# Fitting CSS2019 Data with Normal Distribution for Examining the Public Sense of Gain of the Yellow River Basin in China

Haitao Li, Liyan Yang, and Wen Chen

*Abstract*—**This paper explored the transmission mechanism of the public sense of gain (PSG) and YB conservation and development, suggested to take the PSG as a better regulation and guidance for the sound development of the Yellow River Basin. Based on the data of CSS2019, this paper tried to exam the PSG at the opening stage of Chinese major strategy on YB Conservation and Development. An evaluation index system including 5 factor dimensions and 25 indices was constructed, and the normal distribution was used to fitting the survey data, after that, the dominance matrix method was applied to make decision based on PROMETHEE Ⅱ. The empirical analysis results indicated that the PSG of the middle and upper reaches of the Yellow River was lower than the overall level of China, while that of Henan and Shandong in the lower Yellow River were both higher than its national average; and the public generally had a higher sense of gain on government public service and social civilization, however, the PSG on individual self-fulfillments of Henan and Shandong and that on economic situations of the middle and upper reaches of the Yellow River were both at a lower level.**

*Index Terms*—**public sense of gain, the Yellow River Basin, CSS2019, normal distribution, dominance degree**

## I. Introduction

THE Yellow River Basin is an important industrial and agricultural production base and a critical economic zone of "one belt one road" strategy in China, it is also an important ecological barrier in northwest and north China[1-3]. However, the Yellow River is a rebellious disaster river since ancient times, frequent ice disasters, floods and droughts have brought serious harms to the people along the river [4-7]. In recent decades, breakthroughs have been made in conservation and harness of the ecological environment in the Yellow River Basin, but there are some serious problems badly in need of solutions under the influences of global climate changes and human activities. For example, its ecological environment is still badly fragility, its water scarcity is getting worse, and its economic and social development is still relatively backward in general and so on [8-11]. Therefore, it has become a major challenge for Chinese government and local residents [12]. On the basic of those above, "ecological conservation and high-quality development of the Yellow River Basin" (Hereinafter referred to as "YB Conservation and Development") has been determined as another major national strategy of China in 2019 [13]. The existing researches on YB Conservation and Development mainly includes two aspects, one is to interpret, understand, experience and reflect on this Chinese major strategy [14-15], the other is to contribute intelligences and suggestions for implementing this Chinese major strategy [1, 16]. For example, Liu et al. [17] took provincial region as research unit to evaluate the coupling coordination degree and the interactive response relationship between ecological protection and high-quality development in the Yellow River Basin. Under the guidance of important ideas such as sustainable development, harmony between humans and water and ecological civilization, Zuo et al. [18] constructed a research framework for selecting high-quality development path in the Henan section of the Yellow River Basin. Wang and Miao [19] organized an album on high-quality development of the Yellow River basin published in the Journal of Natural Resources, aimed at providing suggestions for the practice of urban-rural coordination, ecological protection, resource allocation, economic development and cultural inheritance in the Yellow River Basin. On the whole, the local governments at all levels, scholars and all walks of life in the Yellow River Basin are currently working together and striving to protect and harness the Yellow River and improve the quality of economic and social development.

Public sense of gain (hereinafter referred to as PSG) has been gradually accepted as the goal of reform and development, and the benchmark and standard of good governance in China [20]. The new concept fully reflects the new changings and demands of Chinese people's yearning for their better life, and it has soon become one of the hot issues in various fields [21]. Based on the empirical analysis of three

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ancient towns in Shanghai, Huang et al. [22] studied the evaluation and influence mechanism of rural development of ancient towns. Zhang and Liu [23] used the data of China's general social survey (CGSS) to measure the PSG on participation in basic medical insurance. Wen and Liu [24] researched the trends and disparities empirical analysis of the PSG based on Chinese urban and rural social governance dada. Wang et al. [25] researched on the factors of poverty subjects' acquired sense under the background of E-commerce poverty alleviation. Huang [26] explored the influential factors and boosting approaches of ecological sense of gain based on the essence of the sense of gain. Wang et al. [27] explored the mediating effect of community identity between socioeconomic status and sense of gain in Chinese adults by analyzing nationally representative samples of 28,300 adults from the China Family Panel Studies. Zuo et al. [28] took the Happy River Index (HRI) as an integrated index of river health and human well-being and established an HRI assessment framework for the Yellow River Basin. Besides, some researchers payed attentions to the macro mechanism, evaluation system and evaluation methods of the PSG [21, 29-32]. However, for the concept of PSG, there have yet no consistent methods currently on scientific quantitative research, comprehensive mechanism investigation and temporal and spatial changes analysis. Especially, there are few published literatures about the PSG on YB Conservation and Development at present.

Consequently, it is timely and required to take the PSG as a general benchmark to guide the implementations and to measure the achievements of YB Conservation and Development. Considering the PSG is an important macroscopic indicator to measure the good national governance, it is necessary to obtain and describe the subjective psychological cognitive information of the public from all walks of life, and analyze the main influencing factors and spatiotemporal evolution modes of the PSG at a provincial level or a larger regional. Based on this research framework, the research conclusions can not only provide decision bases and policy references for provincial governances on YB Conservation and Development, but in the sense of social science, it can also form panel data to analyze and judge the causal connotation, which is more valuable than cross-sectional data at the individual level. This paper attempts to construct the logical structure of the PSG and YB Conservation and Development, explore their logical principles and transmission mechanisms, and then make a preliminary empirical study to exam the PSG in the Yellow River Basin at the beginning of this Chinese strategy. Besides, this research also attempts to provide practical implications and generalized suggestions to evaluate and improve the quality of people's work and livelihood.

The rest of this paper is arranged as follows: Section II explores and explains the transmission mechanisms of the PSG and YB Conservation and Development, and then based on Chinese Social Survey in 2019 (hereinafter referred to as CSS2019), section III introduces the study area and research data of the Yellow River Basin, Section IV develops an evaluation index system, Section V proposes the evaluation methods based on normal distribution hypothesis, and Section VI presents the detailed results of empirical analysis. Finally, the conclusions are mentioned in Section VII.

## II. The logical mechanisms of the PSG and YB conservation and development

There is no complete consensus currently on the specific definition and theoretical connotation of the PSG [33], but a growing number of scholars and researchers accept that the PSG should be selected as the most appropriate criteria to measure the achievements of reform and governance in China [20]. They generally agree with the following standpoints:

(1) The PSG is a positive subjective feeling of the general public after their actual gains, and the PSGs of groups with different characteristics have great differences.

(2) The measurement and improvement of the PSG should consider these factor dimensions, such as the objective benefits and subjective feelings in individual psychological dimension, the unbalanced distribution of group mood in social groups dimension, and the dynamic variability because of policy implementation in time dimension;

(3) The PSG should be considered from the macro socio-economic and political process of a country or region; it can be divided into dominant sense of gain and recessive sense of gain, where the dominant sense of gain includes income, medical insurance, education and pensions and so on, and the recessive sense of gain includes fairness and justice, democracy, civilization and value recognition and so on;

(4) The research on PSG should pay special attention to investigation and improvement of the sense of gain of the underprivileged groups and ordinary people.

Accordingly, the essential connotation of the PSG is the subjective psychological welfare including high economic and social properties, high comparison properties and high dynamic characteristics [21]. Where, the high economic and social properties mean that the PSG comes from the macro-economic and political process, not from the simple individual physiological and psychological process; the high comparison properties means that the PSG reflects the total comparison of the overall economic and social status in time dimension and space dimension; and the high dynamic characteristics show that the PSG will change dynamically with the development of economy and society, also, it has certain regional differences. This paper attempts to develop a logical structure of the PSG and YB Conservation and Development, see Figure 1.

Figure 1 tries to reflect the logic relationship and transmission mechanism of YB Conservation and Development. The influences of this Chinese strategy on the economic and social development of the Yellow River Basin are extensive and far-reaching, including various aspects such as economic development, governmental services, ecological civilization and people's livelihood and so on, thus it is difficult to measure all subjective and objective changes with indicators alone. The general goal of YB Conservation and Development is to make the Yellow River a happy river for the people, and all work should follow these principles such as to make people's life better, people-cantered and to work for people's general happiness and so on. Thus all of our work, whether the ecological conservation and harness of the Yellow River Basin or the high-quality development of the Yellow River Basin, will return to the work of people-oriented, which is attributed to the cognitions and

feelings of the public in the Yellow River Basin. Consequently, it is reasonable to take PSG as evaluation standard and build its evaluation system to measure the achievements of the YB Conservation and Development.

Besides, the logical structure diagram is accords with the general goal of "Happy River", which was determined by Ministry of Water Conservancy of China, including flood control and safety protection, high quality water resources, healthy water ecology, livable water environment and advanced water culture [15, 34]. The measurement system of high-quality development level of the Yellow River Basin has not yet officially released, and the researches are still in its infancy. But according to existing literatures [8-9, 18, 35-36], the achievements of high-quality development of the Yellow River Basin should be evaluated from 5 aspects: (1) Remarkable benefits of economic development; (2) Better trend of innovation driven development; (3) Significant improvement of people's livelihood; (4) Substantial improvement of environmental deterioration; (5) Prosperity of ecological culture industry. They basically coincide with the connotation and strategic direction of high-quality development of the Yellow River Basin.

