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ECOLOGY BASED STUNTING PREVENTION MODEL IN THE FLOATING HOUSES ALONG THE KAHAYAN RIVER, PALANGKA RAYA CITY, INDONESIA

Mars Khendra Kusfriyadi[1]✉, I Nyoman Sudyana[2], Liswara Neneng[3], Trilianty Lestarisa[4]

[1]Health Polytechnic of the Ministry of Health, Palangka Raya, Central Kalimantan, Indonesia,
[1]Enviromental Science Doctoral Program, University of Palangka Raya, Central Kalimantan
[2,3,4]University of Palangka Raya, Central Kalimantan, Indonesia

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ABSTRACT

Stunting continues to pose a significant public health concern in riverine and ecologically vulnerable communities, where environmental, socio-cultural, and health system factors converge. Populations residing in floating dwellings along the Kahayan River face challenges such as inadequate sanitation, exposure to unsafe water sources, and limited access to essential services, all of which may contribute to an elevated risk of stunting. Accordingly, a comprehensive analytical model is warranted to clarify both direct and indirect ecological pathways influencing stunting among children under five in floating-house settlements. This mixed method cross-sectional study was carried out among children aged 0–59 months residing in floating-house communities along the Kahayan River. A purposive sampling technique was employed to select a total of 193 research participants. Quantitative data were gathered through structured questionnaires and anthropometric assessments, and subsequently analyzed using Structural Equation Modeling Partial Least Squares (SEM-PLS). Qualitative data were collected via in-depth interviews and focus group discussions with mothers, community leaders, healthcare professionals, and local stakeholders. Ecological determinants of stunting encompass individual-level factors such as dietary intake (β = 0.615, t = 12.871) and infectious diseases (β = 0.121, t = 2.370), both of which demonstrate direct impacts on stunting. Conversely, environmental sanitation (β = -0.096, t = 1.985) and cultural factors (β = -0.082, t = 1.665) are found to have indirect effects on stunting. Stunting among riverine floating communities is linked to ecological health factors. To prevent it effectively, a comprehensive approach is needed, including improved sanitation, culturally sensitive nutrition education, infection control, and strengthened community health services. The ecology-based model developed offers a tailored framework for sustainably reducing stunting in disadvantaged river settlements.

Kata Kunci:

Budaya;
Ekologi;
Penyakit infeksi;
Masyarakat rumah lanting;
Sanitasi;
Stunting

ABSTRAK

Stunting masih menjadi tantangan kesehatan masyarakat yang persisten di wilayah bantaran sungai dan permukiman yang rentan secara ekologis, di mana faktor lingkungan, sosial budaya, dan sistem pelayanan kesehatan saling berinteraksi. Masyarakat yang tinggal di rumah lanting di sepanjang Sungai Kahayan menghadapi keterbatasan sanitasi, penggunaan air yang tidak aman, serta akses layanan kesehatan yang terbatas, sehingga berpotensi meningkatkan risiko stunting pada anak. Oleh karena itu, diperlukan model analisis terintegrasi untuk menjelaskan jalur langsung dan tidak langsung yang memengaruhi stunting berbasis ekologi pada anak balita yang tinggal di permukiman rumah lanting. Penelitian ini menggunakan desain *mixed-method* dengan pendekatan potong lintang (*cross-sectional*) pada balita usia 0 – 59 bulan yang tinggal di kawasan rumah lanting di sepanjang Sungai Kahayan. Sebanyak 193 anak menjadi sampel penelitian yang diambil menggunakan metode *purposive sampling*. Data kuantitatif dikumpulkan melalui kuesioner terstruktur dan pengukuran antropometri, kemudian dianalisis secara multivariat menggunakan *Structural Equation Modeling Partial Least Squares* (SEM-PLS). Data kualitatif diperoleh melalui wawancara mendalam dan diskusi kelompok terfokus (FGD) yang melibatkan ibu balita, tokoh masyarakat, tenaga kesehatan, serta pemangku kepentingan lokal. Faktor ekologi yang memengaruhi stunting adalah faktor individu seperti asupan makanan (β = 0.615, t = 12.871) dan penyakit infeksi (β = 0.121, t = 2.370) berpengaruh langsung terhadap stunting, sedangkan sanitasi lingkungan (β = -0.096, t = 1.985) dan budaya (β = -0.082, t = 1.665) berpengaruh tidak langsung terhadap stunting. Stunting pada masyarakat rumah lanting di wilayah sungai merupakan hasil dari interaksi ekologi kesehatan. Upaya pencegahan yang efektif memerlukan strategi multisektoral yang terintegrasi, meliputi perbaikan sanitasi, edukasi gizi yang peka budaya, pengendalian penyakit infeksi, serta penguatan pelayanan kesehatan berbasis masyarakat. Model pencegahan stunting berbasis ekologi yang dikembangkan dalam penelitian ini dapat menjadi kerangka kerja kontekstual untuk penurunan stunting yang berkelanjutan di permukiman sungai yang termarginalkan.

✉ ***Corresponding Author:***

Mars Khendra Kusfriyadi
Telp. 081349411385
Email: marskhendra@polkesraya.ac.id

INTRODUCTION

Stunting remains a global public health problem caused by chronic undernutrition and continues to pose a serious challenge, including in Indonesia (Iskandar Munir, 2024; Siramaneerat et al., 2024). It is defined as a height-for-age below −2 standard deviations of the WHO Child Growth Standards and reflects impaired linear growth associated with recurrent infections and inadequate psychosocial stimulation (Frenquelli et al., 2022). Beyond a physiological condition, stunting represents a multidimensional problem involving interconnected health, environmental, and social determinants (Black et al., 2013).

Nationally, although the prevalence of stunting in Indonesia has shown a declining trend, it remains above the WHO public health threshold (<20%). The 2023 Indonesian Health Survey reported a stunting prevalence of 21.5%, reflecting only a 0.1% decrease compared to 2022 (21.6%). This marginal reduction indicates that the rate of decline is relatively slow, underscoring the need for more innovative and sustainable policy interventions and strategies (Fazila et al., 2022; Jumu et al., 2022; Maya Puspitasari et al., 2024; Mulyasari et al., 2024).

