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RISK ASSESSMENT OF THE IMPLEMENTATION OF PPP SCHEME IN NATURAL GAS NETWORK PROJECT FOR HOUSEHOLDS (CASE STUDY: NATURAL GAS NETWORK FOR HOUSEHOLDS IN BATAM CITY)

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ABSTRACT

The government is actively promoting the use of natural gas over petroleum through the Natural Gas Network for Households (Jargas) program. Due to budget limitations, Jargas development has been gradual, achieving 881,752 Household Connections (SR) by 2022. To accelerate progress, the government is utilizing a Public-Private Partnership (PPP) model, as outlined in the National Medium-Term Development Plan (RPJMN) 2020-2024. This plan targets the construction of 2.5 million SR under the PPP scheme, with Batam City earmarked for 307,749 SR. As this is the first application of the PPP model in Jargas development and no prior risk assessment exists, it is crucial to identify potential risks. This research aims to identify critical risks associated with the PPP scheme. The methodology includes qualitative and quantitative analyses. Initially, qualitative analysis identifies and ranks risks, followed by quantitative analysis using the fuzzy synthetic method to precisely evaluate high-risk levels and identify critical risks. The analysis revealed 91 potential risks, categorized as 17 high-level, 43 medium-high-level, 26 medium-level, and 5 low-level risks. The fuzzy quantitative analysis of high-level risks identified 10 critical risks: delays and cost increases in land acquisition, delays in permit issuance, project lender default, failure to obtain environmental approval, construction delays, extreme weather, rising construction costs, inflation and interest rate fluctuations, flood-prone land, and scope creep. These findings provide essential insights for managing and mitigating risks in Jargas development projects.

KEYWORDS *risk, critical risk, infrastructure, natural gas network for households, natural gas, PPP, fuzzy synthetic*

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INTRODUCTION

Since several years ago, the Government has tried to make various efforts to suppress the growth in fuel oil (BBM) use by switching to alternative energy in accordance with what is mandated in Government Regulation number 79 of 2014 concerning National Energy Policy. One of the Government's strategic steps to replace the use of petroleum is to increase the use of natural gas fuel for the household sector and small customers. This program is called the Natural Gas Network for Households or also known as Jargas. The construction of Gas Jars is one of the national priority programs which aims to diversify energy, reduce subsidies, and provide clean and cheap energy.

So far, Jargas construction has been carried out with funding from the APBN and also independent development by BUMN. Due to budget constraints, construction was carried out in stages. Based on data from the Directorate General of Oil and Gas, the Government with APBN funds has built Jargas since 2009 and by 2022 there will be 703,308 house connections (SR) distributed in 17 provinces and 57 districts/cities. Meanwhile, the total budget for APBN plus non-APBN reached 881,752 SR. In order to accelerate infrastructure development and increase funding efficiency, the Government is procuring Jargas infrastructure through Government and Business Entity Cooperation (KPBU). Based on the National Medium Term Development Plan (RPJMN) 2020-2024, Jargas development is targeted to reach 4 million SR either through the APBN, independent development by BUMN and the PPP scheme. Specifically for the PPP scheme, the Jargas construction target is 2.5 million SR. If we look at the funding indications, the budget allocated for the PPP scheme for city gas network infrastructure or Jargas for 4 million house connections is IDR. 38.4 trillion, where the indicated funding for Jargas infrastructure development using the PPP scheme is IDR. 27.4 trillion or reaching 71.35% of the total budget.

The large target for Jargas infrastructure development carried out through the PPP scheme opens up opportunities for Implementing Business Entities (BUP) to be involved. However, considering that this PPP scheme will be implemented for the first time in the construction of Jargas and there has been no risk study related to this, it is important to carry out a study that can describe potential risks, especially critical risks in the use of the Jargas PPP scheme. With this research, it is hoped that the parties involved in implementing the PPP will gain an overview of the risks involved in the PPP. Specifically, the objectives of this research include identifying potential risks that will be faced by BUP and PJPK in the PPP scheme for Jargas development and determining critical risks at the development and operation stages of Jargas infrastructure under the PPP scheme.

Natural Gas Network

According to Presidential Regulation no. 6 of 2019, what is meant by natural gas is the result of natural processes in the form of hydrocarbons which, under conditions of atmospheric pressure and temperature, are in the form of a gas phase obtained from the oil and gas mining process. Meanwhile, what is meant by natural gas transmission and/or distribution network for households or Jargas is a pipeline network built and operated for the supply and distribution of natural gas to households and small customers.

Until now, the construction of Jargas in Indonesia has never been carried out using a PPP scheme. The definition of PPP is cooperation between the Government and Business Entities in the provision of infrastructure and/or services for the public interest referring to specifications previously determined by the government, which partially or fully uses the resources of the business entity by taking into account the distribution of risks between the parties (kemenkeu.go .id). PPP is characterized by the sharing of investment, risks, responsibilities and rewards between the government and the private sector partners. All capabilities and assets from each party (public and private) are combined to produce a facility that is widely used by the general public. Wibowo and Mohamed (2010) conducted research related to the risks of water distribution PPP projects. The results of his research concluded that the unavailability of raw water, the entry of new competitors, increased construction costs, uncertainty in tariff settings, and contract violations by the government were the dominant risk factors in the water distribution PPP Project.