The logic relationship of high-quality development and ecological conservation and harness of the Yellow River Basin is dialectical unity [8]. Ecological conservation and harness of the Yellow River Basin can provide theoretical framework and regulatory constraints for high-quality development of the Yellow River Basin, and ensure its sustainable development; meanwhile, without the important foundation of high-quality development of the Yellow River Basin, ecological conservation and harness of the Yellow River Basin cannot be carried out smoothly. A scientific and reasonable evaluation system of the PSG on YB Conservation and Development can not only carry out the necessary regulatory constraints, but also provide direction and ideas for YB Conservation and Development. Therefore, the investigation of PSG on YB Conservation and Development should cover a wider public in the Yellow River Basin, including the local ordinary residents, the policymakers, the media workers, the businessmen, the scholars and researchers, and the non-governmental organizations (NGOs)/ non-profit organizations (NFOs)/community-based organizations (CBOs) and so on. Therefore, it is necessary to carry out large-scale social surveys to obtain the fundamental data of the PSG on YB Conservation and Development.

Fortunately, since 2006, Chinese Academy of Social Sciences (CASS) has established Chinese social quality data archive and regularly opened Chinese social survey data to the public. These data are collected in strict accordance with the sampling survey rules and cover a wide range of China, and the data involve the employment status, social lives and attitudes of the public across China. Thus the Chinese social survey (CSS) data can be used as important references to carry out this research. As a tentative research, the social survey data of CSS2019, which was released free of charge by CASS to the whole society at the end of December 2020, will be used in this paper to exam the PSG on YB Conservation and Development.

## III. The Study Area and Research Data of the Yellow River Basin in China

From the perspective of natural geographical boundaries, the Yellow River has a total length 5464km, it flows through 9 provinces of China, including Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Henan and Shandong, with a drainage area of 795000km2 (including the inner drainage area of 42000 km2), and the Yellow River Basin involves 71 prefecture-level cities of the above 9 provinces and 1 county-level city directly under the provincial government [37-38]. It should be noted that, there are 91 prefecture-level cities covered in the Chinese major strategy of YB Conservation and Development, including all regions of the following 7 provinces such as Qinghai, Gansu, Ningxia, Shanxi, Shaanxi, Henan and Shandong, and 6 cities and 1 county in western Inner Mongolia and 2 autonomous prefectures in northwest Sichuan [1], see Figure 2.

From the perspective of economic and social development, the Yellow River Basin has the total population of 324 million, accounting for 23.31% of the total population of China in 2019, having an average population density of 408 persons per square kilometer and the Yellow River Basin has the gross domestic product (GDP) of 19.4 trillion yuan, accounting for 21.55% of the total national GDP of China in 2018, having per capita GDP of 59.88 thousand yuan. Among them, the total population of Henan Province and Shandong Province in the lower reaches of the Yellow River accounts for 60.62% of the total population of the Yellow River Basin in 2019, and they also contributed 64.19% of the GDP of the Yellow River Basin in 2018. However, the general economic and social development situation of the Yellow River Basin lags behind the situation of the whole country, and the gap between its macro-economic development level and that of the whole country has a downward trend [1].

CSS2019 is the latest issue of cross-sectional data published so far, it has collected 10283 valid questionnaires from more than 11000 urban and rural families in 149 cities (counties and districts) of 31 provinces (autonomous regions and province-level municipality). The topics of CSS2019 is social quality and social class change, and its survey covers family employment, economic status, living conditions, social security social values and social evaluation, social participation and social evaluation, social participation and political participation, voluntary service and so on. Accordingly, the survey topics and contents of CSS2019 are consistent with this study, so its raw data can be used for empirical analysis. However, there are great differences of the survey frequency in the main provinces of the Yellow River Basin in CSS2019. The survey frequency in CSS2019 and some statistical data of economic and social development of 7 provinces in the Yellow River Basin are listed and shown in Table Ⅰ and Figure 3.

It can be seen from Table Ⅰ that the sum of survey frequencies of 5 provinces in the middle and upper reaches of the Yellow River is nearly the same as the survey frequency of Henan province and Shandong province in CSS2019. Similarly, the sum of both the GDP and year-end population of these 5 provinces are very close to both the GDP and year-end population of Henan and Shandong. And from

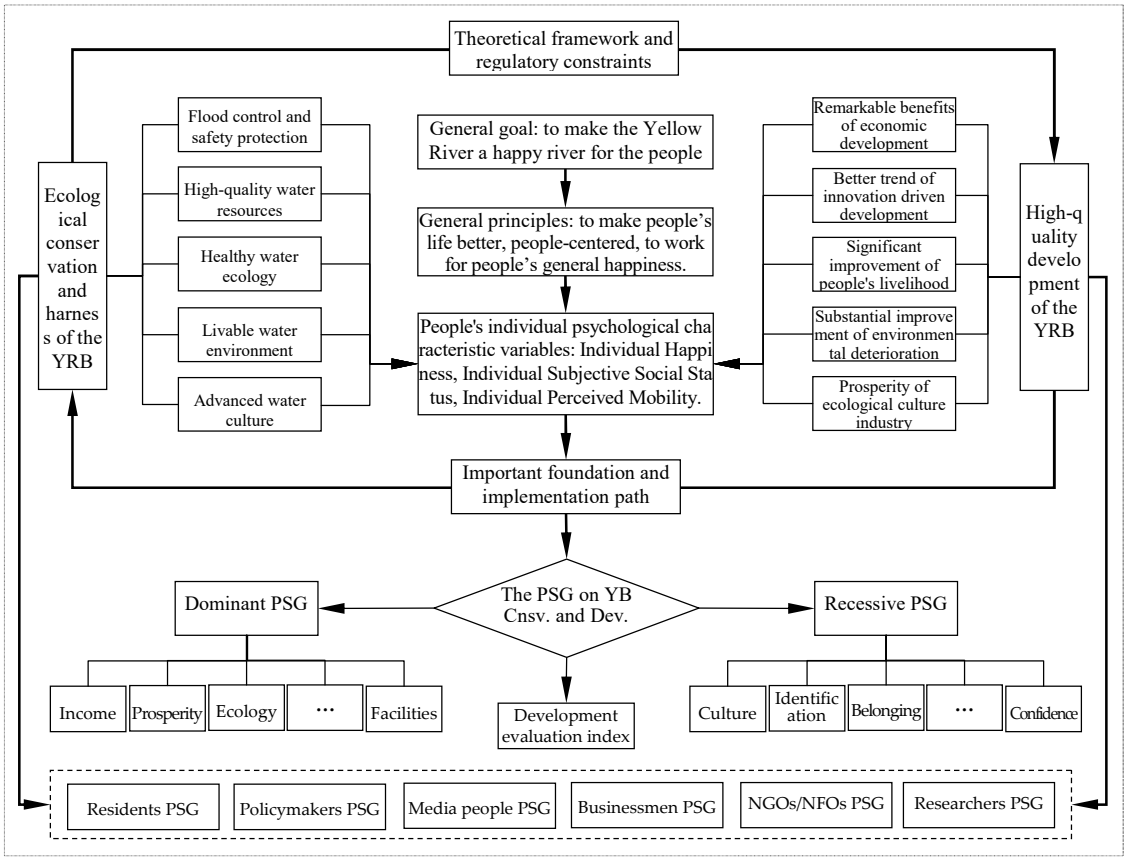


Fig.1. The logical structure diagram of the PSG and YB conservation and development