Central Kalimantan Province has experienced a notable decline in stunting prevalence, from 32.3% in 2019 to 22.1% in 2024. Similarly, Palangka Raya City reported a reduction from 25% in 2019 to 20% in 2024. Although these improvements are significant, they have not yet reached the National Medium-Term Development Plan (RPJMN) target of 14%. This underscores the need for continued and intensified efforts to further address stunting (Kementerian Sekeretarian Negara RI, 2026).

The gradual decline in stunting prevalence is shaped by a range of social, cultural, and ecological factors that substantially influence dietary practices and health-related behaviors (Ariskawati et al., 2024; Lisdeni & Hartono, 2023). Environmental determinants, particularly restricted access to clean water, insufficient sanitation infrastructure, and ongoing exposure to environmental contaminants in floating-house communities, considerably elevate the risk of stunting (Arief et al., 2025). Evidence indicates that children residing in areas with poor sanitation face up to a 33% greater likelihood of experiencing stunting compared to those living in environments with improved sanitation (Woldesenbet et al., 2023).

Stunting prevention initiatives in Indonesia are pursued through two primary strategies: specific and sensitive interventions. Specific interventions concentrate on the health sector and encompass supplementary feeding for children under five, maternal nutrition supplementation, promotion of exclusive breastfeeding, and the management of severe malnutrition. Conversely, sensitive interventions address sectors outside of health, including enhancing access to clean water and sanitation, advancing education, fostering economic development, empowering women, and safeguarding child welfare (Kemenkes RI, 2022). Sensitive interventions may account for as much as 70% of stunting prevention, including in Indonesia. Despite their significant impact, these interventions face complex challenges in implementation, especially in achieving cross-sectoral collaboration and ensuring ongoing program sustainability in remote and disadvantaged regions (UNICEF, 2024).

Several countries have reduced stunting through ecology-based interventions outside the health sector. Tanzania improved sanitation and nutrition by strengthening local resource management (Makori et al., 2018). Bangladesh reduced stunting rates by up to 15% in five years through an integrated ecological approach (Islam et al., 2020). Thailand and the Philippines also achieve notable declines by integrating agricultural, local foods, and community nutrition education (Jr. & Salvador, 2020).

While most research on stunting in Indonesia has concentrated on mainland or urban areas, floating-house communities (*rumah lanting*) found in river basin regions (Daerah Aliran Sungai/DAS) present unique ecological and social characteristics. Aspects including reliance on river water for daily activities, open sanitation systems, and water-based transportation have not been thoroughly investigated regarding their connection to stunting (Fanny Dewi et al., 2025).

The ecological determinants framework emphasizes that children's nutritional status is shaped by the complex interplay among biological factors (e.g., nutrient intake and susceptibility to infectious diseases), behavioral factors (including feeding habits and personal hygiene practices), and environmental conditions (e.g., access to clean water, adequate sanitation, and suitable housing). These elements interact dynamically within the broader community ecosystem (UNICEF, 2025). The framework elucidates that child growth failure arises from the combined influence of biological, behavioral, and environmental determinants operating within an integrated ecological system. Empirical research indicates that suboptimal environmental exposures, for example insufficient water supply, poor sanitation infrastructure, and inadequate hygiene, substantially contribute to stunting by increasing vulnerability to recurrent infections and disrupting nutrient absorption (Das et al., 2021; Sorgho et al., 2021).

Ecological factors are especially important for floating-house settlements, as rivers serve as places to live, sources of drinking water, locations for daily activities, and waste disposal areas. These conditions increase the risk of exposure to pathogens, which can cause Environmental Enteric Dysfunction (EED), frequent diarrhea, and impaired growth in children. Stunting is therefore the result of complex interactions among environmental, behavioral, and socioeconomic influences not solely poor diet. This ecological perspective highlights the need for multisectoral strategies that extend beyond nutrition-focused programs to include sanitation improvements, access to clean water, behavioral change efforts, and sustainable use of local resources (Kwami et al., 2019).

The floating-house settlements along the Kahayan River Basin in Palangka Raya City present complex ecological and social characteristics, with communities heavily dependent on the river for daily living. The use of untreated river water, open defecation practices, inadequate handwashing behavior, and early introduction of complementary feeding before six months increase the risk of infection and worsen children's nutritional status.

The floating-house communities situated along the Kahayan River Basin in Palangka Raya City demonstrate intricate ecological and social dynamics, with residents relying substantially on the river for their daily activities (Badan Pusat Statistik Indonesia, 2024; Gowder, 2024). Practices such as utilizing untreated river water, conducting open defecation, insufficient hand hygiene, and introducing complementary feeding before six months have been identified as factors that heighten infection risk and negatively affect child nutritional outcomes (Arief et al., 2025; Seis et al., 2024).

An ecology-based approach to stunting prevention in the Kahayan River floating-house area holds considerable promise for generating substantial outcomes. Evidence suggests that community-driven clean water management can effectively reduce the incidence of diarrheal diseases (Wolf et al., 2022). Additionally, optimizing local resources, such as incorporating river fish as a protein source, represents an effective strategy for mitigating undernutrition (Food and Agriculture Organization of the United Nations, 2025). Consequently, this study is integral to developing a contextually tailored, ecology-based, and sustainable stunting prevention model for populations residing in the floating-house settlements along the Kahayan River Basin in Palangka Raya City.

METHOD

Type of Research

This research used a mixed-methods design, combining both quantitative and qualitative methodologies to thoroughly investigate ecological determinants of stunting within riverine floating-house communities. The quantitative portion employed a cross-sectional approach to evaluate associations between ecological variables and child nutritional status. Complementing this, the qualitative component comprised in-depth interviews and focus group discussions aimed at contextualizing and interpreting quantitative results within the community's socio-cultural and environmental framework. Ethical clearance was granted by the Ethics Committee of the Health Polytechnic of the Ministry of Health Palangka Raya, approval number No. 983/VII/KE.PE/2025.