Critical Risk

Risk identification is the process of identifying, collecting information, and analyzing various factors that can cause loss, danger, or uncertainty in an activity or project. Risk identification aims to determine what risks can affect project objectives and document their characteristics (PMI, 2009). Broadly speaking, there are two ways to carry out risk analysis, namely quantitatively and qualitatively. Quantitative analysis is used for things that can be calculated mathematically, for example material losses, while qualitative analysis is used for things that cannot be calculated materially, for example disturbances to comfort in the community around the project. Qualitative risk prioritizes identified project risks using a predetermined rating scale. Risks will be assessed based on the probability or likelihood of their occurrence and their impact on project objectives if they occur (Project Management Institute, 2013). Further risk indices (levels) are combined in a risk matrix to provide a measure of risk severity. The risk matrix used is generally a risk matrix consisting of an array of 5 x 5 elements (Aloko, M.N. 2018). The risk matrix is usually divided into red, yellow, and green zones, representing large, medium, and small risk zones, respectively. The red zone is centered in the upper right corner of the risk matrix (high impact and high probability), while the green zone is centered in the lower left corner (low impact and low probability). An illustration of the risk matrix can be seen in Figure 1.

Figure 1. Illustration of the 5x5 Risk Matrix (Graves, R. 2000 in Aloko, 2018)

Quantitative risk analysis is a further analysis of qualitative risk analysis, where quantitative risk analysis is believed to provide probability values for costs and time (Project Management Institute, 2013). To conduct quantitative risk analysis requires high-quality data, a well-developed project model, and a prioritized list of project risks. One of the outputs of quantitative risk analysis is obtaining critical risks.

Critical risk is defined as an event or occurrence that has a very significant negative impact on the achievement of project objectives or can cause the failure of a project. A situation where if control is lost, project objectivity will not be achieved. In this study, analyzing the significance of risks by considering the combination of probability and impact of risks through qualitative analysis, then continues by identifying risks obtained through fuzzy synthetic quantitative analysis that have high significance as critical risks.

Method Fuzzy

Fuzzy theory was first introduced by Prof L.A Zadeh in 1965. Fuzzy means vague or opaque and uncertain. This theory emerged because the concept of Boolen's Logic (1854) only recognized binary terms which were considered unable to describe human perception. Binary logic only provides two possible values, namely 0 (not a member) or 1 (a member) which are determined using a certain membership function. A membership function is a function that pairs each member of a set with a degree of membership or can be called a degree of membership in the form of a number in the range between 0 and 1. In fuzzy logic theory, a value can be true or false simultaneously. The advantage of fuzzy-based methods over probabilistic approaches to risk assessment is their ability to handle unclear and imprecise data, treat uncertainty arising from the subjective nature of assessment experts (lexical uncertainty), treat uncertainty associated with a small number of observations, etc.

Fuzzy Synthetic Method

There are developments in the fuzzy method by introducing the fuzzy synthetic evaluation method which will be used in this research. This method has been used in several project risk identification studies. Fuzzy synthetic evaluation aims to provide a simple and definite risk assessment (Wu and Zhou, 2019). Fuzzy synthetic evaluation can overcome the problem of ambiguity of some factors in the risk assessment process by converting qualitative evaluation into quantitative evaluation through linguistic expressions (Akter et al., 2019 and Jiang et al., 2009). In general, the aim of applying the fuzzy synthetic method in solving various construction cases includes evaluating and prioritizing risks (critical risk) which affects project objectivity for subsequent mitigation. Fuzzy synthetic evaluation is carried out only to assess high risk levels to obtain critical risks that most contribute to increasing overall project risk. In this research, the fuzzy synthetic method contributes to getting a more detailed assessment of the actual perceptions of respondents, allowing for a more real analysis so as to provide a more real decision on the object of study under review. Figure 2 shows flow chart the fuzzy synthetic method used in this research.

The synthetic fuzzy risk assessment model consists of 3 (three) basic elements as follows:

1. The set of criteria or basic factors, in this analysis is defined as R= r_1, r_2, r_3, and so on or the assessment of a risk being reviewed.
2. The alternative set (j), is the respondent's rating scale.
3. Form an evaluation matrix $R = (r_{ij})_{mxn}$.