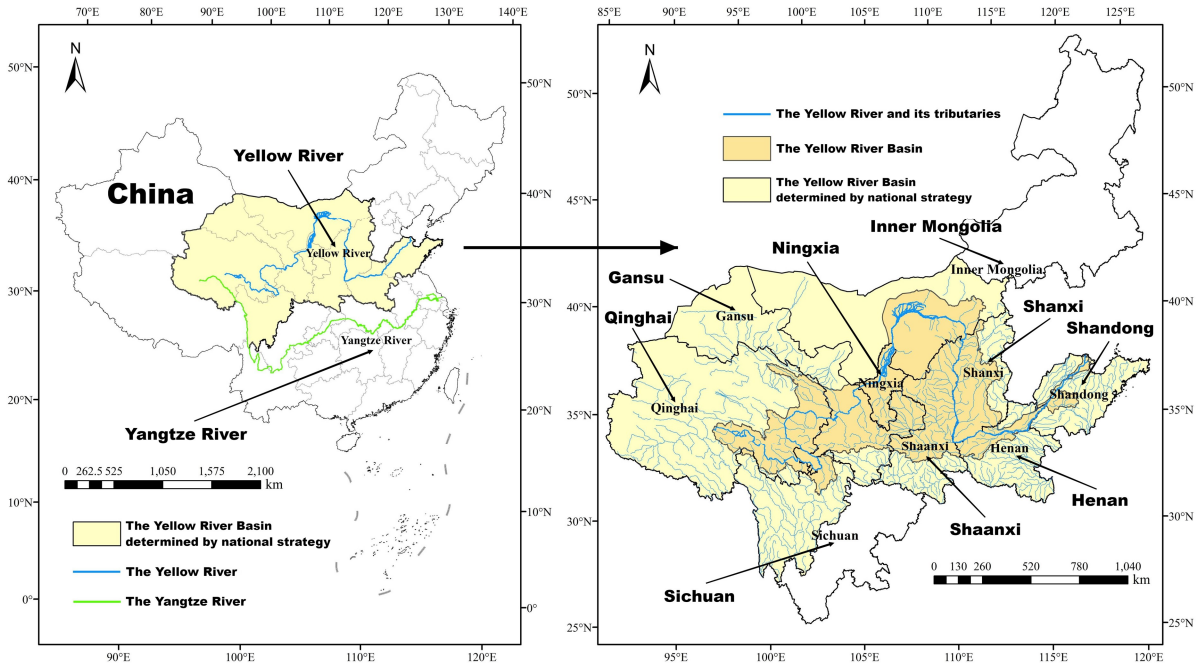


Fig.2. The boundary of the Yellow River Basin determined by the Chinses strategy

Figure 3 and Table 1, the Per Capita Disposable Income (PCDI) and the Per Capita Consumption Expenditure (CONSP), which can be used to measure the living conditions of people in a region, have little differences in their statistical data of the 7 provinces, and they are both listed below the Chinese average (except the PCDI data of Shandong). Therefore, in order to ensure the regional integrity and the survey frequency balanced according to CSS2019, this paper divided the Yellow River Basin into 3 parts: the middle and upper reaches of the Yellow River, Henan Province and Shandong Province, where the middle and upper reaches of the Yellow River includes 5 provinces (autonomous regions) of Qinghai, Gansu, Ningxia, Shaanxi and Shanxi. The rest regions of this Chinese major strategy of YB Conservation and Development, including 9 cities (county or autonomous prefectures) in northwest Sichuan and western Inner Mongolia (see Figure 2), are not considered in this paper.

TABLE I The comparisons of survey frequency and economic social conditions in the Yellow River Basin*

| The divisions of the Yellow River Basin | The middle and upper reaches ($A_1$) | | | | | Henan ($A_2$) | Shandong ($A_3$) | China ($A_c$) |
|---|---|---|---|---|---|---|---|---|
| | Qinghai | Gansu | Ningxia | Shaanxi | Shanxi | | | |
| The survey frequency in CSS2019 | 55 | 147 | 32<br>676 | 236 | 206 | 672 | 595 | 10283 |
| The GDP in 2019/100 million yuan | 2965.95 | 8178.30 | 3748.48<br>57712.58 | 25793.17 | 17026.68 | 54259.20 | 71067.53 | 990865.1 |
| The year-end population in 2019 /10 thousand people | 554 | 2551 | 618<br>10852 | 3718 | 3411 | 9429 | 9417 | 140005 |
| The PCDI in 2019 /Yuan | 22617.7 | 19139.0 | 24411.9 | 24666.3 | 23828.5 | 23902.7 | 31597.0 | 30732.8 |
| The CONSP in 2019/Yuan | 17544.8 | 15879.1 | 18296.8 | 17544.8 | 15862.2 | 16331.8 | 20427.5 | 21558.9 |

*Data sources:China Statistical Yearbook 2020, http://www.stats.gov.cn/tjsj/ndsj/2020/indexch.htm,2020.12.30.

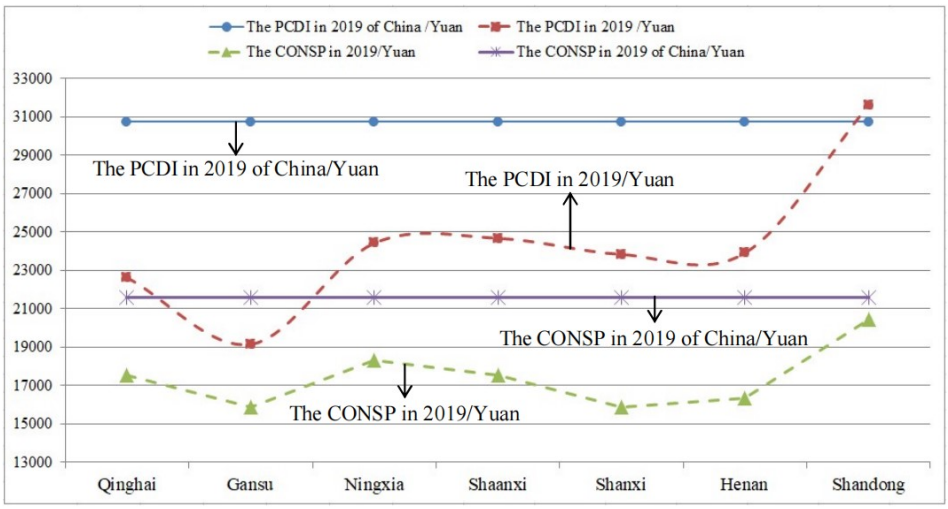


Fig.3. The comparisons of PCDI and CONSP in 2019 of 7 provinces in the Yellow River Basin

## IV. THE EVALUATION INDEX SYSTEM OF THE PSG ON YB CONSERVATION AND DEVELOPMENT

Referring to CSS2019, an evaluation index system of the PSG on YB Conservation and Development, including 5 factor dimensions and 25 indices, is constructed for empirical analysis, and the index weight is also determined by AHP method, as shown in Table Ⅱ.

(1) The PSG on economic situations of individual and family (E). This factor dimension mainly investigates the satisfaction and subjective feelings of the respondents due to the improvement of family and individual income, economic situations and socio-economic level. 5 indices are selected such as socio-economic level at present (E1), socio-economic level five years ago (E2), conditions of household income and expenditure (E3), satisfaction with family's economic situation (E4) and satisfaction with current life (E5).

(2) The PSG on living environment (L). This factor dimension mainly examines the subjective feelings and evaluations of the respondents due to the improvement of the living environment and the positive efforts made by local government to improve the environment. 5 indices are selected such as Air pollution (L1), Water pollution (L2), Noise pollution (L3), The other pollution including land pollution, electromagnetic ionizing radiation pollution etc. (L4), Work for protection and harness the living environment by local government (L5).

(3) The PSG on government public services (G). This factor dimension mainly reflects the subjective feelings of the people on the quality of public services based on the adequacy, convenience and balance of public services provided by the government, including 6 indices as follows: Basic social securities (G1) such as pension, medical care, employment, subsistence allowances and basic security housing and so on, Cracking down on crimes and maintaining public order (G2), Developing economy and increasing people's income(G3), Enthusiasm and effect of serving the people(G4), Providing high quality educational resources and ensuring educational equity(G5), and Ensuring food and drug safety (G6).

(4) The PSG on social civilizations (S). This factor dimension mainly researches the evaluation and recognition degree of the general public on the promotion of overall society civilization due to high-quality development of the economy, including 5 indices as follows: the Social trust level (S1) between people; the Social tolerance degree (S2) on the group of beggars, AIDS patients, homosexuals etc.; the Social equity level (S3) about distribution of wealth, judicatory and administrative execution, public health care, job opportunities and political rights etc.; the Modern citizen morals level (S4) of the general public; and the Observe law and discipline level (S5) of the general public.

(5) The PSG on individual self-fulfillments (I). This factor dimension mainly studies the emotional satisfaction of people's individual self-efficiency, development opportunities and capabilities. 4 indices are selected such as Current job satisfaction degree (I1), Life reality fits the ideal (I2), Believing that the God will always reward the diligent (I3) and Socio-economic level in next 5 years (I4).

TABLE Ⅱ The evaluation index system of the PSG on YB Conservation and Development

