

Effects of Geographic Accessibility and Mahakam River's Water Levels on HSBGN in Mahakam Ulu Regency

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Abstract

Public building unit costs in Mahakam Ulu Regency depend on river-based logistics and unequal geographic accessibility. This study reanalyses the 2025 final-report dataset to quantify differences across four accessibility zones and two river-water conditions. The analytical sample comprises 64 public building unit-cost entries (eight building or fence typologies × four zones × two conditions), 36 material-price observations, and recorded freight tariffs. Paired comparisons identify a highly consistent low-water correction coefficient of 1.2083, equivalent to a 20.83% premium over the normal/high-water scenario. Mean geographic indices relative to Zone I are 1.1411, 1.2799, and 1.4916 for Zones II, III, and IV, respectively, although indices vary by building typology. Across the comparable transport routes, listed low-water freight tariffs are approximately 25% higher than normal-water tariffs. The results yield a transparent two-factor indexing scheme for preliminary budgeting; however, the coefficients are descriptive ratios of an existing cost matrix, not independently validated causal effects. The source documents do not provide complete point-to-point distances, so a rupiah-per-kilometre coefficient cannot be justified.

Keywords

Accessibility; Building Unit Cost; Geographic Zone; River Water Level; Transportation Cost



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INTRODUCTION

The State Building Unit Price (HSBGN) is a reference instrument for estimating government building costs to support budgeting, procurement, control, and auditing of construction projects. The price standards that are generally prepared do not necessarily reflect the difference in real costs in areas with limited transportation access. Location-sensitive pricing is important so that the initial estimate does not experience shortages or overalities (Flyvbjerg et al., 2002) ; (Statistics, 2025) ; (Sarasanty, 2021) . The amount of construction costs can vary between regions due to differences in the unit price of materials and labor wages, so local price characteristics need to be taken into account in the preparation of development cost estimates. Work Unit Price Analysis (AHSP) is a

construction cost calculation approach that uses the coefficient of labor, material, and equipment needs to determine the unit price of each work (Kartika et al., 2022) ; (AlTalhoni et al., 2024; Rahman, Adella Arfy So; Saleh, The Mohamat; Siahay, 2023)

Mahakam Ulu Regency in East Kalimantan has a strong transportation linkage with the Mahakam River. Waterways allow the movement of building materials from distribution centers such as Samarinda and West Kutai, while land access still has limitations in some areas. River transportation is greatly influenced by high water levels because the depth of the channel and the operational capacity of ships can change. Previous research has shed light on the relevance of water transportation and remote factors to infrastructure distribution and financing (Anapah & Sonny, 2025); (Sianturi et al., 2025) ; (Putra et al., 2019; Suhendra et al., 2024; Triatmodjo, 2009) . Various studies have linked project locations, road infrastructure, logistics costs, and material limitations to the uncertainty of cost estimates. However, for Mahakam Ulu, quantitative measurements are still needed that simultaneously distinguish the influence of geographic zone groups and the scenario of normal water height compared to recede. This study utilizes the results of the survey and the HSBGN matrix that has been compiled in the technical work in 2025, instead of using new price estimates. (Shen et al., 2025) (Mbachu & Nkado , 2007; Olanrewaju & Abdul-Aziz, 2015; Winanda et al., 2024) . The objectives of this study are (1) to compare logistics prices between regions/zones, materials, and HSBGN between locations and water level conditions; (2) to calculate the correction index at low tide and zoning; (3) to identify trends from the price matrix; and (4) to formulate the limits of the use of these coefficients in the preparation of HSBGN that is adaptive to local conditions.

METHODS

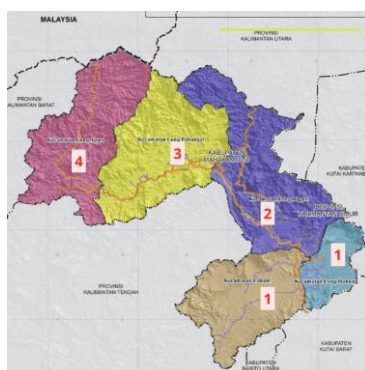


Figure 1. Map of regional zoning division in Mahakam Ulu Regency in the study analysis

