Risk Identification and Assessment of PPP Forestry Projects in China Using a Fuzzy Synthetic Evaluation Approach

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Abstract. At present, the Chinese government is vigorously promoting the use of PPP mode to attract social capital and financial capital into the field of forestry, including ecological construction, protection and utilization, which is of great significance for promoting the construction of ecological civilization and the development of both the economy and the society. Because the financing, organization, implementation and environmental factors of PPP forestry projects are relatively complicated, there are certain risks for both the government and social capital. In order to evaluate the risks of China's forestry projects for the government and social capital, 43 risk factors were identified and divided into 4 groups based on Delphi method and questionnaire survey. 23 key risk factors were selected according to the standardized values. Then, the probability of occurrence (PO), impact size (IS) and overall risk level (ORL) of each key factor were determined by fuzzy synthetic evaluation(FSE) method, and each KRF, KRG and overall risk level (ORL) were calculated. Based on the results, "Government Decision Risk" in KRF was the most critical risk factor, and KRG "Financial Risk" was the most critical risk factor group. Overall, fuzzy comprehensive results showed that the ORL of China's forestry PPP project is relatively high. According to the analysis results, countermeasures were put forward. The research results could provide reference for all participants in PPP forestry projects to make decisions, and formulate a comprehensive risk management plan to use limited resources. In addition, this study could expand professional knowledge and enrich relevant results

Keywords: Risk Identification; Risk Assessment; PPP; Fuzzy Synthetic Evaluation Approach.

1. Introduction

Offered by the National Forestry and Grassland Administration (2019), the newly released data of the ninth national forest inventory, China Forest Resources Report (2014-2018), showed that the latest forest coverage rate in China had reached 22.96%, which was 1.33 percentage points higher than the previous forest inventory, while the net increase in forest area exceeded the total area of Fujian Province. However, the total amount of forest resources was relatively insufficient, the quality was not high, and the distribution was uneven. The fragile function of forest ecosystem had not been fundamentally changed. The shortage of ecological products would still be a prominent problem restricting China's sustainable development. This forced us to step up resources protection and ecological restoration. The task of China's forestry development in the future would be arduous, and PPP cooperation in forestry would have great potential.

Forestry is a resource-based industry according to the high demand for large amount of investment funds, the usual long investment cycle and the slow turnover (Lin, 2018). From the perspective of risk, investment in forestry funds is vulnerable to multiple classes of factors such as natural risks, economic risks and policy risks (Li, 2017). In addition, forestry projects lead to significant external economy, and the products are difficult to quantify due to the lack of universally applicable evaluation indicatorsand the undefined product attributes. Consequently, it is unachievable to accurately predict the investment income of forestry projects, and the establishment of risk assessment model become a very challenging task. However, early research on public-private partnership showed that

objective, reliable and practical risk assessment models for public-private partnership projects were crucial to the successful implementation of public-private partnership projects (Xu et al., 2010).

In 2016, the National Development and Reform Commission, in conjunction with the State Forestry Administration, issued the Guiding Opinions on Promoting Forestry Construction with the Cooperation Model of Government and Social Capital, which proposed to implement PPP model in five key areas of forestry, namely, major ecological projects, national reserve forest construction, forest infrastructure construction, forest protection facilities construction, wildlife protection and utilization. According to the public information released by the Ministry of Finance, the government and the Social Capital Cooperation Center (2019), as of the first half of 2019, the project management bank had 42 forestry projects with a total investment of 72.796 billion, of which only 17 projects had started to be implemented and most of the rest were still in the procurement phase or preparation phase (see Appendix A for details). Many uncertain risk factors such as large scale, large investment and long payback period of a PPP project could affect its smooth implementation (Wu et al., 2017). Forestry projects would also be restricted by objective laws such as natural growth. Therefore, in addition to all kinds of common risks faced by other PPP projects, they might be affected by natural risks such as deteriorating natural environment and extreme climate conditions. Overall, the project income would be unpredictable (Zhang and Yu, 2017). In addition to the complex potential risk factors, inadequate or inappropriate risk management might lead to wrong decision-making, difficult financing, inability to finish the work on time, reduction of operation efficiency and other problems (Wu et al.,2017). Therefore, risks should be identified in early stage since the start of the project to enable effective risk planning and management (Ameyaw et al., 2017). However, for different parties involved in forestry PPP projects, the recognition and evaluation of risks would differ respectively, and correspondingly the priorities and applicabilities in management would also differ, which might become the source of disputes. Especially as a major stakeholder, the government department should be competent to identify and manage PPP risks, otherwise, it would lead to unnecessarily excessive project cost and financial burden (Shrestha et al., 2017b).

According to literature review, the previous literature on risk assessment of forestry projects based on PPP model and the research on this issue could not sastisfy the current need, resulting in the demand for the research in this paper. The purpose of this paper included: (1) to identify and evaluate the risk factors of PPP forestry projects in China; (2) using fuzzy evaluation method to evaluate the overall risk level of PPP forestry projects in China. Although many studies discussed the risks in PPP projects, the risk assessment for forestry projects under PPP mode should be specialized according to the characteristics of forestry projects, and more in-depth investigation would contribute to the standarization, so this study would enrich the research knowledge in this field, and more importantly, facilitate the success of future PPP forestry projects, such as: provide reference for policy makers and project decision makers to avoid mistakes and allow them to optimize the usage of the limited resources; help social capital avoid projects with excessive risks and promote the government to take measures to reduce project risks and henceforth to attract more high-quality social capital; provide risk judgment in advance and correspondingly choose control measures for forestry PPP projects to ensure the expected benefits and smooth implementation of the project. This is also the innovation of this article.

2. Literature reviews.

2.1 Risk management under PPP project

Jin and Zhang (2011) believed that PPP models could be divided into different forms, depending on different risk allocation and risk avoidance in PPP projects, which could be realized by combining expert opinions. This judgement was supported by empirical evidence while PPP mode had been widely applied in infrastructure construction and basic public service provision worldwide, including the projects as below:

i) water conservancy infrastructure. Choi et al. (2010) conducted an analysis of the relationship between foreign companies' decision to participate in China's PPP water conservancy projects and PPP project risks and market access barriers. Ameyaw and Chan (2018) used a set of established risk allocation criteria (RAC) and fuzzy set method to study the allocation of five key risk factors related to public-private partnerships in water infrastructure projects.

ii) transportation. Yi et al. (2016) introduced Hall's three-dimensional structure to analyze the factors of reasonable risk sharing in PPP rail transit projects. By constructing the specific three-dimensional coordinates, management research integrated with effective risk-sharing was conducted simultaneously along the three axes. Xu et al.(2010) and Kumar et al.(2018) identifed key risks and discussed mitigation strategies for PPP expressway projects by applying FSE method and Monte Carlo simulation net present value (NPV) risk model respectively.

iii) Garbage disposal. He Jian (2016) discussed the risk identification, risk assessment, risk sharing and risk control of PPP financing risk management in the construction waste industry. Wu et al.(2018) constructed a risk assessment framework for PPP waste incineration specific for the context of China.

iv) Comprehensive project management. Jin & Zhang (2011) simulated the risk allocation decision-making process of PPP projects by establishing, training, verifying and testing an artificial neural network (ANN) model. Zhang Hongping & Ye Su Dong (2016) focused on the identification of risk factors in the whole life cycle of PPP projects and the transmission path between risk factors, and adopted the principle and method of structural equation model to identify the key risk factors leading to early termination of PPP projects. On the basis of process analysis, Li Qian & Li Xingli (2017) summarized the key work for each stage of PPP project, and identified 36 key success factors such as macroeconomic policy, favorable legal framework and policy support for the key work. Keers & Fenema (2018) concluded through case studies and industry surveys of PPP projects that the organization had to deal with several "intolerable risks" related to project governance and project management responsibilities: inadequate representation of qualified employees, lack of shared performance system, responsibility allocation and decision-making power, unrealistic or inappropriate cooperation agreements and timing of cooperation initiatives. On the basis of the "risk matrix method" proposed by the US Air Force Electronic Systems Center (ESC) in 1995 to assess the potential risks of projects, Li Li (2018) used Borda ordinal method to quantitatively rank the financing risk factors of BOT-TOT-PPP projects, and obtained the key risk sets of such projects at this stage. Yuan et al. (2018) proposed KRI conceptual model to study the residual value risk (RVR) of PPP projects.

v) Other items. Shrestha et al. (2017, 2018) respectively used case analysis and statistical analysis to study the risk identification and allocation of PPP sewage treatment projects. Wu et al. (2017) used fuzzy comprehensive evaluation method to evaluate and rank the risk factors of PPP straw power generation projects in China. The results showed that "government intervention" was the most critical risk factor. Scholar Li Yulong (2017) selected Hanzhong forestry PPP project as the main research object, applied AHP fuzzy analytic hierarchy process method to construct a decision model of risk sharing mechanism, and preliminarily established the risk system index of forestry PPP project.

Based on the systemic review on the existing research results, the current situation could be definitely conclueded as: (1) Among previous studies, there were abundant researches on risk evaluation and management of PPP projects such as transportation, water conservancy, project management, garbage disposal, power generation, etc., while the researches on risk management of forestry PPP projects were relatively rare; (2) Many studies discussed the risk assessment and risk management of PPP projects. However, most of these studies only assessed one aspect of the overall impacts of risk factors and predicted the possibilities of occurrence in the context, or only assessed risks individually and ranked them without considering the interaction and cross-effects of various risk factors, which might have significant influence on the possibility of occurrence for each risk factor and the overall risk of the project. (3) Most of the studies produced results as the scoring of statistical significance, but failed to suggest or explain the countermeasures against the risks

according to the statisitical scoring; (4) Forestry PPP project had distinctive characteristics, so it would be necessary to establish a specialized index system for subsequent risk assessment.