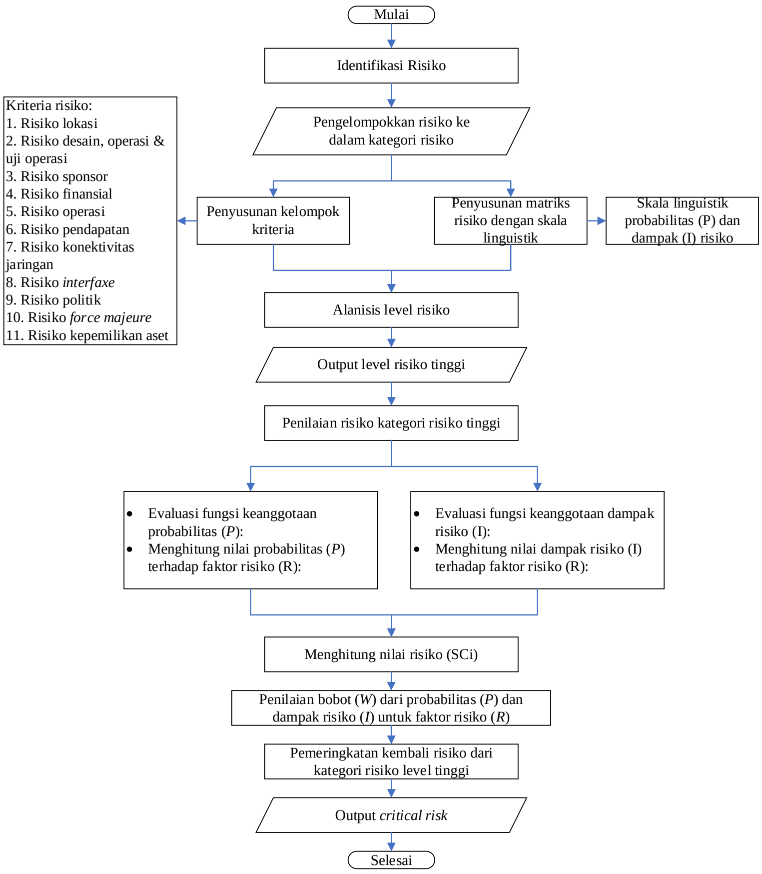

Figure 2. Fuzzy Synthetic Stages

Using the collected probability and impact values for high level risk factors an evaluation matrix is formed $R = (r_{ij})_{mxn}$. A matrix is formed to evaluate the membership function. Element r_{ij} from the evaluation matrix R presents the level of that alternative ij (membership function) meets the risk factors i, Where m is the sum of risks and n is the number of alternatives. The membership function is evaluated to check whether it corresponds to the degree of membership in the form of a number in the interval between 0 to 1. Probability membership function (P) and impact membership function (I) can be seen in equations (1) and (2).

$$(R_i^P)_{1x5} = (r_{ij1}^P, r_{ij2}^P, r_{ij3}^P, r_{ij4}^P\ r_{ij5}^P) \quad (1)$$

$$(R_i^I)_{1x5} = (r_{ij1}^I, r_{ij2}^I, r_{ij3}^I, r_{ij4}^I\ r_{ij5}^I) \quad (2)$$

Each alternative in the set is then given a linguistic scale rating: sj = (1, 2, 3, 4, 5). In each risk factor is given a symbol R then the membership function is in the form of multiplying the linguistic scale of probability or risk impact with the membership function. This value is defined as a factor value. The factor value is used to obtain the probability factor risk value or impact of the risk being reviewed. Furthermore, P and I Risk factors are calculated using the following equation.

$$P_i = \sum_{i=1}^{5} sj\ x\ r_{ij}^P \quad (3)$$

$$I_i = \sum_{i=1}^{5} sj\ x\ r_{ij}^I \quad (4)$$

Next is the risk score (SC) is rated as a product of P and I according to equation (5). The risk score is used to obtain risk results in terms of the influence of the elements of probability and risk impact.

$$SC_i = \sqrt{P_i\ x\ I_i} \quad (5)$$

After value P, I, and SC estimated for each risk factor, the next step is to determine the weight of each risk factor. Risk weight (IN) is analyzed to find out how much influence each risk has. Weight for P of risk factors i estimated by equation (6) with value k is the number of risk factors in the risk category.

$$W_i^P = \frac{P_i}{\sum_{i=1}^{k} P_i} \quad (6)$$

After obtaining the risk value results and the weight of each risk, the calculation is then carried out by ranking the risks which are calculated using range values. The results of the range are the maximum and minimum risk values. The maximum value of the risk rating is defined as critical risk.

Previous Research

There have been several previous studies related to risk management in projects with PPP schemes, including Palupie, Y.M.R. and Yuniarto, H.A. (2016) who conducted research with the aim of analyzing risk allocation in infrastructure projects with a PPP scheme in previous studies. The research method used was a literature study regarding risk allocation in PPP projects. In this research, the author discusses various risks in PPPs which can be allocated to the government, private sector, or borne jointly by both parties. From the results of the literature study, there are 23 types of risks in infrastructure projects with a PPP scheme. The ten main risks that must be allocated appropriately include: (1) financial and economic risks; (2) design and construction risks; (3) operational and maintenance risks; (4) political risk; (5) risk of force majeure; (6) legal and policy risks; (7) income risk; (8) environmental risks; (9) risk of project/contract failure; and (10) land acquisition risks. Of the 10 risks, the risks allocated to the government include political risk, legal risk and land acquisition risk. The private party bears design and construction risks, operational and maintenance risks, and revenue risks. Risks that must be shared between the government and the private sector include financial risks, force majeure risks, environmental risks, and the risk of project/contract failure.

RESEARCH METHOD

The approach used in this research is quantitative analysis and qualitative analysis or what is usually called mixed method. Mixed method is a combination and integration of quantitative and qualitative approaches in the same study (Azorin, 2016). The research framework is explained through a description of the background underlying this research, the research objectives to be achieved, the analytical methods used and the expected study results. The research framework can be seen in Figure 3.