Study Location

The research took place in the floating-house settlement area along the Kahayan River Basin in Palangka Raya City, Indonesia, focusing on the Pahandut and Pahandut Seberang sub-districts. The study was carried out from January to December 2025. Geographically, it covered an area between coordinates 2°12’7.13” S; 113°55’20.078” E (beneath the Kahayan Bridge) and 2°11’47.525” S; 113°56’57.203” E (Rawa Rofi, Pahandut Seberang), as determined from the river itself (Figure 1). Participants included children under five years old living both in floating houses on the river and in settlements situated within 10 to 100 meters of the riverbank. This area was selected due to its riverine environmental characteristics, which pose significant risks for stunting. Settlements located above and along the riverbanks face limited access to clean water, adequate sanitation, and basic health services. Community dependence on river water and the floating housing structure may increase exposure to infectious diseases among children and complicate growth monitoring and health intervention efforts.

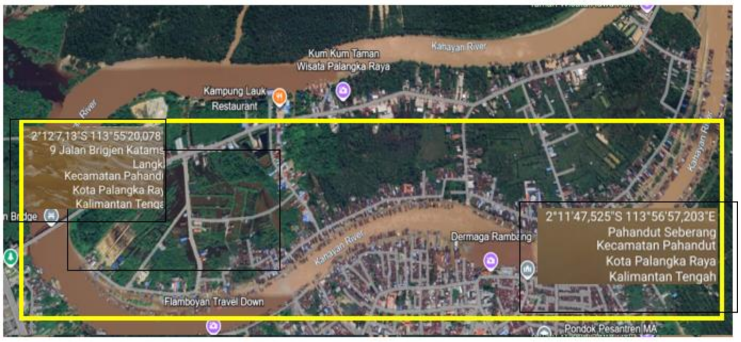

Figure 1. Study Location

Population and Sample

The population for this study comprised all households residing in the floating-house (*Rumah Lanting*) area situated along the Kahayan River Basin in Palangka Raya City, Indonesia. According to existing data, approximately 342 floating houses have been constructed over the river (Febriyani, 2025). The sample size was calculated utilizing the Slovin formula at a significance level (α) of 0.05, as follows.

$$n = \frac{N}{1 + N\, e^2}$$

n = sample size
N = total population = 342 residents
e = level of significance (α = 0.05)

The minimum required sample size was calculated to be 184 participants. To account for possible dropouts or non-responses, the sample size was increased by 5%, bringing the total number of respondents to 192. This study applied purposive sampling for quantitative data, selecting households with children under five (aged 0–59 months) living in floating homes or along the Kahayan River. Qualitative data were gathered through snowball sampling. The number of participants for in-depth interviews was adjusted as needed, continuing until sufficient information was collected and data saturation was reached.

Data Collection

Body height was measured using a microtoise (accurate to 0.1 cm) for children aged 24 months and older who could stand, using the Onemed 725/7230 scale brand, while infants aged 0–24 months who could not stand were measured using a length board (OneHealth B01). All instruments met Indonesian National Standards (SNI) and complied with Minister of Health Decree No. HK.01.07/MENKES/51/2022.

The independent variables examined in this study included dietary intake, infectious diseases, socioeconomic status, cultural factors, health services, food security, and environmental sanitation. All variables were quantitatively assessed on an ordinal scale through a structured questionnaire, with response options arranged in a ranked order, typically employing a Likert-type scale. This scale facilitated the categorization of respondents' perceptions, opinions, or responses into systematically ordered levels.

Data Analysis and Processing

The quantitative data analysis for this study was initially performed using univariate analysis with IBM SPSS Statistics Desktop version 25.0. This approach provided a descriptive summary of respondent characteristics, including frequency distributions and percentages based on variable types. The univariate analysis results served to establish a foundational understanding of the study subjects' profiles before proceeding to subsequent analyses.

A multivariate analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS version 3.2.9 to identify the primary ecological variables affecting stunting among children under five in floating-house settlements along the Kahayan River Basin in Palangka Raya City. This analytical approach was chosen due to its capability to simultaneously evaluate relationships among latent variables and their indicators, as well as its suitability for studies with limited sample sizes. The initial phase involved assessing the outer model by evaluating construct validity and reliability through tests of convergent validity, discriminant validity, and composite reliability. Subsequently, the inner model was analyzed to examine hypothesized relationships among latent variables by assessing R^2 values, path coefficients, and T-statistics. The outcomes of both the outer and inner model analyses were presented visually in a path diagram to clarify the variable relationships. Finally, model evaluation was completed using bootstrapping techniques and analysis of path coefficients to determine the significance of these relationships. Furthermore, in-depth interviews were conducted to complement the quantitative findings and enrich the overall discussion.

RESULT

This study examines seven ecological independent variables: dietary intake, infectious diseases, food security, healthcare services, culture, economy, and environmental sanitation. These variables are hypothesized to affect outcomes directly and indirectly via mediators and were tested statistically using SEM-PLS analysis, implemented in two distinct stages. The initial phase, the measurement model (outer model), assesses the validity and reliability of the measurement instruments based on the collected data. After confirming these criteria, the subsequent phase tests the structural model (inner model) to examine the relationships among variables as outlined by the proposed hypotheses.

Table 1 provides a detailed overview of key demographic and delivery-related characteristics within the study population. It outlines the baseline attributes of 193 children aged 0–59 months residing in floating-house and riverbank settlements along the Kahayan River. The age distribution reveals that the largest cohort comprised children aged >28–40 months (29.0%), followed by those aged >15–28 months (23.3%) and 3–15 months (20.7%). Children aged >53–60 months constituted the smallest proportion (8.8%). These findings demonstrate that the study population primarily consisted of toddlers during the critical period for growth and complementary feeding.

