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Application of the Water Poverty Index at the districts of Yellow River Basin

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Abstract. As one assessment method of the water resources, Water Poverty Index has become an available tool in water resources management for it simply calculation process, comprehensive understanding of the results. This paper introduces the concept of the Water Poverty Index, and applies it at these districts of Yellow River Basin by using equal weightings methodology. During the process of calculating it, some component variables of the WPI have been improved and the data addressed standardization. The result shows that the water resources of Shandong is safe, Sichuan and Henan province is middling safe and low safe, while the WPI of the other six provinces is so low which reflects water resources shortage is very severe. The same time, this paper analysis the main reasons of water poverty, which provides the access to improve the water resource management in these districts.

Introduction

The exploit and use of water resource has been affected on the human activity, and the conventional approaches to water assessment haven't meet the needs of holist and reasonable estimate, which only adopts water resource physical character as the available factor. Therefore, Integrated Water Resources Management (IWRM) has been raised [1]. These approaches to the water assessment has developed the stage of the integrated assessment [2,3].They apply in many fields such as assessing the water resources safety, bearing capacity, renewal capacity and sustainability [4]. However, they are restricted on purely models building and large-scale data, so Sullivan raises the Water Poverty Index by providing a reasonably simple process to combine many relative factors to produce a single index value, enabling more comprehensive understanding of the meaning of the results [5].All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your paper.

Water Poverty Index

Introduction of the Water Poverty Index. Center for Ecology and Hydrology (CEH). It is designed as a composite, inter-disciplinary tool, linking indicators of water and human welfare to indicate the degree to which water scarcity impacts on human populations, which combines physical, social, economic and environ-mental information associated with water scarcity, access to water and ability to use water for productive purposes. WPI include five components:

Resources – how much water is available, taking account of seasonal and inter-annual variability.

Access – A measure of how well provisioned the population currently is, including in domestic use and irrigation;

Capacity – to manage water resources, based on education, health and access to finance;

Use – this captures the use we make of the water;

Environment – this tries to capture the environmental impact of water management.

Calculating Methodology about the WPI. Water Poverty Index would need to be a tool which could be freely and easily used by all countries, at various scales. Thereby, Sullivan adopts the weighted average methodology, which evaluates weight to the five components, the final value falls into the range 0-100.The value is higher, the water resource condition is taken to be the better situation. The expression is:

$$WPI = \frac{w_r R + w_a A + w_c C + w_u U + w_e E}{w_r + w_a + w_c + w_u + w_e} \quad (1)$$

According to the different weights values are given, there are two kinds calculating ways. One is balance methodology, which the equal weight value is given. It is applied on the large scales. The other one is unbalance methodology, which unequal weight value is given on basis of the each component's importance in water resources management. It is applied on the small scales. This paper adopts the balance methodology to calculate WPI at the district level.

Each component is been made up of some sub-component variables. In order to exclude the inflection on different dimensions, this paper put them into standardization. They are divided into the three types.

The first type is that the value is larger, and it contributes more to WPI, for example, the per capita water resources etc. Its expression is:

$$x_{ij}^* = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2)$$

The second type is the sub-components value is smaller, and it contributes more, for example, per ten thousands GDP water use etc. Its expression is:

$$x_{ij}^* = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (3)$$

The third type is when the sub-component's value falls in reasonable ranges, it contributes more to the WPI, for example, right amount of household water use etc. It adopts two calculating methods. We can assign x_{ir} as the middle value, if $x_{ij} \le x_{ir}$, and the expression is as the same as the first type's.

