A FUZZY SET THEORY FOR RISK ALLOCATION IN PUBLIC PRIVATE PARTNERSHIP LOW-COST APARTMENT PROJECTS (CASE STUDY: SURABAYA METROPOLITAN AREA)

Farida Rachmawati
PhD student, Institut Teknologi Sepuluh Nopember
Email: farida_rahma@ce.its.ac.id

Ria A. A. Soemitro &
Tri Joko Wahyu Adi
Associate Professor
Institut Teknologi Sepuluh Nopember
Email: ria@ce.its.ac.id ; trijokowahyuadi@gmail.com

ABSTRACT

Risk regarding financial and operation maintenance are the reasons why the private sector do not interest to involve in the low-cost apartment provision. Equitable allocation of risks between the government and the private sector using the quantitative approach is essential to the success of partnership projects, especially in operation contract. This paper aims to identify risk allocation for partnership risks and to develop fuzzy risk allocation for shared risk using a fuzzy synthetic evaluation model for determining an equitable risk allocation between the government and the private sector. Five critical risk allocation criterias (RACs) that evaluate the risk carrying capability of project participants were further identified, validated, and compiled based on the respondents via face-to-face interviews. A set of knowledge-based fuzzy inference rules was then established to set up the membership function for the five RACs. Based on the research findings, of all 27 risk factors, 5 risk factors to be shared between the public and private sector, namely High government subsidies, Inhabitant conflict, Community support, Low-income group difficulties, and Land acquisition. While 10 risk factors are allocated to private sectors and 12 risk factors are allocated to the public sectors.

Keywords: Risk allocation, partnership, low-cost apartment, Surabaya Metropolitan Area

INTRODUCTION

In Indonesia, low-cost apartment development is one of Government's priorities program in housing provision to reduce housing backlog due to scarcity and high price of land. The existing low-cost apartments (strata-title housing) were always built by the Ministry of Public Works and the Ministry of Public Housing in local government's asset land (Act no 20/2011, article 17). Considering that government funds and resources to construct and operate low-cost apartmentsare limited, the private sector can contribute toward operation and maintenance of such apartments through certain scheme. The scheme might be in the form of Build Operate Transfer (BOT) or contract management. In the Surabaya Metropolitan Area (SMA), there are 33 low-cost apartments constructed over government's asset land and four of them are managed by East Java Province Government. A majority of the low-cost apartments in SMA is constructed by the Indonesian Ministry of PUPR with the local government assuming the authority for managing these low-cost apartments (Ministry of Public Works, 2012).

In Surabaya Metropolitan Area, there are eight low-cost apartment which involve the private sector in their provision or operation, but the interaction is limited on the land rental or initial investment, while all the risks and problems are allocated to the government (Rachmawati et al, 2016). On the other hand, the number of industrial estate is potential to initiate the partnership between local government and private sector to develop low-cost apartment. Private sector may contribute in investing, constructing and operating. But, there are uncertainties face the public private partnership implementation. Financial schemes regarding investment returns are one of the reasons why private sector have not been interested in involving themselves in such partnerships (Rachmawati et al, 2016; Dwijendra, 2013).

In low-cost apartment projects, financial problems are generated by low rental price and the ability of low-income group to pay (Rachmawati et al, 2015a). Low-cost apartment is dedicated for low-income group, which rental price might not be determined high and the government is not willing to raise it as there is limitation on tariff (Li et al, 2005, Minister of Public Housing Regulation no 18/2007). A research has specifically defined that factor as one of partnership risks in low-cost apartment projects (Rachmawati et al, 2015b). This study also makes a point that appropriate risk allocation and risk sharing is the important factor for the successful partnership. Therefore, in order to ensure fair risk allocation, it is thus essential for public clients and private bidders to evaluate all of potential risks throughout the whole project life by paying particular attention to the procurement process while negotiating PPP contracts.

Basically, for social partnerships, wherein the profit is limited, the risk and authority is to be shared equally. Risk is to be allocated to the party that is most prepared to address the problems (Ke et al., 2010). Some risk analysis research has been conducted in Hong Kong (Ke et al, 2010), China (Chan et al, 2011), and the United Kingdom (Ke et al, 2011) including risk

allocation studies in some infrastructure projects. The first stage of risk management is risk identification, which includes the recognition of potential project risk event conditions and clarification of risk responsibilities. Then, risk allocation and risk response are determined.