Table 1. Description of Respondent Characteristics (n=193)

Respondent Characteristics	Total (%)
Father's Occupation	
Other private sector (employee, honorary, non-civil servant teacher, security guard, etc.)	123 (63.7%)
Self-employed/ Trader	26 (13.5%)
Laborers and Craftsmen	20 (10.4%)
Fishermen and Fish Farmers	23 (11.9%)
Civil Servants (PNS)	1 (0.5%)
Father's Education Level	
College	5 (2.6%)
High School	50 (25.9%)
Junior High School	40 (20.7%)
Elementary School	88 (45.6%)
Didn't graduate from elementary school/didn't go to	10 (5.2%)
Father’s Ethnicity	
Banjar	155 (80.3%)
Dayak	30 (15.5%)
Javanese	6 (3.1%)
Makassar	1 (0.5%)

Respondent Characteristics	Total (%)
Mother's Occupation	
Housewife	162 (83.9%)
Self-Employed/Trader	18 (9.4%)
Other Private Sector	10 (5.2%)
Civil Servants (PNS)	2 (1.0%)
Farmers	1 (0.5%)
Mother's Education Level	
Higher Education	9 (4.7%)
Senior High School	53 (27.5%)
Junior High School	45 (23.3%)
Elementary School	81 (42.0%)
Didn't graduate from elementary school/didn't go to school	5 (2.6%)
Mother's Ethnicity	
Banjar	162 (83.9%)
Dayak	26 (13.5%)
Javanese	5 (2.6%)
Age of Children	
3 – 15 months	40 (20.7%)
>15 – 28 months	45 (23.3%)
>28 – 40 months	56 (29.0%)
>40 – 53 months	35 (18.1%)
>53 – 60 months	17 (8.8%)
Child's sex	
Male	95 (49.2%)
Female	98 (50.8%)
Nutritional Status of Children	
Normal	120 (62.2%)
Stunted	46 (23.8%)
Severely Stunted	27 (14.0%)

Assessing the measurement model, also known as the outer model, involves checking its validity and reliability. This evaluation examines convergent and discriminant validity among the indicators that define latent constructs and assesses composite reliability and Cronbach's alpha to measure reliability. Convergent validity demonstrates how strongly an indicator is positively related to other indicators belonging to the same construct. It is evaluated using outer loading and Average Variance Extracted (AVE). Table 2 below shows the results of the outer model analysis that satisfy all criteria for convergent validity.

Table 2. Average Variance Extracted (AVE) Values

Variables & Indicators	AVE
Food Security	0.524
Healthcare Services	0.516
Culture	0.577
Economy	0.666
Environmental Sanitation	0.622
Dietary Intake	0.519
Infectious Diseases	0.553
Stunting Nutritional Status	0.550

As presented in Table 2, each variable in this study demonstrates an Average Variance Extracted (AVE) value exceeding 0.5. Consequently, over half of the variance for every variable is accounted for by its corresponding indicators. Discriminant validity shows that a construct is distinct, reflecting aspects not measured by other constructs. To assess this, cross-loading values are used at the indicator level, while the Fornell-Larcker criterion assesses discriminant validity at the construct level.

Table 3 below shows that all variables in this research model have achieved satisfactory discriminant validity, as indicated by the cross-loading values and Fornell-Larcker values meeting the required criteria.

Table 3. Fornell-Larcker Values

Variables	ASB	BY	EK	KP	PK	PI	SL	ST
Dietary Intake	0.720							
Culture	-0.115	0.760						
Economy	-0.012	-0.019	0.816					
Food Security	0.014	0.026	0.171	0.724				
Healthcare Services	-0.008	0.115	0.259	0.303	0.718			
Infectious Diseases	0.020	-0.251	0.265	0.287	0.368	0.744		
Environmental Sanitation	-0.119	-0.078	0.196	0.275	0.322	0.556	0.789	
Stunting Nutritional Status	0.618	-0.205	0.036	0.014	0.125	0.133	-0.057	0.742

According to Table 3, each construct in this study is distinct from the others. Model reliability is determined using Cronbach's alpha, which reflects how closely related the observed values are for each indicator. Composite reliability offers another way to evaluate reliability, taking into account the outer loading value of every indicator. Reliability scores range from 0 to 1, with higher scores indicating a better measurement instrument. Cronbach's alpha and composite reliability between 0.6 and 0.7 are regarded as the minimum acceptable, while scores between 0.7 and 0.9 are considered good. Scores below 0.6 or above 0.95 suggest that the indicators do not validly measure the construct.

Table 4 presents the results of the reliability assessment for the variables examined in this study. Both Cronbach's alpha and composite reliability analyses indicate that all variables demonstrate satisfactory reliability.

Table 4. Cronbach's Alpha and Composite Reliability Values

Variables	Cronbach's Alpha	Composite Reliability	Description
Dietary Intake	0.765	0.842	Reliable
Culture	0.910	0.924	Reliable
Economy	0.871	0.906	Reliable
Food Security	0.771	0.844	Reliable
Healthcare Services	0.906	0.921	Reliable
Infectious Diseases	0.834	0.878	Reliable
Environmental Sanitation	0.787	0.865	Reliable
Stunting Nutritional Status	0.592	0.786	Reliable

Based on Table 4, all research variables demonstrated Cronbach's Alpha and Composite Reliability values above the recommended threshold (≥0.70), indicating that all constructs have good reliability. The variables of child dietary intake, culture, economic status, food security, health services, infectious diseases, and environmental sanitation were considered reliable. Although the Cronbach's Alpha value for the stunting nutritional status variable was slightly lower (0.592), its Composite Reliability value of 0.786 indicates that the construct remains acceptable for analysis.

Furthermore, the results of the reliability test are supported by the outer model analysis, which is visualized in the following path diagram.