| Factor dimensions | Evaluation indices | Index description and quantitative assignment in CSS2019 | Index weight |
|---|---|---|---|
| Economic situations (E, 0.4534) | Socio-economic level at present ($E_1$) | What is your local socio-economic level at present? 1- Upper-class; 2-Upper middle; 3-Middle; 4-Lower middle; 5-Underclass; 8- Unclear. | 0.0646 |
| | Socio-economic level 5 years ago ($E_2$) | What is your local socio-economic level five years ago? 1- Upper-class; 2-Upper middle; 3-Middle; 4-Lower middle; 5-Underclass; 8- Unclear. | 0.0338 |
| | Conditions of household income and expenditure ($E_3$) | How was your family's overall income and expenditure last year (2018)? 1- Income over spending; 2- Income and expenditure balance; 3- Income less than expenditure; 8- Unclear. | 0.1401 |
| | Satisfaction with family's economic situation ($E_4$) | What is your satisfaction degree with your family's economic situation? 10-point system, in which 1 means very dissatisfied and 10 means very satisfied. | 0.2415 |
| | Satisfaction with current life ($E_5$) | What is your overall satisfaction degree with current life? 10-point system, in which 1 means very dissatisfied and 10 means very satisfied. | 0.5200 |
| Living environment (L, 0.2059) | Air pollution ($L_1$) | How serious is the air pollution in your residential areas? 1- More serious; 2- Serious; 3- Less serious; 4-Nothing serious; 8- Unclear. | 0.1590 |
| | Water pollution ($L_2$) | How serious is the water pollution in your residential areas? 1- More serious; 2- Serious; 3- Less serious; 4-Nothing serious; 8- Unclear. | 0.2601 |
| | Noise pollution ($L_3$) | How serious is the noise pollution in your residential areas? 1- More serious; 2- Serious; 3- Less serious; 4-Nothing serious; 8- Unclear. | 0.0745 |
| | Other pollution ($L_4$) | How serious is the land pollution, electromagnetic ionizing radiation pollution etc. in your residential areas? 1- More serious; 2- Serious; 3- Less serious; 4-Nothing serious; 8- Unclear. | 0.0369 |
| | Work of protection and harness ($L_5$) | What is your evaluation on environmental protection and harness by local government? 1- Very good; 2- Good; 3- Bad; 4- Very bad; 8- Unclear. | 0.4695 |
| Government public services (G, 0.1025) | Basic social securities ($G_1$) | What is your satisfaction degree on the basic social securities provided by local government, such as pension, medical care, employment, subsistence allowances and basic security housing, etc.? 10-point system, in which 1 means very dissatisfied, 10 means very satisfied and 98 means unclear. | 0.1835 |
| | Maintaining public order($G_2$) | What is your evaluation on cracking down on crimes and maintaining public order by local government? 1- Very good; 2- Good; 3- Bad; 4- Very bad; 8- Unclear. | 0.4226 |
| | Increasing people's income($G_3$) | What is your evaluation on increasing people's income by local government? 1- Very good; 2- Good; 3- Bad; 4- Very bad; 8- Unclear. | 0.2302 |
| | Serving the people($G_4$) | What is your evaluation on serving the people by local government? 1- Very good; 2- Good; 3- Bad; 4- Very bad; 8- Unclear. | 0.0400 |
| | Ensuring educational equity($G_5$) | What is your evaluation on ensuring educational equity by local government? 1- Very good; 2- Good; 3- Bad; 4- Very bad; 8- Unclear. | 0.0276 |
| | Ensuring food and drug safety($G_6$) | What is your evaluation on ensuring food and drug safety by local government? 1- Very good; 2- Good; 3- Bad; 4- Very bad; 8- Unclear. | 0.0960 |
| Social civilizations (S, 0.0433) | Social trust level ($S_1$) | What is your evaluation on the trust level between people? 10-point system, in which 1 means very distrust and 10 means very trust. | 0.0659 |
| | Social tolerance degree ($S_2$) | What is your evaluation on the social tolerance degree? 10-point system, in which 1 means very intolerant and 10 means very tolerant. | 0.0515 |
| | Social equity level ($S_3$) | What is your evaluation on the social equity level? 10-point system, in which 1 means very unfair and 10 means very fair. | 0.1095 |
| | Modern citizen morals level ($S_4$) | What is your evaluation on modern citizen morals level? 10-point system, in which 1 means very bad and 10 means very good. | 0.2369 |
| | Observe law and discipline ($S_5$) | What is your evaluation on the level of observe law and discipline? 10-point system, in which 1 means very bad and 10 means very good. | 0.5362 |
| Individual self-fulfillments (I, 0.1949) | Current job satisfaction degree ($I_1$) | What is your satisfaction degree on your current job? 10-point system, in which 1 means very dissatisfied, 10 means very satisfied and 98 means unclear. | 0.1511 |
| | Life reality fits the ideal ($I_2$) | Do you agree with the statement that "my life is roughly in line with my ideal"? 1- Strongly agree; 2- Basically agreed; 3- Partially disagree; 4- Strongly disagree; 8- Unclear. | 0.0757 |
| | Believing that the God will always reward the diligent ($I_3$) | Do you agree with the statement that "the God will always reward the diligent?" 1- Strongly agree; 2- Basically agreed; 3- Partially disagree; 4- Strongly disagree; 8- Unclear. | 0.3014 |
| | Socio-economic level in next 5 years ($I_4$) | What is your local socio-economic level in the next 5 years? 1- Upper-class; 2-Upper middle; 3-Middle; 4-Lower middle; 5-Underclass; 8- Unclear. | 0.4718 |

## V. The Evaluation methods based on Normal distribution Hypothesis

Since the respondents who provided survey data came from a same region and had their same concerns, the survey data statistical histogram of a certain index in the same region generally shows the characteristics of high in the middle and low at both ends, accordingly, it can be primarily concluded that the survey data of a certain index in the same region may follow a normal distribution [39]. More importantly, it has been generally accepted that human cognitions usually have the essence of fuzzy uncertainty, and fuzzy membership function of normal distribution is the most suitable one to describe human fuzzy cognitions [40-43]. In large scale social survey, the respondents are often asked to provide accurate numbers (for example, any number in 1-10) to indicate their subjective cognitions for a certain evaluation object, and the accurate numbers sets are often strictly analyzed with mathematical statistics theory to draw some conclusions. Actually, the research methods on social survey data with rigorous statistical theory are not entirely reasonable, because the accurate numbers still represent the fuzziness and randomness of the respondents' cognitions and responses, instead, the theories and methods of uncertainty decision-making can be tried, for example, the fuzzy and stochastic multi-criteria decision methods [44-45].

Therefore, let $X_{ij}=\left\{x_{ij}^1,x_{ij}^2,\cdots,x_{ij}^q,\cdots,x_{ij}^n\right\}$ be the processed survey data collection of the $j^{th}$ evaluation index of the study region $A_i(i=1,2,3)$ as defined in section 3.2, where $x_{ij}^q\in[1,10]$ is the evaluation score of the $q^{th}$ $(q=1,2,\cdots,n)$ respondent and $n$ is the total number of respondents of the $j^{th}$ evaluation index and the study region $A_i$. This paper makes the following assumptions:

***Assumption* 1**: The public overall cognitions $X_{ij}^{\Delta}$ on the $j^{th}$ evaluation index of the study region $A_i$ can be described by the membership function of a normal distribution with expectation $\mu_{ij}$ and variance $\sigma_{ij}^2$, written as $X_{ij}^{\Delta}\sim N(\mu_{ij},\sigma_{ij}^2)$;

***Assumption* 2**: The survey data collection $X_{ij}=\left\{x_{ij}^1,x_{ij}^2,\cdots,x_{ij}^q,\cdots,x_{ij}^n\right\}$ provided by randomly selected $n$ respondents can be regarded as a sample set of the overall distribution $X_{ij}^{\Delta}\sim N(\mu_{ij},\sigma_{ij}^2)$;

***Assumption* 3**: When there are enough samples ( $n\geq 50$ ), the sample set $X_{ij}=\left\{x_{ij}^1,x_{ij}^2,\cdots,x_{ij}^q,\cdots,x_{ij}^n\right\}$ can be used to estimate the expectation $\mu_{ij}$ and variance $\sigma_{ij}^2$ of the overall distribution $X_{ij}^{\Delta}\sim N(\mu_{ij},\sigma_{ij}^2)$, written as $\hat{\mu}_{ij}$ and $\hat{\sigma}_{ij}^2$ respectively.

Based on these assumptions, the survey data collection $X_{ij}=\left\{x_{ij}^1,x_{ij}^2,\cdots,x_{ij}^q,\cdots,x_{ij}^n\right\}$ can be aggregated and approximately represented by normal distribution information $N(\hat{\mu}_{ij},\hat{\sigma}_{ij}^2)$. Maybe, $X_{ij}\sim N(\hat{\mu}_{ij},\hat{\sigma}_{ij}^2)$ cannot pass the strict normality test with statistical theory, but it doesn't matter, the further research of this paper is the PSG evaluations rather than strict statistical analysis, the above approximate distribution assumptions can do well. After that, the problem to evaluate the PSG has been in fact transformed into a multi-criteria large group decision-making problem under fuzzy and stochastic uncertainty environment.

In summary, the evaluation methods are designed as follows. Firstly, approximately analyze the normal distribution characteristics according to the statistical histograms of the survey data, if there is a slight deviation, use P-P graph or Q-Q graph method to remove the outliers, or to adjust the outliers follow the proximity principle; Then, estimate the parameters of $X_{ij}\sim N(\hat{\mu}_{ij},\hat{\sigma}_{ij}^2)$ and aggregate the comprehensive evaluation information with normal distribution with the index weights in Table Ⅱ; Finally, calculate the dominance values for evaluation objects [46] and construct their dominance matrix, by which, the comprehensive evaluation results can be output based on the idea of PROMETHEEII [47-49], the cause analysis and policy recommendations can be conducted accordingly. The evaluation methods framework of the PSG on YB Conservation and Development is shown as Figure 4.

In Figure 4, the parameters of normal distribution $N(\hat{\mu}_{ij},\hat{\sigma}_{ij}^2)$ can be estimated based on the point estimate method which has been widely accepted

$$\hat{\mu}_{ij}=\frac{1}{n_{ij}}\sum_{q=1}^{n_{ij}}x_{ij}^q \tag{1}$$

$$\hat{\sigma}_{ij}=\sqrt{\frac{1}{n_{ij}-1}\sum_{q=1}^{n_{ij}}(\mathrm{x}_{ij}^q-\mu_{ij})^2} \tag{2}$$

According to equation (1)-(2), the density function of normal distribution $N(\hat{\mu}_{ij},\hat{\sigma}_{ij}^2)$ can be written as

$$f_i^j(x)=\frac{1}{\sqrt{2\pi}\hat{\sigma}_{ij}}e^{-(x-\hat{\mu}_{ij})^2/2\hat{\sigma}_{ij}^2} \tag{3}$$

Next, this paper tries to use only one normal distribution to approximately aggregate all of the survey data on the PSG of the study region $A_i$, written as $f_i(x)$

$$f_i(x)=\sum_{j=1}^{N_j}w_{ij}f_i^j(x) \tag{4}$$

Because $f_i^j(x)$ is a normal distribution density function, $f_i(x)$ is also a normal distribution density function according to the linear property of normal distribution, then

$$f_i(x)=\frac{1}{\sqrt{2\pi}\hat{\sigma}_i}e^{-(x-\hat{\mu}_i)^2/2\hat{\sigma}_i^2} \tag{5}$$

where: $\hat{\mu}_i=\sum_{j=1}^{N_j}w_{ij}\hat{\mu}_{ij},\hat{\sigma}_i=\sqrt{\sum_{j=1}^{N_j}w_{ij}^2\hat{\sigma}_{ij}^2}$ ;

$W_i=\left(w_{i1},w_{i2},\cdots,w_{ij},\cdots,w_{iN_j}\right)$ is the indices weight vector on the PSG of the study region $A_i$ and $N_j=5,5,6,5,4$ which has been given in Table Ⅱ.