Table 1. A data-driven analysis matrix design is available

Data	Scope	Unit of analysis
Final HSBGN recap	8 types × 4 zones × 2 water conditions	64 points, 32 pairs
Detailed material prices	9 types × 4 zones, normal water	36 points

River freight rates	7 routes/modes displayed	Rp/kg and water conditions
Geography	4 zones and travel time information	ordinal category; not km

The final eight categories consist of simple state buildings type A; non-simple state buildings type B; non-simple state houses types A, B, C, D, and E; and fences of houses/state buildings. This is in accordance with . The use of these 64 numbers comes from the number 8 types of hsbgn $\times$ 4 zones $\times$ 2 water conditions. (Ministry of Finance) Jobs General and Housing People, 2024)

Methods of comparison and coefficient identification

For each type t , z -zone, and c -water condition, $H(t,z,c)$ expresses the HSBGN value as listed in the source. The comparison uses the same type-zone pairs so that changes due to differences in building classification are not mixed with changes in water conditions. The hydrological correction coefficient is calculated as $K_{air}(t,z) = H(t,z,recede) / H(t,z,tide)$. Furthermore, the aggregate K_{air} is the average of all 32 pairing ratios. The zone coefficient per type is calculated as $K_{zona}(t,z) = H(t,z,tide) / H(t,I,tide)$. The aggregate zone coefficient is a simple average of the index of eight types in the same zone, with $K_{zona}(I) = 1$. This geographical index is interpreted as the price ratio between accessibility groups, and is not interpreted as a unit coefficient of Rp/km. The material prices in the transportation analysis document are cross-checked with the equation $H_{material} = \text{basic price} + (\text{weight} \times \text{normal tariff per kg})$. Conceptually, the combined cost parameters can be written $H(t,z,c) \approx H(t,I,tide) \times K_{zona}(t,z) \times K_{air}(c)$. The form is an index identity calculated from the data and is only used as a descriptive guide to the type and range of available locations. Testing of predictions outside the data, causal relationship with water elevation, and estimation of cost function per kilometer require additional observations.

Data checks and interpretation limits

The analysis prioritizes the numbers in the source table over conflicting descriptions. The exposure contains the transport rates in the normal and recessed scenarios, while the material price appendix contains the prices in the normal scenario. The data do not contain the time series of water elevation per day, the route distance between points in kilometers, nor the complete actual material cost in both water conditions; therefore the results are not positioned as a causal regression of water depth/height or absolute mileage.

RESULTS AND DISCUSSION

Changes in transport rates due to water level conditions

River transportation is an important distribution route for the movement of materials from the supplier center to the destination district. Table 2 presents five representative routes/modes read directly from the tariff table. All tariff pairs experienced a relatively

similar increase, namely 25% in the low tide condition. The reported travel time was three days (72 hours) for boats from Samarinda, 15 hours from West Kutai to Long Bagun, and four and six hours for long boats from Long Bagun to Long Pahangai and Long Apari.

Table 2. Comparison of freight rates listed on normal and low water conditions

Routes and modes	Normal (Rp/kg)	Recede (Rp/kg)	D (%)	Time
Samarinda–Long Bagun (logistics vessel)	6.666,67	8.333,33	25,0	3 days
West Kutai–Long Bagun (logistics ship)	1.666,67	2.083,33	25,0	15 hours
Samarinda–Long Bagun (taxi boat)	10.000,00	12.500,00	25,0	3 days
Long Bagun–Long Pahangai (long boat)	666,67	833,33	25,0	4 jam
Long Bagun–Long Apari (long boat)	1.000,00	1.250,00	25,0	6 jam

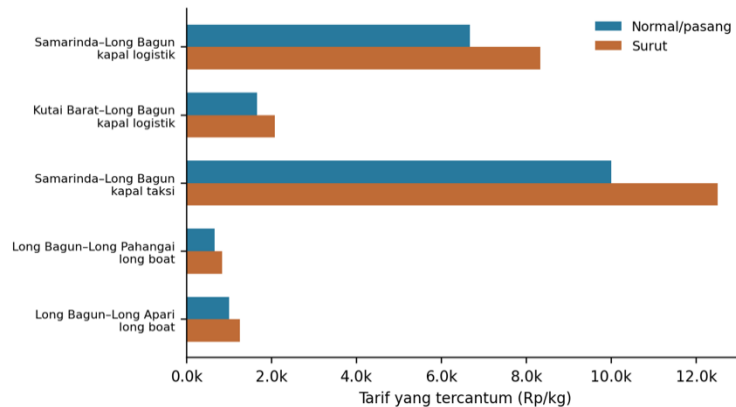


Figure 1. Comparison of river transport rates by mode/route and water level conditions