2.2 Fuzzy synthetic evaluation approach

Fuzzy Comprehensive Evaluation (FSE) is a multi-attribute risk assessment framework and can be used as a risk assessment tool for private investors, decision makers and policy makers (Ameyaw et al., 2015). In the PPP project risk assessment system, most of the influential factors were qualitative indicators with no measurement data, so there would be some ambiguity (Song and Zhang, 2013). Jin and Zhang (2011) conducted an industry-wide questionnaire survey to test the risk allocation practices in PPP projects and collect data for establishing ANN models. Ameyaw et al. (2017) determined the risk and relative risk degree of NSDP project also by questionnaire survey method. Shrestha et al. (2017b) collected data through expert questionnaires and interviews, and used quantitative and qualitative analysis methods for analysis. Zhang et al.(2016) researched through sorting out and summarizing articles on PPP published in Chinese and international journals, and it was found that the coupon survey method was one of the commonly used research methods for the domestic and global researchers in this area. For various types of uncertainty problems due to multi-criteria, many examples suggested that FSE method could be very practical. (See Table 1 for details)

According to the above research studies, the conclusion supported that FSE method was applicable to deal with multi-criteria and multi-objective problems, especially risk assessment (Wu et al., 2017). This method made up for the deficiency of the traditional method which mainly relied on quantitative indicators, and its accuracy was improved compared to that of the traditional method. In addition, this method could adjust the index system and weighting functions to adapt to different industries, therefore it had certain expansibility (Fan et al., 2016). The risk assessment of China's forestry projects based on PPP involved a fuzzy problem with multi-level uncertainty, because the research time on PPP forestry projects was generally too short to cover the duration of the projects, and the universally applicable evaluation critirion system had not been established. If relying on experts' subjective judgment to sort out the uncertainty based on professional experience and knowledge, it shoud be feasible to establish a risk assessment model by FSE method to solve this problem.

3. Literature reviews

3.1 Questionnaire survey

Risk identification is the first task of the whole risk management (He, 2016). There are many methods available to identify project risks. This paper used Delphi method to obtain a list of risk factors. This method aimed at minimizing the influence of dominant individual, group pressures and irrelevant communication, as well as reducing (statistical) interferrence (Strand et al., 2017).

First of all, an in-depth analysis for the previous research on risk management of PPP model forestry projects was conducted to identify possible risk factors, i.e. to clarify various risk parameters that might affect the project results (He, 2016). Secondly, while PPP mode had become an infrastructure project construction mode attached with increasinly importance to the governments and social capital around the world. Some international experts and specialized agencies summarized large amount of experiences and lessons learned from existing business activities (Wu et al., 2017), and generated a preliminary list of risk factors on the basis of consulting relevant literature and professional research results. Next, a preliminary list of risk factors obtained in the previous step was submitted to 5 experts with extensive research and practical experiences in PPP projects. According to their anonymous feedback, indicators were further screened and adjusted. In order to minimize excessive time wasting or avoid producing meaningless results due to premature termination, two rounds of Delphi questionnaires were designed in this study. Finally, through the above work, a list of 43 risk factors affecting PPP forestry projects in China was acquired. The reference materials and terminology explanation of risk factors were attached (Appendix B).

As stated in Section 2.2, the questionaire survey had been proved as highly competent for this kind of study. Therefore, in order to facilitate the quantitative analysis and evaluation of the risks for PPP forestry project, this paper selected the questionnaire survey method to quantify the qualitative indicators. The questionnaire survey method could measure the proportion of expert opinions and reveal the reasoning underlying these proportions through analyzing the information in the questionnaire and was consequently widely used in risk assessments (Wu et al., 2017).

In order to achieve the purpose of this study, respondents were required to evaluate 43 risk factors in China's PPP-based forestry projects, considering the probability of occurrence (PO) and the impact size (IS). The questionnaire used a 7-point system to evaluate PO and IS of each factor (1 = =extremely low, 2 = very low, 3 = low, 4 = medium, 5 = high, 6 = very high, 7= =extremely high). Compared with the 5-point scale, it could more accurately describe risk factors and provide more choices for respondents, thus providing more accurate original data for subsequent operations and analysis. (Wu et al., 2017)

The questionnaire included three parts: (i) Expert information table, including the basic information of the investigated experts; (ii) Risk factor scoring table: it included 43 risk factors and the definitions of each risk factor. If the respondents failed to fully understand the meaning of a certain risk, the definition part could be used as a reference. Experts needed to score PO and IS of each risk from 1 to 7 respectively. (iii) The opinions and suggestions of experts, which were collected and sorted out according to various risks of PPP forestry projects.

In order to make the results of the questionnaire effective and accurate, the target objects were required to have the following conditions at the same time as the inclusion criteria: (i) frontline participants with rich practical experience in PPP projects from all parties, especially having in-depth knowledge of risk management in PPP projects; (ii) staff, experts or scholars who had a good understanding of the risks of PPP forestry projects and had first-hand marketing experience.

According to the above criteria, 41 qualified experts were selected to evaluate the risk factors. The small sample size was due to the limited number of experts meeting the above two criteria at the same time. The questionnaire survey started in January 2019 and the deadline was the edd of May 2019. Finally, 35 experts responded to the questionnaire, with the response rate of 85.37%. Table 2 summarized the information of 35 respondents.

3.2 Determination of risk factors and identification of key risk factors (KRFs)

In this paper, the 7-point method ws used to define the PO and IS of each risk as e^1= extremely low, e^2 = very low, e^3 = low, e^4 = medium, e^5 = high, e^6 = very high, e^7= extremely high, the set of grade categories were defined as:

$$E^T=(1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7) \tag{1}$$

Establish and calculate the average score matrix of PO and IS for each risk, expressed as Eq. (2) and Eq. (3).

$$= S \cdot E^T = \begin{pmatrix} S_{11} & \cdots & S_{17} \\ \vdots & s_{ie} & \vdots \\ S_{431} & \cdots & S_{437} \end{pmatrix} \cdot E^T = \begin{pmatrix} a_1 \\ \vdots \\ a_{43} \end{pmatrix} \tag{2}$$

$$s_{ie} = \frac{r_{ie}}{r_T} \tag{3}$$

Where

A the average score of PO or IS for each risk factor with the value ranging from 0 to 7;

r_{ie} the number of experts who chose score e to rank the risk factor of item I to;

r_T the total number of experts who answered the questionnaire.

Then, the overall risk level (ORL) of each risk factor and the normalized overall risk value N were calculated respectively.

$$\mathrm{ORL} = \sqrt{A_{LO} * A_{MI}} \tag{4}$$

$$N = \frac{IRL - MAX\ IRL}{MAX\ IRL - MIN\ IRL} \quad (5)$$

When N⩾0.5, this risk factor was selected as the key risk factor (KRF). Through this method, a total of 23 KRFs werw selected and analyzed in the next step. The calculation results were listed in Table 3.

4. Fuzzy synthetic evaluation

4.1 Establish the risk evaluation index system for PPP forestry project in China

As shown in Table 4, 43 risk factors were divided into four groups, namely political risk, socio-economic risk, financial risk and construction/operation risk. The risk group including the 23 selected key risk factors was called the key risk group (KRG). The risk assessment for China's PPP forestry project was set up as a three-tier structure:

KRFs was regarded as the first-level, namely the lowest R level, shown as Eq.6, KRGs was regarded as the second-level, namely the G level, shown as Eq.7, and the overall project was the third-level, namely the highest P level.

$$\begin{gathered} G_1 = (r_{13}\ r_{16}\ r_{17}\ r_{18}\ r_{19}\ r_{110}\ r_{111}\ r_{113}) \\ G_2 = (r_{24}\ r_{28}) \\ G_3 = (r_{32}\ r_{33}\ r_{34}\ r_{35}) \\ G_4 = (r_{41}\ r_{42}\ r_{43}\ r_{45}\ r_{46}\ r_{49}\ r_{412}\ r_{413}\ r_{415}) \end{gathered} \quad (6)$$

$$P = (g_1\ g_2\ g_3\ g_4) \quad (7)$$

4.2 Determine appropriate weightings for the KRFs and KRGs

In order to evaluate each KRG, the weightings of PO and IS for each KRG and KRF were calculated using Eq. 8.

$$W_i = \frac{A_i}{\sum_{i=1}^{x} A_i} \quad (8)$$

Where

a certain KRF or KRG of PO and IS weighting functions for a project;

average rate of KRF or KRG;

the sum of the average rates of all KRFs or KRGs within the weighting range;

X the number of targets within the weighting range.

The weighting function set was showed as:

$$W_i = (W_1\ W_2\ \cdots\ W_i) \quad (9)$$

Taking the risk group "construction/operation risk" as an example, the weighting of PO allocated to the risk of "occurrence and emergency of objective events" couldbe calculated as:.

$$W_{r415} = \frac{3.771}{4.4+4.171+5.686+4.257+4.8+4.114+4.086+4.8+3.771} = 0.094 \quad (10)$$

The sum of the weightings of each KRF in each KRG was set up to be 1, for example, the sum of each KRF in the fourth KRG was calculated as:

$$\sum_i^9 W_{g4} = 0.11 + 0.104 + 0.142 + 0.106 + 0.12 + 0.103 + 0.102 + 0.12 + 0.094 = 1 \quad (11)$$

After calculating the weighting of PO for each KRF, the average rate of PO for each KRG was calculated according to Eq.8, and the PO weightings of 4 KRGs were calculated respectively:

$$\begin{aligned} W_{g1} &= \frac{37.086}{37.086+8.914+18.942+40.086} = 0.353 \\ W_{g2} &= \frac{8.914}{37.086+8.914+18.942+40.086} = 0.085 \\ W_{g3} &= \frac{18.942}{37.086+8.914+18.942+40.086} = 0.18 \\ W_{g4} &= \frac{40.086}{37.086+8.914+18.942+40.086} = 0.382 \end{aligned} \quad (12)$$

Similarly, the weighting IS for each KRG and KRF was calculated. The calculation results were shown in Table 4.

