Stakeholder Partnership for Selecting the Public-Private Community Model on the Development of Traditional Village as Vernacular Heritage in Madura, Indonesia

Christiono Utomo[1*], Sulfiah Dwi Astarini[2], Yani Rahmawati[3]

[1*] Department of Civil Engineering, Institut Teknologi Sepuluh Nopember, 60111, Indonesia
[2] National Research and Innovation Agency (BRIN), Tangerang Selatan, 15314, Indonesia
[3] Department of Architecture Engineering and Planning, Universitas Gadjah Mada, 55281, Indonesia

*Corresponding author: **christiono@its.ac.id**

https://doi.org/10.5755/j01.sace.42983

JSACE X/X

Stakeholder Partnership for Selecting the Public-Private Community Model on the Development of Traditional Village as Vernacular Heritage in Madura, Indonesia

Received 2025/11/07
Accepted after revision 2025/12/19

Abstract

Choosing a financing model for the development of a traditional village as vernacular heritage that satisfies all stakeholders, including the community, is an essential yet relatively unexplored issue. This study aims to develop a support system model that accommodates stakeholders' diverse backgrounds and interests when choosing one option. The model's research approach consists of three stages. The first is an analysis of two value attributes: considerable capital expenditure, life-cycle cost, and a desirable partnership return. The second is the decision process, which develops a decision hierarchy, judgment, synthesis, and satisficing options on value criteria. The data are derived from focus groups and surveys, and the analysis employs the Analytical Hierarchy Process (AHP) and satisficing game theory methods. The third is the best-fit options process, which involves forming a coalition and analyzing the optimum payoff to reach an agreement. It requires a non-financial return to accommodate the community as a stakeholder in vernacular heritage settlement development. The results show that the proposed model increases strategic financing value, allowing stakeholders in vernacular heritage development to analyze project partnership investment options.

Keywords: development; partnership; public-private community; stakeholders, vernacular heritage.

Introduction

Background

Market and financial considerations are the driving forces behind the preservation of vernacular heritage. Placing vernacular heritage in a commodity area transforms it into real property with an economic value. It must run with all property management functions, including marketing, leasing, and tenant relations. Examples of development with financial considerations are gentrification, renovation, and socio-economic development (Huang & Li, 2023). The forms of development that consider the preservation are rehabilitation, restoration, and reconstruction (Shi & Huang, 2023). Whatever the form, operational continuity is a must, so consideration must be given not only to the ability to finance capital expenditure but also to operational expenditure as a form of return on development capital.

ktu 1922

Journal of Sustainable Architecture and Civil Engineering
Vol. x / No. x / 202x
pp. x-x
DOI 10.5755/J01.SACE.42983

One consideration is determining land use and the combination of capital improvements and operating costs to exploit the site for land settlement improvement. However, vernacular heritage as a commodity cannot be distributed like other real property products because it is not just a space where attributes associated with a location are not easy to change (Karahan & Davardoust, 2020). Vernacular heritage has historical value and socio-cultural attachment to the community that grows and develops together.

A vernacular settlement emerged from ethnic societies, rooted in their traditions and utilizing local techniques and materials. It is the answer to the building's setting and is always open to transformation (Salman, 2018). Adapting buildings to new uses becomes an economic and social need. It requires a reassessment of the role and value of traditional buildings and their environments, especially those with unique histories or that highlight their historical significance. It is impossible to continuously protect and oppose change to bring the building back to profitable use. This process protects parts of the heritage building and makes it known and acceptable to the community (Fadli & AlSaeed, 2019).

With limited government and community budgets, developing vernacular heritage settlements requires financing through partnerships. One of the partnerships is the public-private partnership (PPP). Adding community stakeholders to PPP (PPCP) is a more inclusive form of PPP expansion, in which communities are partners in the design and maintenance of public projects or services. According to Žuvela et al. (2023) the PPCP model for vernacular heritage requires consideration of local community values to ensure not only commercial benefits are achieved, but also social and cultural benefits.

Numerous previous studies have involved community financing partnerships. One is community participation in the development process in developing countries (Kang et al., 2019). It is a study on the active community participation approach to support sustainable development (Osei-Kyei & Chan, 2015). In Indonesia, certain community engagement practices have been incorporated into the PPP model. They become the third stakeholder, in addition to the private and public. Local communities, often referred to as village people, are unique in their preservation of culture. The traditional village is a community of indigenous people, characterized by a rich social life. Traditional communities are widespread in Indonesia: Kahyangan Tiga on Bali Island, Huta/Nagori on Sumatra Island, Taneyan Lanjang on Madura Island and others. Decisions for multiple stakeholders require an optimization or satisficing approach. The decision can be accepted by different interests and satisfy all parties, so a cooperative form is an option.

Several factors contribute to the success of vernacular heritage within the building's settlement heritage and its environment. These factors are effective design collaboration processes and financing factors that ensure sustainability. The change and development of vernacular settlements require the utilization of multidisciplinary expertise due to the diversity of stakeholders. It is a form of respect for the community's cultural identity. Criteria such as stakeholder preferences will serve as the basis for informed decision-making. Decisions that are acceptable to all stakeholders require a hierarchical approach to eliminate inappropriate solutions.

Significance

Conventional decision theory bases optimization on rational choice. Behavioural sciences, economics, and engineering apply this rational choice (Simonson & Sela, 2011). Another concept is being good enough or satisfying (De Almeida et al., 2016). Optimization and satisfaction differ in how the alternative solution is compared to the decision criteria. Each option has its own set of individual positive and negative attributes in terms of satisfaction. A key benefit of applying the coalition algorithm is its decentralized approach to fragmented decision-making across the public, private, and community sectors. Other essential benefits could be effectively decomposing large-scale problems and improving collaboration. As a multi-person process, negotiation

becomes critical in selecting the development alternative for vernacular heritage and the PPCP model to finance it. Furthermore, this new method encourages a novel approach for managing the development of vernacular heritage.

Finding and innovation

The research differs from previous research by identifying financing opportunities and appropriate funding sources through private sector partnerships. It determines the pattern of collaboration, which is mutually beneficial for the government, the private sector, and the community. This research applies the satisficing game method, in which the value criteria are the returns and investments of the solution techniques. Cooperative decisions require a coalition algorithm among stakeholders, including the community. This problem can be solved using the Analytical Hierarchy Process (AHP), but the approach must shift from optimization to satisficing via coalition formation with an agreement option.