The magnitude of 25% reflects the tariff ratio in the transportation table, while the next calculated HSBGN coefficient is 20.83%. The two are not identical because the HSBGN value includes a combination of other types of work and cost components, not just transportation costs. Arithmetic checks show that the tariff per kilogram on the two long boat routes is not equivalent to the distribution of the travel costs listed by the 5-ton ship capacity; the tariff figure is still presented according to the source and requires clarification before being used for the actual transportation booking.

Disparity in material prices between zones

The recap of 36 detailed material prices shows a nominal increase from Zone I to Zone IV for the nine types of materials analyzed. The increase in costs for relatively cheap goods

tends to be larger in percentage, because shipping costs are a larger part of the initial price. In the source table, the normal transportation rates used are IDR 6,666.67/kg (Zone I), IDR 10,000.00/kg (Zone II), IDR 10,666.67/kg (Zone III), and IDR 11,000.00/kg (Zone IV), respectively.

Table 3. Example of material price calculated under normal water conditions (Rp per unit of product)

Material	Zone I	Zone II	Zone III	Zone IV
Light Brick	24.974,34	29.974,34	30.974,34	31.474,34
Batako	9.441,67	12.775,00	13.441,67	13.775,00
Multiplex	146.666,67	180.000,00	186.666,67	190.000,00
Aluminium Composite Panel	1.727.478,67	1.760.812,00	1.767.478,67	1.770.812,00
Bamboo	134.479,00	184.479,00	194.479,00	199.479,00

Indexed, the average of nine materials relative to Zone I became 1.1879 (Zone II), 1.2255 (Zone III), and 1.2443 (Zone IV). The range of material changes is quite wide; for example, the increase in Zone IV compared to Zone I reached about 48.33% in bamboo, but only 2.51% in aluminum composite panels. Because the unit of each material is different, the nominal price is not averaged across materials; what is compared is the proportional index per item.

Comparison of HSBGN by water level zone and scenario

Table 4 and Table 5 contain a recap of all 64 HSBGN values. The units in the table are the unit price according to the final HSBGN recap, which is Rp/m² for the building type; the fence value follows the reference unit of fence Rp/m' and cannot be assumed to be Rp/m² of the building. Thus, the aggregation of the following types is a relative index/pattern analysis; the nominal average is not used as a single price standard for a particular project.

Table 4. Value of HSBGN tide/normal condition based on the final recap (Rp per reference unit)

Klasifikasi	Zone I	Zone II	Zone III	Zone IV
Simple building A	12.799.588	14.234.635	15.619.890	17.712.433
Building is not simple B	15.385.364	17.110.319	18.775.423	21.290.703
A simple house	11.620.126	13.344.077	15.096.212	17.755.726
Houses are not simple B	10.104.457	11.603.546	13.127.141	15.439.762
Houses are not simple C	8.588.789	9.863.014	11.158.070	13.123.797
The house is not simple D	8.083.566	9.282.836	10.501.713	12.351.809
Houses are not simple E	7.073.120	8.122.482	9.188.999	10.807.833
Country fence	10.898.099	12.672.545	14.193.795	16.616.678

Table 5. HSBGN value of receivable conditions based on the final recap (Rp per reference unit)

Klasifikasi	Zone I	Zone II	Zone III	Zone IV
Simple building A	15.465.743	17.199.709	18.873.513	21.401.933
Building is not simple B	18.590.135	20.674.398	22.686.344	25.725.556
A simple house	14.040.598	16.123.649	18.240.753	21.454.244
Houses are not simple B	12.209.216	14.020.564	15.861.524	18.655.864
Houses are not simple C	10.377.833	11.917.479	13.482.296	15.857.484
The house is not simple D	9.767.372	11.216.451	12.689.219	14.924.691
Houses are not simple E	8.546.451	9.814.395	11.103.067	13.059.105
Country fence	13.168.173	15.312.236	17.150.363	20.077.932

The lowest value in the normal condition matrix is IDR 7,073,120 (State House type E, Zone I), while the highest is IDR 21,290,703 (State Building is not simple type B, Zone IV). In the receding scenario, the range is IDR 8,546,451 to IDR 25,725,556 for the same category and zone pairs. Each type shows a nominal and relative increase from Zone I to Zone IV; this is according to the geographical zoning structure based on regional affordability.

