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FACTORS INFLUENCING UNIT COSTS OF INFRASTRUCTURE IN AREAS WITH LIMITED ACCESSIBILITY

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Abstract

Infrastructure development in Indonesia is a national strategic program that must be achieved because it concerns the people's livelihoods. The government is currently undertaking various efforts to attain massive-scale infrastructure development throughout the national territory. Central Papua Province is a province in eastern Indonesia that requires infrastructure development to meet the needs and rights of the community to access development and improve community welfare in various fields. The unit price of building materials for infrastructure development that is effective and efficient is crucial in Central Papua, given the limited accessibility, which results in the unit price of infrastructure development being expensive. This study aims to compile factors that influence the high unit price of infrastructure development in Central Papua based on logistics costs. Through quantitative and qualitative methods (mixed methods), this study will produce factors that are considered significant in influencing the high unit cost of infrastructure development. The quantitative method will be carried out through secondary data processing from projects completed from 2020 to 2024 to map the costs considered dominant in influencing the unit price of infrastructure development. Meanwhile, the qualitative method is carried out through in-depth interviews with experts, including government, contractors, and logistics service providers, to confirm factors considered influential in the unit cost of infrastructure development in Central Papua. The results of this study will have a direct impact on the government's efforts to determine the unit cost of infrastructure development based on factors that are considered to have a significant influence.
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Keywords: Accessibility, Unit Price, Infrastructure, Logistics, Government Project

Introduction

Unit cost estimation is a critical aspect of planning infrastructure development in any region. It is a fundamental factor used to evaluate the feasibility and appropriateness of infrastructure projects (Masri, Nawawi, and Sipan 2016). Excessively high costs that do not translate into equivalent societal benefits are a major concern in public infrastructure provision. Therefore, infrastructure projects must aim to be competitive and affordable (Yap and Ng 2018; Anisah, Lenggogeni, and Agustina 2022; Barakchi, Torp, and Belay 2017). Properly built infrastructure can lead to substantial economic benefits for the surrounding communities. Thus, identifying and modeling the most influential factors affecting infrastructure unit costs becomes essential for achieving optimal results (Pujitha and Venkatesh 2020; Shrestha, Pradhananga, and Mani 2014).

The Indonesian government plays a central role in infrastructure development, as nearly 70% of the country's infrastructure projects are publicly funded through the national and regional budgets (APBN/APBD)(Bigwanto et al. 2024; Nahdi et al. 2024). The massive allocation of state funds requires that the government ensures infrastructure is both adequate and effective for community use. However, this ambition often comes with complex challenges. Many government infrastructure projects suffer from inefficiencies and waste (Aji Kurniawan, Susilowati, and Miftakhul Jannah 2024; Gazali et al. 2025; Fath et al. 2024; Luangcharoenrat et al. 2019; Sapuay 2016; E.M. Sari, Irawan, Wibowo, Siregar, and Praja 2023; Alwi et al. 2002). Elizar et al. (2017) note that various factors contribute to such inefficiencies, including policy constraints, regulatory frameworks, technology limitations, and low awareness regarding construction waste management. Successful waste management in infrastructure development is influenced by the synergy between appropriate regulations, effective systems, technology adoption, and stakeholder awareness (Barritt 2016; Chintapalli and Vakharia 2023; Jouhara et al. 2017; Sapuay 2016).

To address procurement and budgeting, the government has enacted Presidential Regulation (Perpres) No. 12/2021, which governs the procurement of goods and services for infrastructure projects using APBN/APBD funding (Fath et al. 2024; Al Fath et al. 2024; Sari et al. 2025). The regulation outlines procurement procedures, including direct appointment and open bidding, and defines contract types such as lump sum, unit price, a combination of both, turnkey, and cost-plus-fee contracts (Ashcraft 2022; Pal and Nassarudin 2020; E.M. Sari, Irawan, Wibowo, Siregar, Tamin, et al. 2023; Endah Murtiana Sari et al. 2023; Thais da C L Alves 2018). In unit price contracts, estimated volumes are still approximate at the time of contract signing, while payments are based on actual measured volumes upon completion (Bayram and Al-Jibouri 2016; Pujitha and Venkatesh 2020). Final contract values are thus determined only after the project is finished. This complexity necessitates careful forecasting of unit costs to ensure project estimates closely reflect actual quantities and pricing. In many regions across Indonesia, unit prices for infrastructure projects vary significantly based on the logistics and supply methods for construction materials (Christopher 2016; Ferdi Fordausy and Wisnu Isvara 2023). These supply methods directly impact factors such as cost inflation, especially in regions with challenging access (Castelblanco et al. 2024; Rahman and Adnan 2020; Suryadi et al. 2025).