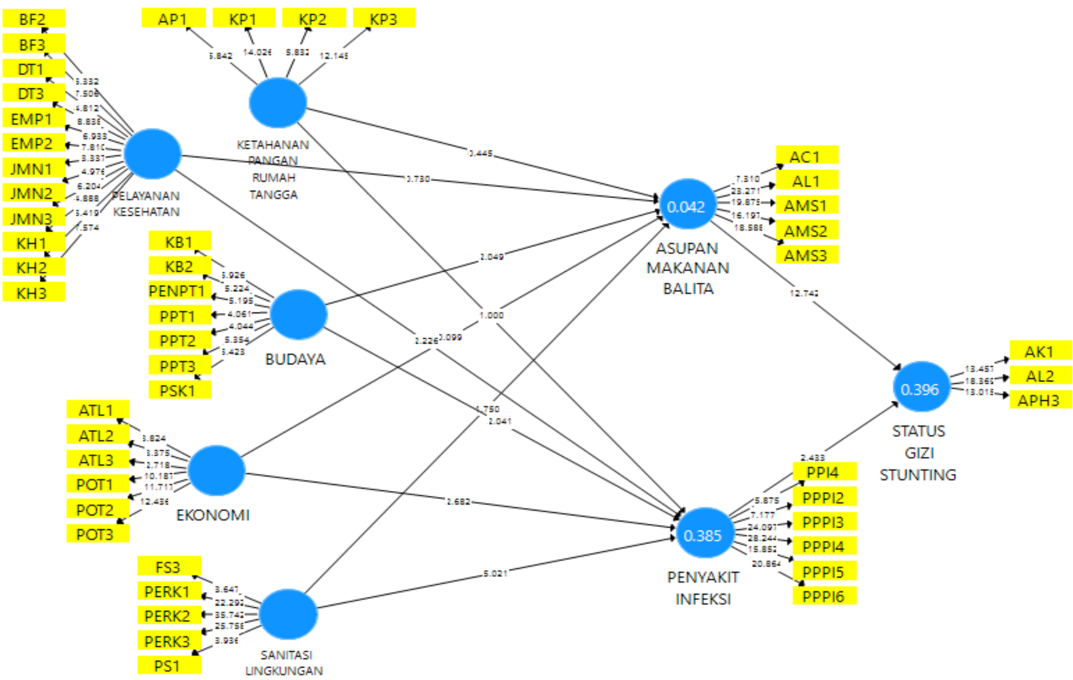

Figure 2. Initial Model of Ecological Factors Determining the Incidence of Stunting in Floating House Areas along the Kahayan River Basin, Palangka Raya City

Description

BF	:	Physical Evidence / Tangible	POT	:	Parents' Occupation
DT	:	Responsiveness	FS	:	Sanitation Facilities
EMP	:	Empathy	PPI	:	Knowledge of Infectious Diseases
JMN	:	Assurance	PS	:	Waste Management
KH	:	Reliability	AC	:	Fluid Intake
AP	:	Food Access	AL	:	Fat Intake
KP	:	Food Availability	AMS	:	Snack Intake
KB	:	Cultural Beliefs	AK	:	Carbohydrate Intake
PENPT	:	Application of Traditional Medicine	APH	:	Animal Protein Intake
PPT	:	Traditional Parenting Practices	PPPI	:	Infectious Disease Prevention Behavior
PSK	:	Social and Community Influence	PERK	:	Hygiene Behavior
ATL	:	Access to Services			

Figure 2 shows how the constructs relate to their indicators, interact with each other, connect to mediators such as dietary intake and infectious diseases, and link to the endogenous latent construct stunting nutritional status. Stunting nutritional status is indicated by animal protein intake, fat intake, and carbohydrate intake. Dietary intake is measured by fat intake, snack intake, and fluid intake. Indicators for infectious diseases include knowledge about such diseases and behaviors that prevent them. Food security is reflected through food access and availability.

Reliability, assurance, empathy, responsiveness, and tangible features represent the healthcare services construct. Cultural beliefs, the use of traditional medicine, parenting customs, and social or community influences define the cultural construct. The economic construct is indicated by parents' occupations and their access to healthcare. Environmental sanitation is characterized by the quality of sanitation facilities, waste management practices, and hygiene behaviors. All these indicators were selected based on analysis using the outer model.

Figure 2 displays both the path coefficients and the outer loading values for each construct and their respective indicators. It is important to note that these results pertain solely to the initial model; subsequent analysis of the inner model is performed to assess whether the constructs exert direct or indirect effects.

The evaluation of the inner model in this research utilizes bootstrapping and blindfolding methods, conducted with SmartPLS 3.2.9 software. A significance threshold of 0.05 (corresponding to a 95% confidence level) is applied using a one-tailed test. Accordingly, a construct is deemed to have a significant effect if its T-statistic exceeds 1.64 or if the p-value is less than 0.05.

To maintain the integrity of the regression analysis, all constructs were evaluated for collinearity. The results indicate that each construct in this research model exhibits VIF values below 3, as detailed in Table 5. These findings demonstrate the absence of collinearity among the constructs, ensuring that the regression results remain unbiased.

Table 5. Variance Inflation Factor (VIF) Values

Variables	VIF	Description
Dietary Intake	1.000	No collinearity
Culture	1.031	No collinearity
Economy	1.097	No collinearity
Household Food Security	1.153	No collinearity
Healthcare Services	1.251	No collinearity
Infectious Diseases	1.000	No collinearity
Environmental Sanitation	1.091	No collinearity
Stunting Nutritional Status	1.190	No collinearity

The following phase involves evaluating the variance of the endogenous constructs dietary intake, infectious diseases, and stunting nutritional status by examining the R^2 value. This value, which falls between 0 and 1, reflects how well the inner model explains these constructs, with higher values indicating stronger explanatory power.

Table 6. Coefficient of Determination (R^2) of Endogenous Variables

Variabel	R^2	R^2 *Adjusted*	Kategori
Dietary Intake	0.034	0.009	Weak
Infectious Diseases	0.427	0.412	Moderate
Stunting Nutritional Status	0.396	0.390	Moderate

Table 6 shows the coefficient of determination (R^2), measuring how much variance is explained by the model for each variable. For dietary intake, the R^2 was 0.034 (Adjusted R^2 = 0.009), indicating weak explanatory power only 3.4% of its variation is accounted for, implying that other factors have a greater influence. The R^2 for infectious diseases was 0.427 (Adjusted R^2 = 0.412), showing moderate explanatory power; sanitation, culture, health services, and socioeconomic conditions explained 42.7% of infection variation among children, highlighting the importance of ecological determinants.

The R^2 value for stunting nutritional status was 0.396 (with an Adjusted R^2 of 0.390), indicating a moderate level. In other words, the model accounted for about 40% of the variation in stunting, demonstrating that ecological factors such as infection, sanitation, culture, and dietary intake—play a significant role in influencing growth outcomes.