This paper focuses on risk allocation between public and private sector using fuzzy set theory. This study might be different to previous other studies as it uses the residential property specifically proposed for low-income groups, therefore the risk factors and risk allocation would be different as well. Partnership for low-cost apartments is a form of social partnership as it is the government's program for low-income individuals. The paper adopts the fuzzy set theory which relates to quantification and reasoning of natural language to create a risk allocation model. In general, this present study has two objectives. First, it aims to review the risk allocation criteria. Second, the study intends to provide quantitative model for risk allocation process. This study is expected to contribute in guiding public and private sector in risk management decision making in low-cost apartment projects under partnership agreement, so that the problem of misallocation of risk and conflicts could be addresses.

RISK ALLOCATION IN LOW-COST APARTMENT PROJECT

Number of previous research studies on critical success factor in PPP projects, claimed that risk allocation is significant factor. A study from China pointed out that these risks arise from multiple sources including capital budget, construction time, construction cost, operation cost, politics and policies, market conditions, cooperation credibility, and economic environment (Chan et al, 2011). While another study analysed that the major risks are government's intervention; (2) poor political decision making; (3) financial risk; (4) government's reliability; (5) market demand change; (6) corruption; (7) subjective evaluation; (8) interest rate; (9) immature juristic system; and (10) inflation.

The risk identification and its allocation are obviously varied from project to project. They also depend on the actual project structure and contractual arrangement. (Karim, 2011). A study on risk identification in the low-cost apartment projects in Indonesia pointed out that risks facing the implementation of low-cost apartment development projects are: (1) shareholder commitment; (2) inadequate distribution of responsibilities and risk; (3) changes in tariffs and tax regulations; (4) poor public decision-making process; (5) land availability; (6) higher maintenance and operation cost; (7) limitations on housing financier support; (8) low-income group ability to pay. The risk used in this study are listed as follows:

Table 1. Risk factors

No	Risk	References
Policy and law		
1	Law and policy changes	Trangkanont & Charoenngam, 2014; Li et al, 2001; Wibowo & Alfen, 2014
2	Poor public decision-making process	Ke et al, 2011; Li et al, 2001
3	Shareholder commitments	Preliminary survey
4	Inadequate distribution of responsibility and risk	Preliminary survey
5	Incapable concessionaire	Ke et al, 2011; Li et al, 2001
6	Change in tariffs/tax regulations	Wibowo & Alfen, 2014
7	Corruption and low law enforcement	Ke et al, 2011; Li et al, 2001; Wibowo & Alfen, 2014
Economic		
8	Interest rate volatility	Ke et al, 2011; Li et al, 2001
9	Inflation rate volatility	Ke et al, 2011; Li et al, 2001
10	High government subsidies	Preliminary survey
Operational		
11	Operational cost overrun	Ke et al, 2011; Li et al, 2001
12	Higher maintenance cost	Li et al, 2001
13	Availability of facilities and utilities	Preliminary survey
14	Availability of qualified human resources	Preliminary survey
15	Inhabitant conflict	Preliminary survey
16	Community support	Preliminary survey
17	Tariff regulations	Preliminary survey
18	Low-income group difficulties	Preliminary survey; Trangkanont & Charoenngam, 2014
19	Low return of investment	Preliminary survey
Project Finance/Sponsor		
20	Limitation of housing finances	Trangkanont & Charoenngam, 2014; Preliminary survey
21	Lack of government guarantees	Li et al, 2001
Design and Construction		
22	Construction time delay	Ke et al, 2011
23	Building quality	Preliminary survey
Location		
24	Land acquisition	Ke et al, 2011
25	Location selection	Preliminary survey
Natural risk		
26	Force majeure	Li et al, 2001

27	Weather and environment	Li et al, 2001

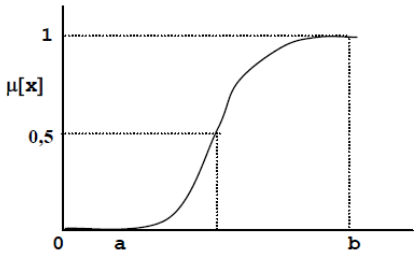
Generally, each risk should be allocated to the party best able to manage it and at the least cost (Ke et al, 2010). But it does not mean that all risks should be passed to the private sector, but to seek a solution minimizing both the total management costs of the public and private sectors. The risk allocation depends on the partnership scheme. For example, if private sector only builds the low-cost apartment, all risks related to operation and maintenance activities must be managed by the government. Therefore, local government must manage financial risk to avoid additional expenses, such as low revenues and high maintenance costs. On the other hand, major risks associated with financing in the construction stage (such as construction delays) are retained by the private sector. (Rachmawati et al, 2015b).