4.3 Establish the membership function for each KRF and KRG

As mentioned earlier, a total of 23 KRFs and 4 KRGs were identified to assess the risk level of PPP forestry projects in China. The membership function of a particular KRF was calculated by Eq.10, which was showed as:

$$F_{rmi} = \frac{f_{krmi}}{e_k} = \frac{f_{1rmi}}{e_1} + \frac{f_{2rmi}}{e_2} + \frac{f_{3rmi}}{e_3} + \frac{f_{4rmi}}{e_4} + \frac{f_{5rmi}}{e_5} + \frac{f_{6rmi}}{e_6} + \frac{f_{7rmi}}{e_7} = \frac{f_{1rmi}}{extremely\ low} + \frac{f_{2rmi}}{very\ low} + \frac{f_{3rmi}}{low} + \frac{f_{4rmi}}{moderate} + \frac{f_{5rmi}}{high} + \frac{f_{6rmi}}{very\ high} + \frac{f_{7rmi}}{extremely\ high} \quad (13)$$

The function (in Eq.10) could also be written as:

$$F_{rmi} = (f_{1rmi}\ f_{2rmi}\ f_{3rmi}\ f_{4rmi}\ f_{5rmi}\ f_{6rmi}\ f_{7rmi}) \quad (14)$$

and the summation of F_{rmi} must be 1, that was:

$$\sum_{k=1}^{7} f_{krmi} = 1 \quad (15)$$

Where

the i-th risk factor of a certain KRG m (m= 1, 2, 3, 4,…etc.);

the membership degree of the first-level index r_{mi} at level. Its value refered to the percentage of experts who expressed opinions on PO and was of risk factor e_k at level k, which could be obtained from the expert rating results.

The 10th risk factor in the 1st key risk group was elucidated as an example. According to the survey results, the expert ratios of each PO rating werer: "extremly low" 0%, "very low" 2.86%, "low" 31.43%, "medium" 48.57%, "high" 11.43%, "very high" 5.71%, and "extremly high" 0%. Therefore, the PO membership function was:

$$F_{r110} = \frac{0}{extremely\ low} + \frac{0.029}{very\ low} + \frac{0.314}{low} + \frac{0.486}{moderate} + \frac{0.114}{high} + \frac{0.057}{very\ high} + \frac{0}{extremely\ high} \quad (16)$$

which can also be written as:

$$(0 \quad 0.029 \quad 0.314 \quad 0.486 \quad 0.114 \quad 0.057 \quad 0) \quad (17)$$

and similarly the IS membership function is:

$$(0 \quad 0 \quad 0 \quad 0 \quad 0.286 \quad 0.6 \quad 0.114) \quad (18)$$

In this way, the membership functions of PO and IS for all KRFs were calculated respectively (as shown in Table 4).

4.4 Define a fuzzy matrix for KRFs of Each KRG s

Firstly, in order to evaluate the importance of a certain KRG to a project, a fuzzy matrix B_{rm} was established for each KRG. According to Eq.11, a fuzzy matrix within the target group that representing F of all KRFs (both PO and IS) was defined as follows:

$$T_{rm} = (F_{rm1}\ F_{rm2}\ \ldots\ F_{rmi}) = \begin{pmatrix} f_{1rm1} & f_{2rm1} & f_{3rm1} & f_{4rm1} & f_{5rm1} & f_{6rm1} & f_{7rm1} \\ f_{1rm2} & f_{2rm2} & f_{3rm2} & f_{4rm2} & f_{5rm2} & f_{6rm2} & f_{7rm2} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ f_{1rmi} & f_{2rmi} & f_{3rmi} & f_{4rmi} & f_{5rmi} & f_{6rmi} & f_{7rmi} \end{pmatrix} \quad (19)$$

Therefore, B_{rm} could be obtained by using the weighting function and membership function of KRF in a KRG, and fuzzy synthesis calculation was according to Eq.14:

$$B_{rm} = W_{rm} \cdot T_{rm} = (b_{gm1}\ b_{gm2}\ \ldots\ b_{gmi}) \quad (20)$$

Where $b_{gmi} = \cup\ (w_{rm} \cap f_{krmi}), k = (1, 2, 3, 4, 5, 6, 7)$, this was the membership degree of an e_k level of a KRF, and the symbol "•" represented its fuzzy synthesis operation.

The third key risk group "financial risk" was taken as an example:

$$T_{r3LO} = \begin{pmatrix} 0.000 & 0.000 & 0.000 & 0.400 & 0.571 & 0.289 & 0.000 \\ 0.000 & 0.000 & 0.029 & 0.257 & 0.629 & 0.086 & 0.000 \\ 0.000 & 0.000 & 0.114 & 0.314 & 0.400 & 0.171 & 0.000 \\ 0.000 & 0.000 & 0.057 & 0.343 & 0.371 & 0.200 & 0.029 \end{pmatrix} \quad (21)$$

Next, the fuzzy composition operation was calculated according to Eq.14:

$$B_{r3LO} = W_{r3LO} \cdot T_{r3LO} = (0.2474\ \ 0.2504\ \ 0.2458\ \ 0.2564) \cdot \begin{pmatrix} 0.000 & 0.000 & 0.000 & 0.400 & 0.571 & 0.289 & 0.000 \\ 0.000 & 0.000 & 0.029 & 0.257 & 0.629 & 0.086 & 0.000 \\ 0.000 & 0.000 & 0.114 & 0.314 & 0.400 & 0.171 & 0.000 \\ 0.000 & 0.000 & 0.057 & 0.343 & 0.371 & 0.200 & 0.029 \end{pmatrix} = (0.000\ \ 0.000\ \ 0.050\ \ 0.329\ \ 0.492\ \ 0.122\ \ 0.007) \quad (22)$$

The fuzzy matrices of the remaining three groups of PO and IS could be calculated by the same method. The calculation results were shown in Table 5.

4.5 Calculating and evaluating the overall risk level of PPP forestry projects in China

Now, the weight function and membership function werer used to carry out fuzzy synthetic operation in order to obtain the overall risk level of PPP forestry projects.

Next, after the evaluation vector B_{rm} (m=1, 2, 3, 4) of the second-layer was obtained, the third-layer fuzzy matrix T_G was sebsequently calculated to evaluate the overall risk level of a PPP forestry project:

$$T_{Gm} = \begin{pmatrix} B_{r1} \\ B_{r2} \\ B_{r3} \\ B_{r4} \end{pmatrix} = \begin{pmatrix} b_{g11} & b_{g12} & b_{g13} & b_{g14} & b_{g15} & b_{g16} & b_{g17} \\ b_{g21} & b_{g22} & b_{g23} & b_{g24} & b_{g25} & b_{g26} & b_{g27} \\ b_{g31} & b_{g32} & b_{g33} & b_{g34} & b_{g35} & b_{g36} & b_{g37} \\ b_{g41} & b_{g42} & b_{g43} & b_{g44} & b_{g45} & b_{g46} & b_{g47} \end{pmatrix} \quad (23)$$

In the same way as Eq.14, the could be caulculated to evaluate the overall project risk:

$$B_{gm} = W_{gm} \cdot T_{gm} = (b_{g1}\ b_{g2}\ \ldots\ b_{g7}) \quad (24)$$

On the basis of the above calculation, considering the evaluation vector =(1 2 3 4 5 6 7), the PO and IS for each key risk group (KRG) and overall risk level (ORL) were further quantified by using Eq.17 and Eq.18:

$$\text{ORLgm} = \sqrt{(BrmLO \times E^T) \times (BrmMI \times E^T)} \quad (25)$$

$$\text{ORLp} = \sqrt{(BGLO \times E^T) \times (BGMI \times E^T)} \quad (26)$$

where

the comprehensive risk level of each KRG;

the comprehensive risk level of PPP forestry projects.

The values of ORLgm and ORLp were between 1 and 7.

First of all, the fuzzy matrix in the probability of occurrence (PO) and impact size (IS) of all KRFs could be expressed as:

$$T_{GLO} = \begin{pmatrix} B_{r1LO} \\ B_{r2LO} \\ B_{r3LO} \\ B_{r4LO} \end{pmatrix} = \begin{pmatrix} 0.000 & 0.017 & 0.124 & 0.273 & 0.406 & 0.138 & 0.042 \\ 0.000 & 0.056 & 0.201 & 0.157 & 0.471 & 0.072 & 0.042 \\ 0.000 & 0.000 & 0.050 & 0.329 & 0.492 & 0.122 & 0.007 \\ 0.003 & 0.036 & 0.154 & 0.281 & 0.369 & 0.107 & 0.050 \end{pmatrix} \quad (27)$$

$$T_{GMI} = \begin{pmatrix} B_{r1MI} \\ B_{r2MI} \\ B_{r3MI} \\ B_{r4MI} \end{pmatrix} = \begin{pmatrix} 0.000 & 0.037 & 0.026 & 0.100 & 0.356 & 0.366 & 0.150 \\ 0.000 & 0.014 & 0.171 & 0.143 & 0.371 & 0.071 & 0.229 \\ 0.000 & 0.000 & 0.031 & 0.060 & 0.347 & 0.472 & 0.090 \\ 0.000 & 0.003 & 0.045 & 0.069 & 0.313 & 0.322 & 0.248 \end{pmatrix} \quad (28)$$

According to Eq.16, the fuzzy evaluation matrix for calculating PO and IS of the the overall project was showed as follows:

$$\text{BPO} = \text{WPO} \cdot \text{TPO} = (0.407 \quad 0.076 \quad 0.168 \quad 0.349) \cdot \begin{pmatrix} 0.000 & 0.017 & 0.124 & 0.273 & 0.406 & 0.138 & 0.042 \\ 0.000 & 0.056 & 0.201 & 0.157 & 0.471 & 0.072 & 0.042 \\ 0.000 & 0.000 & 0.050 & 0.329 & 0.492 & 0.122 & 0.007 \\ 0.003 & 0.036 & 0.154 & 0.281 & 0.369 & 0.107 & 0.050 \end{pmatrix} =$$
$$(0.001 \quad 0.024 \quad 0.128 \quad 0.277 \quad 0.413 \quad 0.119 \quad 0.387)$$

$$\text{BIS} = \text{WIS} \cdot \text{TIS} = (0.389 \quad 0.075 \quad 0.162 \quad 0.374) \cdot \begin{pmatrix} 0.000 & 0.004 & 0.026 & 0.100 & 0.356 & 0.366 & 0.150 \\ 0.000 & 0.014 & 0.171 & 0.143 & 0.371 & 0.071 & 0.229 \\ 0.000 & 0.000 & 0.031 & 0.060 & 0.347 & 0.473 & 0.090 \\ 0.000 & 0.003 & 0.045 & 0.069 & 0.313 & 0.322 & 0.248 \end{pmatrix} =$$
$$(0.000 \quad 0.003 \quad 0.045 \quad 0.085 \quad 0.340 \quad 0.345 \quad 0.183)$$

Then, calculate the ovrall risk level of each KRG according to Eq.17:

$$\begin{aligned} \text{ORLg1} &= \sqrt{(Br1LO \times E^T) \times (Br1MI \times E^T)} = 5.058 \\ \text{ORLg2} &= \sqrt{(Br2LO \times E^T) \times (Br2MI \times E^T)} = 4.707 \\ \text{ORLg3} &= \sqrt{(Br3LO \times E^T) \times (Br3MI \times E^T)} = 5.102 \\ \text{ORLg4} &= \sqrt{(Br4LO \times E^T) \times (Br4MI \times E^T)} = 5.042 \end{aligned} \quad (29)$$

Finally, calculate the overall risk level(ORL) of the project according to Eq.18:

$$\text{ORLp} = \sqrt{(BGLO \times E^T) \times (BGMI \times E^T)} = 5.036 \quad (30)$$

To sum up, the FSE risk assessment model was used to calculate PO, IS and ORL of the overall project and each key risk group. The specific calculation results were shown in Table 6.