The Phenomenon of vernacular heritage

Vernacular heritage is a cultural heritage where, in terms of architecture, spatial planning and choice of materials, it is represented by local communities in creative ways that connect buildings with local culture, customs and the environment (Aktürk & Fluck, 2022). It is the values and practices inherent to these settlements; thus, vernacular settlement becomes a medium where vernacular heritage grows, develops, and is inherited (Ali et al., 2022). The architectural system plays an essential role in depicting the identity of a city, and is even believed to play a crucial role in supporting sustainability (Alves, 2017; Keshtkaran, 2011; Mileto et al., 2021). In short, it emphasizes harmony among building form, climate conditions, energy efficiency, and environmental friendliness. It not only reflects the building's physical appearance but also the identity of a particular community.

In some countries, various vernacular heritages have depicted local construction traditions and cultural arrangements, for example, Rize evleri in Turkey uses s*tone-infilled timber frames, muskali dolma*, or *çakatura* as construction techniques in building structures in response to climate (extreme rain, wind and lateral forces due to sloping landscapes) (Aktürk & Fluck, 2022). Buildings in Yazd, Iran, specifically use local materials such as mud and *adobe*, which have thermal capacity to store heat (Keshtkaran, 2011). The Sesga House in Valencia, Spain, integrated J*uniperus thurifera, Pinus nigra*, and *Populus alba* wood as the main structural elements of the building, providing stability, weathering resistance, and longevity (Mileto et al., 2021). The wall system using straw (*Warichchi* or *Katumeti*), covered with mud or cow dung, is used in buildings in Sri Lanka to keep rooms cool and save costs (Dayaratne, 2018). These various contexts have shown that vernacular heritage generally forms as an adaptive response to environmental risks and as a manifestation of the local community's social and cultural values .

In some cases, vernacular heritage begins to transform in response to environmental factors and socio-economic dynamics that influence its sustainability, such as modernization, including changes in lifestyle, work, and increasing modifications to modern houses. In Indonesia, *Imah Panggung* is still maintained by the Sundanese community in the city of Bekasi to preserve the continuity of spatial values (Ali et al., 2022). The same thing also happened in Praigoli, West Sumba, where the traditional village heritage (*wanno kalada*) is still maintained, even though the availability of materials such as wood, palm fiber, and bamboo is decreasing, along with the traditional knowledge and skills of the younger generation being reduced due to economic shifts and job migration (Solikhah & Fatimah, 2020). In another study in Kampung Sanan, Malang, vernacular houses underwent gradual changes due to the need for space for home-based enterprise (HBE) activities, specifically for tempe production (Tutuko & Shen, 2014). The same case also occurred in the Gayo community in Aceh, where there was a revolution in traditional stilt houses to become

landed houses due to limited land, the increasingly scarce availability of wood materials and the increased use of modern materials for building durability (Wulandari et al., 2024).

There are two central values of vernacular heritage: tangible and intangible, both of which are interrelated. Tangible value refers to the physical aspects of a building, including its form, spatial typology, construction techniques, and use of local materials that reflect the building's distinctive characteristics and long-term adaptability (Aktürk & Fluck, 2022; Keshtkaran, 2011; Tutuko & Shen, 2014; Wulandari et al., 2024). Meanwhile, intangible values , as a cultural system, include traditional knowledge, social relations, belief systems, cultural practices, and community governance that provide meaning, function, and sustainability to tangible values (Astuti et al., 2022; Dayaratne, 2018; Keshtkaran, 2011; Nursanty et al., 2024). The integration of these two values forms the basis for designing development and conservation strategies for sustainable vernacular settlements.

AHP Model for Assessing Vernacular Heritage

Vernacular heritage demands multidisciplinary involvement because the development of architectural heritage lies not only in the building's characteristics but also in the social, cultural, and ecological values it embodies. Study Astuti et al. (2022) in Batujaya, Karawang, emphasized that, for conservation and sustainability, a bottom-up approach is needed through community involvement, cooperation among local governments, and the central government, which serves as an inseparable unit of community governance. This is also in line with Muqoffa et al. (2024), who investigated the relationship between vernacular houses and energy sustainability in case studies of traditional dwellings in Surakarta and Wonogiri. In this case, a deep understanding of construction techniques and the use of local materials is required, so it is essential to involve architectural experts, builders, and cultural experts in collaboration. Meanwhile, Nursanty et al. (2024) stated that the development and management of vernacular settlements require an integrative approach because they relate to the local area's image, which must be maintained in its authenticity.

Multidisciplinary involvement ultimately does not rely on just one perspective in the decision-making process. Even in evaluating the heritage value of buildings, a method is required that can accommodate various tangible and intangible aspects simultaneously (Lian & Dimitrijević, 2025; Šiožinytė et al., 2014). Based on this, the AHP is a method that can help make the right decisions, as it facilitates the management of multiple criteria and alternatives that must be considered simultaneously (Saaty, 2004).

As a flexible decision process, AHP provides a clear rationale by reducing complex decisions to one-to-one comparisons and synthesizing results. Group decision also successfully applies AHP (Aguarón et al., 2019) and negotiation (Saaty & Alexander, 1989). This method can also be applied in many scenarios, such as selecting alternatives, allocating resources, combining alternatives with various constraints, and comparing processes or systems (Subramanian & Ramanathan, 2012).

Several studies have employed AHP to assess cultural heritage, guiding conservation and reuse efforts. Various studies focus on the physical building, such as (Chen et al., 2024), which evaluated the heritage value of the Mawei shipbuilding industry in China. The research highlights eight criteria for building value, including historical, artistic, social, cultural, scientific, technological, economic, and functional values, which serve as the basis for compiling adaptive, community-oriented policies. Another study from Lian & Dimitrijević (2025), also spread the industrial heritage value for the Shaanxi steel mills. Meanwhile, the study of Liu et al. (2021) which combined Delphi and AHP for cultural heritage restoration, emphasized spatial safety criteria such as structural safety and security as the top priority. This is because the safety criteria for heritage building spaces must protect occupants from various risks, including accidents and natural disasters.

In another study, AHP was used by Kittipongvises et al. (2020), combined with GIS, to assess potential flood factors in Ayutthaya Historical Park in Thailand. The research underscores the importance of aligning conservation with local community involvement. In this case, the criteria highlighted as causes of flooding are runoff, river basins and density of road networks due to urbanization. Dammag et al. (2024) conducted a study on cultural heritage sites in the city of Ibb, Yemen. The study combines GIS and SWOT-AHP analysis to evaluate the risks associated with cultural heritage sites and identify priority strategies to protect sites from short-term to long-term threats. There is also a study by Kutut et al. (2014) who used AHP combined with ARAS (Additive Ratio Assessment) to determine priority rankings for the restoration of various cultural heritage sites in Vilnius, Lithuania. In particular, his research emphasizes the value of buildings in terms of their utility and the restoration of property through investment.