FUZZY SET THEORY

Fuzzy set theory has been adopted in numerous studies, not only engineering studies, in order to overcome ill-defined and complex real-world problems due to partial and imprecise information. This method is very useful for uncertain reasoning that involves human intuitive thinking.

A fuzzy set is characterized by membership functions (MFs) which describe numerical values ranging between (0, 1) and allow the processing and quantification of qualitative and imprecise data (Ameyaw and Chan, 2016). It also allows the use of linguistic variables whose values are not numbers but words or sentences in a natural or artificial language which are less specific than numerical ones (Lam et al, 2007). It is common used from a questionnaire survey.

For example, let x be a linguistic variable with the label “temperature” with U = [0, 100]. The linguistic values called terms of this variable could be called “cold”, “cool”, “normal”, “warm” and “hot”. T (X) will define the term set:
T (temperature) = {cold, cool, normal, warm, hot}
If a base variable μ is equal to the temperature, then a fuzzy subset N (X) and its membership function of the term cool:



$$f(x;a,b)=\begin{cases}0; & x\le a\\ 2[(x-a)/(b-a)]^2; & a\le x\le (a+b)/2\\ 1-2[(b-x)/(b-a)]^2; & (a+b)/2\le x\le b\\ 1; & x\ge b\end{cases}$$

Figure 1. Fuzzification of input variable

The fuzzy inference rules can be built to represent the knowledge and heuristic rules of experienced personnel. They are usually in the form: “IF a set of conditions/premises is satisfied, THEN a set of consequences can be produced”.

RESEARCH METHODOLOGY

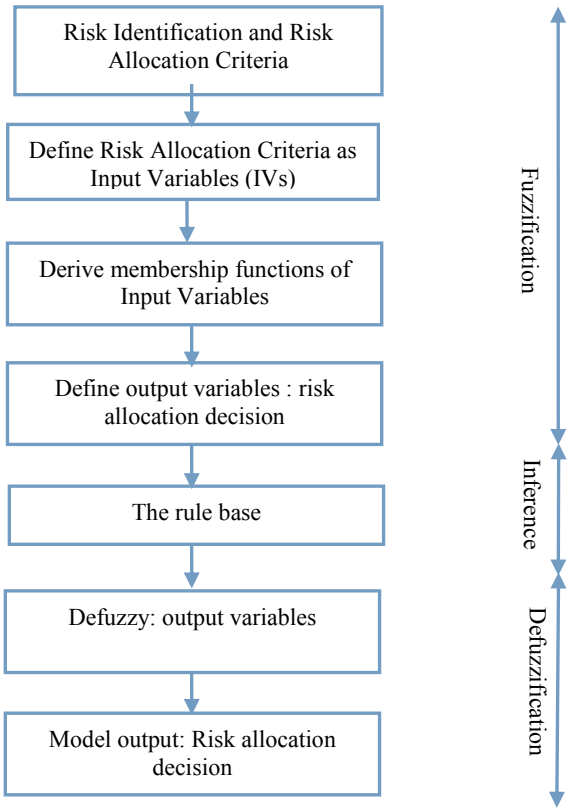


Figure 2. Model Construction

Figure 2 describes how the model is constructed. This paper expands on the preliminary findings and currently focuses on the Build Operate Transfer Contract between public and private sector. A mathematical model based on the fuzzy set theory is developed to support the decision making of risk allocation. The model mainly consists of three stages, namely: fuzzification, inference engine and defuzzification. Fuzzification is a procedure that converts raw data from the survey into membership values of corresponding fuzzy subsets. The transformed data are then fed into the inference engine containing a rule base. The fuzzy mathematic operations are implemented, producing membership values belonging to the output variables. Defuzzification is followed to convert the fuzzy inferences from the engine to a single output action giving a clear indication to the human user. The detailed procedures are explained in the following sub chapter.