If $x_{ij} > x_{ir}$, its expression is:

$$x_{ij}^* = 1 - \frac{x_{ij} - x_{ir}}{\max x_{ij} - x_{ir}} \quad (4)$$

However, there are some shortages about this calculate methodology, for example, there is 0 or 1 borderline value. Therefore, Heidecke has improved the approach, which increases the variable maximum by 5% and lessens the minimum by 5%[6].This approach enhances the result authenticity. For example, the first type is adjusted:

$$x_{ij}^* = \frac{x_{ij} - \min x_{ij}/1.05}{\max x_{ij} * 1.05 - \min x_{ij}/1.05} \quad (5)$$

After calculating these sub-components, these values are put into weighted average and multiply 20, and then we can acquire five components, which falls into[0,20].

$$Y_i = 20 * \left(\sum_{j=1}^{n} x_{ij}^* \Big/ n\right) \quad (6)$$

Application of the WPI at THE District of Yellow River Basin

Basic Document and Data Processing. Yellow River basin is one of the seven main basins in China, which flows through Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Henan and Shandong province, finally empties into Pohai. There are differentiates of the integrated water resources condition in the nine provinces because of the discrepancies on hydrology, physiognomy, non-science, economic and environment, etc. Through calculating the WPI value of these districts, we can compare water resources poverty degree and reasons in these districts, and then the policy maker can use this tool to alleviate the water poverty degree by integrate the water resources management.

During the process on collecting and dealing with the data, this paper is on the foundation of data authentic and easy to access, so there are some adjustments on the sub-components variable comparing to the district level scale. The sub-components and sources of data formational are shown in the table 1.

Table 1 Sub-components variable of the WPI and Sources of the data

Components of WPI	Sub-components	Sub-components variable adjusted	Sources of the data
Resource	Per capita local water resource	Total amount of local water resources	National Bureau of statistics of China official website. Yellow River water resources bulletin2007
		Per capita local water resource	
	Quantitative and qualitative evaluation of the variability or reliability of resources	runoff coefficient	China water resources bulletin2007
Access	Access to clean water as a percentage of household	%of benefiting from the Water sanitation improvement	National Bureau of statistics of China official website.
	Access to sanitation as a percentage of population	Access rate to sanitary toilets	
		Per thousand Medical and technical personnel	
	Access to irrigation coverage adjusted by climate characteristics	The area of saving water to irrigation	
Capacity	Wealth level	per capita GDP	China statistical yearbook 2008; National Bureau of statistics of China official website; China education statistical yearbook 2008
	Under-five mortality rate	Population life expectancy by region	
	Educational level	%Population aged six and over is the senior secondary school and over	
	%of households receiving a pension/remittance	No source	
Use	Domestic water consumption rate	Per ten thousands GDP water use	China water resources bulletin2007
	Agricultural water use	Agriculture water use	
	Household water use	Per capita water use(L/D) divided into rural and urban	
	Industrial water use	Per ten thousands industrial value added water use	
Environment	People's use of natural resources	No sources	Every province Soil and water convention bulletin; Every province Environment bulletin.
	Area of soil erosion	Area of soil erosion	
	biology diversity	biology diversity	
	water quality condition	%of Monitored Section Water Quality gets to grade Ⅰ-Ⅲ	
		%of industrial waste water meeting discharges standards	

Calculate the WPI. We can acquire the Water Poverty Index values of the nine provinces by calculating data, as is shown at the Table 2 and Table 3.

Table2 WPI scores in these districts of the Yellow River Basin

Region	Resource YR	Access YA	Capacity YC	Use YU	Environment YE	WPI
Shandong	6.9	15	13.2	16.8	10.9	62.8
Sichuan	11.9	5.2	10.8	12.4	17.5	57.8
Henan	7.8	8.7	6.4	15.3	11.8	50
Shanxi	2	9.8	11.7	14.2	6.8	44.5
Shaanxi	6	5.5	6.5	15.3	10.6	43.9
Inner Mongolia	1.4	8.8	11.9	12.8	5	39.9
Qinghai	9.1	6.2	6.7	8.4	7.4	37.8
Ningxia	3.7	4.7	9.8	4	7.9	30.1
Gansu	2.4	6.1	5	9.4	6.4	29.3