The R^2 values show that infectious diseases and stunting nutritional status have moderate explanatory power, whereas dietary intake has weak explanatory power in this model. In fact, dietary intake demonstrates very low explanatory power, suggesting that feeding practices among toddlers in floating houses are mainly shaped by external factors not included in the model especially cultural, economic, and food access influences. This indicates that the variable may need to be revised or expanded with additional variables to better explain stunting. Additionally, hypothesis testing was performed to assess how each exogenous construct affects the endogenous constructs.

In this study, hypotheses were evaluated by assessing the path coefficient (β) and its statistical significance using the T-statistic. The SEM-PLS approach incorporates a bootstrapping technique, which offers the advantage of resampling up to 5,000 bootstrap samples to improve the accuracy of standard error estimates for PLS. Bootstrapping results yield β and T-statistic values for each examined path.

Hypotheses were tested at a significance level of 0.05 through a one-tailed test, with acceptance criteria defined as a T-statistic value exceeding 1.64. The outcomes of these hypothesis tests are detailed in Table 7.

Table 7. Structural Model Direct Effects And Indirect Effects of Ecological Determinants on Stunting

Path	Direct Effect		Indirect Effect		Conclusion
	β	T-Statistik	β	T-Statistik	
1. ASM => SGS	0.615	12.871			Accepted
2. PI => SGS	0.121	2.370			Accepted
3. KP => ASM	0.048	0.612			Rejected
4. KP => PI	0.097	1.397			Rejected
5. PK => ASM	0.044	0.537			Rejected
6. PK => PI	0.202	2.187			Accepted
7. BDY => ASM	-0.134	1.708			Accepted
8. BDY => PI	-0.242	2.339			Accepted
9. EK => ASM	-0.003	0.035			Rejected
10. EK => PI	0.108	1.865			Accepted
11. SL => ASM	-0.156	2.117			Accepted
12. SL => PI	0.425	5.189			Accepted
13. BDY => ASM => SGS			-0.082	1.665	Accepted
14. SL => ASM => SGS			-0.096	1.985	Accepted
15 SL => PI => SGS			0.051	2.348	Accepted

Description

ASM	:	Dietary Intake	KP	:	Food Security
PI	:	Infectious Diseases	EK	:	Economy
BDY	:	Culture	SL	:	Environmental Sanitation
PK	:	Healthcare Services	SGS	:	Stunting Nutritional Status

Table 7 indicates that dietary intake (ASM) exerted the most substantial direct influence on stunting (β = 0.615, t = 12.871), with inadequate consumption significantly elevating the risk of stunted growth. Additionally, infectious diseases (PI) demonstrated a notable direct effect (β = 0.121, t = 2.370), reinforcing infection as an important biological determinant.

Environmental sanitation (SL) had the most substantial impact on infectious diseases (β = 0.425, t = 5.189), and it also influenced dietary intake (β = −0.156, t = 2.117). Cultural practices (BDY) were found to affect both dietary intake (β = −0.134, t = 1.708) and infection rates (β = −0.242, t = 2.339). Health services (PK) were associated with a reduction in infection levels (β = 0.202, t = 2.187), whereas economic status (EK) played a role in infection (β = 0.108, t = 1.865) but did not affect dietary intake. No notable effects were observed from food security (KP).

Sanitation and cultural factors were found to influence stunting indirectly through pathways involving dietary intake and infection. The pathway from sanitation to infection to stunting was significant (β = 0.051, t = 2.348), as was the pathway from sanitation to dietary intake to stunting (β = −0.096, t = 1.985). Additionally, culture impacted stunting through its effect on dietary intake (β = −0.082, t = 1.665).

As presented in Table 7, four of the fifteen hypotheses proposed in this study were not supported, as indicated by T-statistic values below 1.64, signifying a lack of statistical significance. The remaining eleven hypotheses were supported. In summary, dietary intake and infection are direct determinants of stunting, whereas sanitation and cultural factors influence growth outcomes indirectly through their effects on these mediators.

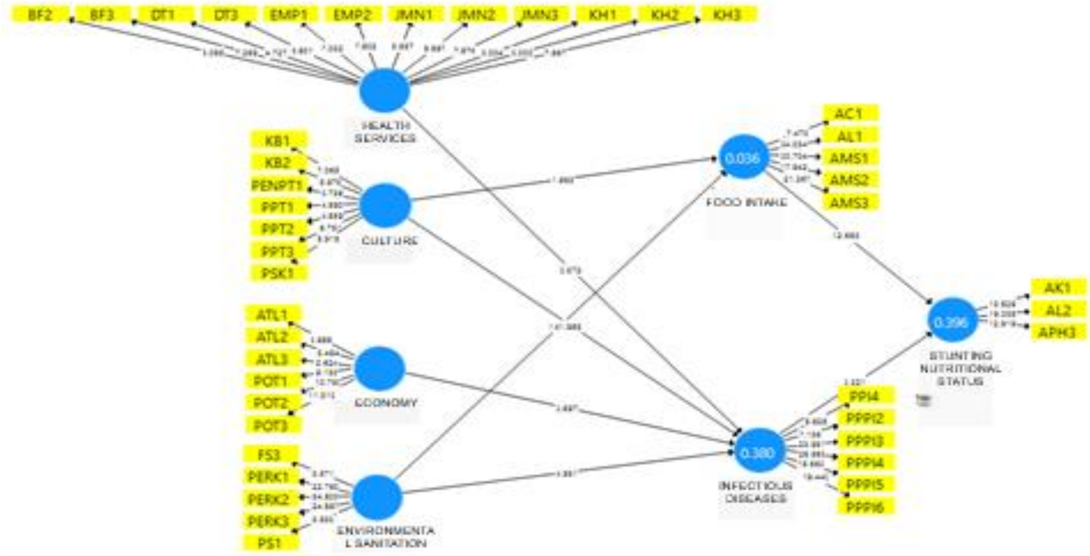

Figure 3. Final Ecology Based Stunting Prevention Model In The Floating House Along Kahayan River Palangka Raya City, Indonesia

Figure 3 demonstrates that stunting in children who live in floating-house settlements results from a complex interplay of environmental, socio-cultural, and health system factors, rather than being attributed to a single nutrient deficiency. The SEM-PLS model reveals both direct and indirect connections between sanitation, cultural practices, diet, infectious diseases, and growth faltering.