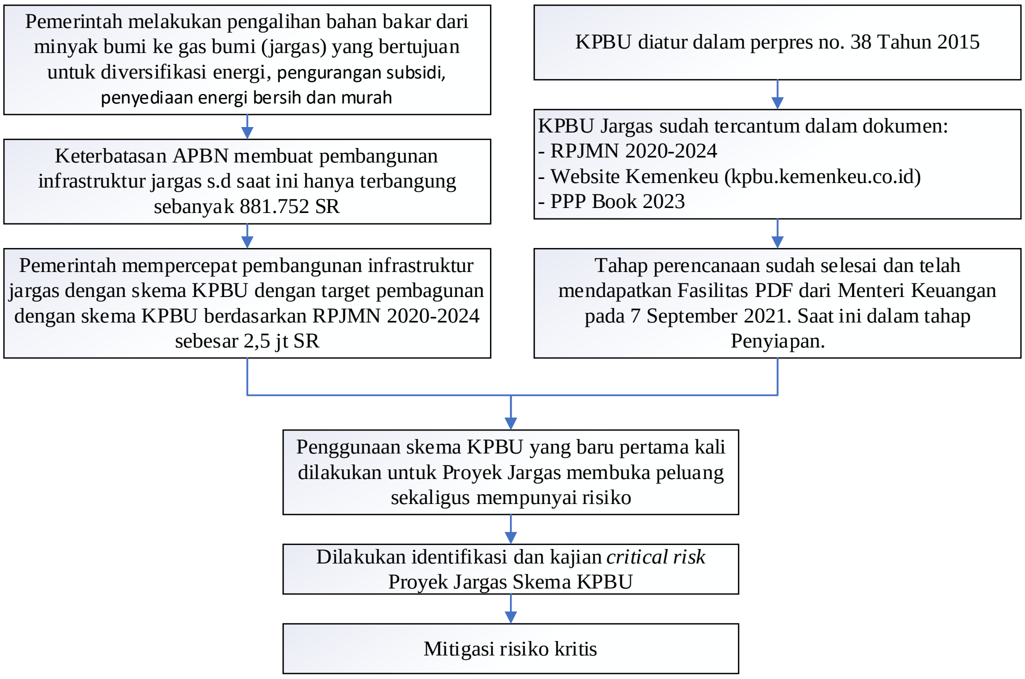

Figure 3. Conceptual Framework

In order to make it easier to carry out the research stages, details of the activity stages are needed which are outlined in the form of a research flow diagram. The research flow diagram can be seen in Figure 4.

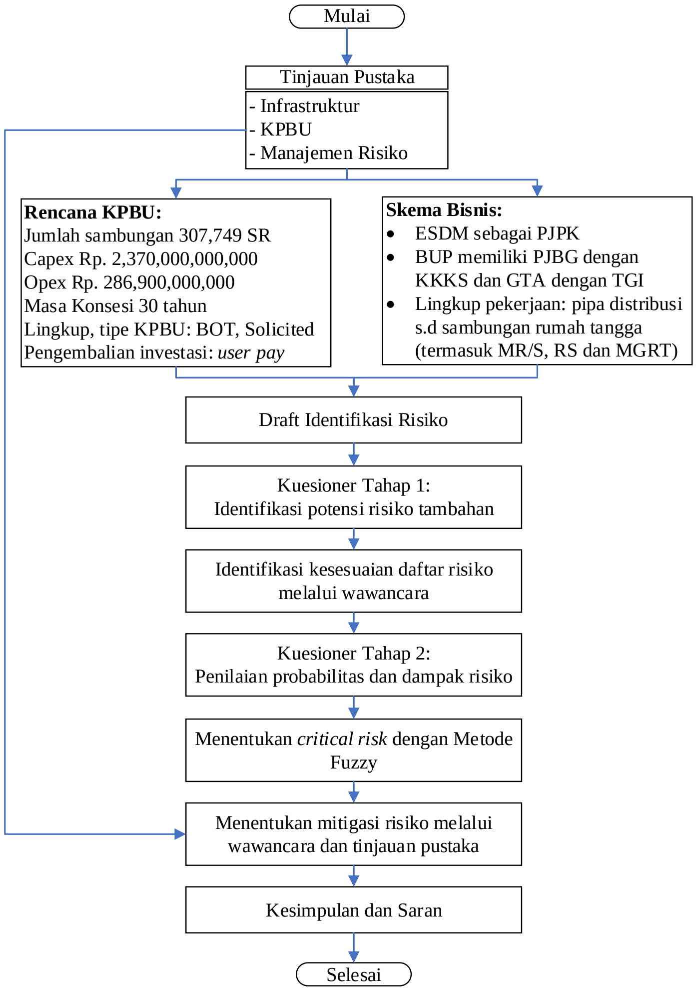

Figure 4. Research Flow Chart

RESULT AND DISCUSSION

Technical Data

Based on data from kpbu.kemenkeu.go.id and PPP Book, general information regarding the Natural Gas Network for Households in Batam City is as follows:

Project Name	:	Construction of a Natural Gas Distribution Network for Households Using the Batam City PPP Scheme
Number of Connections	:	307,749 Home Extension
Capex Value	:	Rp. 2,370,000,000,000
Opex value	:	Rp. 286,900,000,000
PJPK	:	Minister of Energy and Mineral Resources
Province	:	Riau islands
City	:	Batam
Sector	:	Oil and gas and renewable energy including bio energy
Status	:	Setup
Construction Period	:	1 year

Concession Time	:	30 years (1 year construction period and 29 years operation period)
Return on Investment	:	Payment by the User in the form of a tariff
PPP Type	:	Solicited
Scope of PPP	:	Build, Operate, and Transfer (BOT)
Project Scope	:	Construction of distribution pipes from transmission pipes to household connections (including supporting installations such as Meter Regulating Station (MR/S), Regulating Station (RS), and Household Meters).
IRR	:	In the calculation process
NPV	:	In the calculation process
Information	:	The project has received PDF Facilities from the Minister of Finance on September 7 2021
Executive Body	:	Directorate General of Oil and Gas