Table3 Compare the score of WPI in these districts

Region	WPI	Compare to the safe value	Compare to WPI value of China (48<WPI<55.9）	Compare to WPI value of Yellow River（WPI=45）
Shandong	62.8	safe	greater	greater
Sichuan	57.8	middling safe	greater	greater
Henan	50	low safe	equal	greater
Shanxi	44.5	unsafe	less	less
Shaanxi	43.9	unsafe	less	less
Inner Mongolia	39.9	unsafe	less	less
Qinghai	37.8	unsafe	less	less
Ningxia	30.1	unsafe	less	less
Gansu	29.3	unsafe	less	less

Notation: water resources safe value is based on the standard which made by CEH: Safe, WPI>62;midding safe degree: 56<WPI<61.9;low safe degree: 48<WPI<55.9 and unsafe: 35<WPI<47.9. WPI value of China is based on the WPI value of the 147 nations having calculated by Sullivan The WPI value of Yellow River basin is based on the WPI on seven basin of China having calculated by Shao Wei-wei. [6]

Analysis of the Result. These figures show that the district with the best water situation is Shandong province, with a WPI value of 62.8, which falls into the safe range. This reflects the fact that in east inshore district access, capacity and use generate relatively high component scores. In the northwest inland district, the WPI score is significantly lower, such as Qinghai and Gansu, the value only has 30.1 and 29.3, which are quite unsafe in water resource using. Compare to the WPI value of China and Yellow River basin, Shandong, Sichuan and Henan province WPI scores is over to the values, and the other six provinces hasn't arriving at the levels.

For dissemination purposes, these variations both between and within locations are further illustrated through the use of pentagram diagrams along with the final WPI scores, which show the component scores that indicate the strengths and weaknesses in each location. These are illustrated in Figure1-3, where higher scores indicate a lower degree of water poverty.

As is shown in Figure 1, The WPI values of the three districts are higher. It seems evident that in Shandong, much more access to water sanitation, capacity and productive use is made of water, as illustrated by the higher value on these components, but the resource and the environmental impact of that water use in the assessed locations seems to be quite severe, illustrated by the low scores on the environmental axis in Fig 1. This is in part due to the impact of locating the backward position and estuary. In Sichuan, much better environment of water use and resource amount are shown, however, its access and use score is lower than the other two districts. In Hehan, the management capacity of the water resource is relative deficiency which links to the lower fortune level and education degree.

As is shown in Fig 2, It seems evident that the three regions WPI values is lower than figure 3-1.It is significant lower in the resource amount and the access to acquire the sanitation water, also the environment condition is reflected much worse, especially in shanxi and Inner Mongolia. Moreover, the capacity of management water resources is relative lag. This is due to the atrocious weather and the growth slowly of the economic. This suggests that enhance the investment in economical development, water conservancy and environment protection.

As is shown in Fig3, in Qinghai, Ningxia and Gansu regions, the WPI value is lower than 40, also the each component score is less than 10.The degree to water resources poverty is quite sever, and the water resources condition is extremely unsafe, This is due to the bad natural condition, undeveloped economics, the lower education level etc. We can alleviate the degree to water poverty which improves the investment on the capacity and the use efficiency by rising up the fortune, education level and saving water technology.

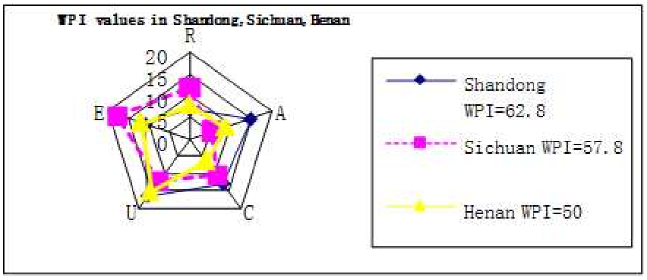
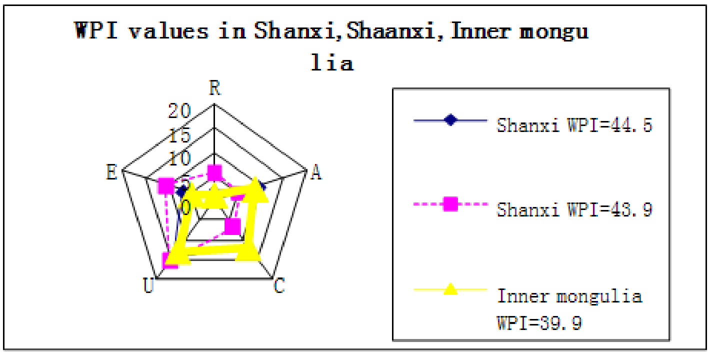


Fig1 WPI values of Shandong, Henan and Sichuan



Fige2 WPI values in Shanxi, Shaanxi, and Inner Mongolia.