The stunting prevention model was developed using statistical path analysis and IPMA. Dietary intake and infectious diseases are key variables due to their direct impact and high importance scores. Environmental sanitation and culture indirectly affect stunting through these mediators, while health services and economic factors act as predisposing variables. Figure 4 illustrates this ecology-based model for the *Rumah Lanting* area in the Kahayan Watershed, Palangka Raya City.

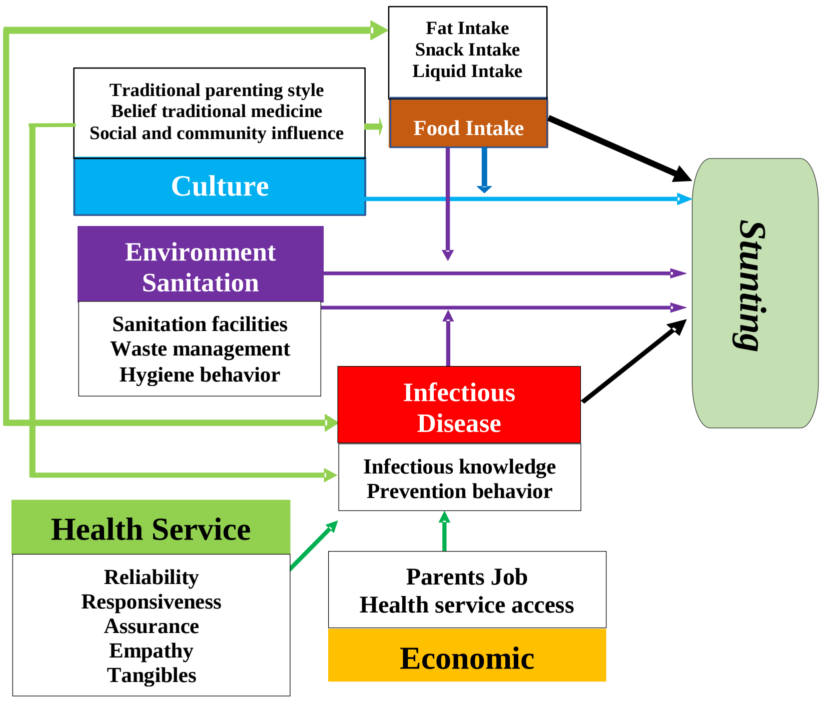

Figure 4. Stunting Prevention Model base on Ecological factor

DISCUSSIONS

The findings presented in Table 7 of this study show that dietary intake positively influences stunting nutritional status. According to SEM-PLS analysis using SmartPLS 3.2.9, there is a positive β value of 0.615 and a T-statistic of 12.871, which exceeds the threshold of 1.64. This indicates that dietary intake has the strongest direct impact on stunting nutritional status compared to other variables. Interviews reveal that feeding practices for infants and young children in floating-house settlements (*rumah lanting*) are mostly shaped by family members especially mothers and grandmothers. These complementary feeding (MP-ASI) practices often deviate from recommended health standards, including early introduction of solid foods, reliance on processed or instant foods, and overly diluted food preparation. Moreover, household habits and traditional routines, rather than established nutrition guidelines, largely determine how children are fed. This suggests that structured dietary practices and adherence to evidence-based feeding recommendations are generally lacking at the household level.

The findings of this study align with those reported by (Wardita et al., 2025), who conducted research involving 352 respondents from coastal areas in the Batang-batang and Dungkek sub-districts of Sumenep Regency, Madura. Their results indicated that supplementary feeding exerted the most significant direct effect on stunting (β = 0.438; t = 11.173). Dietary intake was identified as the primary determinant influencing stunting.

Another study also reported a relationship between dietary intake, specifically animal protein consumption, and the incidence of stunting (p = 0.007). The study found that the dietary intake level of stunted children averaged less than twice per week. This may be due to the relatively low consumption of animal protein among these children, which contributed to stunting in 32 children out of a total sample of 59 respondents. A study conducted by (Puspitasari et al., 2024) identified a significant association between dietary intake particularly animal protein consumption and the incidence of stunting (p = 0.007). The findings indicated that children who were affected by stunting consumed animal protein less than twice per week on average. This reduced frequency of animal protein intake may have contributed to stunting, which was observed in 32 out of 59 respondents in the sample.

Dietary intake is a direct determinant of the nutritional status of children in the Kahayan River Basin (DAS). The quality and quantity of intake, including animal protein, essential micronutrients, drinking water, as well as complementary and snack foods, influence linear growth and reduce the risk of stunting (Angelica et al., 2023; Gunawan & Prameswari, 2022; UNICEF, 2021). Appropriate feeding practices, including exclusive breastfeeding, locally based complementary feeding (MP-ASI), and adequate meal frequency, have been shown to improve child nutritional status, even though the availability of fish and local food does not always reflect household consumption because much is sold. Integrated nutrition interventions that combine access to nutritious foods, maternal education through posyandu cadres, and sanitation improvements are effective strategies to sustainably reduce stunting.

Children's nutritional status in the Kahayan River Basin (DAS) is largely shaped by their dietary intake. Both the amount and quality of food such as animal protein, key micronutrients, safe drinking water, and various complementary and snack foods play a role in supporting healthy growth and lowering the risk of stunting (Angelica et al., 2023; Gunawan & Prameswari, 2022; UNICEF, 2021). Proper feeding practices, including exclusive breastfeeding, locally sourced complementary feeding (MP-ASI), and sufficient meal frequency, have been linked to improved child nutrition even though much of the available fish and local foods are sold rather than consumed at home (Asiah et al., 2020; Rismawati et al., 2024). Sustainable reductions in stunting can be achieved by combining increased access to nutritious foods, maternal education via posyandu cadres, and better sanitation as part of integrated nutrition interventions (Ari Setyawati et al., 2023; Wardani et al., 2023).