One such region is Puncak Regency in Central Papua, a mountainous area with steep valleys and limited road infrastructure. Air transport is the primary mode of logistics, especially for distributing construction materials. Small aircraft are commonly used to transport essential goods, construction materials, and other necessities. This air-based logistics model incurs high operational costs, requiring efficient and cost-effective logistical management (Maria et al. 2020).

In remote areas like Puncak, logistics costs are influenced by factors such as travel distance, cargo type, flight frequency, aircraft capacity, and limitations of local airport facilities. Consequently, the prices of consumer goods and building materials are significantly higher compared to more accessible regions. This situation imposes severe economic burdens on local communities and restricts the growth of local businesses due to elevated distribution costs (Suryadi et al. 2022). Sustainable logistics in limited-access regions is further challenged by resource scarcity including the number of available small aircraft, limited fuel supplies, and extreme weather conditions that frequently disrupt flight schedules (Zamroni et al. 2021). Therefore, an integrated logistics model is needed, one that not only reduces operational costs but also accounts for geographic, economic, and social realities.

According to Bertelsen (1997), logistics was originally the art of troop movement and placement. Initially focused on internal logistics, the field has evolved toward external logistics and supply chain synchronization. Two major approaches to logistics can be identified: planning-based logistics and consumption-based logistics.

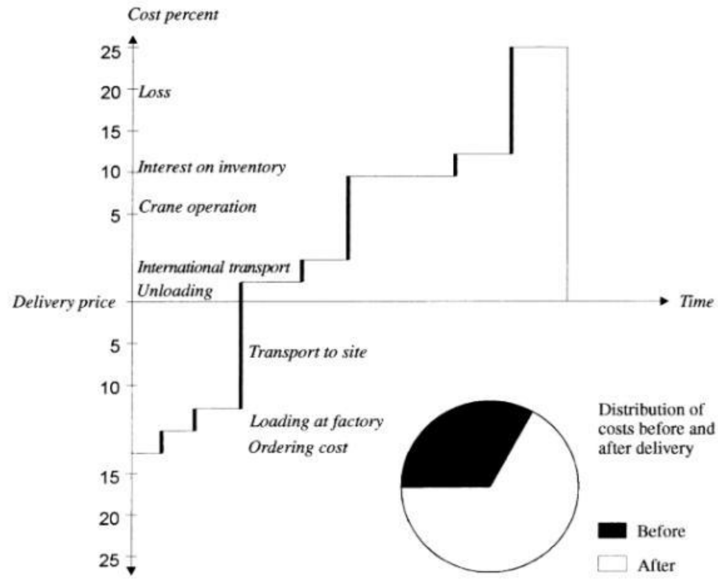

Figure 1. logistics cost prediction (Bertelsen Jorgen Nielsen et al. 1997)

Figure 1 illustrates how ineffective logistics management can lead to substantial cost overruns relative to initial project estimates. The root causes of poor material management often include inadequate planning and scheduling, repetitive logistical errors, and ineffective coordination (Prajogo, Oke, and Olhager 2016).

Addressing logistics inefficiencies is key to achieving optimal unit costs in infrastructur. Effective methods and tools must be devised to estimate costs accurately in limited-access regions. Bertelsen's study highlights that failures in logistical planning can lead to a minimum 10% increase in total construction costs (Briggs, Loveridge, and Glendinning 2017; Garschagen and Sandholz 2018). Contributing factors include excessive transportation, inadequate on-site storage, high material loss, shortages, shipment errors, and material damage before use. Additionally, San Ong (2013) identifies other key contributors to high and unpredictable construction costs: interest rate fluctuations and inflation. Failure to accurately estimate unit costs leads to uncontrolled construction budgets.

The purpose of this study is to develop a logistics-based unit cost model specifically tailored to the unique conditions of Central Papua, where infrastructure costs range from IDR 14 (USD 848) to 30 (USD 1818) million per square meter compared to IDR 7 (USD 424) to 10 (USD 689) million in urban areas like Jakarta. Identifying the dominant cost drivers in such regions is crucial to formulating practical solutions and more accurate pricing strategies for infrastructure.