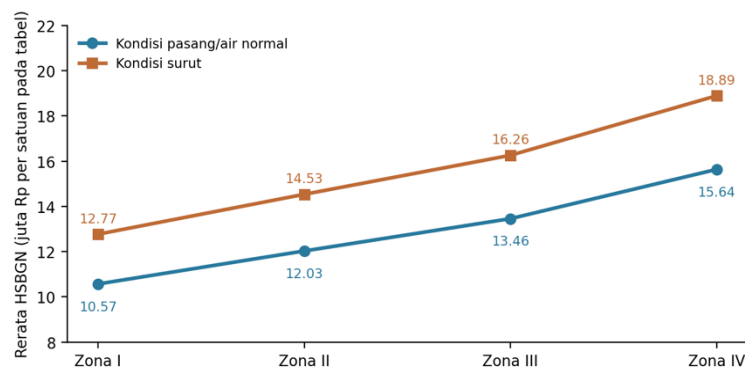


Figure 2. Nominal average trends from eight HSBGN categories in four zones and two water conditions; averages are used only for inter-scenario pattern visualization.

Hydrological correction coefficient and cost difference

The multiplier on all 32 pairs resulted in a value K_{air} close to 1.2083, with a percentage increase range of 20.8300–20.8300%. A very narrow range comes from rupiah rounding; in practice, the final table applies a factor of around 1.2083 uniformly to different types and zones. This means that the coefficient can be identified consistently from the cost matrix, but its uniformity also suggests that the table may be formed through one common correction rule, rather than 32 independent observations of market price changes.

Table 6. Average difference between the HSBGN of the receding condition to normal (index of eight types)

Area	Install (Rp)*	Ebb (Rp)*	Δ nominal (Rp)*	K _{air}
Zone I	10.569.139	12.770.690	2.201.552	1,2083
Zone II	12.029.182	14.534.860	2.505.678	1,2083
Zone III	13.457.655	16.260.885	2.803.230	1,2083
Zone IV	15.637.343	18.894.601	3.257.258	1,2083

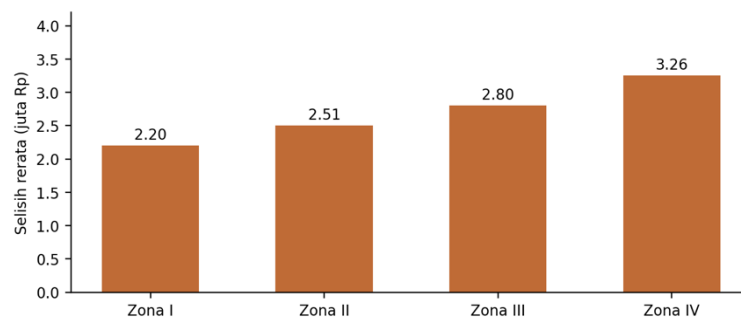


Figure 3. The average difference in the nominal HSBGN table between receding and normal conditions is getting larger towards Zone IV.

Geographic coefficients based on accessibility zoning

Table 7. Geographic coefficients relative to Zone I by price group and source

Groups	K(I)	K(II)	K(III)	K(IV)
State buildings (2 types)	1,0000	1,1121	1,2203	1,3838
Country house (5 types)	1,0000	1,1484	1,2991	1,5280
Country fence (1 type)	1,0000	1,1628	1,3024	1,5247
Average 8 types of HSBGN	1,0000	1,1411	1,2799	1,4916
Rerata 9 material, normal	1,0000	1,1879	1,2255	1,2443

In the eight types of HSBGN, the mean coefficients of Zones II, III, and IV were 1.1411; 1.2799; and 1.4916. However, the values are not entirely uniform for all classifications: state buildings show a Zone IV ratio of about 1.3838, while state houses are around 1.5280. Therefore, the calculation of project estimates that maintain building types can use a type-specific index, whereas the average value in Table 7 is only used as a macro indicator.