4.6 Results and discussion

Based on the results of the questionnaire survey, this paper adopted the arithmetic average method to calculate the average score value for the probability of occurrence (PO) of 43 risk factors and the impact on the project (IS), and also calculated the comprehensive risk level (ORL) and ranking of each factor. The calculation results were shown in Table 6. According to the results, the findings included:

(1) "Government decision-making risk" ranked first among all risk factors, with a score of 5.495 between "high" and "extremely high", indicating that government decision was the most critical risk for China's PPP forestry projects. On the one hand, government decision on forestry PPP might be inconsistent and policy effectiveness would be difficult to guarantee. On the other hand, the government might deliberately ignore some of the shortcomings of the project in order to improve its performance, and the evaluation of the project would be too subjective. In fact, government decision-making risks were not uncommon in PPP projects, and the criticality of this risk factor was mentioned in many expert documents such as the works of Xu et al.(2010), Chou et al.(2015), Wu et al.(2018) and Yuan et al.(2018).

(2) " Land acquisition" scored 5.368, ranking second. There were four main underlying factors. First, land requisition might be hindered due to land use policy, environmental impact assessment, high cost of land acquisition, and the government's failure to complete the task. Second, delays in land acquisition might postpone the commencement of the project, resulting in an increase in the project cost. Third, after winning the bid, the government authority might propose changes to the bidding site in the project contract. Fourth, in terms of the ownership of forest land in China, the land available for forestry projects could be divided into state-owned, collective and contracted to individuals. To carry out projects in different ways, the contradictions among all parties in the interests were particularly complicated to be dealt with. Moreover, it would involve the transfer of state-owned forest farm assets, equity, forest land or villagers' contractual and management rights. The uncertainty of transfer price would also be an urgent problem to be solved.

(3) "Cost overrun" scored 5.276, ranking third. Forestry PPP projects had the characteristics of large amount of funds and long investment cycle. Investors required risk premium of higher liquidity and high financing cost.

(4)The score of "Operation risk" was 5.232, ranking fourth. Li Yulong (2017) classified operational risk as one of the key risks of forestry PPP projects. On the one hand, it was due to the insufficient operational experience of social capital partners, which resulted in poor operational effect and excessive debts, thus affecting the policy maintenance, operation and repair of the project. On the other hand, it was due to objective factors rather than its poor operational level that the operating cost of the operators was overspent.

(5) The score of "revenue risk" was 5.229, ranking fifth. Zhang and Yu (2017) pointed out that the forestry industry had the attribute of public goods. The common problems resulted from the attribute of public goods were "free riding behavior" and "market failure". Except a few projects with stable income sources, most forestry projects had large uncertainty in income. Meanwhile, Lin Strontium (2017) also pointed out that, the key implementation areas of forestry PPP projects determined their prominent public welfare characteristics. The government usually only set social capital participants to obtain reasonable returns in the bidding scheme formulation stage, and the overall return rate would not be high. In addition, the relevant national policies would be more likely to change in a long operating cycle, and the project's expected operating income might be remarkably influenced. These views were in consistence with the results of this paper.

Next, the ORL of 43 risk factors was standardized, and the standardized value N greater than or equal to 0.5 was selected as the key risk factor (KRF) and divided into 4 key risk groups (KRG). As the results of calculation, which were showen in Table 6, i the "financial risk" comprehensive rating was 5.102, ranking first. "Political Risk" had the comprehensive rating of 5.058, ranking second. Construction and operation risk had the rating of 5.042, ranking third. Socio-economic risks had the rating of 4.707, ranking fourth. The results showed that the comprehensive risk scores of the three risk groups "financial risk", "political risk" and "construction and operation risk" should be evaluated to either the level of "high" or even "extremely high". In order to successfully manage PPP forestry projects, all parties involved should be cautious about these risks, which had the potential to become obstacle to the success of the public-private partnership project (Xu et al., 2014).

Finally, through fuzzy comprehensive calculation, the overall risk level of PPP forestry projects in China was 5.035, which was higher than 4.47 (Wu et al. ,2014) and 3.51 (Xu et al. ,2010) as the average values of previous PPP straw power generation projects in China. Therefore, investment in PPP forestry projects should be considered risky.

5. Suggestions on Preventing Risks of Forestry PPP Projects

5.1 Political risks and corresponding prevention advice

(1) Breach of contract by the government: ① strengthen the timeliness and transparency for dispensing government subsidies; ② establish a sound system with standard procedures, in order to

create optimal conditions for the operation of PPP projects; ③ ensure that the independent judicial system of the forestry sector PPP project could function smoothly to provide institutional guarantee and fundamentally guarantee partners, which would especially increase the confidence of investors and investment enthusiasm.

(2) Change of government officials: ① publicalize government affairs and encourage common people in the society to contribute to the supervision and management of projects; ② the reform of the major policy decisions must be approved by the responsible committee instead of any individual, with standarized procedures, methods, contents of official documents and backtracking results at regular intervals, to ensure legal and qualified procedure specification.

(3) Government intervention: This risk can be solved by promoting the transformation of government functions, especially with the focus on the administrative coordination, policy support, project supervision. Furthermore, the decisions of the cooperation company in the project should be independent from the intention of the goverment, to avoid excessive reliance on the leading role of the goverment, which can also effectively minimize the corruption due to the involvement in project construction and the operation risk, resulting in improved practice of the public power by the government.

(4) Land acquisition: the government should authorize land use plans according to the requirements of the specific project. Especially for the projects designated for public welfare, the government should actively promote the transfer of land use right with all the relevant authorities based on availability, performance-based project evaluation, and the amount of payment from the project company. As the consequence, it can encourage the the financing facilities to participate, and attract more social capital due to the advantageious transfer of land use right.

(5) Government decision-making risk: ① set up the top priority to ensure that the project can smoothly landing, instead of blindly pursuiting unreasonableachievements, with the considerations of project security, policies and regulations, reasonable and lawful profits, social harmony and stability, and economic development, as well as the government's credibility in the perspective of project risk control;② starting from the project selection, value analysis, fiscal capacity analysis, to the specific implementation, procurement, construction, operation and maintenance of the project, and then to capital exit, property rights transfer and the project supervision, etc., all the above-mentioned procedures need to have clear specifications; ③ allow public participation and fair competition in the selection of social capital for theproject, with the scientific professional design of top quality, to construct a project development environment that is supportive of equality.

(6) Changes in policies, laws and rules:As the first step, the changes PPP protocol, policies and regulations caused by law changes which can affect smooth operations of the project should be identified and evaluated in a timely manner for all the likely consequences, including whether the operation of the project needs to be changed, whether the terms should be changed to adapt to the renewed law, the predictive revenue loss, the potential change of project cost and so on, by the discussions involved both parties through consultation and to reach the agreement of cooperation.

(7) Immature laws: The government should gradually improve the relevant laws and regulations including industry-specific rules and regulations, to regulate and guarantee the concrete operation of PPP, clarify the status and role of forestry in the construction of ecological civilization, and refine the multipurpose use and management of forest, in order to further facilitate the reform of foresty.

(8) Choice of Social Capital: ①follow the principles of openness, fairness, justice and honesty; ② consider the nature of potential partners and their diversified scaleds. In addition to the company, the private individuals, non-governmental organizations, charitable foundation, professional societies and associations, universities, and communities should also be included as the main bodies, to actively encourage the participation of all kinds of long-term financial funds in the PPP projects, with equal treatment to all kinds of investment subjects; ③ it is not advisable to limit the range of social capital, to assign the specific categories of social capital, qualifications, technology, experience, financial or credit conditions for establishing exclusive requirements, and in contrast, it is suggested

to set reasonable participation qualifications according to scientific research, as well as formulate the assessment for bidding standards.

5.2 Socio-economic risks and corresponding prevention advice

(1) Change of interest: strengthen the interest rate risk management, be cautious for the changes in interest rates, anticipate the risk and protect the project in advance, and cut the interest rate risk of future uncertainty to the affordable range with floating interest rate contracts.

(2) Ecological civilization risk: ①strengthen the forest resources monitoring system , establish and improve the management files of forest resources, regularly publish of the official reports on forest resources and accept social supervision; ② improve the quality of forest resources by strict control with the management system of the forest resources, which is suggested to be the core of PPP forestry projects, and according to the cutting quota of forest management plan formulation, set up the annual production plan and schedule the forest management activities, including the establishment and implementation of the management plan for forest inspection; ③ the government should shift policy perspective to focus on the maintenance of public welfare forest resources and build the policy system with the priority for the construction of ecological civilization. In terms of the forest resource protection under the premise of sustainable development, forestry development should be promoted in a scientific and reasonable manner.

5.3 Financial risks and corresponding prevention advice

(1) financing and refinancing risk: ① the investor in the process of project financing should conduct prudent financial strategic planning, especially with the reasonable control of financial leverage;② in the financing process, policy advantages of the forestry project should be fully utilized, including relatively low interest rates, expanded reimbursement deadline, and privileged project loans, to reduce the financing cost and avoid the debt-collection lag; ③ the government should improve the financial policy to promote the practice of cost-saving financing measures.

(2) revenue risk: ① improve the project payment mechanism. For most of the forestry projects which are closely related to public welfare, when users have paid enough to produce the reasonable return for the investment of social capital, they should be able to negotiate with the government to acquire preferential subsidies, equity investment, loans and other preferential policies as financial aid to the social capital; ② directly promote the benefit by planting economic crops in the forest.