Input Variables for risk allocation decision

Questionnaire regarding risk allocation criteria and the private sector's capability to take the risk were directly administered to 40 purposive respondents, which encompassess 20 government officers from low-cost apartment person in-charge and 20 respondents from the private sector (the land owner, low-cost apartment operator, housing developer, industrial estate developer and financier). Low-cost apartment development programs involve three tiers of government—national (ministry), province, and local—and the target survey questionnaire respondents included all three tiers of government officers. The respondents were asked to answer the questionnaire during the interview and discussion in order to explain in detail about the risks in low-cost apartment projects. Respondents were requested to select their preferences for risk allocation criteria. They got a list of risk allocation criteria and they were requested to validate the relevant risk allocation criteria associated with the ability of the private sector to develop and to manage low-cost apartment projects. The criteria are identified as follows:

1. Be able to assess the possible severity of the risk consequence
   For example: a private sector able to accurately foresee and assess the implementation of low-cost apartment development project in all stages (initiation, construction, operation, maintenance, and disposal). This ability also means the measurement capability to manage the risk in the future (Ameyaw and Chan, 2016)
2. Be able to avoid, minimize, monitor, and control the chance of risk occurrence
   For example: A party may be able to control the high maintenance cost and change in tariff regulation.
3. Be able to manage the consequences of the risk
   A party is able to manage the risk impact to minimize the severity, extra cost and delay once the risk occurs
   For example: the private sector may be more flexible than the public sector at managing the cash flow of the low-cost apartment.

4. Be able to cope social and environmental issue
   For example: A party should be able to communicate to stakeholders once the risk occurs to minimize the social impact.
5. Be able to bear the risk at the lowest price
   The risk bearing party must be able to take the right decision to mitigate the risk, whether retaining, reducing or transferring the loss, as bearing a risk is associated with cost.

The risk allocation criteria as the linguistic input variables will be denoted by IV_1-IV_5. To evaluate a risk event, the percentage is used to indicate the capability of private sector to foresee, to control, to manage, to cope some issues and to bear the risk. Based on the fuzzy set theory, the linguistic values are defined to describe the input variables to build fuzzy inference rules in the next stage. The finalized term set is: {low, moderate, high}. The detail input variables are listed as follows:

Private sector is able to assess the possible severity of the risk consequence		Range of capability
TIV_{11}	Low	0-50
TIV_{12}	Moderate	25-75
TIV_{13}	High	50-100

Private sector is able to avoid, minimize, monitor, and control the chance of risk occurrence		Range of capability
TIV_{21}	Low	0-50
TIV_{22}	Moderate	25-75
TIV_{23}	High	50-100

Private sector is able to manage the consequences of the risk		Range of capability
TIV_{31}	Low	0-50
TIV_{32}	Moderate	25-75
TIV_{33}	High	50-100

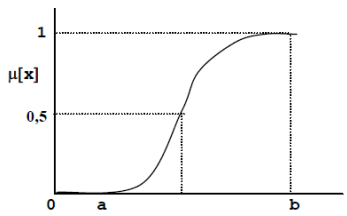
Private sector is able to bear the risk at the lowest price		Range of capability
TIV_{41}	Low	0-50
TIV_{42}	Moderate	25-75
TIV_{43}	High	50-100

Private sector is able to cope social and environmental issue		Range of capability
TIV_{51}	Low	0-50
TIV_{52}	Moderate	25-75
TIV_{53}	High	50-100

Fuzzification of the input variables

There are some fuzzification functions, for example phi, sigmoid, triangle, etc. In this paper, the S function or π function is used. This function has the formula as follows:

$$f(x;a,b)=\begin{cases}0; & x\le a\\ 2[(x-a)/(b-a)]^2; & a\le x\le (a+b)/2\\ 1-2[(b-x)/(b-a)]^2; & (a+b)/2\le x\le b\\ 1; & x\ge b\end{cases}$$



$$f(x;a,b)=\begin{cases}1; & x\le a\\ 1-2[(x-a)/(b-a)]^2; & a\le x\le (a+b)/2\\ 2[(b-x)/(b-a)]^2; & (a+b)/2\le x\le b\\ 0; & x\ge b\end{cases}$$