Research Methods

This research adopts a mixed-methods approach combining both quantitative and qualitative methods (Plag I 2020): First the quantitative phase involves evaluating current project data, focusing on the unit cost of construction materialsboth local and imported and the logistics used for material transport. This method is used to establish the prevailing unit costs particularly for building projects in Central Papua.Second the qualitative phase begins with mapping previous research relevant to factors affecting infrastructure unit costs. This is followed by validation through in-depth interviews with experts (Grime and Wright 2016). A total of seven experts were interviewed: three government officials, two contractors, and two logistics service providers (Alomari, Gambatese, and Tymvios 2018; Ameyaw et al. 2016).

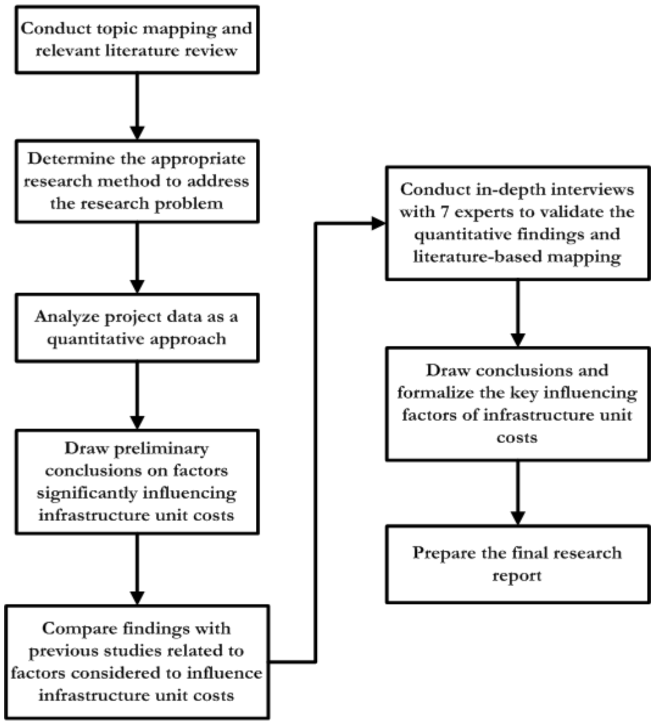

Figure 2. Research methodology

The overall research methodology is visualized in Figure 2, which illustrates the combination of quantitative and qualitative approaches applied to address the research problem.

Results and Discussion

Quantitative Analysis

Infrastructure development in Central Papua is regulated by Puncak Regent Regulation No. 14 of 2023. Implementation of this area has shown varying degrees of cost deviation. Below is a summary of unit costs and observed deviations across different infrastructure types.

Table 1. Unit Prices in Central Papua

Infrastructure Type	Minimum Price (IDR)	Maximum Price (IDR)	Deviation (%)
Residential Building	10,555,555	14,086,629	33%
Office & Dormitory	17,249,891	18,667,332	8%

Infrastructure Type	Minimum Price (IDR)	Maximum Price (IDR)	Deviation (%)
Multipurpose Hall	14,941,604	15,998,530	7%
School Building	17,249,891	20,063,438	16%
Road Construction	4,266,000,000	4,620,561,837	8%
Bridge	825,000,000	876,973,096	6%
Retaining Wall	5,326,913	5,831,678	9%

Table 1. above illustrates the unit costs for for various infrastructure projects in Central Papua. Each cost component consists of the price of both local and imported materials, which can be explained as follows:

Table 2. Comparison of Construction Material Unit Prices in Central Papua and Java

No	Material Type	Unit	Unit Price in Papua (IDR)	Material Origin	Unit Price in Java (IDR)	Deviation (%)
1	Cement	50 Kg	1,314,563	Imported	70,000	1778%
2	Glass Material 5 mm	per sheet	344,177	Imported	160,000	115%
3	Sand	3 m3	8,000,000	Local	780,000	926%
4	River Stone	3 m3 (medium truck)	7,000,000	Local	900,000	678%
5	Wall Paint	5 kg	491,250	Imported	42,000	1070%
6	Wood Base Paint	1 can	94,410	Imported	55,000	72%
7	Corrugated Zinc Sheet (Type 20)	Per sheet	167,308	Imported	48,000	249%
8	Ceramic Tile 40x40 (Asia Tile)	Per piece	499,534	Imported	40,000	1149%
9	Soft Wood Plywood (Albasia)	122 x 244 cm 3mm	160,844	Imported	52,000	209%
10	Multiplex	6mm	243,792	Imported	65,000	275%
11	Sitting Toilet (TOTO Brand)	Per unit	2,856,188	Imported	1,490,000	192%
12	Nails 1/4 -1/2	per kg	48,750	Imported	20,000	144%
13	Roof Panel (KR.5/TR3/KR.9)	0,25 mm	156,223	Imported	75,000	108%
14	Canal C75	6m 0,75	136,600	Imported	91,500	49%
15	Diesel Fuel	per liter	52,500		6,800	672%
16	Gasoline	per liter	52,500		10,000	425%