(3) Inadequate supervision of project funds: strengthen the relationship between the government and the society by introducing effective supervision to the whole process of project implementation, to establish and perfect the system of project audit, Especially strengthen the audit work of funds, strengthen the dynamic management of the usage of funds, improve risk control financial medium and the manangement of long-term debt and the budget for the government, in order to provide relatively reliable accounting information.

(4) Cost overrun: the project company should strengthen the cost control during the whole process of the project, by improving the management and efficiency, optimization of time limit for a project, the rational allocation of resources and other ways, in order to reduce spending and henceforth increase the revenue.

5.4 Construction/operation risks and corresponding prevention advice

(1) Contract Terms and Allocation of Power and Responsibility: ① standardize contract management, by fully understand that the characteristics of forestry project is different from the PPP projects in other industries, in order to design the contract according to the template specific for forestry PPP project; ② pay attention to the early stage of negotiate communication between the cooperation and the government, to ensure the PPP terms of the contract are clearly demonstrated on the basis of feasibility study, and to protect the rights of cooperation by all the parties in the project and to guarantee the reasonable allocation of risk; ③besides the usual terms for PPP contracts, both

the government and social capital are responsible to inform each other about any future potential risks and benefits to retain necessary consultation and negotiation conditions.

(2) Credit worthiness of different stakeholders: as public administration, the government should not only act as a social managers to maintain social public interest, to ensure the smooth implementattion of project and to produce good social benefits, but also to safeguard the government's credibility. On the other side, profit is the nature demand of social capital, and therefor the social capital must be supervised through effective regulation, which promotes the entity to pursuit the balance between profit and social responsibility.

(3) Long concession period: ① the sustainablility of the social capital should be evaluated according to the major investment activities, the industry's political system, the administrative system and policies of the enterprise, laws and regulations and so on, which may affect the longer-term operation of the project and restrict the investment and management behavior of the enterprise; ② the project should strengthen the stability and predictability of long-term operation and maintenance of its assets, as well as standarize the supervision duringthe project life cycle, which is the key to prevent the risk, to guranteee the the success of the project and to improve the utility of forest resources.

(4) Inability of concessionaire: ① the government should be comprehensive review bidding company in public bidding phase, considering the business quotation, professional ability and performance ability in terms of comprehensive strength of any paticipants, to select the most appropriate social capital as the winning party; ② the government should set a clear rewards and punishment mechanism, through the regular assessments for temporary company operation performance during the project, and the assessment results and operational performance must get effective feedback, to encourage the entity of social capital to improve project management capability and to maximize the efficiency and profit of the project; ③ the project company should keep trying to innovate the traditional concept of forestryunder the background of continuous technology innovation, and through the production in a variety of ways with the application of new techniques, promote the popularization and application of new technology. Therefore, the achievements will not be subjected to the former project plan or and acquired privilege.

(5) Lack of PPP experience: ① construct team of experts, establish the authorized advisory guide apply professional guidance and support, and also consider the suggestions from the non-professional group who are experienced in PPP projects or in forestry. All of the above should be promoted by all the parties in the project especially by the forestry department, in order to maximize the efficiency to solve difficulties and problems in the project; ② select a batch of large scale forestry projects with the expectation of high earning, which can take the advantage to acquire franchise, investment subsidies, government purchase contractss and social capital partication, to construct pilot program for PPP forestry projects. Subsequently, on the basis of summarized experience, the successful form can be copied, and the standarization of the empirical mode can be promoted, and the advanced experienced may be promoted nation-wide according to the regional variances; ③ the relevant departments should speed up the construction of forestry education training system, which reserves talents for the development of forestry technology and facilitates the research study on the standarization of project mode.

(6) Deviation from expected target: ① the construction of the project should be operated step-by-step in accordance with the requirements in different stages of the project, and should strictly comply with the basic construction criteria especially the national regulations and standards According to the project planning, the key steps of construction and implementation should be organzied and scheduled; and after the approval of the preliminary design, the implementation of the project should follow the schedule, and any potential interferences should be regularly checked and excluded as early as possible; ② to establish the project organization, careful arrangemand strictly enforce the regulations of the national technical standards, the supervision for construction quanlity and the accountability, including project information feedback system, the system of examination and

acceptance of construction quality, and the supervision system along the lifetime of the project, to ensure the successful completion of the project according to the target.

(7) Project completion and transfer risk: ① before the expiration of the contract, the government or the relevant authority and the project company should jointly set up the agreement on the transfer commission of the PPP project in accordance with the laws and regulations, which included detailed transfer procedures, the implementation of training plan, how to hand over equipment, facilities, and goods with a detailed list of spare parts, and etc.; ② for the termination of contract, project facilities (including all kinds of facilities required by the normal operation of the project, for example, equipment, land use rights, the information system, maintenance manuals, and etc.) should be handed over to the government in accordance with the regulations of the project agreement or the policy of the designated agency, and the project company needs to ensure that transfer of project facilities will not be interferred with unreported external factors such as mortgage, lease contract, or transferred property rights.

(8) Operation risk: ①strengthen the process control in the process of project implementation, strengthen the supervision and management of operational activities, standardized operation, ensure to complete the project according to contract agreement, and ensure that the operational performance meet the requirements of the government to get paid for performance appraisal by the government; ② promote technology innovation in forestry, get rid of the traditional forestry mode, enhance resource integration with the utilization of investment in foresty construction according to the economic scale; ③ and improve the management of information, timely grasp the construction condition, handle problems in time, improve work efficiency, to create a good operating conditions for the project construction.

(9) Occurrence and emergency of objective events: ① optimize prevention measures in advance by recognizing and modifying policies according to the geological condition, taking actions in response to weather forecast in time, increasing the intensity of afforestation management, and promoting construction safety policies and engineering insurance; ② the project company should be aware of natural disasters, major workplace accidents, environmental hazards and man-made destruction and all other kinds of possible accident, to make correponding preventive plans and maintenance scheme, as well as clear the affected area beforehand, with the coordination of relevant departments and the completion of relevant personnel duties.

6. Conclusion

This article utilized the literature material method, Delphi method and questionnaire investigation to identify 43 risk factors for China's PPP forestry projects, and based on this, to identify 23 key factors which were divided into four groups. By using the proposed FSE model, PO, IS and ORL were calculated for each KRF and KRG. The results showed that the "government decision-making risk", "land expropriation risk", "cost overruns experience", "operational risk" and "revenue risk" were the top 5 among most critical risks in China's PPP forestry projects, and the key risk group of "financial risk" was ranked first.

Finally the fuzzy synthetic evaluation results showed that the overall risk level of China's PPP forestry projects was relatively high compared to other PPP projects.

On the basis of the analysis, this article disscussed the underlying reasoning in view of the government for the social capital and made some suggestions to prevent risks, to minimize the influences of realized risks or to take preventive and remedial action as soon as possible, in order to achieve the smooth implementation and success of the projects.

7. Tables

Table 1. Research on FSE Application in PPP Projects in Recent Years

NO.	Year	Author(s)	Abstract
1	2010	Xu et al	A fuzzy comprehensive evaluation model was established to evaluate the overall risk level of PPP expressway projects in China.
2	2013	Wu et al.	The risk assessment model established for the risk factors of PPP straw power generation projects in China evaluated the possibility and degree of influence of each risk factor and the risk level of the whole project respectively.
3	2015	Ameyaw	FSE was used to investigate the risk factors of PPP water supply projects in developing countries and evaluate their risk level.
4	2016	Zhu et al.	Aiming at the limitation of current big data privacy protection mechanism, a fuzzy evaluation method of social network privacy risk was proposed. The method had good applicability and could provide reference for improving social network service level in big data environment.
5	2016	Shidpour et al.	Rough set and fuzzy set were used to ensure the accuracy of quantitative and qualitative evaluation of design concepts.
6	2016	Yang et al	FSE and multivariate statistical analysis were applied to determine the enrichment characteristics of heavy metals and the potential risks of polluted sediments in Fenghe River in Qinling Mountains.
7	2016	Hu et al.	A structured program organizational evaluation method based on FSE method was proposed to establish organizational performance indicators for large-scale engineering projects in China.
8	2016	Fan et al.	Using fuzzy comprehensive evaluation model, the enterprise financial risk index system was established.
9	2017	Ameyaw et al.	Based on the Nugua Seawater Desalination Plant (NSDP) in Ghana, the major financial risks related to the start-up of water supply projects were identified and evaluated through fuzzy comprehensive evaluation method.
10	2017	Liu et al.	The risk assessment model established for the risk factors of ultra-deep drilling projects respectively evaluated the possibility and degree of influence of each risk factor and the risk level of the whole project.