In general, existing research has focused on risk (Dammag et al., 2024; Kittipongvises et al., 2020), while others have focused on strategy (Chen et al., 2024; Kutut et al., 2014; Lian & Dimitrijević, 2025; Liu et al., 2021). The types of decisions also vary, for example, conservation and reuse (Chen et al., 2024; Kittipongvises et al., 2020; Lian & Dimitrijević, 2025), restoration (Kutut et al., 2014; Liu et al., 2021) and zonation (Dammag et al., 2024). However, there are still implementation limitations, especially in complex heritage projects involving many stakeholders. Dammag et al. (2024) and Liu et al. (2021) criticized AHP for being prone to subjectivity, as experts evaluating indicators may be influenced by their work backgrounds, potentially biasing the weighting of criteria. Meanwhile, Kittipongvises et al. (2020) and Lian & Dimitrijević (2025) agree that expert involvement is often dominant and often ignores local communities, even though vernacular heritage is essentially an expression of local culture originating in local communities.

AHP-based satisficing agreement options and coalition formation

The AHP enables a more complex hierarchy, which may involve increasing the number of sub-criteria, sub-alternatives, and even stakeholders. This paper presents a different approach to using AHP in previous research studies, including the application in construction (Darko et al., 2019). As discussed in the literature, the effectiveness of AHP is limited by its dependence on expert judgment, its limited ability to overcome conflicts of interest, and its inability to accommodate interactive dynamics among stakeholders. Based on this, the research's novelty lies in the use of AHP within a satisficing game approach. Through this approach, each stakeholder, including local communities, can be explicitly modeled as a negotiation strategy to find a compromise solution for the PPCP scheme.

The first approach is optimization, which selects alternatives with the highest value as the best choice. This paper applies the concept of satisficing, in which the chosen option is not the highest value but one that all stakeholders can accept. Second are group decisions and negotiations. Suppose the previous research employs aggregation to determine the value of the decision-making group. In that case, the AHP-based satisficing option enables a joint decision through negotiations facilitated by coalition formation. Table 1 compares the positioning of the proposed new concept.

This value model follows the satisfaction concept (De Almeida et al., 2016). It enables collaboration by forming coalitions. By separating into two categories, namely "what is expected to be received" and "consideration of costs to obtain," the coalition will form an agreement that satisfies all stakeholders. The meaning of value may be open to interpretation. This can be expressed as:

$$\text{Value} = \text{Desirable (Return)} / \text{Considerable (Cost)}.$$

Stakeholders may choose to cooperate by forming coalitions. Given that all coalition members are allowed to receive more than they can individually, this will benefit each coalition member. Expected returns can quantify the benefit of a coalition. The coalition has been used in many kinds

of research in multi-person decision-making and negotiation (Guo & Lim, 2007) and applications of cooperative game theory in power system allocation problems (Kratima et al., 2013) for co-operative information agent-based systems (Smirnov & Sheremetov, 2012) and COTS selection (Wanyama, 2006). This research considers negotiation in which the players may cooperate by forming coalitions. Cooperation is the nature of a group decision in a collaborative environment (Xu et al., 2014).

Table 1

AHP in the proposed new concept

No	Implementation of AHP in construction			Source
	Objective	Decision Criteria	Decision Model	
1	Negotiation model with conflicts for optimum buffer stocks	Cost, schedule, quality, safety	Integrating a DSS fuzzy into MADM	Ng and Fang (2008)
2	Selecting alternatives for an ICT-based logistics system	Procurement, waste, misplacement, delivery lateness,	decision trees, MADM, uncertainty, what-if analysis	Fadiya et al. (2015)
3	A proposed decision model for selecting a partner	Business, technical, and management	Multi-agent system (combining AHP and fuzzy approximate reasoning)	Nyongesa et al. (2017)
4	Describe the application areas of AHP in construction	Risk, sustainability and competitive advantage	Using normalized eigenvalues to determine priority weights of criteria	Darko et al. (2019)
This study: Selecting vernacular heritage and its PPCP financing model.		Value-based, considerable and desirable	Coalition formation, agreement options, and satisficing game theory	

Methods

This method combines group decisions in MCDM to get a choice that satisfies all parties through three stages. The three stages determine desirable and considerable criteria, a multi-criteria decision process, a satisficing option, and coalition formation. Adjusting the funding source to local conditions and practices in developing vernacular heritage settlements selects the PPCP. The main objective is to determine how all stakeholders involved in the community can accept the financing method.

Description of the object

The case study is the traditional village of Arosbaya, Bangkalan, Madura, Indonesia. Madura is an island in eastern Java, approximately 5,000 square kilometers in size (**Fig. 1**). Since the 18th century, the island of Madura has been known for its two distinct areas of mastery: Western Madura (comprising Bangkalan and Sampang) and Eastern Madura (encompassing Pamekasan and Sumenep). At that time, the dynamics of vernacular heritage occurred as colonial influence developed in the central part of Bangkalan. In contrast, traditional housing is concentrated in the peripheral areas of Bangkalan city, extending from the center of Arosbaya in the north to the central and southern regions of Madura.

Usually, the housing group consists of one or two houses. All of these are called Taneyan; the literal meaning is a yard surrounded by homes and other buildings. The Taneyan is used for the land around it and is often planted with fruit trees and shrubs. If this group consists of several buildings, it is referred to as Taneyan Lanjang. The arrangement of the Taneyan exhibits a distinct pattern that can be classified as a dwelling typology. The place of worship is called the center of the Taneyan. It is almost always built to the west of the yard; from that place, you can see the whole yard. The first dwelling is usually located on the north side of the yard, facing south. Often, kitchens and stalls are located opposite the house, facing north. The Taneyan Lanjang, as a vernacular heritage settlement, has undergone significant change due to urban development and limited land.

The aim of cultural sustainability serves as the basis for the vernacular heritage development plan. The decision of this plan depends on the stakeholders involved as decision-makers.