No	Material Type	Unit	Unit Price in Papua (IDR)	Material Origin	Unit Price in Java (IDR)	Deviation (%)
17	Kerosene	per liter	52,500		10,200	415%
18	Electric Cable NYM 2x1.5 mm	Per roll (100 m)	1,706,250	Imported	913,800	87%
19	Philips Desk Lamp (QDS303,18W)	per unit	326,448	Imported	43,000	659%
20	MCB 10 A 1pP	Per unit	111,930	Imported	38,000	195%

The table 2. above shows that the prices of both imported and local materials are significantly higher than those on Java. For example, cement in Puncak Regency is 18 times the price on Java, and sand, a local material, is 10 times more expensive than on Java. Another factor affecting the price of imported materials is the fuel used, such as gasoline and diesel, which are emulsifiers for asphalt road construction. Several factors contribute to the significantly higher prices of imported materials, including the logistics of transporting these materials to Central Papua, which requires expensive transportation, including small aircraft.

Qualitative Analysis

a. Literature Mapping

A mapping of previous research was conducted to provide a theoretical comparison of the phenomenon occurring in Central Papua regarding the high cost of materials, which determines the unit price of infrastructure. Several previous studies were synthesized to uncover the factors causing the high unit price of Central Papua. Below is a mapping of previous research related to these factors:

Table 3. Mapping of previous research

No	Researcher	Factors that influence the unit price
1	ACVentures (2020) (Pratama, Harianto, and Taryana 2023)	• Distance and Location of Suppliers • Transportation Availability • Fuel Price Fluctuations • Warehouse and Storage Management • Weather and Natural Conditions
2	World Bank (2024)(Hadžikadunić et al. 2023)	• Frequency of shipments reaching the consignee within the scheduled or expected delivery time • Ability to track and trace shipments • Competence and quality of logistics services • Ease of arranging competitive international shipping rates • Quality of trade and transportation infrastructure

No	Researcher	Factors that influence the unit price
		• Efficiency of customs clearance and restrictions
3	Nguyen & Le Hoang Thuy to Nguyen (2020)(Nguyen and Le Hoang Thuy To Nguyen 2020)	• interest rates • investment objectives • empowerment of new architects • drawing production • requirements, orders • expected work volume • construction costs • consumer price index • gross domestic product • construction permits • currency supply
4	Baek & Ashuri (2018) (Baek and Ashuri 2018)	• number of bidders • total contract value • quantity of tender items • dollar value at the time of the contract • price of building materials
5	Mohamed et.al (2021) (Mohamed, Ibrahim, and Hagras 2021)	• building type • architectural type • financial aspect • social aspect • government system • environmental aspect • economic aspect
6	Fageda et.al (Fageda et al. 2019)	• air transport
7	Ferdi Firdausy et.al (2023) (Ferdi Fordausy and Wisnu Isvara 2023)	• poor logistics • weather conditions

Table 3. above shows factors from previous research considered to influence the high cost of infrastructure, particularly in locations with limited accessibility, such as Central Papua. The results of in-depth interviews with seven experts concluded and weighted each factor deemed significant, categorizing it as "very important," "important," and "unimportant." Factors with a weighting of more than 50% for "very important" and "important" are considered significant and are recommended as strategies for managing the unit price of infrastructure in Central Papua.