Table 2. The information of respondents

1.Attention to Forestry PPP Projects:				
	High	Medium	Minuent	
Percentage	74.29%	25.71%	0.00%	
2.Degree of education:				
	Senior posts	Scholar	Master	Doctor
Percentage	2.86%	34.29%	42.86%	11.43%
3.Organization of respondents:				
	Academic sector	companies	Government	
Percentage	42.86%	42.86%	42.86%	
4.Number of PPP projects that respondents have participated in:				
	5 or above	3-4	0-2	
Percentage	45.71%	45.71%	45.71%	

Table 3. Ranking of risk factors

Rank	risk factors	APO	AIS	ORL	N	Renferences
1	Government decision-making risk	5.057	5.971	5.495	1.00000	(5)(7)
2	Land acquisition	5.171	5.571	5.368	0.93362	(1)(2)(3)(5)(7)(14)
3	Cost overrun	4.800	5.800	5.276	0.88610	(1)(2)(3)(5)(6)(7)(10)(13)(14)(15)
4	Operation risk	4.743	5.771	5.232	0.86298	(1)(4)(5)(7)(8)(10)(12)(13)(14)(15)
5	revenue risk	4.714	5.800	5.229	0.86148	(1)(2)(3)(4)(5)(6)(10)(12)(13)(14)(15)
6	Choice of Social Capital	4.657	5.657	5.133	0.81143	(3)(9)(13)
7	Contract Terms and Allocation of Power and Responsibility	4.371	6.000	5.121	0.80547	(1)(3)(4)(5)(7)(8)(11)(13)(14)(15)
8	Financing and refinancing risk	4.657	5.571	5.094	0.79113	(3)(4)(5)(7)(9)(10)(12)(13)(14)(15)
9	Inability of concessionaire	4.200	6.143	5.079	0.78361	(3)(11)(13)(14)(15)

Rank	risk factors	APO	AIS	ORL	N	Renferences
10	Goverment breach of contract	4.486	5.686	5.050	0.76843	(9)(10)
11	Lack of PPP experience	4.800	5.257	5.023	0.75448	(3)(5)(7)(15)
12	Government intervention	4.743	5.286	5.007	0.74593	(3)(5)(6)(13)(14)
13	Long concession period	5.686	4.400	5.002	0.74321	(3)(8)(10)(12)(15)
14	Occurrence and emergency of objective events	3.686	6.343	4.835	0.65652	(1)(3)(5)(7)(10)(11)(12)
15	Deviation from expected targe	4.029	5.743	4.810	0.64344	(1)(7)(8)(10)(13)(14)
16	Ecological civilization risk	4.600	5.000	4.796	0.63610	(1)(3)(5)(7)(8)(10)(13)(14)(15)
17	Change of government officials	4.371	5.200	4.768	0.62149	(7)(11)(13)(14)
18	Inadequate supervision of project funds	4.629	4.829	4.728	0.60056	(3)
19	Changes in policies,laws and rules	3.800	5.829	4.706	0.58948	(1)(3)(5)(7)(10)(11)(13)(14)
20	Change of interest	4.429	5.000	4.706	0.58917	(1)(3)(5)(11)(13)(14)
21	Project completion and transfer risk	4.057	5.429	4.693	0.58262	(1)(3)(5)(11)(13)(14)(15)
22	Creditworthiness of different stakeholders	4.114	5.286	4.663	0.56718	(3)(4)(7)(10)(11)(13)(14)
23	Immature laws	4.600	4.600	4.600	0.53422	(7)(8)(10)(12)(13)(14)(15)
24	Project implementation risks	3.829	5.314	4.511	0.48775	(1)(3)(5)(7)(8)(10)(11)(13)(15)
25	local governments'lack of understanding	3.571	5.600	4.472	0.46770	(10)(13)(14)(15)
26	Public attitude risk	3.971	5.029	4.469	0.46599	(3)(5)(8)(11)(10)(14)(15)
27	Macroeconomics	4.057	4.914	4.465	0.46409	(3)(4)(8)(13)(14)(15)
28	Organization and coordination risk	4.171	4.771	4.461	0.46209	(3)(5)(7)(10)(14)
29	Government credit	5.314	3.686	4.426	0.44355	(3)(5)(10)
30	Information asymmetry	4.200	4.543	4.368	0.41356	(1)(8)(13)(14)(15)
31	Unavailability of the supporting facilities	3.514	5.429	4.368	0.41341	(1)(5)(8)(13)(14)
32	Technical risk	3.714	4.971	4.297	0.37665	(1)(3)(5)(7)(8)(10)(13)
33	Change of project company	3.029	6.057	4.283	0.36933	(3)(4)
34	Market and industry risks	3.886	4.514	4.188	0.31999	(5)(7)(8)(12)(13)(14)
35	Government system risk	3.086	5.571	4.146	0.29819	(3)(5)(7)(8)(10)
36	Foreign exchange fluctuation	4.171	4.114	4.143	0.29634	(1)(3)(4)(5)(6)(7)(11)
37	Horizontal competition	4.200	4.057	4.128	0.28864	(3)(7)(8)(10)(13)(14)
38	Imperfect supervision system	3.600	4.629	4.082	0.26474	(3)(5)(10)(15)
39	Pricing risk	3.771	4.314	4.034	0.23962	(7)(9)(10)(14)(15)
40	Deviation between project residual value and expected residual value	3.914	4.086	3.999	0.22159	(1)(3)(5)(14)
41	Inflation	2.771	5.286	3.827	0.13228	(1)(2)(3)(4)(5)(6)(7)(11)(13)(14)
42	Project approval	3.400	4.114	3.740	0.08687	(1)(3)(4)(5)(10)(14)
43	Taxation risk	3.286	3.886	3.573	0.00000	(3)(4)(5)

Rank	Author	Rank	Author	Rank	Author	Rank	Author	Rank	Author
(1)	Shrestha et al.(2017a)	(4)	Ameyaw et al. (2017)	(7)	Yuan et al. (2018)	(10)	Zhang and Ye (2016)	(13)	Shrestha et al.(2017b)
(2)	Kumar et al. (2018)	(5)	Wu et al. (2018)	(8)	Jin and Zhang (2011)	(11)	Yulong Li(2017)	(14)	Shrestha et al.(2018)
(3)	Wu et al. (2017)	(6)	Ameyaw & Chan (2016)	(9)	Choi et al. (2010)	(12)	Zhang and Yu(2017)	(15)	Li Li(2018)

Table 4. The weights of PO and IS for key risk factors (KRF) and key risk factor group (KRG)

Group	NO.	Risk factor	PO				IS			
			R value	R weight	G sum	G weight	R value	R weight	G sum	G weight
G1 Political risk	R13	Goverment breach of contract	4.486	0.121	37.086	0.353	5.686	0.130	43.800	0.347
	R16	Change of government officials	4.429	0.119			5.200	0.119		

Group	NO.	Risk factor	PO				IS			
			R value	R weight	G sum	G weight	R value	R weight	G sum	G weight
	R17	Government intervention	4.771	0.129			5.286	0.121		
	R18	Land acquisition	5.200	0.140			5.571	0.127		
	R19	Government decision-making risk	5.086	0.137			5.971	0.136		
	R110	Changes in policies,laws and rules	3.886	0.105			5.829	0.133		
	R111	Immature laws	4.571	0.123			4.600	0.105		
	R113	Choice of Social Capital	4.657	0.126			5.657	0.129		
G2 socio-economic risk	R24	Change of interest	4.371	0.490	8.914	0.085	5.000	0.500	10.000	0.079
	R28	Ecological civilization risk	4.543	0.510			5.000	0.500		
G3 financial risk	R32	Financing and refinancing risk	4.686	0.247	18.943	0.180	5.571	0.253	22.000	0.174
	R33	revenue risk	4.743	0.250			5.800	0.264		
	R34	Inadequate supervision of project funds	4.657	0.246			4.829	0.219		
	R35	Cost overrun	4.857	0.256			5.800	0.264		
G4 construction/operation risk	R41	Contract Terms and Allocation of Power and Responsibility	4.400	0.110	40.086	0.382	6.000	0.119	50.371	0.399
	R42	Creditworthiness of different stakeholders	4.171	0.104			5.286	0.105		
	R43	Long concession period	5.686	0.142			4.400	0.087		
	R45	Inability of concessionaire	4.257	0.106			6.143	0.122		
	R46	Lack of PPP experience	4.800	0.120			5.257	0.104		
	R49	Deviation from expected targe	4.114	0.103			5.743	0.114		
	R412	Project completion and transfer risk	4.086	0.102			5.429	0.108		
	R413	Operation risk	4.800	0.120			5.771	0.115		
	R415	Occurrence and emergency of objective events	3.771	0.094			6.343	0.126		
Sum					105.029					

Table 5. The calculation results of the fuzzy composition operation of PO and IS for each KRF and KRG

Group	NO.	Risk factor	PO			IS		
			F weight	F of KRFs	TGPO	F weight	F of KRFs	TGIS
G1 Political risk	R13	Breach of contract by the government	0.12	(0.00,0.00,0.14,0.43,0.34,0.06,0.03)	(0.00,0.02,0.12,0.27,0.41,0.14,0.04)	0.13	(0.00,0.00,0.00,0.11,0.31,0.34,0.23)	(0.00,0.00,0.03,0.10,0.36,0.37,0.15)
	R16	Change of government officials	0.12	(0.00,0.00,0.34,0.06,0.49,0.11,0.00)		0.12	(0.00,0.00,0.03,0.14,0.54,0.17,0.11)	
	R17	Government intervention	0.13	(0.00,0.00,0.00,0.46,0.31,0.23,0.00)		0.12	(0.00,0.00,0.00,0.23,0.31,0.40,0.06)	
	R18	Land acquisition	0.14	(0.00,0.00,0.06,0.14,0.46,0.23,0.11)		0.13	(0.00,0.00,0.03,0.09,0.40,0.26,0.23)	
	R19	Government decision-making risk	0.14	(0.00,0.00,0.00,0.26,0.43,0.26,0.06)		0.14	(0.00,0.00,0.00,0.00,0.20,0.63,0.17)	