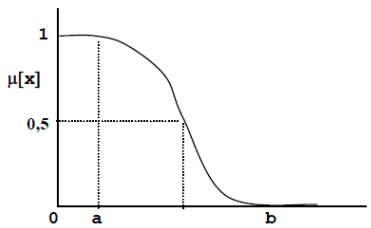


Figure 3 represents the membership functions of the terms of input variables in the model. While fuzzification for IV 1-5, in which S function or π function are used alternatively for the term set.

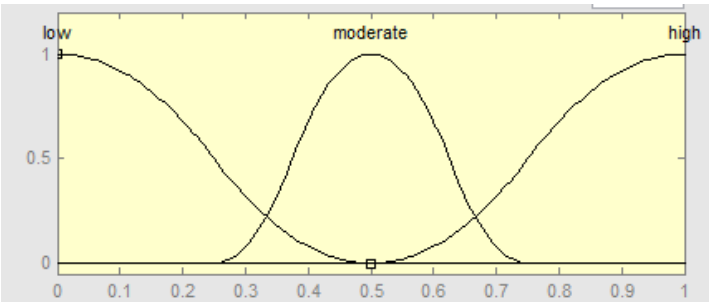
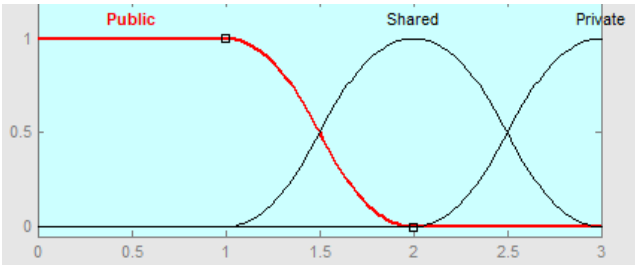


Figure 3. Membership function of input variables

Output variable – risk allocation decision

The output variable of the model is the risk allocation decision which is defined on the basis of the risk allocation as mentioned in Lam et al, 2007 with some adjustments. The scale represents a range of risk apportionment from fully bearing by the public sector through a shared portion to fully bearing by the private sector. Three values of output variable (OV) are identified: Public sector's risk (1); shared risk (2); and contractor's risk (3). The S and π function is used to represent the scale.



The rule base

Rule base is needed in the inference engine to transform the encoded knowledge and to form inferences and draw conclusion. It is produced based on the experience and knowledge of the expert team. The common mathematic model which involves N number input variable (IV), and M number of output variable (OV) is:
IF $\{IV_1 \text{ is } TIV_{ik}\}$ and ….. and $\{IV_u \text{ is } TIV_{uv}\}$ THEN OV_j
Where:

$$i \in \{1,\ldots,N\},\ k \in \{1,\ldots,\ S_i\},\ u \in \{1,\ldots,N\},$$
$$v \in \{1,\ldots,\ S_u\},\ j \in \{1,\ldots,M\} \text{ and } u \neq i$$

Given that the membership function of TIV_{ik} is given by μ_{ik} and as the study uses Mamdani method for inference system, the membership function of the output variable (OV_{pj}) of the pth rule is given by using the "minimum" operation of the fuzzy set theory:

There are 40 rules used in this study. Theoritically, the rule base could be more enourmous, as the larger the rule base is, the better the result can be.

Defuzzification

Defuzzification is the last step in the fuzzy set theory which aims to convert the result of the inference engine to the real number. The center of-sum method is used to determine the overall level of risk allocation of all examined rules. It is a popular defuzzification method in most fuzzy control algorithms and tools. If total T rules are examined, the numerical defuzzified value, d(OV), is computed as:

$$d(OV) = \sum_{p=1}^{T} (\mathrm{OV}_j^p) \times \mu\left(\mathrm{OV}_j^p\right) / \sum_{p=1}^{T} \mu\left(\mathrm{OV}_j^p\right)$$

The result can be concluded that the OV having the highest membership grade of d(OV) will be chosen (max[l(OVj)] where j 2 {1, . . . , M})