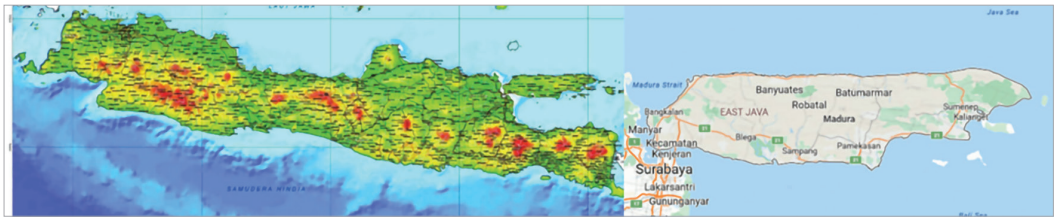


Fig. 1
Location of Madura Island

In selecting the PPCP model for vernacular heritage, three stakeholders are involved in the decision: Government, Private, and Community, as shown in Table 2. They expressed their preference and formed a coalition to select the PPCP model. The decision-making process is designed in a collaborative environment to establish a profitability level that all Stakeholders accept. A total of twenty-six participants were involved in this study, with the community group division consisting of eighteen people, including several village-level management representatives from the Arosbaya sub-district. The private group represents the business management in Arosbaya, Madura, comprising five people, and the public group consists of the city planning department in Bangkalan city, with three members. Stakeholders were selected using several techniques. For the community, cluster random sampling was used to represent 18 traditional villages in Arosbaya. For the private sector, purposive sampling was used, with representatives appointed according to their management function. For the government, purposive sampling was used, with representatives from the city planning department. The number of stakeholders is 26, which is below the general recommendations for vernacular heritage, which range from 10 to 30 people (Lian & Dimitrijević, 2025). The large number of people is due to the traditional village-cluster representation. This is a balance to overcome forms of coordination or cooperation that do not achieve mutual and individual satisfaction.

Table 2
The stakeholders

Stakeholders (SH)	Reasons	Members	Sampling
SH1: Government	Maintain regulations and bridge the interests of all parties' decisions	City planning department	Purposive
SH2: Private	Ensuring the development process, including the provision of funding and business management	Representative of business development, finance, general affairs, design, and engineering	Purposive
SH3: Community	Ensuring vernacular heritage throughout the entire life cycle	Representatives from 18 traditional villages	Cluster Random

The model of stakeholder partnership is shown in Fig.2. Each stakeholder group assigns its own preference groups using the mean distribution. The payoffs between stakeholders are then based on these preference groups. The coalition process for mutually satisfying choices is then based on this partnership model.

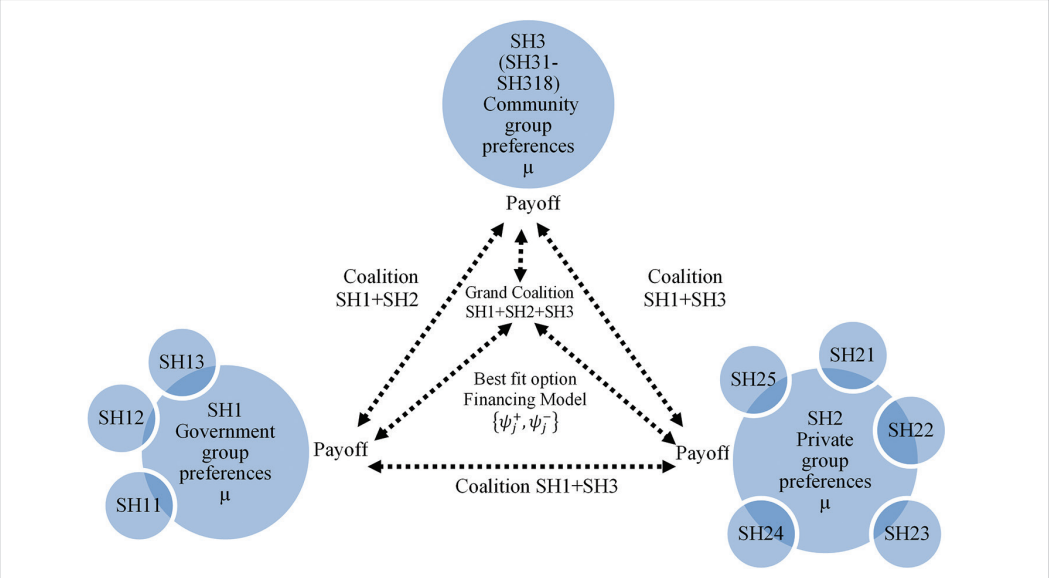
Process

The decisions applied a three-stage decision-making process. The first stage is to determine the decision preference among the desirable and considerable solutions for the PPCP model. Desirable means what the three parties expect from PPCP and the consequences of the costs incurred. It is to get the value of the decision. Stage two is the multi-criteria decision process and the satisficing option. Stage three is coalition formation. It consists of two steps to determine the

optimal solutions by analysing the optimum payoff. The second step is analysing the best-fit options for the group.

Fig. 2

The model of stakeholder partnership



Results and Discussion

This study comprises six steps derived from a three-stage decision-making process: Stage 1 has 1 step, Stage 2 has three steps, and Stage 3 has two steps.

Step 1: Desirable and considerable criteria

This model combines financial and non-financial aspects. One uses costs as the criteria to be considered, and the other uses functions as the desired criteria. It includes social, economic, and environmental aspects related to sustainability and value creation. Desirables and considerables refer to the satisficing options (Sandorf et al., 2022; Stirling, 2009) that presented a simple and tractable model that captures satisficing behavior. A natural way to satisfy options is to separate the attributes into two categories. Categorizing this problem helps identify the function as desirable (Pd) and the cost as considerable (Pc).

Setting the decision preference: This step determines the decision preference. The preference attribute appears to be a desirable and considerable solution for the PPCP model. Based on the satisficing approach, the criteria were divided into two categories. The first category, 'considerable', contains two cost criteria. The second category is 'desirable,' which includes five function criteria. Data sources for this stage are literature and expert judgment. The judgment is based on the opinions of two experts from the Heritage Council and experts in project finance.

Meanwhile, five desirable criteria are sustainability in cultural heritage and building culture (d1), capturing value creation in the local community (d2), a high-level consortium of three parties and business image (d3), balance profitability sharing (d4), and risk allocation and transfer (d5). The concept underlying these criteria stems from considering the interests of collaborative financing, the interests of each stakeholder, and the goal of reusing vernacular heritage. Each of these criteria for each stakeholder can be a conflict and a trade-off. For example, d1 is the goal set by public stakeholders, d2 by community stakeholders, d3 by private stakeholders, and d4 and d5 by the three stakeholders to ensure the sustainability of the collaboration.

Step 2: Decision hierarchy

The first step in any MCDM is to construct a decision hierarchy (Fig. 3). The hierarchy is arranged according to the AHP decision logic. Information from Step 1 becomes the basis for preparing the

initial hierarchical model. A focus group was then conducted with three stakeholder groups. Focus groups confirm the expert's sub-criteria and determine possible alternatives. This hierarchy, confirmed by the decision-maker, becomes a conceptual model for the group decision process. Five levels form the hierarchy: Goals to select the financing model; desirable and considerable criteria; sub-criteria; heritage development alternatives; and financing model alternatives. At the first level, the decision's goal is "The best-fit options of the financing model for PPCP vernacular heritage development.