Group	NO.	Risk factor	PO			IS		
			F weight	F of KRFs	TGPO	F weight	F of KRFs	TGIS
	R110	Changes in policies,laws and rules	0.10	(0.00,0.03,0.31,0.49,0.11,0.06,0.00)		0.13	(0.00,0.00,0.00,0.00,0.29,0.60,0.11)	
	R111	Immature laws	0.12	(0.00,0.00,0.11,0.29,0.54,0.03,0.03)		0.11	(0.00,0.00,0.14,0.20,0.60,0.03,0.03)	
	R113	Choice of Social Capital	0.13	(0.00,0.11,0.09,0.11,0.51,0.09,0.09)		0.13	(0.00,0.03,0.03,0.06,0.26,0.40,0.23)	
G2 socio-economic risk	R24	Change of interest	0.49	(0.00,0.11,0.17,0.14,0.49,0.00,0.09)	(0.00,0.06,0.20,0.16,0.47,0.07,0.04)	0.50	(0.00,0.03,0.17,0.06,0.46,0.09,0.20)	(0.00,0.01,0.17,0.14,0.37,0.07,0.23)
	R28	Ecological civilization risk	0.51	(0.00,0.00,0.23,0.17,0.46,0.14,0.00)		0.50	(0.00,0.00,0.17,0.23,0.29,0.06,0.26)	
G3 financial risk	R32	Financing and refinancing risk	0.25	(0.00,0.00,0.00,0.40,0.57,0.03,0.00)	(0.00,0.00,0.05,0.33,0.49,0.12,0.01)	0.25	(0.00,0.00,0.00,0.00,0.46,0.51,0.03)	(0.00,0.00,0.03,0.06,0.35,0.47,0.09)
	R33	revenue risk	0.25	(0.00,0.00,0.03,0.26,0.63,0.09,0.00)		0.26	(0.00,0.00,0.00,0.00,0.31,0.57,0.11)	
	R34	Inadequate supervision of project funds	0.25	(0.00,0.00,0.11,0.31,0.40,0.17,0.00)		0.22	(0.00,0.00,0.14,0.17,0.40,0.29,0.00)	
	R35	Cost overrun	0.26	(0.00,0.00,0.06,0.34,0.37,0.20,0.03)		0.26	(0.00,0.00,0.00,0.09,0.23,0.49,0.20)	
G4 construction/operation risk	R41	Contract Terms and Allocation of Power and Responsibility	0.11	(0.00,0.00,0.14,0.43,0.31,0.11,0.00)	(0.00,0.04,0.15,0.28,0.37,0.11,0.05)	0.12	(0.00,0.00,0.00,0.03,0.20,0.51,0.26)	(0.00,0.00,0.05,0.07,0.31,0.32,0.25
	R42	Creditworthiness of different stakeholders	0.10	(0.00,0.03,0.31,0.29,0.31,0.00,0.06)		0.10	(0.00,0.00,0.20,0.06,0.29,0.17,0.29)	
	R43	Long concession period	0.14	(0.00,0.00,0.03,0.06,0.31,0.40,0.20)		0.09	(0.00,0.03,0.17,0.29,0.40,0.11,0.00)	
	R45	Inability of concessionaire	0.11	(0.00,0.06,0.17,0.26,0.51,0.00,0.00)		0.12	(0.00,0.00,0.00,0.00,0.23,0.40,0.37)	
	R46	Lack of PPP experience	0.12	(0.00,0.09,0.00,0.06,0.77,0.06,0.03)		0.10	(0.00,0.00,0.03,0.03,0.66,0.23,0.06)	
	R49	Deviation from expected targe	0.10	(0.00,0.03,0.46,0.11,0.29,0.06,0.06)		0.11	(0.00,0.00,0.03,0.06,0.31,0.34,0.26)	
	R412	Project completion and transfer risk	0.10	(0.00,0.06,0.17,0.51,0.20,0.06,0.00)		0.11	(0.00,0.00,0.03,0.17,0.29,0.37,0.14)	
	R413	Operation risk	0.12	(0.00,0.00,0.00,0.37,0.49,0.11,0.03)		0.11	(0.00,0.00,0.00,0.03,0.34,0.46,0.17)	
	R415	Occurrence and emergency of objective events	0.09	(0.03,0.09,0.20,0.57,0.03,0.06,0.03)		0.13	(0.00,0.00,0.00,0.03,0.17,0.23,0.57)	

Table 6. The PO, IS and ORL of overall project and KRGs

Group	PO		IS				
	G weight	TGPO	G weight	TGIS	BRPO*E^T	BRIS*E^T	ORLg
G1 Political risk	0.407	(0.000,0.017,0.124,0.273,0.406,0.138,0.042)	0.389	(0.000,0.004,0.026,0.099,0.356,0.366,0.150)	4.647	5.505	5.058
G2 socio-economic risk	0.076	(0.000,0.056,0.201,0.157,0.471,0.073,0.042)	0.075	(0.000,0.014,0.171,0.143,0.371,0.071,0.229)	4.430	5.000	4.706
G3 financial risk	0.168	(0.000,0.000,0.050,0.329,0.492,0.122,0.007)	0.162	(0.000,0.000,0.031,0.060,0.347,0.472,0.090)	4.708	5.529	5.102
G4 construction/operation risk	0.349	(0.003,0.036,0.154,0.281,0.369,0.107,0.050)	0.373	(0.000,0.002,0.045,0.069,0.313,0.322,0.248)	4.498	5.651	5.042
	BGPO	(0.001,0.024,0.128,0.277,0.413,0.119,0.039)	BGIS	(0.000,0.003,0.045,0.085,0.339,0.345,0.183)	4.647	5.505	5.058
	BGPO*E^T	4.589	BGIS*ET	5.526	ORLp	5.036	

Table 7. Appendix a Summary unit of PPP center project management warehouse forestry (Unit: ten thousand yuan)

NO.	Name of Project	Investment(CNY)	Initiation time	Stage
1	Project of East China Medicinal Botanical Garden (Lishui Botanical Garden) in Lishui City, Zhejiang Province	839,090,000	2015/3	Execution
2	Construction Project of Ruhe Wetland Park and Forest Avenue in Ruzhou, Pingdingshan City, Henan Province	960,000,000	2015/11	Execution
3	PPP Project of Vegetation Restoration and Treatment Project in Fuxian Lake Runoff Area, Chengjiang County, Yuxi City, Yunnan Province	1,692,910,000	2016/1	Execution
4	PPP Project for Late Maintenance of Phase I and Phase II Greening of Daqing Mountain South Slope, G6 Expressway and 110 National Highway in Inner Mongolia Autonomous Region	253,000,000	2016/11	Execution
5	Nanping City, Fujian Province to Build Ecological Civilization Experimental Zone - National Reserve Forest Quality Precision Improvement Project	21,533,190,000	2017/3	Execution
6	Landscape Improvement and Greening Project on Both Sides of Huang Highway in Hangjin Banner, Ordos City, Inner Mongolia Autonomous Region	160,320,000	2017/4	Execution
7	Government and Social Capital Cooperation (PPP) Project for Forestry Ecological Construction such as National Reserve Forest in Yuanmou County, Chuxiong Prefecture, Yunnan Province	954,460,000	2017/5	Execution
8	PPP Project for Forest Resources Protection in Key Ecological Areas of Jiangle County, Sanming City, Fujian Province	428,640,000	2017/6	Execution
9	Construction Project of National Reserve Forest in gongyi city, Henan Province	655,890,000	2017/7	Execution
10	PPP Project of National Reserve Forest Base in Xiayi County, Henan Province	1,422,000,000	2017/8	Execution
11	PPP Project for Ecological Poverty Alleviation Project of Greening Around the City, Greening on Both Sides of the Passage and Greening of Barren Mountains in Kelan County , Shanxi Province	363,640,000	2017/9	Execution
12	The Second Phase of National Reserve Forest Base in Puyang City, Henan Province	2,030,610,000	2017/9	Execution
13	Phase III PPP Project of National Reserve Forest Base in Puyang City, Henan Province	622,770,000	2017/9	Execution
14	PPP Project for Construction of National Reserve Forest Base in Dengzhou City, Henan Province	976,730,000	2017/10	Execution
15	The Government and Social Capital Cooperation (PPP) Project for Forestry Ecological Construction such as Yaoan National Reserve Forest in Chuxiong Prefecture, Yunnan Province	945,710,000	2017/11	Execution
16	PPP Project for Cultivation and Protection of Forest Resources in Key Ecological Areas in Pingnan County, Fujian Province	333,670,000	2017/12	Execution
17	The Government and Social Capital Cooperation (PPP) Project for Forestry Ecological Construction in Wuding County of Yunnan Province	515,100,000	2018/8	Execution
18	"Green Man Xiangzhou" Promotion Project in Xiangzhou District, Xiangyang City, Hubei Province	435,370,000	2017/1	Procurement
19	In 2017, Qingxu County, Taiyuan City, Shanxi Province, established the National Forest City PPP Project	92,150,000	2017/3	Procurement
20	Ecological Corridor Greening Construction Project in Baofeng County, Pingdingshan City, Henan Province	730,000,000	2017/3	Procurement
21	National Reserve Forest Construction Project in Xiangyang City, Hubei Province	7,097,590,000	2017/6	Procurement

NO.	Name of Project	Investment(CNY)	Initiation time	Stage
22	Construction Project of Mountain Greening within Visual Range in Lishi district of Luliang City, Shanxi Province	487,300,000	2017/6	Procurement
23	PPP Project for Forest Ecological Protection and Poverty Alleviation Green Corridor Greenway in the Southern Suburb of Datong City, Shanxi Province	94,000,000	2017/7	Procurement
24	Construction Project of Huaihe River Source National Reserve Forest in Nanyang City, Henan Province	412,430,000	2017/8	Procurement
25	Jianning County, Fujian Province to Build Ecological Civilization Pilot Zone-PPP Project of National Reserve Forest Quality Precision Improvement Project	291,590,000	2017/8	Procurement
26	Nanyang City, Henan Province National Reserve Forest Base Construction (Phase I) PPP Project Forest Construction Project	13,817,150,000	2017/12	Procurement
27	National Reserve Forest Base Construction Project in Lushi County, Sanmenxia City, Henan Province (Phase I)	505,920,000	2018/1	Procurement
28	PPP Project for Construction of National Reserve Forest Base in Jun County, Henan Province	537,590,000	2018/4	Procurement
29	Forestry Ecological Construction Projects such as National Reserve Forest in Lufeng County, Chuxiong Prefecture, Yunnan Province	955,260,000	2018/5	Procurement
30	National Reserve Forest Construction Project in Anyang City, Henan Province	5,974,400,000	2017/1	Preparation
31	Construction Project of National Reserve Forest Base in Ye County, Pingdingshan City, Henan Province	914,430,000	2017/2	Preparation
32	PPP Project for Accurate Improvement of Forest Quality in Mufu Mountain, Xianning City, Hubei Province	7,482,530,000	2017/8	Preparation
33	PPP Project for Promoting Ecological Corridor and Forest Landscape along the Yangtze River in Yingjiang District of Anqing City, Anhui Province	156,210,000	2017/11	Preparation
34	Shanxi Forestry Ecological Poverty Alleviation PPP Project	17,438,000,000	2018/1	Preparation
35	Government and Social Capital Cooperation (PPP) Project for Forestry Ecological Construction such as National Reserve Forest in Nanhua County, Chuxiong Prefecture, Yunnan Province	982,930,000	2018/3	Preparation
36	Construction Project of yima city National Reserve Forest Base in Henan Province	504,240,000	2018/5	Preparation
,37	The Government and Social Capital Cooperation (PPP) Project for Forestry Ecological Construction such as National Reserve Forest in Mouding County, Chuxiong Prefecture, Yunnan Province	624,970,000	2018/6	Preparation
38	Construction Project of National Reserve Forest in jia county, Henan Province	695,230,000	2018/8	Preparation
39	Forestry Ecological Poverty Alleviation (Phase I) Project in Lijiang City, Yunnan Province	4,046,520,000	2018/8	Preparation
40	PPP Project for Forestry Ecological Construction in Dongli District of Tianjin City	981,560,000	2018/9	Preparation
41	Construction Project of National Reserve Forest Base in Mianchi County, Henan Province	1,250,880,000	2018/9	Preparation
42	The PPP Project of National Reserve Forest Base Construction in Neiqiu County, Xingtai City, Hebei Province in 2018	530,000,000	2019/1	Preparation

Table 8. Appendix B

Group	NO.	Risk Factor	Additional remarks
G1 Political risk	R11	Government system risk	(1) government corruption; (2) "lazy government"; (3) there is no separation between government and enterprise, and the division of functions is not clear.