EVALUATION OF THE MODEL

Studies of these four cases reveal the variety of partnership schemes in low-cost apartment project implementations. Generally, in the existing partnerships, the interaction between the public and private sector, particularly the industrial estate, is limited to land rental or the initial investment, while all the risks and problems are entrusted to the government. The provincial government pays the land rental fee to the industrial estate, as for example, in the implementation of Griya Asri low-cost apartment project. While the low-cost apartments in Sidoarjo District were constructed over traditional village's asset land and managed by the District Government, Warugunung low-cost apartment is built by the Indonesian Government National Housing Corporation (Perumnas) and operated by the Surabaya Municipal Government. Unlike the other case studies, Siwalan Kerto low-cost apartment, which is constructed by the Ministry of Public Works and Public Housing; and East Java Province Government, is completely managed by the provincial government through its state-owned company. This building is allocated to local inhabitants as well as migrant communities. This study uses 3 low-cost apartments as the case study: Warugunung, Griya Asri and Tambak sawah, which the operations are managed by local government. In the previous research, 27 risk events have been identified.

One of the risk events "Tariff" is taken as an example to demonstrate how the model works. For IV1, the mean percentage of capability of the private sector to assess the risk judged by the respondents is 26.7%. As described in figure 3, it is fuzzified into the fuzzy subsets of the term TIV_{11} "low" and TIV_{12} "moderate" with membership grade of 0.9% and 32% respectively. The results of other input variables are as follows:

Private sector is able to assess the possible severity of the risk consequence	TIV_{11}: 0.65
	TIV_{12}: 0.009
Private sector is able to avoid, minimize, monitor, and control the chance of risk occurrence	TIV_{21}: 0.125
	TIV_{22}: 0.68
Private sector is able to manage the consequences of the risk	TIV_{31}: 0.996
	TIV_{32}: 0
Private sector is able to cope social and environmental issue	TIV_{41}: 0.65
	TIV_{42}: 0.009
Private sector is able to bear the risk at the lowest price	TIV_{51}: 0.969
	TIV_{52}: 0

The other values of input variables are determined with the same method.

While the rule of this risk event for the inference engine is as follows:

IF the capability of private sector to assess the possible severity of the risk consequence is Low: $IV_1 = TIV_{11}$
And the capabilities of private sector to avoid, minimize, monitor, and control the chance of risk occurrence is Low: $IV_2 = TIV_{21}$
And the capability of private sector to manage the consequences of the risk is Low: $IV_3 = TIV_{31}$
And the capability of private sector to cope social and environmental issue is Low:
$IV_4 = TIV_{41}$
And the capability of private sector to bear the risk at the lowest price is Low: $IV_5 = TIV_{51}$
THEN the risk should be allocated to the public sector: $OV_1 = 1$

The "min" operation is adopted to determine the membership value of output variable. The tariff risk has value 0.862, which is plotted in the public sector's risk, as the membership function for share's risk is 0. Therefore, it is recommended that this risk event is borne to the public sector. The calculations of all risks are presented in the table 2:

Table 2. Risk Allocation Decision

No	Risk	Numerical Result	Risk Allocation Decision
Policy and law			
1	Law and policy changes	1.5	Public Sector
2	Poor public decision-making process	1.5	Public Sector
3	Shareholder commitments	1.5	Public Sector

4	Inadequate distribution of responsibility and risk	1.5	Public Sector
5	Incapable concessionaire	1.5	Public Sector
6	Change in tariffs/tax regulations	1.5	Public Sector
7	Corruption and low law enforcement	1.5	Public Sector
Economic			
8	Interest rate volatility	2.61	Private Sector
9	Inflation rate volatility	2.61	Private Sector
10	High government subsidies	2	Shared
Operational			
11	Operational cost overrun	2.53	Private Sector
12	Higher maintenance cost	1.5	Public Sector
13	Availability of facilities and utilities	1.5	Public Sector
14	Availability of qualified human resources	2.55	Private Sector
15	Inhabitant conflict	2	Shared
16	Community support	2	Shared
17	Tariff regulations	0.86	Public Sector
18	Low-income group difficulties	2	Shared
19	Low return of investment	1.5	Public Sector
Project Finance/Sponsor			
20	Limitation of housing finances	2.6	Private Sector
21	Lack of government guarantees	1.5	Public Sector
Design and Construction			
22	Construction time delay	2.7	Private Sector
23	Building quality	2.7	Private Sector
Location			
24	Land acquisition	2	Shared
25	Location selection	2.55	Private Sector
Natural risk			
26	Force majeure	2.65	Private Sector
27	Weather and environment	2.65	Private Sector