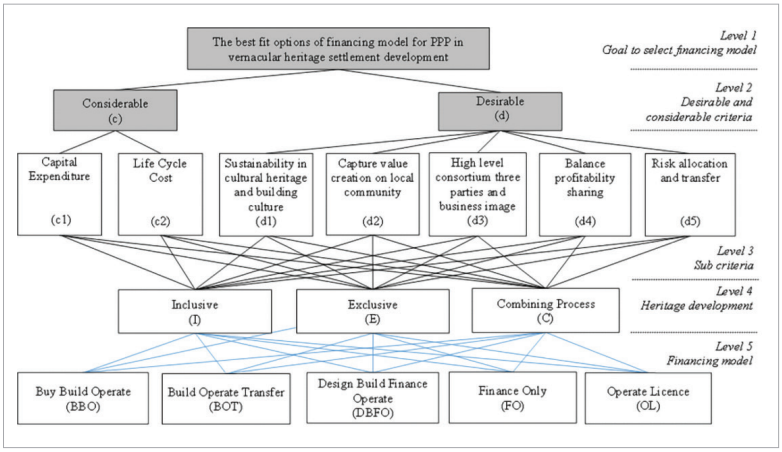


Fig. 3

The model of stakeholder partnership

There are three vernacular heritage alternatives at the fourth level: inclusive, exclusive, and a combination of both processes (Fig. 4). An inclusive alternative means that vernacular settlement will become part of urban modernization; it can integrate into various functions of property buildings. An exclusive alternative means they are located in a particular function as a cultural preserve or developed in specific clusters within the city. A process combining alternative vernacular heritage methods develops alongside urban development. The lowest decision hierarchy is the most common form of PPCP financing (Yescombe & Farquharson, 2018). There are the buy-build operation (BBO), build-operate-transfer (BOT), design-build-finance-operate (DBFO), finance-only (FO), and operating license (OL) options.

Step 3: Judgment and result

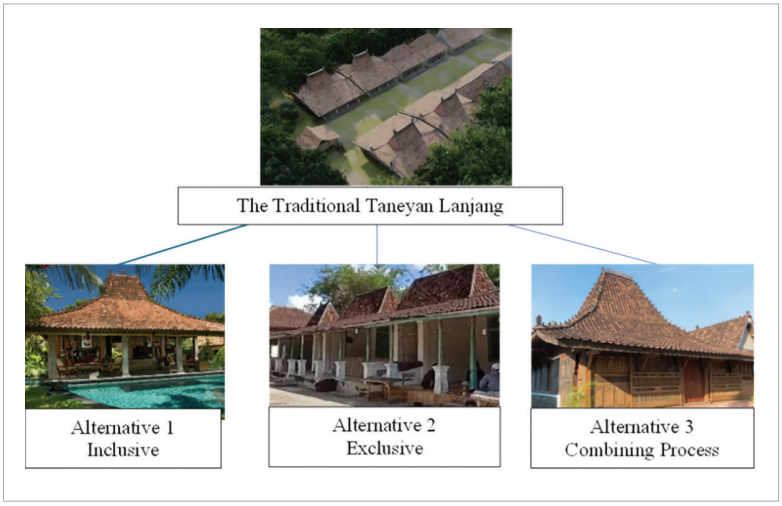


Fig. 4

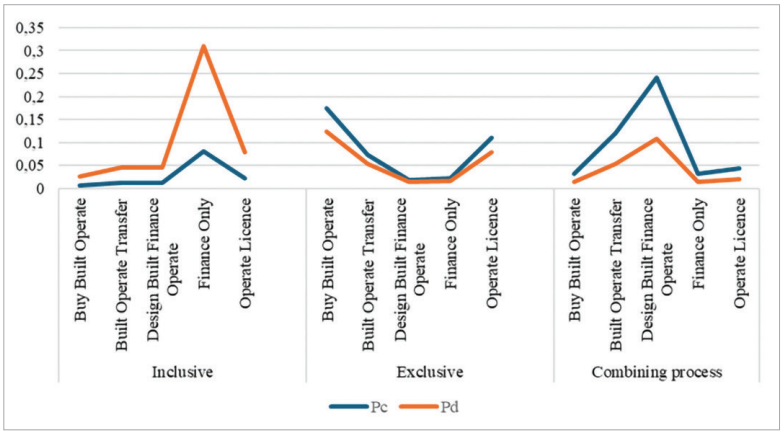
The development alternatives

The first analysis is the criteria for each stakeholder, each with a different priority. Risk allocation and transfer (d5), the capture of value creation in the local community (d2), and the sustainability of cultural heritage and building culture (d1) are the priorities for group private, group community, and group public, respectively. The second analysis is to get the weight of each alternative against each criterion. Each criterion has a different priority for alternatives. For example, the priority for the criteria of capture value creation on the local community is inclusive alternatives. Meanwhile, the priority for sustainability in cultural heritage and building cultures is exclusive. The alternative combining process is the priority for risk allocation and transfer criteria. This result is

interesting because there is a conflict among the alternatives as the best option based on the criteria. The third analysis determines the alternative priority for each stakeholder. This analysis is a synthesis of the first and the second. Group communities prefer to develop settlements and buildings that are inclusive. As the owner and occupant, they have to hope their property can grow along with business development. The private selects the combining process or the exclusive alternative, and it can be developed specifically for certain businesses that generate income. An exclusive alternative is a choice for public groups due to its ease of control and budgetary considerations. The last result is the value of (Pd/Pc) for each financing alternative and each cultural heritage development alternative (Fig. 5).

Fig. 5

Desirable and considerable criteria for each financing alternative and development alternative



Step 4: Satisficing option on value criteria of desirable and considerable

The same scale compares the two categorizations representing the value of an alternative (Pd/Pc). Table 3 provides the value for each stakeholder. Two stakeholders' inclusiveness was chosen, but it was not necessarily the best solution. Interestingly, the stakeholders rejected the combining process individually. Nevertheless, it does not mean each coalition will reject this alternative.