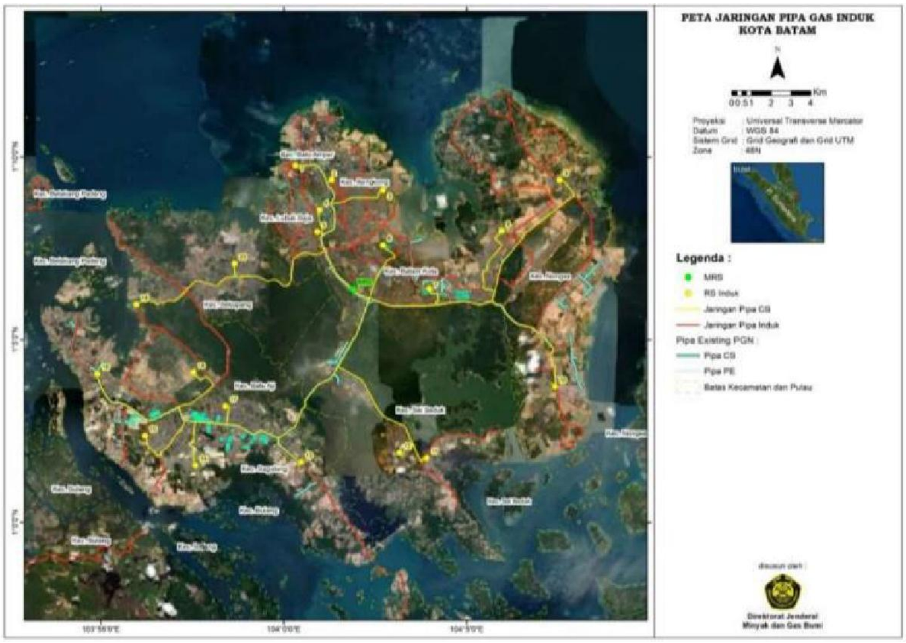

Figure 4. Batam City Gas Jar Layout (PPP Book 2023)

The business scheme that will be implemented, BUP will have a Gas Sales and Purchase Agreement (PJBG) with the Cooperation Contract Contractor (KKKS). Apart from that, BUP will also have a Gas Transportation Agreement (GTA) or agreement with the Transmission Pipe Owner Business Entity.

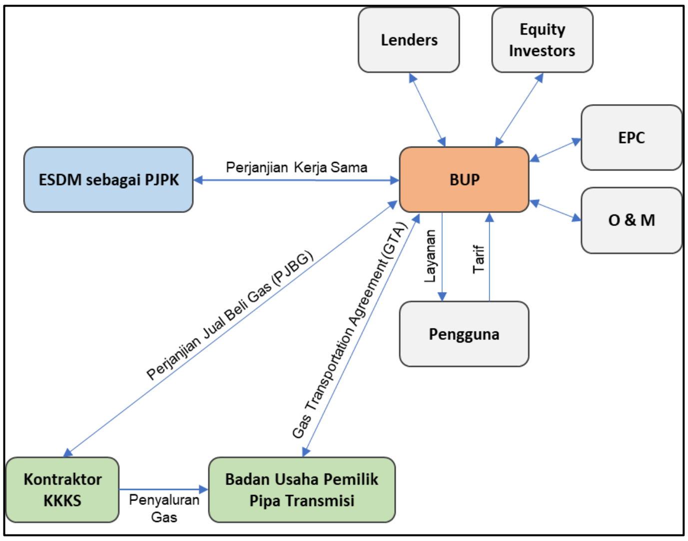

Figure 5. Business Scheme Plan

Respondent Data

Respondents who participated in this research were 16 (sixteen) people consisting of 2 (two) representatives of the PJPK (Ministry of Energy and Mineral Resources) and 14 (fourteen) representatives of BUP. There were 10 respondents who participated in filling out the stage 1 questionnaire and there were 11 respondents who participated in filling out the stage 2 questionnaire. 70% of respondents to the stage 1 questionnaire had more than 10 years of experience in the construction sector, while in the stage 2 questionnaire, there were 55% of respondents who had experience of more than 10 years.

Stage 1 Questionnaire

The questionnaire distributed to respondents represents every party who has capabilities in the infrastructure sector and also knows about PPP. The distribution of this questionnaire was carried out to determine the existence of other potential risks outside the risk matrix for the oil and gas sector contained in the PPP Risk Allocation Reference book in Indonesia published by PT. Indonesian Infrastructure Guarantee (Persero). The risk list was then distributed to respondents for study and then a questionnaire was conducted to respondents to provide input if there were other potential risks that might occur but were not yet listed in the risk reference. Based on the results of the stage 1 questionnaire, an additional 18 potential risks were obtained, bringing the total risk to 91.

Stage 2 Questionnaire

Stage 2 of the questionnaire is to fill in the scale of possibility and magnitude of risk impact carried out by respondents representing the PJPK, BUP and people who have experience in infrastructure projects, especially gas pipeline infrastructure. The assessed risk list is a combination of PII risk references with an additional risk list based on the results of the stage 1 questionnaire which has been validated by experienced practitioners.

Risk Level Analysis

The results of the analysis of 91 risk lists assessed by respondents showed that the maximum average value was 15.55 and the minimum average value was 4.82. Next, range value calculations are carried out to group risk levels. The range value is the difference between the maximum average and minimum average, namely 15.55 – 4.82 = 10.73. Then the range value is divided by 4 according to the number of risk levels, namely high, medium high, medium and low. So the level limit value obtained is 10.73 / 4 = 2.68. The risk levels from the risk factor analysis are shown in Table 1.