Group	NO.	Risk Factor	Additional remarks
	R12	Government credit	The government misused the project to borrow money in disguised form, causing a financial crisis, leading to a decline in the government's credibility, thus affecting the project's benefits.
	R13	Breach of contract by the Goverment	The government department fails to pay the project funds to the project company on time and in full, or the relevant subsidies promised by the government are not in place, which violates the contract promise.
	R14	Imperfect supervision system	The government has weak supervision and management functions, such as imperfect supervision system, weak supervision system and insufficient on-site supervision capability.
	R15	Lack of understanding by the local government	The government department's unclear orientation of the preoject and lack of scientific overall planning lead to unreasonable project planning.
	R16	Change of government officials	The personnel change in the government and the change of relevant project managers may lead to conflicts between government decisions and current projects, affecting the smooth implementation of projects.
	R17	Government intervention	The government intervenes in PPP forestry projects through economic or administrative means. If social capital is required to build a landscape around the central idea of the government, this may affect the normal operation of the project.
	R18	Land acquisition	(1) Land requisition may be hindered due to factors such as land index, environmental impact assessment, high cost of land acquisition, and the government's failure to play a leading role. (2) Delays in land acquisition may lead to delays in project commencement and increase in project cost; (3) After winning the bid, the government authority proposed changes to the project contract site.
	R19	Government decision-making risk	(1) The government's decision on forestry PPP is inconsistent and the effectiveness of the policy is difficult to guarantee; (2) The government deliberately ignored some shortcomings of the project in order to improve its own performance, and the evaluation of the project was too subjective.
	R110	Changes of policies, laws and rules	The previously promised policies and laws and regulations will change during the operation of the project.
	R111	Immature laws	(1) Rationality of project ownership: The government and social capital all want to own PPP project assets due to different considerations. Because there is no clear legal basis, the government and the enterprise often hold back in the negotiation process, making the project difficult to land. (2) The forestry ownership system is not perfect: China enacted the Forestry Law of the People's Republic of China in 1984 and revised it in 1998. The Forestry Law stipulates in principle that the legitimate rights and interests of the owners and users of forests, trees and woodlands shall be protected according to law, but there are no detailed rules on the rights and regulations for the possession, use, income and disposal (logging) of forests, trees and woodlands. (3) For a long time, China did not have a systematic legal and policy system in the fields of economic management such as investment and financing of forestry industry, which further increased the risk of investment in forestry industry. ④ Other relevant policies and laws and regulations are not perfect.
	R112	Project approval	Due to the complexity and difficulty of the process of PPP project licensing and approval, which takes too long, it brings risks to the normal operation of the project.
	R113	Choice of Social Capital	(1) The uncertainty of social capital selection method; (2) the bidding stage is not competitive enough (such as transparent bidding procedures, insufficient number of bidders, improper bidding practices), resulting in the inability to choose better partners; (3) the winning company did not thoroughly study the bidding documents, feasibility studies and other materials in the early stage, and the long negotiation process after winning the bid may lead to the indefinite delay and smooth implementation of the project.
G2 socio-economic risk	R21	Macroeconomics	Regional economy is unstable; global or local economic development is unfavorable.
	R22	Market and industry risks	(1) Risks arising from changes in demand due to market competition, macroeconomic factors, social environment or

Group	NO.	Risk Factor	Additional remarks
			demographic changes, etc.; (2) industrial management changes and related industries are unstable.
	R23	Inflation	If the inflation rate is lower than the level assumed in the financial model, the expected income and the specified rate of return thus achieved will be adversely affected.
	R24	Change of interest	The change of interest rate will directly affect the project financing cost.
	R25	Foreign exchange fluctuation	Exchange rate changes may affect financing costs in the refinancing process or affect cost accounting in Sino-foreign cooperation projects.
	R26	Horizontal competition	Competition risks brought by other similar projects approved by the government, such as eco-wetland tourism projects, etc.
	R27	Information asymmetry	Including the lack of regulations on xx information sharing between the two parties, the large information differences and conflicts between the parties involved, the unreliability of reference data, and insufficient mastery of engineering-related information.
	R28	Ecological civilization risk	(1) the promotion of similar tourism projects may lead to environmental degradation or have a negative impact on the surrounding original environment; (2) Environmental issues are sensitive, and improper application of pesticides and fertilizers is involved in forestry projects.
	R29	Public attitude ris	The following factors may lead the public to oppose PPP forestry projects: ① Land compensation, environmental impact and other issues that have not been properly resolved; (2) social conditions such as local social culture, local people's awareness of energy conservation and environmental protection, safety concept, social responsibility and other factors; (3) Local residents do not have a clear understanding of PPP project; (4) the impact of noise, pollution, transportation and construction on the interests of the surrounding people.
G3 financial risk	R31	Taxation risk	Risks brought by tax changes.
	R32	Financing and refinancing risk	(1) the project financing cost is high and difficult; (2) the limitation of refinancing technology; (3) unreasonable financing management of project investors; (4) the financial system is not perfect; ⑤ The financial market is sluggish; ⑥ The availability of private capital; ⑦ Narrow financing channels; ⑧ Excessive reliance on government subsidies and insufficient government funding.
	R33	revenue risk	(1) The project company's inaccurate prediction of market demand and the long-term investment return rate of the project lead to insufficient project income and difficult recovery of investment cost; (2) the income distribution is not reasonable enough; (3) The services provided by the project company cannot meet the needs of the government, so the government refuses to pay the fees, resulting in a reduction in the expected income.
	R34	Inadequate supervision of project funds	PPP projects involve many parties and bring great risks to the supervision of fund usage and performance.
	R35	Land expropriation	The actual construction cost and operating cost are higher than expected.
	R36	Deviation between project residual value and expected residual value	(1) the actual surplus value of the project is lower than the expectation; (2) the actual profit of the project is lower than the expectation; (3) the cost of residual value during the project is higher than the expectation.
G4 construction/operation risk	R41	Contract Terms and Allocation of Power and Responsibility	(1) Unreasonable contract design and vague clauses and disputes in the contract lead to unclear division of rights, responsibilities and obligations of both parties to the cooperation. In the process of project implementation, disputes arise due to mutual prevarication and wrangling, and the management scope and income distribution do not meet the expectations of both parties, thus affecting the overall implementation of the project; (2) Midway change and early termination of the contract; (3) labor relation disputes.
	R42	Creditworthiness of different stakeholders	This is mainly due to the lack of guarantee, bad creditibility, breach of contract or delay in the execution of the contract.
	R43	Long concession period	Long project cycle is one of the characteristics of PPP forestry projects. Although there are generally government feasibility gap subsidies in the process of project promotion, there are still some problems such as slow effect and unexpected requirement for

Group	NO.	Risk Factor	Additional remarks
			continuous investment, which will affect the smooth progress of forestry PPP projects. In addition, long-term projects without a good long-term mechanism will also cause problems in project operation and management.
	R44	Change of project company	Risks caused by reorganization or bankruptcy of the project company, change of the franchise company mode or shortening of the franchise period.
	R45	Inability of concessionaire	The project company may have risks such as lack of project management skills, low communication efficiency and deviation in determining the economic benefits of the project.
	R46	Lack of PPP experience	The standarized mode for PPP forestry projects are still in the exploratory stage. The government and social capital may have problems such as lack of management experience and decision-making ability, and lack of confidence in the benefits of the project itself.
	R47	Organization and coordination risk	Refers to the risk that the project participants, functional departments and project members are uncoordinated and the organizational structure is unreasonable, which affects the normal operation of the project organization.
	R48	Unavailability of the supporting facilities	The development of the project lacks the support of infrastructure such as transportation, electricity, water conservancy and site.
	R49	Deviation from expected targe	(1) the final effect of the project is not up to expectations, the quality of public services and projects is not up to standard, and the project cannot play its due role; (2) The project was delayed and failed to be completed within the expected time limit.
	R410	Project implementation risks	The project construction includes equipment and materials procurement, construction, trial operation and other aspects, and there may be problems such as poor project quality, process complexity, and blocked project construction process.
	R411	Technical risk	(1) the contractor does not have a comprehensive grasp of the application of new technologies, new materials and new equipment; (2) During the construction process, new requirements are put forward for green construction and environmental protection, making the construction technology more difficult; (3) The geological conditions in the north and south of China are quite different, the project has great regional characteristics, and the technology introduced by the project has not adjusted to local conditions; (4) The technical scheme of the project is immature, the technology is updated, and the operator does not have advanced technology level; (5) The large scale of the project involves a wide range of areas and is complicated to operate.
	C412	Project completion and transfer risk	(1) As the two parties failed to reach a consensus on the remaining issues during the signing, construction and operation of the contract, the project could not be handed over smoothly. (2) The complexity and controversy of the transfer of creditor's rights and stock rights of social capital will affect the smooth transfer of the project; (3) The project handover is affected due to the high deviation of the expected target of the project.
	C413	Operation risk	Due to improper operation and management, project operation and management problems such as poor project performance, over-high liabilities, increase in actual operation cost and maintenance cost appear.
	C414	Pricing risk	The price adjustment is inflexible, the charging standard and price adjustment mechanism are imperfect, and there are problems in pricing products and services.
	C415	Occurrence and emergency of objective events	The impact of the following factors on the implementation of the project: ① local rock and soil, climate and natural environment; (2) unexpected weather, natural disasters and diseases and insect pests; (3) major safety and quality accidents; (4) force majeure and other unforeseen circumstances.

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