This research tries to use dominance matrix method to comprehensively evaluate the PSG of the study regions on YB Conservation and Development. According to reference [50], the dominance between any two continuous distributions $f_1(x),f_2(x)$ is $D_{f_1>f_2}$, where

$$D_{f_1>f_2}=\int_{-\infty}^{+\infty}\int_{-\infty}^{x_1}f_1(x_1)f_2(x_2)dx_2dx_1.$$

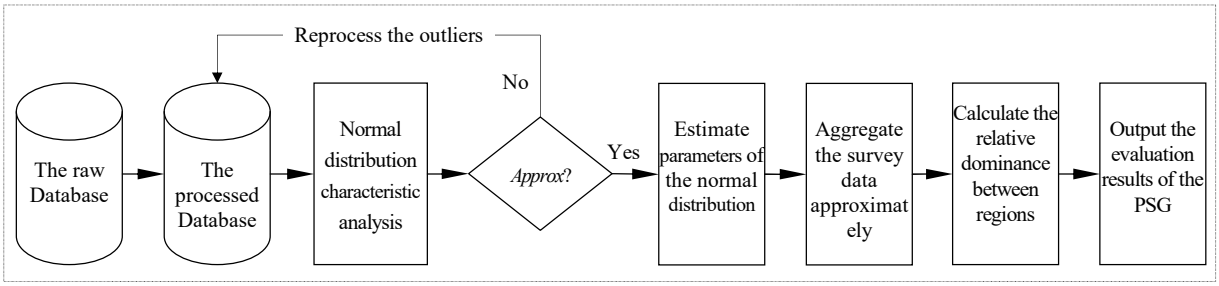


Fig.4. The framework of evaluation methods of the PSG on YB Conservation and Development

Then the dominance value for any two evaluation objects described by normal distribution $Z_i$ over $Z_{i'}$ can be written as

$$D_{Z_i \succ Z_{i'}} = D_{f_i(x) \succ f_{i'}(x)} = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\mu_i - \mu_{i'}}{\sqrt{\sigma_i^2 + \sigma_{i'}^2}}} e^{-t^2/2} dt = \int_{-\infty}^{\frac{\mu_i - \mu_{i'}}{\sqrt{\sigma_i^2 + \sigma_{i'}^2}}} \frac{1}{\sqrt{2\pi}} e^{-t^2/2} dt \quad (6)$$

In the same way, the dominance of $A_{i'}$ over $A_i$ $(i, i' = 1,2,3)$ can be written as

$$D_{Z_{i'} \succ Z_i} = D_{f_{i'}(x) \succ f_i(x)} = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\mu_{i'} - \mu_i}{\sqrt{\sigma_i^2 + \sigma_{i'}^2}}} e^{-t^2/2} dt = \int_{-\infty}^{\frac{\mu_{i'} - \mu_i}{\sqrt{\sigma_i^2 + \sigma_{i'}^2}}} \frac{1}{\sqrt{2\pi}} e^{-t^2/2} dt \quad (7)$$

The dominance values of $D_{Z_i \succ Z_{i'}}, D_{Z_{i'} \succ Z_i}$ can be obtained by querying the standard normal distribution table, and they can be written as $d_{ii'}, d_{i'i}$. Accordingly, the dominance matrix of the PSG among *m* evaluation objects on YB Conservation and Development can be established as

$$D = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1m} \\ d_{21} & d_{22} & \cdots & d_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ d_{mm} & d_{mm} & \cdots & d_{mm} \end{bmatrix},$$

where *m* can be set according to the changes of the number of evaluation objects.

The degree of the PSG on YB Conservation and Development to which $Z_i$ is superior and inferior to all other evaluation objects can be written as

$$\varphi_i^+ = \sum_{i'=1}^{m} d_{ii'}, \varphi_i^- = \sum_{i'=1}^{m} d_{i'i} \quad (8)$$

Therefore, the net dominance of $Z_i$ can be calculated

$$\varphi_i = \varphi_i^+ - \varphi_i^- = \sum_{i'=1}^{m} d_{ii'} - \sum_{i'=1}^{m} d_{i'i} \quad (9)$$

Finally, the net dominance of each evaluation object can be regard as its comprehensive evaluation result of the PSG, by which the further decision analysis and policy recommendations can be conducted.

## VI. Empirical analysis

In the raw database of CSS2019, the data of some indices are missed, overflowing the routine evaluation criteria (e g. "-8 Unclear", "98-Unclear"), and the evaluation criteria of some indices are inconsistent, for example, 1-10 scale, 1-5 scale, and 1-4 scale. In addition, the polarity definitions of some evaluation indices are also inconsistent, for example, the score "1" means "Upper-class" or "Very good" when indicating one's local socio-economic level or one's evaluation on ensuring food and drug safety by local government, but the score "1" means "very dissatisfied" when indicating one's overall satisfaction degree with his/her current life. Therefore, in order to use the unified evaluation methods for empirical analysis, this paper designs the following principles to preprocess the raw data of CSS2019.

a. Imputing missing data. If the missing data of an index accounts for less than 10% of the total survey, the missing data will be imputed according to the moderate (or median) value of its evaluation scale, for example 6 of 1-10 scale, 3 of 1-5 scale etc. If the missing data of an index accounts for more than 90% of the total survey, this index should be removed from Table Ⅱ. Otherwise, the raw data can be directly used instead of imputing missing data.

b. Removing overflow data. The amount of the data overflowing routine evaluation scale in CSS2019 is extremely small, thus the overflow data can be removed directly.

c. Evaluation scales consistency processing. This research will process the other evaluation scales according to the 10-point system (1-10 scale), and the processing methods and results are shown in Table Ⅲ.

Accordingly, the raw data of CSS2019 is preprocessed and their evaluation scales are unified to 10-point system. It should be noted that the index of "Other pollution (L4)" has been finally removed from the evaluation index system in this case, and the weight vector of the sub-index layer of Living environment (L) is finally determined as $W_l = (0.1651, 0.2701, 0.0774, 0.4875)$.

TABLE Ⅲ The consistent processed scales according to the 10-point system

| NO. | The original scales in CSS2019 | The consistent processed scales in this paper | Index in Table2 |
|---|---|---|---|
| 1 | 1-Upper-class; 2-Upper middle; 3-Middle; 4-Lower middle; 5-Underclass | 2-Underclass; 4-Lower middle; 6-Middle; 8-Upper middle; 10-Upper-class; | $E_1$, $E_2$, $I_4$ |
| 2 | 1-Income over spending; 2-Income and expenditure balance; 3-Income less than expenditure | 3-Income less than expenditure; 6-Income and expenditure balance; 9-Income over spending | $E_3$ |
| 3 | 1-More serious; 2-Serious; 3-Less serious; 4-Nothing serious | 1-More serious; 3-Serious; 6-Less serious; 9-Nothing serious | $L_1$, $L_2$, $L_3$, $L_4$ |
| 4 | 1-Very good (Strongly agree); 2-Good (Basically agreed); 3-Bad(Partially disagree); 4-Very bad (Strongly disagree) | 1-Very bad (Strongly disagree); 4- Bad(Partially disagree); 7-Good (Basically agreed); 10-Very good (Strongly agree) | $L_5$, $G_2$, $G_3$, $G_4$, $G_5$, $G_6$, $I_2$, $I_3$ |

Then, the statistical histogram of each evaluation index of study region $A_1$, $A_2$ and $A_3$ can be drawn with the pre-processed data, by which, it can be approximately judged that each group of data may follow the normal distribution. And then, the expectation $\hat{\mu}$ and standard deviation $\hat{\sigma}$ of the normal distribution can be estimated according to equation (1)-(2). Due to the limited space, this paper takes Economic situations (E) in $A_1$, $A_2$ and $A_3$ as examples to illustrate the above analysis process. Their estimated parameters of normal distribution of its sub-index $E_1$, $E_2$, $E_3$, $E_4$ and $E_5$ are listed in Table IV. Besides, the surveyed regions of China in CSS2019 are taken as study region $A_C$ for comparative analysis.

The weight vector of indice $E_1$-$E_5$ to economic situations (E) is $W_E = (0.0646, 0.0338, 0.1401, 0.2415, 0.5200)$, which can be found in Table Ⅱ. Together with equation (4)-(5) and Table IV, the approximately aggregated parameters of normal distribution about economic situations (E) can be calculated, as shown in Table V. Accordingly, the normal distribution density function $f_{iE}(x)(i = 1, 2, 3, C)$ about economic situations (E) can be obtained according to equation (5).

