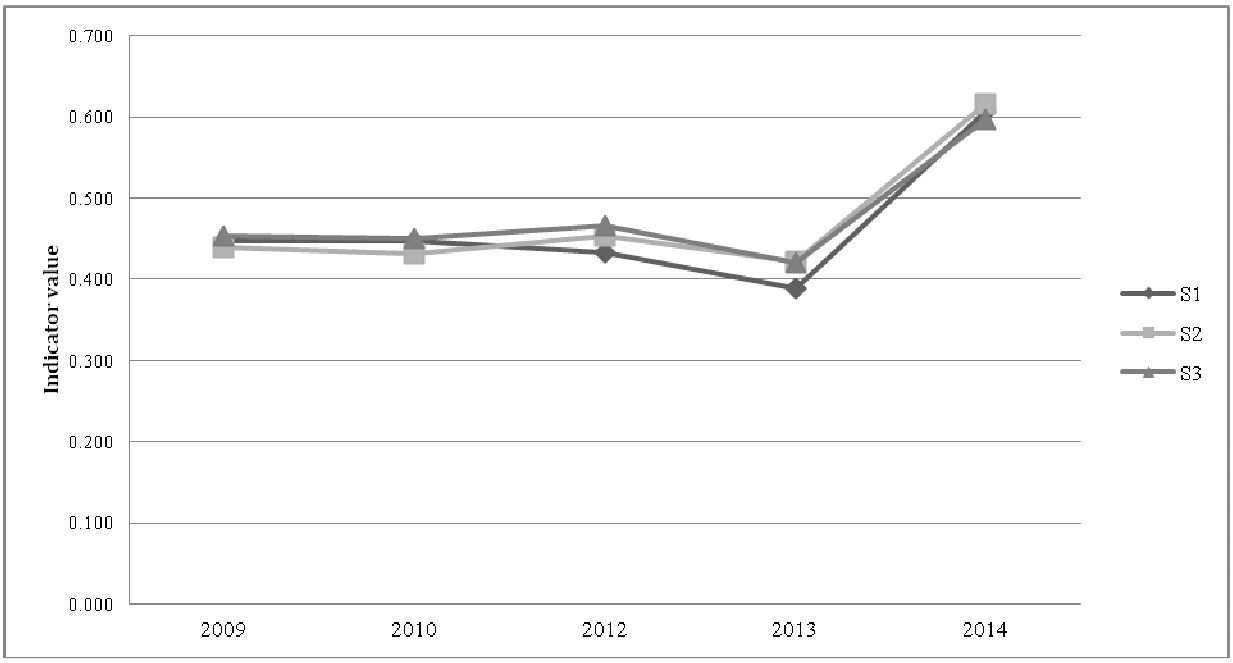

Figure 2: Indicator trends between 2009 and 2014

3.3. Discussion

The Jiyuan Sustainability indicator reveals a change in Jiyuan's state of sustainability. Before 2013, Jiyuan's sustainability is approximately steady before 2013 and even faces a drop in 2013. Even though local decision-makers' willingness to shift towards a more sustainable development model is apparent, the reliance on second industry and lead production negatively impact indicator value. The after-2013 period shift is supported not only by a linear improvement of the social components (income or health and pension coverage) but also by a less second-sector-dependent economy, an increase of the third sector proportion in the GDP, and an important investment in environmental protection. Our study supports that Jiyuan has been following the path of a transformation towards a less resources-oriented development. The strategy adopted relies on the two main measures: (a) to reduce the importance of the second sector in the local economy and to promote third-sector activities (b) to invest in environmental protection to manage the issues due to a past development and ensure that current activities do not impact the environment as they used to. The indicator is a relevant tool to provide a comprehensive analysis but shall not be regarded as a very accurate measure. Indeed, this outlook would not be relevant as the indicator shows the following weaknesses (a) its value can be sensitively impacted by exogenous facts such as, for instance, an important investment for environmental protection for a year due to a project implementation (b) some data are flow while others are stocks. Therefore, the indicator is a talkative tool for a trend-perspective but shall not be considered as a yearly accurate measure.
Furthermore, the five-year perspective to analyze the trend might be judged as short but it is a first step and a first methodology provided for RBC monitoring at the local-scale. The indicator value has to be correlated to the public policies and private strategies implemented in Jiyuan. It can be a useful tool for policy-makers to assess their ability to foster their plans.

Conclusions

The indicator shows a positive evolution toward sustainability: the development of the third sector of the economy has been the major cause of economic differentiation and diversity, providing support to revenue. Meanwhile, an important investment for environmental protection took place also contributing both to environmental sustainability and economic strength. With such results we may foresee an improvement of the environmental condition for Jiyuan and a shift toward a more sustainable development path. The promotions of industrial restructuring and of third service industry highlighted in the Jiyuan Implementation plan of 2015 are consistent with the trend draws by the indicator value. The indicator analysis could be useful for local decision-makers to assess the efficiency of plans implementation for the past few years. The indicator has to be analyzed by correlating local decisions or contexts. It shall not be taken as a comprehensive tool but as a tool that can

give a refreshed perspective and comparison on local plans implementation. A further study should be achieved in years to come to analyze the 13th 5-year plan effects on the city and to have a long-term period to assess. In addition, a similar indicator could be computed in some other RBC to analyze their potential shift towards sustainability and be able to compare their strategies.

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