Table 1. Risk Level Limit Value

No	Average Limit		Risk Level	Amount Risk	Response to Risk
	Down	Top			
1	12.86	15.55	High (H)	17	Intolerable/Intolerable
2	10.18	12.86	Medium High (M*)	43	Undesirable/Undesirable
3	7.50	10.18	Medium (M)	26	Tolerable/Tolerable
4	4.82	7.50	Low (L)	5	Negligible/Can be ignored

From the results of the risk level analysis of the range values, it was found that 17 risks were classified as risk level categories high, 43 risks medium high, 26 risks medium and 5 risks low. Next, a sharper analysis is carried out on high level risks/high.

Table 2. High Level Risk/high

Code	Risk	Rate-rate Risk Value	Risk Level
R1	Delays and increases in land acquisition costs	15.55	H
R2	Land cannot be acquired	13.09	H
R6	Risk of failure to obtain environmental approval	14.82	H
R10	Disturbing the comfort of the community around the project area	13.27	H
R14	Delay in issuing permits	14.36	H
R15	The location includes private property	12.91	H
R16	Flooded land	13.45	H
R20	Delay in completion of construction	13.73	H
R21	Increase in construction costs	13.82	H
R22	BUP's poor performance	13.36	H
R29	Project lender default	14.55	H
R35	Inflation and interest rate risks	13.18	H

R39	Scope creep	13.27	H
R54	Risk of stopping facility operations due to unforeseen factors	13.09	H
R85	Extreme weather	13.36	H
R86	Pandemic	13.55	H
R89	Transfer of assets after the PPP contract ends	12.91	H

Quantitative analysis is calculated using the fuzzy synthetic analysis method, where the risk assessment in linguistic attributes is translated into numerical variables. This analysis was carried out only on the 17 high level risks shown in Table 2. Summarized from research by Andric et al (2019) and Jiskani et al (2020), the risk assessment stages of risk factors are as follows:

Membership Value

The initial stage of calculating the membership value is to group probability and impact data from the results of the stage 2 questionnaire which are classified as high level risk.

Table 3. High Level Probability and Impact Assessment Data

	R 1		R 2		R 6		R 10		R 14		R 15		R 16		R 20		R 21		R 22		R 29		R 35		R 39		R 54		R 85		R 86		R 89	
	P	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*	*P*	*I*
S1	5	5	5	4	5	5	4	4	5	5	4	4	3	4	4	4	5	5	4	5	5	5	4	5	4	5	4	4	5	4	5	4	4	4
S2	1	2	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	3	1	2	2	2	1	2	1
S3	1	1	5	5	5	5	5	4	1	5	5	4	5	5	3	5	5	5	3	5	4	4	4	2	5	2	5	3	5	5	5	5	3	5
S5	3	4	3	4	2	4	3	3	4	4	3	5	2	4	4	4	4	4	3	4	4	4	3	4	4	4	3	3	4	4	2	3	3	3
S10	4	4	4	4	2	4	1	4	3	4	2	4	4	4	3	4	3	3	4	2	4	2	4	4	3	4	2	4	4	3	4	3	4	4
S11	5	4	4	4	5	5	5	5	5	5	5	5	5	5	3	4	3	2	3	4	2	4	5	5	3	4	5	5	4	4	3	4	4	3
S12	4	4	2	2	3	5	2	3	4	4	4	3	4	4	5	3	3	4	5	4	5	3	5	2	5	5	5	3	3	4	4	5	5	4
S13	5	4	4	4	4	4	5	4	5	5	3	3	4	4	5	4	4	5	3	5	5	5	4	4	2	4	4	3	5	4	4	3	4	5
S14	3	3	2	2	3	2	4	2	4	3	1	1	3	3	3	3	2	4	2	2	2	3	2	2	4	3	3	4	3	3	3	3	4	3
S15	5	5	4	2	5	5	4	3	4	4	5	5	5	3	5	5	5	4	5	4	4	5	5	5	4	5	5	5	2	4	5	5	4	4
S16	5	5	5	4	3	3	5	5	5	1	2	5	5	1	5	2	5	2	5	4	4	5	1	5	2	5	2	2	5	1	2	3	1	4

By using probability data (P) and impact (I) in Table 3, the probability membership values are obtained as in Table 4 and impact membership values as in Table 5.

Table 4. Probability Membership Value

Risiko	1	Nilai Keanggotaan	2	Nilai Keanggotaan	3	Nilai Keanggotaan	4	Nilai Keanggotaan	5	Nilai Keanggotaan
R 1	2	0.18	0	0.00	2	0.18	2	0.18	5	0.45
R 2	1	0.09	2	0.18	1	0.09	4	0.36	3	0.27
R 6	1	0.09	2	0.18	3	0.27	1	0.09	4	0.36
R 10	2	0.18	1	0.09	1	0.09	3	0.27	4	0.36
R 14	2	0.18	0	0.00	1	0.09	4	0.36	4	0.36
R 15	2	0.18	2	0.18	2	0.18	2	0.18	3	0.27
R 16	1	0.09	1	0.09	2	0.18	3	0.27	4	0.36
R 20	1	0.09	0	0.00	4	0.36	2	0.18	4	0.36
R 21	1	0.09	1	0.09	3	0.27	2	0.18	4	0.36
R 22	1	0.09	1	0.09	4	0.36	2	0.18	3	0.27
R 29	1	0.09	2	0.18	0	0.00	5	0.45	3	0.27
R 35	1	0.09	2	0.18	1	0.09	4	0.36	3	0.27
R 39	1	0.09	2	0.18	2	0.18	4	0.36	2	0.18
R 54	0	0.00	2	0.18	3	0.27	2	0.18	4	0.36
R 85	0	0.00	2	0.18	2	0.18	3	0.27	4	0.36
R 86	0	0.00	3	0.27	2	0.18	3	0.27	3	0.27
R 89	1	0.09	1	0.09	2	0.18	6	0.55	1	0.09