After that, the dominance values $D_{A_{iE} \succ A_{i'E}}, D_{A_{i'E} \succ A_{iE}}$ $(i = 1, 2, 3, C)$ can be obtained by querying the standard normal distribution table according to equation (6)-(7), thus the dominance matrix of the PSG about economic situations (E) among $A_1, A_2, A_3$ and $A_C$ can be established as

$$D_E = \begin{bmatrix} 0.500 & 0.414 & 0.329 & 0.459 \\ 0.586 & 0.500 & 0.412 & 0.536 \\ 0.671 & 0.588 & 0.500 & 0.614 \\ 0.541 & 0.464 & 0.386 & 0.500 \end{bmatrix}$$

Finally, the net dominance of the PSG about economic situations (E) among $A_1, A_2, A_3$ and $A_C$ can be calculated according to equation (8)-(9), thus their comprehensive evaluation results can be calculated as follows:

$\varphi_{1E} = -0.5956, \varphi_{2E} = 0.0062, \varphi_{3E} = 0.7475, \varphi_{CE} = -0.2181$.

Therefore, the PSG ranking results about economic situations (E) is $A_{3E} \succ A_{2E} \succ A_{CE} \succ A_{1E}$. That is, for the sense of gain on economic situations of individual and family, the PSG in Shandong is better than that in Henan, and both of them are above the overall level of China, however, the PSG of the middle and upper reaches of the Yellow River is at the bottom.

In the same way, the net dominances of the PSG about living environment (L), government public services (G), social civilizations (S), and individual self-fulfillments (I) among $A_1, A_2, A_3$ can be calculated according to equation (8)-(9), and their PSG ranking results are listed in Table VI. It can be seen from Table VI that the PSG in Shandong is the best one in all factor dimensions, the PSG in Henan takes the second place (except the factor dimension of individual self-fulfillments (I)), and both of them are above the overall level of China, however, the PSG of the middle and upper reaches of the Yellow River is at the bottom (except the factor dimension of individual self-fulfillments (I)). Accordingly, the total PSG can be determined as $A_{1T} \prec A_{CT} \prec A_{2T} \prec A_{3T}$, which are basically consistent with the actual economic and social situations of the Yellow River Basin.

In addition, the PSG about economic situations (E), living environment (L), government public services (G), social civilizations (S), and individual self-fulfillments (I) in each study region can be investigated with the same methods as above without consideration of their weights, and their ranking results are listed in Table VII.

Some interesting discussions can be drawn from Table VI and Table VII:

(1) The general public in the Yellow River Basin are generally satisfied with the government's public services, followed by the overall civilization of the society. General public satisfaction with government work should attribute the achievements to the Chinese government's unremitting efforts in the functional transition of the governments and the construction of mental civilization for a long time. It also shows that as long as the government serves the people wholeheartedly, it will be recognized and praised.

(2) The public in the middle and upper reaches of the Yellow River (A1) are generally the most dissatisfied with their individual and family economic situations, and the PSG about economic situations (E) of Henan and Shandong are also in the middle and lower levels. The possible reason is that the Yellow River Basin has a relatively concentrated poverty-stricken population in China, and it involves 5 of China's 14 contiguous poverty-stricken areas, which are mainly distributed in Henan and the upper and middle reaches of the Yellow River [51], thus the public are very eager to improve economic situations and live a good life. Fortunately,

TABLE IV The data characteristics and estimated parameters of normal distribution

| | $A_1$ | | | | | $A_2$ | | | | | $A_3$ | | | | | $A_C$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ | $E_2$ | $E_3$ | $E_4$ | $E_5$ | $E_1$ | $E_2$ | $E_3$ | $E_4$ | $E_5$ | $E_1$ | $E_2$ | $E_3$ | $E_4$ | $E_5$ | $E_1$ | $E_2$ | $E_3$ | $E_4$ | $E_5$ |
| MIN | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 3 | 1 | 1 |
| MODE | 6 | 6 | 6 | 5 | 8 | 6 | 6 | 6 | 5 | 8 | 6 | 6 | 6 | 5 | 8 | 6 | 6 | 3 | 5 | 8 |
| MAX | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 9 | 10 | 10 |
| $\hat{\mu}$ | 4.58 | 4.50 | 5.29 | 5.25 | 6.97 | 4.86 | 4.44 | 5.59 | 5.93 | 7.29 | 5.09 | 4.68 | 5.78 | 6.49 | 7.66 | 4.68 | 4.40 | 5.48 | 5.72 | 7.09 |
| $\hat{\sigma}^2$ | $1.83^2$ | $1.92^2$ | $2.09^2$ | $2.48^2$ | $2.14^2$ | $1.91^2$ | $1.90^2$ | $2.24^2$ | $2.49^2$ | $2.00^2$ | $1.80^2$ | $1.95^2$ | $2.23^2$ | $2.36^2$ | $1.81^2$ | $1.85^2$ | $1.99^2$ | $2.30^2$ | $2.46^2$ | $2.23^2$ |

TABLE V The approximately aggregated parameters of normal distribution

| $A_1$ | | $A_2$ | | $A_3$ | | $A_C$ | |
|---|---|---|---|---|---|---|---|
| $\hat{\mu}_{1E}$ | $\hat{\sigma}^2_{1E}$ | $\hat{\mu}_{2E}$ | $\hat{\sigma}^2_{2E}$ | $\hat{\mu}_{3E}$ | $\hat{\sigma}^2_{3E}$ | $\hat{\mu}_{CE}$ | $\hat{\sigma}^2_{CE}$ |
| 6.08 | $1.304^2$ | 6.47 | $1.249^2$ | 6.85 | $1.152^2$ | 6.29 | $1.545^2$ |

TABLE VI The results ranking of the PSG on YB Conservation and Development

| Factor dimensions | Weight | The study regons of the Yellow River basin | | | | | | China | | Results ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $A_1$ | | $A_2$ | | $A_3$ | | $A_C$ | | |
| Economic situations (E) | 0.4534 | $\hat{\mu}_{1E}$ | $\hat{\sigma}^2_{1E}$ | $\hat{\mu}_{2E}$ | $\hat{\sigma}^2_{2E}$ | $\hat{\mu}_{3E}$ | $\hat{\sigma}^2_{3E}$ | $\hat{\mu}_{CE}$ | $\hat{\sigma}^2_{CE}$ | $A_{1E} \prec A_{CE} \prec A_{2E} \prec A_{3E}$ |
| | | 6.08 | $1.304^2$ | 6.47 | $1.249^2$ | 6.85 | $1.152^2$ | 6.29 | $1.545^2$ | |
| Living environment (L) | 0.2059 | $\hat{\mu}_{1L}$ | $\hat{\sigma}^2_{1L}$ | $\hat{\mu}_{2L}$ | $\hat{\sigma}^2_{2L}$ | $\hat{\mu}_{3L}$ | $\hat{\sigma}^2_{3L}$ | $\hat{\mu}_{CL}$ | $\hat{\sigma}^2_{CL}$ | $A_{1L} \prec A_{CL} \prec A_{2L} \prec A_{3L}$ |
| | | 6.25 | $1.567^2$ | 6.56 | $1.399^2$ | 6.74 | $1.404^2$ | 6.36 | $1.452^2$ | |
| Government public services (G) | 0.1025 | $\hat{\mu}_{1G}$ | $\hat{\sigma}^2_{1G}$ | $\hat{\mu}_{2G}$ | $\hat{\sigma}^2_{2G}$ | $\hat{\mu}_{3G}$ | $\hat{\sigma}^2_{3G}$ | $\hat{\mu}_{CG}$ | $\hat{\sigma}^2_{CG}$ | $A_{1G} \prec A_{CG} \prec A_{2G} \prec A_{3G}$ |
| | | 6.93 | $1.207^2$ | 7.17 | $1.158^2$ | 7.71 | $1.036^2$ | 7.08 | $1.126^2$ | |
| Social civilizations (S) | 0.0433 | $\hat{\mu}_{1S}$ | $\hat{\sigma}^2_{1S}$ | $\hat{\mu}_{2S}$ | $\hat{\sigma}^2_{2S}$ | $\hat{\mu}_{3S}$ | $\hat{\sigma}^2_{3S}$ | $\hat{\mu}_{CS}$ | $\hat{\sigma}^2_{CS}$ | $A_{1S} \prec A_{CS} \prec A_{2S} \prec A_{3S}$ |
| | | 6.67 | $1.457^2$ | 7.02 | $0.857^2$ | 7.46 | $1.333^2$ | 6.88 | $1.160^2$ | |
| Individual self-fulfillments (I) | 0.1949 | $\hat{\mu}_{1I}$ | $\hat{\sigma}^2_{1I}$ | $\hat{\mu}_{2I}$ | $\hat{\sigma}^2_{2I}$ | $\hat{\mu}_{3I}$ | $\hat{\sigma}^2_{3I}$ | $\hat{\mu}_{CI}$ | $\hat{\sigma}^2_{CI}$ | $A_{CI} \prec A_{2I} \prec A_{1I} \prec A_{3I}$ |
| | | 6.42 | $2.081^2$ | 6.34 | $2.181^2$ | 6.62 | $2.184^2$ | 6.29 | $1.364^2$ | |
| The total PSG on YRB Conservation and Development (T) | | $\hat{\mu}_{1T}$ | $\hat{\sigma}^2_{1T}$ | $\hat{\mu}_{2T}$ | $\hat{\sigma}^2_{2T}$ | $\hat{\mu}_{3T}$ | $\hat{\sigma}^2_{3T}$ | $\hat{\mu}_{C}$ | $\hat{\sigma}^2_{C}$ | $A_{1T} \prec A_{C} \prec A_{2T} \prec A_{3T}$ |
| | | 6.29 | $1.738^2$ | 6.56 | $1.753^2$ | 6.90 | $1.887^2$ | 6.41 | $0.816^2$ | |