Table 4. Factor weighting

No	Factors that influence the price	Very Improtant	Important	Not Important
1	Supplier Distance and Location	71.42%	28.58%	
2	Transportation Availability	71.42%	28.58%	
3	Fuel Price Fluctuations	42.85%	42.85%	14.30%
4	Warehouse and Storage Management	42.85%	42.85%	14.30%
5	Weather and Natural Conditions	100%		
6	Frequency of Shipments Reaching the Consignee	42.85%	28.58%	28.58%
7	Ability to Track and Trace Shipments		28.58%	71.42%
8	Competence and Quality of Logistics Services	42.85%	28.58%	28.58%
9	Interest Rates	42.85%	28.58%	28.58%
10	Production Drawings		28.58%	71.42%
11	Order Requirements	42.85%	28.58%	28.58%
12	Expected Work Volume		28.58%	71.42%
13	Construction Permits	42.85%	28.58%	28.58%
14	Government Regulations	100%		
15	Air Transportation	71.42%	28.58%	

The table 4. above shows that three factors are considered insignificant in influencing the unit price in areas with limited accessibility, such as Central Papua: the ability to track and trace shipments, the production of drawings, and the expected volume of work. Meanwhile, findings that were considered very significant with a very important value of > 50% included Supplier Distance and Location (71.42%), Transportation Availability (71.42%), Weather and Natural Conditions (100%), Government Regulations (100%), and Air Transportation (71.42%). This is in line with what was conveyed by Pratama et al. (Pratama et al. 2023), Nguyen and Le Hoang Thy To Nguyen (Nguyen and Le Hoang Thuy To Nguyen 2020), Mohamed et.al (2021), (Mohamed et al. 2021), Fageda et.al (Fageda et al. 2019), Ferdi Firdausy et.al (2023), (Ferdi Fordausy and Wisnu Isvara 2023). This very significant factor affects the price of materials, especially imported materials such as cement, wall paint, ceramic tiles, softwood plywood (Albasia), multiplex, etc., which have increased by at least 200%. Meanwhile, extreme weather conditions such as strong winds and government regulations that have not yet fully regulated material prices cause local material prices to fluctuate and be unpredictable because they depend on local suppliers who do not use standardized pricing. Another thing is the existence of interest rates that cannot be guaranteed, causing materials such as cables to also experience high prices compared to Java.

Therefore, in general, the factors influencing the unit price of infrastructure can be described as follows:

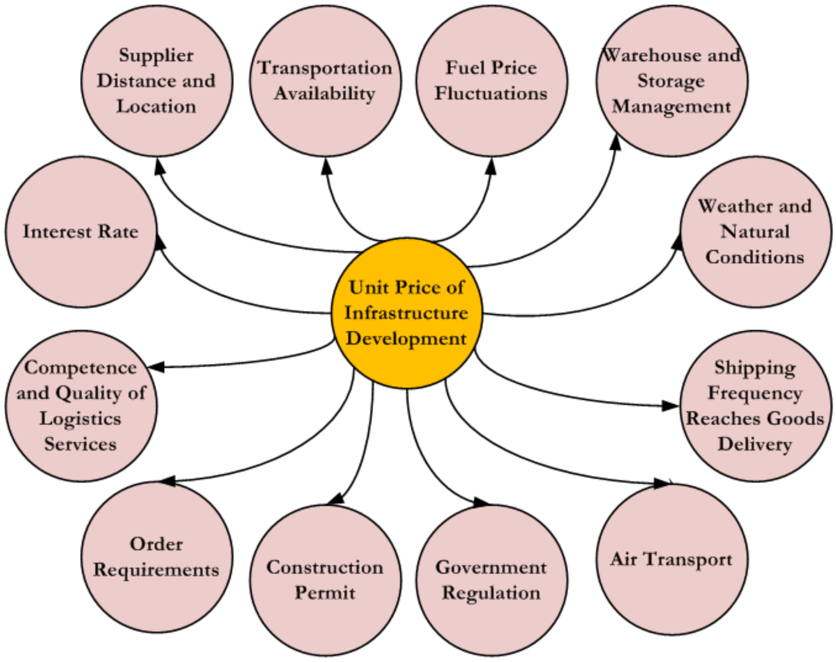

Figure 3. Mapping of Unit Price Factors for Infrastructure

Figure 3 above shows that there are tweleve factors that are considered to influence the determination of unit prices for infrastructure development in Central Papua.

Conclusion

From the research results above, the following conclusions can be drawn: (1) The high unit price in areas with limited accessibility in Central Papua Regency is due to the logistics costs of both imported and local materials used in infrastructure; (2) There are twelve factors affecting of the unit price in areas with limited accessibility. These factors can be used as a strategy to address the high unit price of infrastructure. These factors must be grouped into two main groups, distinguishing between factors that can be controlled by regulators and contractors and those that cannot intervention by stakeholder. This distinction is crucial for implementing a targeted strategy for calculated unit price of infrastructure in areas with limited accessibility.

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