Table 3

Satisficing option for each financing model

	Group of Community			Group of Private			Group of Public		
Inclusive	Pc	Pd	Value	Pc	Pd	Value	Pc	Pd	Value
BBO	0.070	0.0260	3.791	0.0240	0.0153	0.638	0.0103	0.0165	1.599
BOT	0.010	0.0450		0.0414	0.0264		0.0178	0.0284	
DBFO	0.010	0.0450		0.0414	0.0264		0.0178	0.0284	
FO	0.080	0.3090		0.2815	0.1798		0.1211	0.1937	
OL	0.020	0.0790		0.0724	0.0462		0.0311	0.0498	
Exclusive	Pc	Pd	Value	Pc	Pd	Value	Pc	Pd	Value
BBO	0.174	0.1241	0.713	0.0601	0.1538	2.559	0.1389	0.1883	1.355
BOT	0.073	0.0523		0.0253	0.0648		0.0585	0.0793	
DBFO	0.019	0.0133		0.0064	0.0164		0.0148	0.0201	
FO	0.022	0.0154		0.0074	0.0191		0.0172	0.0234	
OL	0.110	0.0785		0.0380	0.0973		0.0879	0.1191	
Combining Process	Pc	Pd	Value	Pc	Pd	Value	Pc	Pd	Value
BBO	0.032	0.0143	0.4485	0.0274	0.0241	0.881	0.0330	0.0172	0.521
BOT	0.119	0.0535		0.1023	0.0901		0.1233	0.0642	
DBFO	0.242	0.1085		0.2074	0.1827		0.2499	0.1303	
FO	0.031	0.0139		0.0266	0.0234		0.0321	0.0167	
OL	0.044	0.0199		0.0379	0.0334		0.0457	0.0238	

There are two conditions of satisfaction. The first is the value of each alternative for each Stakeholder, and the second is the PPCP model's satisfaction with the vernacular heritage development alternative. Table 3 uses the PPCP model to calculate the value of development. The calculation process reveals the value of each option for each stakeholder across five PPCP alternatives. It also selects a combination of the development option and the PPCP model. Three combination

options become alternatives for the next step. They are inclusive-finance only (I-FO) with Pd = 0.3090, exclusive-buy built operate (E-BBO) with Pd = 0.1538, and combining process-design built finance operate (C-DBFO) with Pd = 0.1303

Step 5: Payoff optimum to determine the optimal solution

Two kinds of Pareto-optimal payoffs represent the criteria. Table 4 presents the Considerable and Desirable, respectively. The empirical behavioral data from the survey analysis reveal five styles and seven negotiation outcomes. The outcomes can be functional or dysfunctional. A stakeholder's (max-min) payoff value determines the payoff optimum by applying the coordinating scenario.

Table 4

Best fit options for each coalition

		I-FO		E-BBO		C-DBFO	
		Desirable	Considerable	Desirable	Considerable	Desirable	Considerable
Grand	w-	14.753	5.196	139.018	87.911	172.802	319.912
	w+	0	0	0	8.082	0	0
	Ranking	1st	1st	2nd	2nd	3rd	3rd
	Rating	+++		++		+	
SH1+2	w-	117.032	0	133.238	107.668	177.552	5.099
	w+	0	0	0	0	0	0
	Ranking	2nd	1st	1st	3rd	3rd	2nd
	Rating	++		+		++	
SH1+3	w-	9.192	32.527	125.268	61.583	164	32.65
	w+	9.192	0	0	0	0	0
	Ranking	2nd	2nd	3rd	3rd	1st	1st
	Rating	++		+		+++	
SH2+3	w-	15.556	14.849	157.634	89.802	177.5	16.124
	w+	0	0	0	0.707	0	0
	Ranking	2nd	1st	3rd	3rd	1st	2nd
	Rating	++		+		++	
SH1		0.2643	0.2608	0.1859	0.1767	0.1138	0.257
	Ranking	3rd	3rd	2nd	2nd	1st	1st
	Rating	+		++		+++	
SH2		0.2753	0.2801	0.1469	0.2801	0.1203	0.2743
	Ranking	3rd	3rd	2nd	3rd	1st	1st
	Rating	+++		++		+++	
SH3		0.3057	0.2198	0.1413	0.2421	0.1282	0.2189
	Ranking	3rd	2nd	2nd	3rd	1st	1st
	Rating	++		++		+++	

There are four possible coalitions. The possible coalition is (1) a group of communities with a group of private, (2) a group of communities with a group of public, (3) a group of private with a group of public, and (4) a grand coalition among all stakeholders. It is writen as SH1+2, SH1+3, SH2-2, and SH1+2+3, respectively. There is an empty coalition of no members. The Table also shows the alternative combinations of the development option and the PPCP model: I-FO (Inclusive and Finance Only), E-BBO (Exclusive and Buy-Build-Operate), and C-DBFO (Combining process and Design-Build-Finance-Operate).

Step 6: Best fit options for the group

The best option is the one with the least negative value for both desirable and considerable outcomes. However, when two alternatives have the same negative value, a higher positive value is better than a lower negative value. It is illustrated in Table 4. AHP is essentially an optimization model that uses a data distribution based on the mean. Its weakness is its inability to achieve both

collective and individual satisfaction. Satisfaction-based game theory using payoffs can address this weakness. However, the consequence is the possibility of deadlock. In the satisficing model, AHP is used to input decision data from stakeholders.

Additionally, two measures of collective decision-making outcomes are considered errors: noise and bias (Kahneman et al, 2021). In multi-stakeholder situations, noise is most likely, while bias is most likely when the collaborative effort is coordinative. The model in this paper, with an outcome-based satisficing game, reduces the risk of bias.

Conclusions

This study aims to develop a support system model for selecting a financing approach for the development of a traditional village as a vernacular heritage that satisfies all stakeholders involved in the community. AHP, based on satisfaction, can accommodate a group decision-making approach. Using satisficing game theory with coalition formation can facilitate PPCP collaboration in developing the vernacular heritage by selecting a financing model. The decision support is still at each stakeholder's valuation level and needs validation for practical application. It can serve as a basis for stakeholder negotiations, using the satisficing logic. The resulting model offers managerial implications for enhancing community participation in the management, thereby ensuring the sustainability of the asset's operations.

This study has several limitations. It does not directly examine the tangible and intangible values inherent in vernacular heritage. These two values are essential components in understanding the cultural sensitivity and ecological context that can influence vernacular settlement development decisions. This limits the depth of interpretation of the model, especially regarding stakeholder preferences formed based on perceptions of physical and non-physical aspects.

Recommended future work is further development to include a comprehensive evaluation of tangible and intangible values as part of the decision-making framework for a model that is more responsive to the socio-cultural aspects of the communities involved, multi-attribute decision-making approaches, specifically by eliciting user preference models, such as neural network applications, and establishing expert quantitative data. Real-time analysis of the value of technical solutions requires the development of trade-off algorithms.