TABLE VII The results ranking of the PSG in each study region of the Yellow River Basin

| Study region | Factor dimensions | | | | | | | | | | Results ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Economic situations (E) | | Living environment (L) | | Government public services (G) | | Social civilizations (S) | | Individual self-fulfillments (I) | | |
| $A_1$ | $\hat{\mu}_{1E}$ | $\hat{\sigma}^2_{1E}$ | $\hat{\mu}_{1L}$ | $\hat{\sigma}^2_{1L}$ | $\hat{\mu}_{1G}$ | $\hat{\sigma}^2_{1G}$ | $\hat{\mu}_{1S}$ | $\hat{\sigma}^2_{1S}$ | $\hat{\mu}_{1I}$ | $\hat{\sigma}^2_{1I}$ | $A_{1E} \prec A_{1L} \prec A_{1I} \prec A_{1S} \prec A_{1G}$ |
| | 6.08 | $1.304^2$ | 6.25 | $1.567^2$ | 6.93 | $1.207^2$ | 6.67 | $1.457^2$ | 6.42 | $2.081^2$ | |
| $A_2$ | $\hat{\mu}_{2E}$ | $\hat{\sigma}^2_{2E}$ | $\hat{\mu}_{2L}$ | $\hat{\sigma}^2_{2L}$ | $\hat{\mu}_{2G}$ | $\hat{\sigma}^2_{2G}$ | $\hat{\mu}_{2S}$ | $\hat{\sigma}^2_{2S}$ | $\hat{\mu}_{2I}$ | $\hat{\sigma}^2_{2I}$ | $A_{2I} \prec A_{2E} \prec A_{2L} \prec A_{2S} \prec A_{2G}$ |
| | 6.47 | $1.249^2$ | 6.56 | $1.399^2$ | 7.17 | $1.158^2$ | 7.02 | $0.857^2$ | 6.34 | $2.181^2$ | |
| $A_3$ | $\hat{\mu}_{3E}$ | $\hat{\sigma}^2_{3E}$ | $\hat{\mu}_{3L}$ | $\hat{\sigma}^2_{3L}$ | $\hat{\mu}_{3G}$ | $\hat{\sigma}^2_{3G}$ | $\hat{\mu}_{3S}$ | $\hat{\sigma}^2_{3S}$ | $\hat{\mu}_{3I}$ | $\hat{\sigma}^2_{3I}$ | $A_{3I} \prec A_{3L} \prec A_{3E} \prec A_{3S} \prec A_{3G}$ |
| | 6.85 | $1.152^2$ | 6.74 | $1.404^2$ | 7.71 | $1.036^2$ | 7.46 | $1.333^2$ | 6.62 | $2.184^2$ | |

the poverty alleviation is one of the important contents of this Chinese major strategy, and the PSG about economic situations will certainly be improved in the future.

(3) The PSG about living environment (L) of the three study regions in the Yellow River Basin are all in the middle and lower levels of their respective lists. Since ancient times, the Yellow River has been both a "mother" river and a "devil" river, and the Chinese government have tried to harness and improve the Yellow River and gained lots of achievements, however, there are still many ecological and environmental problems affecting people's quality of life [9], and these issues have also been concerned in this Chinese major strategy.

(4) The PSG about individual self-fulfillments (I) in Henan and Shandong are both at the bottom of their respective lists, while it is at the middle level of their list of the public in the middle and upper reaches of the Yellow River. The result suggests that the public are generally dissatisfied with their individual self-efficiency, development opportunities and development capabilities, especially the people in Henan and Shandong, thus it should arouse more attentions of the local governments.

On the whole, the evaluation results of the PSG on Yellow River Basin Conservation and Development in this paper are basically in line with the actual situations, and the results can also provide decision references for their further work of the local governments in the Yellow River Basin. It is suggested that the local governments should conduct a deeper social investigations on the PSG in a smaller area directed against their shortages, so as to obtain more detailed decision supports and to formulate corresponding improvement countermeasures.

## VII. Conclusions

(1)The PSG was proposed as the most suitable macro-criterion in this paper to measure the achievements of YB conservation and development, and the PSG on YB conservation and development has been specifically defined as the further subjective psychological welfare increment of the general public generated after their effectively obtaining material, health or psychological welfare effectively from the implementation process of this Chinese strategy. Accordingly, the logical principles and transmission mechanisms of the PSG and YB conservation and development has been constructed, and it was suggested that a good evaluation system of the PSG can provide better regulations and guidances for the sound development of the Yellow River Basin. Furthermore, it was suggested that a large-scale social survey should be carried out regularly and continuously to investigate the general feelings of a wider public in the Yellow River Basin, including the local ordinary residents,

policymakers, media workers, businessmen, scholars and researchers, and NGOs/NFOs/CBOs and so on.

(2) Based on the data of CSS2019, which were released by CASS at the end of 2020, this paper attempted to exam the PSG at the beginning of Chinese major strategy on YB conservation and development. An evaluation index system including 5 factor dimensions and 25 indices has been constructed, and the consistent processed methods of the raw data in CSS2019 have been developed. After that, the normal distribution of continuous distribution instead of discrete distribution has been used to describe the survey data, and the linear property of normal distribution and dominance matrix method are applied to make decision based on PROMETHEE Ⅱ. The human cognitions usually have both the essences of fuzziness and randomness, and fuzzy membership function of normal distribution is the most suitable one to describe human fuzzy cognition, thus the evaluation results with uncertain decision-making methods in this paper are more scientific and reasonable than that with rigorous statistical methods.

(3) The empirical results indicated that the PSG on the general economic and social development situations of the Yellow River Basin at the beginning of this Chinese strategy is basically equal to that of the overall level of the entire China, specifically, the PSG of Shandong and Henan are both above the overall level of China and the PSG of the middle and upper reaches of the Yellow River is lower than the national average. Therefore, governments at all levels in the middle and upper reach of the Yellow River are suggested to make more efforts to change their disadvantages in the next few years. Besides, Henan and Shandong are both suggested to develop a more active employment policy to improve the environment for entrepreneurship and employment, so as to promote the public to realize their individual value-pursuing, meanwhile, they should also continue to make greater efforts in improving people's livelihood and harnessing the ecological environment under the guidance of the national strategy of YB conservation and development.

(4) The further researches will be conducted in the following directions. The first is to continue to explore the driving mechanisms and spatio-temporal evolution models of the PSG on YB conservation and development, based on the panel data of social surveys in the past and years to come; the second is to conduct micro-region social survey investigations on the basis of macro social survey and its comprehensive evaluation results, so as to provide more accurate decision suggestions for local governments; The third is to introduce and develop more scientific and reasonable evaluation methods from the perspective of multidisciplinary integration, uncertainty theory, Big Data analysis techniques, online public sentiment analysis methods and behavioural economics theory are all on the list of further attempts.

## REFERENCES


[1] Y. Xu and C.S. Wang, 'Ecological protection and high-quality development in the Yellow River Basin: framework, path, and countermeasure', *Bulletin of Chinese Academy of Sciences*, vol. 35, no.7, pp.875-883, 2020.

[2] H.C Zhou, 'Yellow River safety needs ecological protection and high-quality development', *China Development Observation*, vol. 16, no.Z8, pp.12-14, 2020.

[3] Y.H. Wang, E.H. Mao and M.S. Xu, 'An historical analysis on the strategy changes of the Yellow River governance', *Environmental Protection*, Vol. 48, no.Z1, pp.28-32, 2020.

[4] D. Luo, W.X. Mao and H.F. Sun, 'Risk assessment and analysis of ice disaster in Ning-Meng reach of Yellow River based on a two-phased intelligent model under grey information environment', *Natural Hazards*, vol.88, no.1, pp.591-610, 2017.

[5] S.Z. Qi and H.L Liu, 'Natural and anthropogenic hazards in the Yellow River Delta, China', *Natural Hazards*, vol.85, no.3, pp.1907-1911, 2017.

[6] P.F. Wu, D.X. Liu, J.H. Ma et al. 'Reconstructing the man-made Yellow River flood of Kaifeng City in 1642 AD using documentary sources', *International Journal of Disaster Risk Reduction*, vol.41, no.1, p.101289, 2019.

[7] A. Omer, Z.G. Ma, Z.Y. Zheng et al., 'Natural and anthropogenic influences on the recent droughts in Yellow River Basin, China', *Science of the Total Environment*, vol.704, no.1, p.135428, 2020.

[8] P. Shao, Q. Wang and Y.J. Shan, ' Research on ecological protection and high quality development of Yellow River basin based on text analysis', *Journal of Arid Land Resources and Environment*, vol.34, no.11, pp.78-83, 2020.

[9] A. Omer, N.A. Elagib, Z.G. Ma et al., 'Water scarcity in the Yellow River Basin under future climate change and human activities', *Science of the Total Environment*, vol.749, no.1, p.141446, 2020.