Table 5. Impact Membership Value

Risiko	1	Nilai Keanggotaan	2	Nilai Keanggotaan	3	Nilai Keanggotaan	4	Nilai Keanggotaan	5	Nilai Keanggotaan
R 1	1	0.09	1	0.09	1	0.09	5	0.45	3	0.27
R 2	0	0.00	3	0.27	1	0.09	6	0.55	1	0.09
R 6	1	0.09	1	0.09	1	0.09	3	0.27	5	0.45
R 10	1	0.09	1	0.09	3	0.27	4	0.36	2	0.18
R 14	2	0.18	0	0.00	1	0.09	4	0.36	4	0.36
R 15	2	0.18	0	0.00	2	0.18	3	0.27	4	0.36
R 16	2	0.18	0	0.00	2	0.18	5	0.45	2	0.18
R 20	1	0.09	1	0.09	2	0.18	5	0.45	2	0.18
R 21	1	0.09	2	0.18	1	0.09	4	0.36	3	0.27
R 22	1	0.09	2	0.18	0	0.00	5	0.45	3	0.27
R 29	1	0.09	1	0.09	2	0.18	3	0.27	4	0.36
R 35	0	0.00	4	0.36	0	0.00	3	0.27	4	0.36
R 39	1	0.09	1	0.09	1	0.09	4	0.36	4	0.36
R 54	1	0.09	1	0.09	4	0.36	3	0.27	2	0.18
R 85	1	0.09	1	0.09	2	0.18	6	0.55	1	0.09
R 86	1	0.09	0	0.00	5	0.45	2	0.18	3	0.27
R 89	1	0.09	0	0.00	3	0.27	5	0.45	2	0.18

Factor Value

At this stage the membership value is calculated using the previous assessment scale using equations (3) and (4) to obtain the probability risk factor value and impact risk value for each risk variable being reviewed. The calculation results are displayed on Table 6 and Table 7.

Table 6. Probability Risk Factor Value

Risiko	1	Nilai Keanggotaan	2	Nilai Keanggotaan	3	Nilai Keanggotaan	4	Nilai Keanggotaan	5	Nilai Keanggotaan	ΣResponden	Nilai Faktor
R 1	2	0.18	0	0.00	2	0.18	2	0.18	5	0.45	11	3.73
R 2	1	0.09	2	0.18	1	0.09	4	0.36	3	0.27	11	3.55
R 6	1	0.09	2	0.18	3	0.27	1	0.09	4	0.36	11	3.45
R 10	2	0.18	1	0.09	1	0.09	3	0.27	4	0.36	11	3.55
R 14	2	0.18	0	0.00	1	0.09	4	0.36	4	0.36	11	3.73
R 15	2	0.18	2	0.18	2	0.18	2	0.18	3	0.27	11	3.18
R 16	1	0.09	1	0.09	2	0.18	3	0.27	4	0.36	11	3.73
R 20	1	0.09	0	0.00	4	0.36	2	0.18	4	0.36	11	3.73
R 21	1	0.09	1	0.09	3	0.27	2	0.18	4	0.36	11	3.64
R 22	1	0.09	1	0.09	4	0.36	2	0.18	3	0.27	11	3.45
R 29	1	0.09	2	0.18	0	0.00	5	0.45	3	0.27	11	3.64
R 35	1	0.09	2	0.18	1	0.09	4	0.36	3	0.27	11	3.55
R 39	1	0.09	2	0.18	2	0.18	4	0.36	2	0.18	11	3.36
R 54	0	0.00	2	0.18	3	0.27	2	0.18	4	0.36	11	3.73
R 85	0	0.00	2	0.18	2	0.18	3	0.27	4	0.36	11	3.82
R 86	0	0.00	3	0.27	2	0.18	3	0.27	3	0.27	11	3.55
R 89	1	0.09	1	0.09	2	0.18	6	0.55	1	0.09	11	3.45