Acknowledgment

All Authors are thankful to Riset Kolaborasi Indonesia ITS 2023-2024 contract-based number 0004/01.PKS/PPK-HETI/ITS/2024

References

Aguarón, J., Escobar, M. T., Moreno-Jiménez, J. M., & Turón, A. (2019). AHP-group decision-making based on consistency. Mathematics, 7(3). https://doi.org/10.3390/math7030242

Aktürk, G., & Fluck, H. (2022). Vernacular Heritage as a Response to Climate: Lessons for Future Climate Resilience from Rize, Turkey. Land, 11(2), 1-19. https://doi.org/10.3390/land11020276

Ali, A., Rukayah, R. S., Sardjono, A. B., & Juwono, S. (2022). New Variations of Sundanese Architecture in the City: The Case of Kampung Kranggan Vernacular Settlement in Indonesia. Journal of the International Society for the Study of Vernacular Settlements, 9(5), 110-122.

Alves, S. (2017). The Sustainable Heritage of Vernacular Architecture: The Historic Center of Oporto. Procedia Environmental Sciences, 38, 187-195. https://doi.org/10.1016/j.proenv.2017.03.105

Astuti, E. Y., Krisnugrahanto, P. A., Ayushitarum, L., Temples, B., & Astuti, E. Y. (2022). The Historic Environment : Policy & Practice A Sustainable Approach to Endangered Heritage : The Batujaya Temples, Indonesia A Sustainable Approach to Endangered Heritage : The. The Historic Environment: Policy & Practice, 13(4), 509-525. https://doi.org/10.1080/17567505.2022.2149128

Chen, X., Jiang, L., Cheng, B., Zhang, Y., Shi, X. L., Di Zheng, Y., & Fu, Y. (2024). Evaluating Urban Industrial Heritage Value using Industrial Heritage Matrix Analytic Hierarchy Process Models A Case Study of Mawei

Shipbuilding in Fuzhou City. International Review for Spatial Planning and Sustainable Development, 12(2), 99-118. https://doi.org/10.14246/irspsd.12.2_99

Dammag, B. Q. D., Jian, D., & Dammag, A. Q. (2024). Cultural Heritage Sites Risk Assessment and Management Using a Hybridized Technique Based on GIS and SWOT-AHP in the Ancient City of Ibb, Yemen. International Journal of Architectural Heritage, 1-36. https://doi.org/10.1080/15583058.2024.2364717

Darko, A., Chan, A. P. C., Ameyaw, E. E., Owusu, E. K., Pärn, E., & Edwards, D. J. (2019). Review of application of analytic hierarchy process (AHP) in construction. International Journal of Construction Management, 19(5), 436-452. https://doi.org/10.1080/15623599.2018.1452098

Dayaratne, R. (2018). Toward sustainable development : Lessons from vernacular settlements of Sri Lanka. Frontiers of Architectural Research, 7(3), 334-346. https://doi.org/10.1016/j.foar.2018.04.002

De Almeida, C. R. F., Weigang, L., Meinerz, G. V., & Li, L. (2016). Satisficing Game Approach to Collaborative Decision Making Including Airport Management. IEEE Transactions on Intelligent Transportation Systems, 17(8), 2262-2271. https://doi.org/10.1109/TITS.2016.2516444

Fadiya, O., Georgakis, P., Chinyio, E., & Nwagboso, C. (2015). Decision-making framework for selecting ICT-based construction logistics systems. Journal of Engineering, Design and Technology, 13(2), 260-281. https://doi.org/10.1108/JEDT-07-2011-0047

Fadli, F., & AlSaeed, M. (2019). Digitizing vanishing architectural heritage: The design and development of Qatar historic buildings information modeling (Q-HBIM) platform. Sustainability (Switzerland), 11(9). https://doi.org/10.3390/su11092501

Guo, X., & Lim, J. (2007). Negotiation support systems and team negotiations: The coalition formation perspective. Information and Software Technology, 49(11-12), 1121-1127. https://doi.org/10.1016/j.infsof.2006.11.006

Huang, Y., & Li, E. (2023). Culture heritage utilization evaluation of historic villages: 10 cases in the Guangzhou and Foshan Area, Guangdong Province, China. Journal of Asian Architecture and Building Engineering, 22(5), 2994-3005. https://doi.org/10.1080/13467581.2022.2145207

Kang, S., Mulaphong, D., Hwang, E., & Chang, C. K. (2019). Public-private partnerships in developing countries: Factors for successful adoption and implementation. International Journal of Public Sector Management, 32(4), 334-351. https://doi.org/10.1108/IJPSM-01-2018-0001

Karahan, F., & Davardoust, S. (2020). Evaluation of vernacular architecture of Uzundere District (architectural typology and physical form of building) in relation to ecological sustainable development. Journal of Asian Architecture and Building Engineering, 19(5), 490-501. https://doi.org/10.1080/13467581.2020.1758108

Keshtkaran, P. (2011). Harmonization between climate and architecture in vernacular heritage: A case study in Yazd, Iran. Procedia Engineering, 21, 428-438. https://doi.org/10.1016/j.proeng.2011.11.2035

Kittipongvises, S., Phetrak, A., Rattanapun, P., Brundiers, K., Buizer, J. L., & Melnick, R. (2020). AHP-GIS analysis for flood hazard assessment of the communities nearby the world heritage site on Ayutthaya Island, Thailand. International Journal of Disaster Risk Reduction, 48(April), 101612. https://doi.org/10.1016/j.ijdrr.2020.101612

Kratima, F. E., Gherbi, F. Z., & Lakdja, F. (2013). Applications of Cooperative Game Theory in Power System Allocation Problems. Leonardo Journal of Sciences, 23, 125-136. http://193.226.7.140/ljs/A23/125_136.

Kutut, V., Zavadskas, E. K., & Lazauskas, M. (2014). Assessment of priority alternatives for preservation of historic buildings using a model based on ARAS and AHP methods. Archives of Civil and Mechanical Engineering, 14(2), 287-294. https://doi.org/10.1016/j.acme.2013.10.007

Lian, W., & Dimitrijević, B. (2025). Analytic Hierarchy Process-Based Industrial Heritage Value Evaluation Method and Reuse Research in Shaanxi Province-A Case Study of Shaanxi Steel Factory. Sustainability (Switzerland), 17(9). https://doi.org/10.3390/su17094125

Liu, Y., Li, H., Li, W., Li, Q., & Hu, X. (2021). Value assessment for the restoration of industrial relics based on analytic hierarchy process: a case study of Shaanxi Steel Factory in Xi'an, China. Environmental Science and Pollution Research, 28(48), 69129-69148. https://doi.org/10.1007/s11356-021-14897-0https://doi.org/10.1007/s11356-021-14897-0

Mileto, C., Vegas, F., Llatas, C., & Soust-Verdaguer, B. (2021). A sustainable approach for the refurbishment process of vernacular heritage: The sesga house case study (valencia, spain). Sustainability (Switzerland), 13(17). https://doi.org/10.3390/su13179800

Muqoffa, M., Yaningsih, I., Rachmanto, R. A., & Caroko, N. (2024). Exploring natural ventilation strategies in Javanese vernacular houses for sustainable design.