[10] F.J. Jin, L. Ma and D. Xu, 'Environmental stress and optimized path of industrial development in the Yellow River Basin', *Resources Science*, vol.42, no. 1, pp.127-136, 2020.

[11] K. Liu, Y.R. Qiao, T. Shi et al., 'Study on coupling coordination and spatiotemporal heterogeneity between economic development and ecological environment of cities along the Yellow River Basin', *Environmental Science and Pollution Research*, vol.28, no.6, pp.6898-6912, 2021.

[12] D.H. Yan, H. Wang, M. Zhou et al., 'scientific ideas and development prospects of global water management modes', *Water Resources Protection*, vol.36, no.3, pp.1-7, 2020.

[13] J.P. Xi, 'Speech at the symposium on ecological conservation and high-quality development of the Yellow River Basin', *Struggle*, vol.62, no.20, pp.4-10, 2019.

[14] Q.T. Zuo, X.X. Fei and D.L Li, 'Special planning ideas and content framework of water conservancy for ecological conservation and high-quality development of the Yellow River Basin', *Yellow River*, vol.42, no.9, pp.21-25, 2020.

[15] Y.G. Niu and J.P Zhang, 'Thoughts on the national strategy of ecological protection and high quality development in the Yellow River Basin', *Yellow River*, vol.42, no.11, pp.1-10, 2020.

[16] K.Z. Yang and Y.N. Dong, 'Research on restricting factors and countermeasures of ecological protection and high-quality development of Yellow River basin—Analysis based on the multi-dimensional framework of "element-space-time"', *Journal of Hydraulic Engineering*, vol.51, no. 9, pp.1038-1047, 2020.

[17] L.K. Liu, L.T. Liang, P. Gao et al., 'Coupling relationship and interactive response between ecological protection and high-quality development in the Yellow River Basin', *Journal of Natural Resources*, vol.36, no.1, pp.176-195, 2021.

[18] Q.T. Zuo, Z.Z. Zhang, D.L. Li et al., 'Regional division and research framework for high-quality development path optimization in the Henan section of the Yellow river', *South-to-North Water Transfers and Water Science and Technology*, vol.19, no.2, pp.209-216, 2021.

[19] F. Wang and C.H. Miao, 'Systematisms, integrity and coordination: thinking and strategy of high quality development in the Yellow River Basin', *Journal of Natural Resources*, vol.36, no.1, pp.270-272, 2021.

[20] P.Q. Wang and C.Y. Ji, 'Relative acquisition in Transitional society: measurement, change and comparison', *Chinese Public Administration*, vol.34, no.1, pp.6-12, 2018.

[21] Y.S Cheng, Y. Zhang G.Y. He, 'Sense of fulfilment of the Chinese public: indicator construction, temporal and spatial changes, and macro mechanisms', *Journal of China Executive Leadership Academy Pudong*, vol.14, no.2, pp.110-123, 2020.

[22] H.P. Huang, X.D. Sun, Z.H. Bing et al., 'The evaluation and influence mechanism of the development of rural tourism in ancient towns', *Economic Geography*, vol.49, no.9, pp.233-240, 2020.

[23] Z.F. Zhang and X. Liu, 'Participation in basic medical insurance and people's "sense of acquisition" based on the data analysis of China's general social survey', *Shandong Social Science*, vol.34, no.12, pp.147-152, 2020.

[24] H. Wen and Z.P. Liu, 'Timing comparison of the sense of gain to China: trends and disparities empirical analysis based on Chinese urban and

rural social governance dada', *Journal of Social Sciences*, vol.40, no.3, pp.3-20, 2018.
[25] X.T. Wang, C.P. Kang and X.D. Wang, 'Research on the factors of poverty subjects' acquired sense under the background of E-commerce poverty alleviation', *Issues in Agricultural Economy*, vol.41, no.3, pp.112-124, 2020.
[26] A.B. Huang, 'The influential factors and boosting approaches of ecological sense of gain', *Theoretical Investigation*, Vol.36, no.2, pp.25-32, 2019.
[27] Y.L. Wang, C.Yang, X.Y. Hu et al., 'The mediating effect of community identity between socioeconomic status and sense of gain in Chinese adults', *International Journal of Environmental Research and Public Health*, vol.17, no.5, p.1553, 2020.
[28] Q.T. Zuo, M.H. Hao, Z.Z. Zhang et al., 'Assessment of the happy river index as an integrated index of river health and human well-being: a case study of the Yellow River, China', *Water*, vol.12, no.11, p.3064, 2020.
[29] W.W. Zhang, 'On the generation of the people's sense of gain: logical regulation, realistic dilemma and solution—learning Xi Jinping's important arguments on the people's sense of gain', Socialism Studies, vol.41, no.6, pp.8-15, 2018.
[30] H.J. Dong, X.Y. Tan, X.J. Dou et al., 'The structure of Chinese sense of gain', *Psychological Exploration*, vol.39, no.5, pp.468-473, 2019.
[31] X.Y. Tan, H.J. Dong, Y. Zhang et al., 'Connotation and structure of the sense of gain and its influence on life satisfaction', *Sociological Studies*, vol.35, no.5, pp.195-217, 2020.
[32] J.L. Yang and S.H. Zhang, 'Analysis of the general social survey data on the Chinese people's sense of fulfilment', *Studies on Marxism*, vol.37, no.3, pp.102-112+160, 2019.
[33] Cao, X.Q., 'The connotation of "Gain" and the foreign experiences', *Frontiers*, vol.6, no.2, pp.18-28, 2017.
[34] E, J.P., 'To write a new chapter of river protection and governance in the new era', *Water Resources Development Research*, vol.20, no.1, pp.1-2, 2020.
[35] H. Xu, N. Shi, L.L. Wu et al., 'High-quality development level and its spatiotemporal changes in the Yellow River Basin', *Resources Science*, vol.42, no.1, pp.115-126, 2020.
[36] C.M. Liu and Q.S. Ma, 'Spatial correlation network and driving factors of high-quality development in the Yellow River Basin', *Economic Geography*, vol.40, no.10, pp.91-99, 2020.
[37] B.S. Wu, Z.Y. Wang and C.Z. Li, 'Yellow River Basin management and current issues', *Journal of Geographical Sciences*, vol.14, no.1, pp.29-37, 2004.
[38] A.J. Guo, Y.N. Zhang, F.L. Zhong et al., 'Spatiotemporal patterns of ecosystem service value changes and their coordination with economic development: a case study of the Yellow River Basin, China', *International Journal of Environmental Research and Public Health*, vol.17, no.5, p.8474, 2020.
[39] R.R. Ren, W.W. Li, M. Zhao et al., 'A large group decision making method based on public evaluation', *Management Review*, vol.30, no.10, pp.238-247, 2018.
[40] D.Y. Li and C.Y. Liu, 'Study on the universality of the normal cloud model', *Engineering Science*, vol.6, no.8, pp.28-34, 2004.
[41] J.Q. Wang, P. Lu, H.Y. Zhang et al., 'Method of multi-criteria group decision-making based on cloud aggregation operators with linguistic information', *Information Sciences*, vol.274, no.1, pp.177-191, 2014.
[42] Z.Y. Yang, L.Y. Zhang and C.L. Liang, 'A method for group decision making with multiplicative consistent interval-valued intuitionistic Fuzzy preference relation', *IAENG International Journal of Applied Mathematics*, vol.51, no.1, pp.152-163, 2021.
[43] X. Deng, Y.X. Lin and H.D. Zhuang, 'Uncertain portfolio with Fuzzy investment proportion based on Possibilistic Theory', *Engineering Letters*, Vol.29, no.2, pp.803-812, 2021.
[44] H.T. Li, D. Luo and J.F. Wang, 'A stochastic EMD method of aggregating LGDM experts' information', *Statistics and Decision*, vol.34, no.19, pp.46-50, 2018.
[45] W.H. Ye, J.J. Geng, X.X. Geng et al., 'A new method for multi-Attribute decision-Making based on single-valued neutrosophic sets', *Engineering Letters*, Vol.28, no.4, pp.1302-1309, 2020.
[46] Y. Liu, Z.P. Fan and Y. Zhang, 'A method for stochastic criteria decision making based on dominance degree', *Information Science*, vol.181, no.19, pp.4139-4153, 2011.
[47] S. Corrente, S. Greco and R. Stowinski, 'Multiple criteria hierarchy process with ELECTRE and PROMETHEE', *Omega*, vol.41, no.5, pp.820-846, 2013.
[48] H. Kuang, D.M. Kilgour and K.W. Hipel, 'Grey-based PROMETHEE II with application to evaluation of source water protection strategies', *Information Sciences*, vol.294, no.1, pp.376-389, 2015.
[49] M. Kadziński and K. Ciomek, 'Integrated framework for preference modelling and robustness analysis for outranking-based multiple criteria sorting with ELECTRE and PROMETHEE', *Information Sciences*, vol.352. no.5, pp.167-187, 2016.
[50] F.J. Quesada, I. Palomares and L. Martínez, 'Managing experts' behaviour in large-scale consensus reaching processes with uninorm aggregation operators', *Applied Soft Computing*, vol.35, no.8, pp.873-887, 2015.
[51] J.J. Qiao, Q.K. Zhu and X.Y. Xin, 'Spatial characteristics and influencing factors of rural poverty in the Yellow River Basin', *Resources Science*, vol.42, no.1, pp.184-196, 2020.