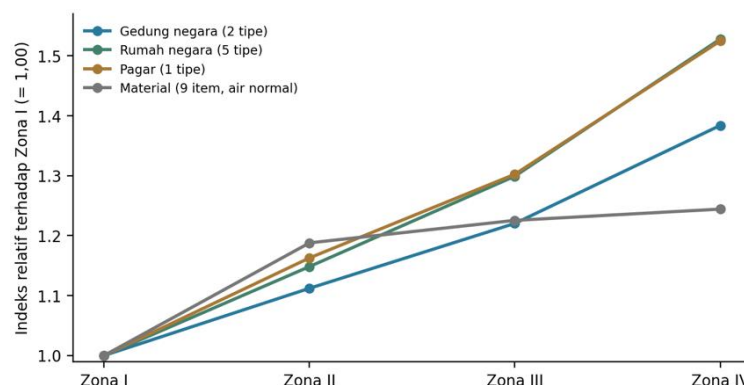


Figure 4. Geographical index based on building class and material, all normalized to Zone I = 1.00.

The differences in the material price index and HSBGN reflect the composition and weight of non-standard materials, labor, tools, and components in each of the AHSP/HSBGN results. There is no basis for directly equating the price index of the nine material samples with the composite building coefficient. The four zones form an ordinal sequence that can indicate relative isolation, but not a regression line to physical distance. Without the route length of each shipment, the price slope in Rp/km cannot be validly calculated.

Formulation of correction index and implications for the preparation of HSBGN

Based on the result matrix, the operational formulas that can be further tested are: $H(t,z,tide) \approx H(t,I,tide) \times K_{zona}(t,z) \times 1.2083$. Under normal conditions, the water coefficient is 1. Each element in the equation can be retrieved from a primary table with the same classification t as well as a z zone. This formula results in a match against the historical table because the coefficient is calculated from the same table; the success of the match is not proof of validation in a new project or another period.

In the practice of preparing estimation documents, two parameters that should be recorded separately are (i) location/accessibility groups, which are related to the choice of modes and loading and unloading locations, and (ii) river water height conditions, which are related to shipping capabilities when distribution is carried out. Planners are not advised to add at once the total HSBGN coefficient and the transport coefficient on the material components that have taken into account these conditions, because it has the potential to result in double calculations.

Limitations and validation requirements

A number of limitations need to be noted: (1) the water level is declared as a normal versus receding scenario, without numerical observation of water elevation; (2) the shipping distance of kilometers per point is not yet available; (3) the detailed material price only represents normal conditions in the annexed table accessed; (4) there is a difference in the narrative in the Final Report regarding the direction of the price increase, while the HSBGN Final table explicitly shows that the retreat is more expensive; and (5) some freight rates with

5-ton capacity vessels require checking the consistency of costs per trip, cargo, and rates per kilogram. These limitations are important so that the coefficient is not stated as a statistically proven cause-and-effect relationship. Follow-up research can collect GPS route distances, daily water elevation and discharge, actual vessel type and load, travel time, cost per trip, and actual transaction price on the same observation date. Such iterative data can then be analyzed through multivariable logistics cost models, panel regression, or sensitivity tests to separate distance and hydrological impacts from material characteristics and vessel capacity.

CONCLUSION

Analysis of the eight HSBGN classifications in the four zones of Mahakam Ulu Regency showed a consistent pattern of price increases from Zone I to Zone IV, both for normal and low water level conditions. The average geographical indices relative to Zone I were 1.1411 (Zone II), 1.2799 (Zone III), and 1.4916 (Zone IV), with differences according to the type of building. In 32 similar price pairs, the value of the retreat condition was recorded to be higher by around 20.83%, so that the water correction coefficient was $K_{air} = 1.2083$. The transport rates compared from the logistics table increased by about 25% at low tide. The two percentages measured different and non-interchangeable cost levels. The parameters obtained can be used as a comparison ratio and a zone-based HSBGN evaluation tool and water level scenario, provided that they follow the same unit, building type, and price component. To produce a distance-based geographic coefficient (Rp/km) and prove the causal relationship of water level to cost, transportation distance data and recorded hydrological conditions are still needed as well as independent validation.

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