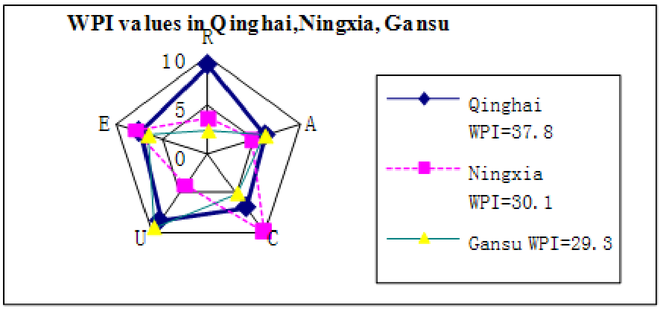


Fig3 WPI values in Qinghai, Ningxia, and Gansu.

Conclusions

In this paper, we have applied the Water Poverty Index on these districts of the Yellow River basin. It has been demonstrated that only the water resources of Shandong province is relative abundant, but the water quality is polluted severely. The water resource amount of Sichuan is enough, which located in the middling safe range, while the proportion of access to acquire the clean water and sanitation and per capital GDP is lower. In Henan province, it is shown that the water resources using is low safety which is due to the fortune and educational level is lower. Compare to the three provinces, it is proved that the other six regions the condition of integrated water resources management is worse, illustrated by the low score of the components. This is due to lag development of the economic, society security, and water conservation building.

We have shown how the Water Poverty Index goes some way towards meeting the need of district scale. However, there are some deficiencies during the application of the Water Poverty Index, for example, the data for the WPI components should come from existing sources, which links to the diverse institutions of economics, environment, ecology, and society etc. However to realize that currently this data may be inconsistent, unreliable or even invalid for what it claims to represent, so results from any assessment process should be treated with caution. Moreover, there are different requires in variety scales. In this paper, the data sources from the official governments, therefore, the result is as near as match to the current situation of the water resources in these restricts7, which would facilitate more effective water management strategies.

However, it has many shortages, illustrated by the deficiency of the census data, (such as the per capita resources, the proportion of household owning the retirement pay and wages), meantime the universality on setting the sub-components is not enough. So result from these, the WPI value doesn't mirror the real result absolutely. In light of this, there will be other work ongoing to take these issues further.

References

[1] J United Nations Conference on Environment and Development, (UNCED), Rio Declaration on Environment and Development, Report of the United Nations Conference on Environment and Development, Agenda 21, Chapter 18: Protection of the quality and supply of freshwater resources: Application of integrated approaches to the development, management and use of water resources, Rio de Janeiro, 1992,6:3-14.

[2] Falkenmark, M., & Suprapto, R. A. Population-landscape interactions in development: a water perspective to environmental sustainability. Ambio,1992,21(1):31–36.

[3] Ohlsson, L. (1998). Water and social resource scarcity.FAO issue paper. Rome: FAO.

[4] Bossel H. Indicators of sustainable development: Theory, Method, Applications[R]·International Institute of Sustainable Development Winnipeg: Canadian Cataloguing in Publication Data, 1999.20-55.

[5] Sullivan.C.A, Meigh J. Integration of the biophysical and social sciences using an indicator approach: addressing water problems at different scales [J]. Water resources management, 2007,21 (1):111-128.

[6] SHAO Wei-wei, YANG Da-wen. Water poverty index and its application to main river basins in China[J].Shuili xuebao,2007,38(7):866-872.

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