Table 7. Impact Risk Factor Value

Risiko	1	Nilai Keanggotaan	2	Nilai Keanggotaan	3	Nilai Keanggotaan	4	Nilai Keanggotaan	5	Nilai Keanggotaan	ΣResponden	Nilai Faktor
R 1	1	0.09	1	0.09	1	0.09	5	0.45	3	0.27	11	3.73
R 2	0	0.00	3	0.27	1	0.09	6	0.55	1	0.09	11	3.45
R 6	1	0.09	1	0.09	1	0.09	3	0.27	5	0.45	11	3.91
R 10	1	0.09	1	0.09	3	0.27	4	0.36	2	0.18	11	3.45
R 14	2	0.18	0	0.00	1	0.09	4	0.36	4	0.36	11	3.73
R 15	2	0.18	0	0.00	2	0.18	3	0.27	4	0.36	11	3.64
R 16	2	0.18	0	0.00	2	0.18	5	0.45	2	0.18	11	3.45
R 20	1	0.09	1	0.09	2	0.18	5	0.45	2	0.18	11	3.55
R 21	1	0.09	2	0.18	1	0.09	4	0.36	3	0.27	11	3.55
R 22	1	0.09	2	0.18	0	0.00	5	0.45	3	0.27	11	3.64
R 29	1	0.09	1	0.09	2	0.18	3	0.27	4	0.36	11	3.73
R 35	0	0.00	4	0.36	0	0.00	3	0.27	4	0.36	11	3.64
R 39	1	0.09	1	0.09	1	0.09	4	0.36	4	0.36	11	3.82
R 54	1	0.09	1	0.09	4	0.36	3	0.27	2	0.18	11	3.36
R 85	1	0.09	1	0.09	2	0.18	6	0.55	1	0.09	11	3.45
R 86	1	0.09	0	0.00	5	0.45	2	0.18	3	0.27	11	3.55
R 89	1	0.09	0	0.00	3	0.27	5	0.45	2	0.18	11	3.64

Next, the risk value or score is calculated (SC) using equation (5) and calculating the weight of each risk using equation (6) with calculation results as in Table 8.

Table 8. Risk Value and Weight

Code Risk	Assess Risk Factors		Risk Value (SC)	Risk Weight
	Probability	Impact		
R 1	3.73	3.73	**3.73**	**0.0611**
R 2	3.55	3.45	**3.50**	**0.0574**
R 6	3.45	3.91	**3.67**	**0.0602**
R 10	3.55	3.45	**3.50**	**0.0574**
R 14	3.73	3.73	**3.73**	**0.0611**
R 15	3.18	3.64	**3.40**	**0.0558**
R 16	3.73	3.45	**3.59**	**0.0588**
R 20	3.73	3.55	**3.64**	**0.0596**
R 21	3.64	3.55	**3.59**	**0.0589**
R 22	3.45	3.64	**3.54**	**0.0581**
R 29	3.64	3.73	**3.68**	**0.0603**
R 35	3.55	3.64	**3.59**	**0.0589**
R 39	3.36	3.82	**3.58**	**0.0587**
R 54	3.73	3.36	**3.54**	**0.0580**
R 85	3.82	3.45	**3.63**	**0.0595**
R 86	3.55	3.55	**3.55**	**0.0581**
R 89	3.45	3.64	**3.54**	**0.0581**

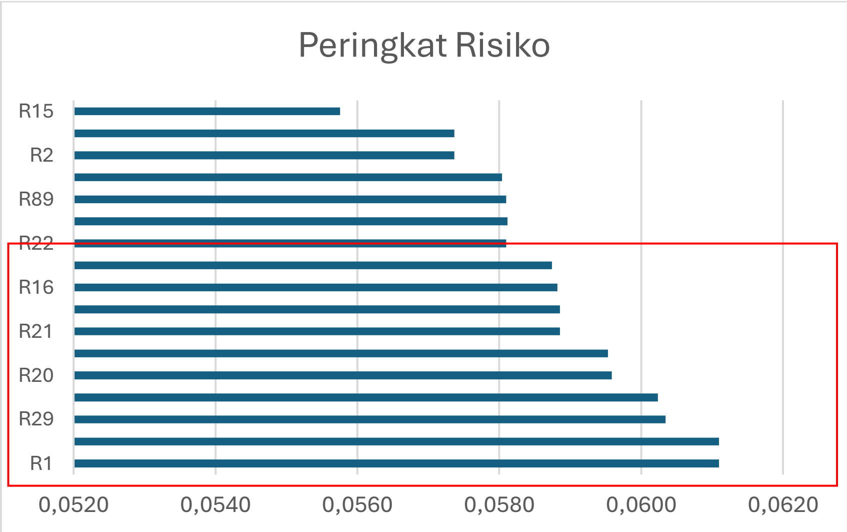

Figure 6. Risk Level

Based on calculations using the fuzzy analysis method which can also be seen from the risk ranking on Figure 6 10 critical risks were obtained, namely delays and increases in land acquisition costs (R1), delays in issuing permits (R14), project lender defaults (R29), failure to obtain environmental approvals (R6), delays in completing construction (R20), extreme weather (R85). , increase in construction costs (R21), risk of inflation and interest rates (R35), land flooding (R16), scope creep (R39).

CONCLUSION

The study identified 91 potential risks through literature reviews and interviews. After qualitative analysis, these risks were categorized into four levels: 17 high-level risks, 43 high/medium-high risks, 26 medium risks, and 5 low-level risks. From the high-level risks, a more detailed fuzzy quantitative analysis was conducted, pinpointing 10 critical risks. These include delays and cost increases in land acquisition (R1), permit issuance delays (R14), project lender defaults (R29), failure to obtain environmental approval (R6), late construction completion (R20), extreme weather (R85), rising construction costs (R21), inflation and interest rate fluctuations (R35), land flooding (R16), and scope creep (R39).

The findings highlight the most significant threats requiring mitigation, particularly in land acquisition, regulatory approvals, financial risks, and external factors like weather and economic conditions. By prioritizing these critical risks, stakeholders can develop targeted strategies to enhance project stability and reduce potential disruptions. This structured risk assessment provides a clear framework for proactive risk management in similar projects.

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