Table 2 presents the result of the fuzzy inference system for risk allocation decision. The model is adopted to the partnership which the operation is managed by the local government. Generally, the risk associated with the operation and maintenance, for example higher maintenance cost, availability of facilities and utilities, shareholder commitment, and operation cost overrun. In addition, local government must pay a yearly land rental fee to the private sector. Therefore, local government must manage financial risk to avoid additional government subsidies, such as low revenues and high maintenance cost (Rachmawati, et al, 2015b).

The risks related to the regulation are solely allocated to the public sector. For example regulation and law changes, tariff adjustment, tax regulation and public decision making. A high tariff for the users, change in regulation or a wrong decision by the government on the PPP project may result in great political and social pressures. Under these situations, it is possible that the government would be forced to tackle this unprecedented situation.

There are 5 risks that should be shared to both public and private sector. They are land availability, high government subsidy, inhabitant conflict, community support and low-income group difficulties to pay the rental fee regularly. This reflects the fact that both the public and private sectors are willing to be responsible for these risks. Private sector has the responsibility to contribute in low-cost housing provision, however, government has to support for some issues such as inhabitant conflict, low-income group difficulties and government subsidy. Given that partnership in low-cost apartment project is considered as social partnership which dedicated to low-income group, there should be the government support in terms of condusive financing policy. In addition, the study point out that in order to accelerate the low-cost apartment project, it is necessary for the government to assist the land acquisition and development permit processes. Although the responsibility to provide land depends on the partnership scheme, the strategy such as land banking and the state-owned company's asset land, will render the project more attractive for investors as they will not be required to allocate funds to provide and prepare land. The provision of low-cost apartment on the high land price will give small profit margin that is not attaractive to developers (Widoyoko, 2007).

Actually, for some factors, the result of the model is slightly different to the usual contracting practice. Force majeure and weather are commonly treated as shared risk in most contract arrangements. While land availability and land selection are always borne to the public sector. Furthermore, risks will be shared by both parties when government involvement in the form of policies is required. For example, because low-cost apartments are dedicated to serving low-income groups, and are a government program, the inhabitant recruitment and selection process is a risk to both public and private parties. Finally, the findings provide useful information that government may conduct incentive strategy and the role of guarantee fund institution to attract more private sectors to boost the development of low-cost apartments. Furthermore, the risk allocation should be clearly stated in the agreement to avoid the misallocation and conflict.

CONCLUSION

This paper has studied the allocation preferences for low-cost apartment projects under partnership agreements using fuzzy inference system. The case studies used are 3 low-cost apartments which are managed by local government. The risk identification results in 27 risk factors. Five critical risk allocation criterias (RACs) that evaluate the risk carrying capability of project participants regarding ability to assess the possibility of the risk, ability to monitor the risk, ability to manage the consequence, ability to bear the risk at the lowest price and ability to cope social and environmental issue, were further identified, validated, and compiled based on the respondents. The risk allocation analysis using fuzzy inference system shows 5 risk factors to be shared between the public and private sector, namely High government subsidies, Inhabitant conflict, Community support, Low-income group difficulties, and Land acquisition. While 10 risk factors are allocated to private sectors and 12 risk factors are allocated to the public sectors. The study reveals that the risks related to the regulation are solely allocated to the public sector.

The advantage of fuzzy inference system is the systematic framework in risk allocation practice. Eventhough it is based on expert judgement, it examines the allocation of risks more fundamentally based on accepted risk allocation principles. The outcome of the model can be in numerical or linguistic indication which provides appropriate signals to different users. It is believed that this paper has helped to depict the perspectives of PPP experts who intend to develop other low-cost apartment projects in other areas. In this study, the scope of the proposed model is limited to risk allocation between the public sector (government) and the private sector in a traditional contract arrangement. This paper recommends further research with more respondent for the model stability and to gain broader knowledge about critical success factors to attract their involvement in the partnership.

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