Journal of Asian Architecture and Building Engineering, 24(6), 4985-5004. https://doi.org/10.1080/13467581.2024.2439348

Ng, S. T., & Fang, Y. (2008). Negotiation of on-site buffer stocks: A fuzzy non-structural fuzzy decision support system approach. Construction Innovation, 8(3), 202-217. https://doi.org/10.1108/14714170810888967

Nursanty, E., Cauba, A. G., Angger, J., & Waskito, P. (2024). Vernacular branding : sustaining city identity through vernacular architecture of indigenous villages. Place Branding and Public Diplomacy, 20(4), 482-503. https://doi.org/10.1057/s41254-024-00349-2

Nyongesa, H. O., Musumba, G. W., & Chileshe, N. (2017). Partner selection and performance evaluation framework for a construction-related virtual enterprise: a multi-agent systems approach. Architectural Engineering and Design Management, 13(5), 344-364. https://doi.org/10.1080/17452007.2017.1324398

Osei-Kyei, R., & Chan, A. P. C. (2015). Review of studies on the critical success factors for public-private partnership (PPP) projects from 1990 to 2013. International Journal of Project Management, 33(6), 1335-1346. https://doi.org/10.1016/j.ijproman.2015.02.008

Saaty, T. L. (2004). Decision making - the Analytic Hierarchy and Network Processes (AHP/ANP). Journal of Systems Science and Systems Engineering, 13(1), 1-35. https://doi.org/10.1007/s11518-006-0151-5

Saaty, T. L., & Alexander, J. M. (1989). Conflict resolution: the analytic hierarchy approach. RWS Publications.

Salman, M. (2018). Sustainability and vernacular architecture: Rethinking what identity is. In K. Hmood (Ed.), Urban and architectural heritage conservation within sustainability (pp. 57-72). IntechOpen. https://doi.org/10.5772/intechopen.82025

Sandorf, E. D., Campbell, D., & Chorus, C. (2022). A simple satisficing model. PLoS ONE, 17(10 October), 1-30. https://doi.org/10.1371/journal.pone.0275339 https://doi.org/10.1371/journal.pone.0275339

Shi, B., & Huang, L. (2023). Research on optimization of post-earthquake restoration planning strategy of Jiuzhaigou world heritage site based on value correlation: from the perspective of heritage site administrators. Journal of Asian Architecture and Building Engineering, 22(5), 3028-3045. https://doi.org/10.1080/13467581.2023.2171734

Simonson, I., & Sela, A. (2011). On the heritability of consumer decision making: An exploratory approach for studying genetic effects on judgment and choice. Journal of Consumer Research, 37(6), 951-966. https://doi.org/10.1086/657022

Šiožinytė, E., Antuchevičienė, J., & Kutut, V. (2014). Upgrading the old vernacular building to contemporary norms: multiple criteria approach. Journal of Civil Engineering and Management, 20(2), 291-298. https://doi.org/10.3846/13923730.2014.904814

Smirnov, A. V., & Sheremetov, L. B. (2012). Models of coalition formation among cooperative agents: The current state and prospects of research. Scientific and Technical Information Processing, 39(5), 283-292. https://doi.org/10.3103/S014768821205005X

Solikhah, N., & Fatimah, T. (2020). Lessons Learned from Vernacular Architecture Toward Sustainable Human Settlements : Insights from Praigoli Village. Journal of the International Society for the Study of Vernacular Settlements, 7(4), 37-52.

Stirling, W. C. (2009). Satisficing Games and Decision Making: With Applications to Engineering and Computer Science. In Cambridge University Press. Cambridge University Press. https://doi.org/10.1108/03684920510595571

Subramanian, N., & Ramanathan, R. (2012). A review of applications of Analytic Hierarchy Process in operations management. International Journal of Production Economics, 138(2), 215-241. https://doi.org/10.1016/j.ijpe.2012.03.036

Tutuko, P., & Shen, Z. (2014). Vernacular Pattern of House Development for Home- based Enterprises in Malang, Indonesia. International Review for Spatial Planning and Sustainable Development, 2(3), 63-77. https://doi.org/10.14246/irspsd.2.3_63

Wanyama, T. (2006). Decision support for COTS selection, University of Calgary, Canada. https://www.elibrary.ru/item.asp?id=9406536

Wulandari, E., Idawati, D. E., Nasution, B., Sabila, F., & Ul, Z. (2024). Mountainous Socio-economic and Geographical Factors in recent Aceh Gayo Vernacular Architecture Mountainous Socio-economic and Geographical Factors in recent Aceh Gayo Vernacular Architecture. IOP Conference Series: Earth and Environmental Science, 1361. https://doi.org/10.1088/1755-1315/1361/1/012048

Xu, H., Kilgour, D. M., Hipel, K. W., & McBean, E. A. (2014). Theory and implementation of coalitional analysis in cooperative decision making. Theory and Decision, 76(2), 147-171. https://doi.org/10.1007/s11238-013-9363-6

Yescombe, E. R., & Farquharson, E. (2018). Public-Private Partnerships for infrastructure: Principles of policy and finance (S. Bentley (ed.); 2nd edition). Butterworth-Heinemann. https://doi.org/10.1016/B978-

0-08-100766-2.00002-4

Žuvela, A., Šveb Dragija, M., & Jelinčić, D. A. (2023). Partnerships in Heritage Governance and Management: Review Study of Public-Civil, Public-Private and Public-Private-Community Partnerships. Heritage, 6(10), 6862-6880. https://doi.org/10.3390/heritage6100358

About the authors

CHRISTIONO UTOMO

Assoc. Prof
Department of Civil Engineering, Institut Teknologi Sepuluh Nopember, 60111, Indonesia

Main research area
Value Creation; Collaborative; Sustainable Investing; Multi Agent

Address
Kampus Sukolilo. Jl. Raya ITS, Sukolilo Surabaya 60111, Indonesia
E-mail: christiono@its.ac.id

SULFIAH DWI ASTARINI

Researcher
National Research and Innovation Agency, Tangerang Selatan, 15314, Indonesia

Main research area
Construction Management; Design Management; Performative Design; Design for Sustainability

Address
Jl. Raya Serpong, Muncul, Kec. Setu, Kota Tangerang Selatan, Banten 15314
E-mail: sulf002@brin.go.id

YANI RAHMAWATI

Lecture
Department of Architecture Engineering and Planning, Universitas Gadjah Mada, 55281, Indonesia

Main research area
Integrated Design; BIM; Design Pedagogy; Sustainable Construction

Address
Bulaksumur, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281
E-mail: yani.rahmawati@ugm.ac.id