Infectious diseases exert a direct influence on stunting via biological mechanisms such as elevated energy demands, impaired nutrient absorption, and diminished appetite (Sutarto et al., 2021). The stilt-house environment in the DAS, characterised by inadequate sanitation, restricted water access, and heightened flood risk, increases vulnerability to gastrointestinal and respiratory infections. Comprehensive interventions integrating nutrition education, optimal feeding practices, and WASH programs have been shown to effectively reduce infection rates and enhance child nutritional outcomes (Nasution & Susilawati, 2023; Olo et al., 2020).

Household food security and economic conditions do not have a significant direct effect on dietary intake, although they can indirectly mediate nutritional status. This emphasizes the need for a multisectoral approach integrating food security, nutrition education, improved feeding practices, health service access, and sanitation to enhance children's dietary intake and nutritional status. Research indicates that economic conditions play a significant role in infectious diseases through access to healthcare services, sanitation, and environmental conditions. Therefore, development interventions in the watershed (DAS) context should incorporate economic factors as essential supports for infrastructure improvement and health literacy enhancement.

Household food security and economic conditions have not been shown to exert a significant direct impact on dietary intake, although they may indirectly influence nutritional status (Black et al., 2013; Ruel & Alderman, 2013; UNICEF, 2021). This underscores the importance of adopting a multisectoral strategy that integrates food security measures, nutrition education, improved feeding practices, access to healthcare services, and enhanced sanitation, in order to improve children's dietary intake and overall nutritional status. Evidence from literacy research (Akinbode et al., 2021; de Glanville et al., 2019) demonstrates that economic conditions significantly affect the prevalence of infectious diseases by shaping access to healthcare, sanitation, and environmental quality. Accordingly, development interventions within the watershed (DAS) context should consider economic factors as critical components for strengthening infrastructure and advancing health literacy.

The interview findings from this study indicate that while health services, including community health posts, are accessible and utilized, community participation remains limited especially among families with a greater number of children or those facing time constraints. Health services play a significant role in reducing infectious diseases but do not have a direct effect on dietary intake. Programs focused on prevention, health promotion, immunization, and early detection conducted at posyandu or health centers have proven effective in decreasing infection morbidity and supporting nutritional status, particularly when these initiatives are integrated with nutrition education and appropriate feeding practices (Arisjulyanto & Suweni, 2024; Nurfikri & Nurhasanah, 2022; Renaldo Tegar Prasetyo et al., 2023).

The findings from the interviews conducted in this study indicate that cultural beliefs and traditional practices continue to significantly shape children's dietary habits. Food taboos, such as the avoidance of eggs and fish during early childhood due to perceived risks of allergies, boils, or intestinal worms, highlight the enduring impact of intergenerational norms on child nutrition decisions. Despite ongoing nutrition education initiatives delivered through integrated health posts and primary healthcare centers, uptake at the household level remains less than optimal. Community adherence to nutritional guidance is limited and often inconsistent, underscoring a persistent disconnect between knowledge dissemination and actual changes in child feeding behaviors.

Culture plays an important role in shaping both dietary habits and infectious disease patterns, affecting caregiving styles, local customs, traditional medicine use, and hygiene practices. Nutrition and health interventions that respect cultural differences such as educating about complementary feeding, promoting the use of local foods, and adapting communication within communities have proven effective in increasing diet variety, improving feeding behaviors, and supporting adherence to health guidelines. These measures contribute to lowering rates of stunting and infection (Aryastami & Mubasyiroh, 2021; Juliandar et al., 2023; Loihala et al., 2023; Simbolon et al., 2024).

According to interview data from this study, sanitation conditions in floating-house settlements (*rumah lanting*) are characterised by dependence on river water and drilled well sources. Water is frequently utilized without sufficient treatment and, in some instances, consumed unboiled. Alum (*tawas*) continues to be employed as a means of clarifying water. Sanitation infrastructure remains inadequate, as household latrines discharge directly into the river and solid waste is commonly disposed of in the river due to perceived convenience. These practices result in an elevated risk of infectious diseases among children, such as diarrhoea, intestinal worm infections, fever, and skin infections. Self-medication is prevalent among families, typically involving over-the-counter medications or traditional remedies prior to seeking formal healthcare. Children are often observed engaging in recreational activities and bathing in contaminated river water. Additionally, handwashing with soap is infrequent and inconsistent among both children and caregivers.

According to research conducted by Akbar et al., (2025) in the riverside areas within the operational scope of UPTD Puskesmas Martapura Barat, Banjar Regency, involving 43 respondents, the majority exhibited suboptimal environmental sanitation conditions. Additionally, a high prevalence of stunting was observed among children under five years of age. Statistical analysis demonstrated a significant correlation between environmental sanitation in riverside communities and the incidence of stunting in children under five (p-value = 0.020).

Environmental sanitation affects stunting directly through infectious diseases and indirectly through impaired dietary intake. This finding is consistent with previous studies indicating that poor sanitation conditions, limited access to clean water, and unhygienic household waste management increase exposure to pathogens, reduce appetite, and impair nutrient absorption, thereby contributing to stunting. Community-based interventions, such as STBM combined with nutrition education, hygiene promotion, and monitoring of children's dietary intake, effectively reduce infection risk and improve nutritional status through the indirect sanitation–infection–intake–stunting pathway.

Environmental sanitation exerts both direct and indirect influences on stunting, primarily through infectious diseases and compromised dietary intake. This observation aligns with existing literature, which demonstrates that inadequate sanitation conditions, restricted access to clean water, and ineffective household waste management increase pathogen exposure, diminish appetite, and hinder nutrient absorption, thereby contributing to stunting (Huriah & Nurjannah, 2020; Rizky & Marlenywati, 2023; Slodia et al., 2022). Community-based interventions, including STBM initiatives augmented by nutrition education, hygiene promotion, and ongoing monitoring of children's dietary intake, have proven effective in reducing infection risk and enhancing nutritional status via the sanitation–infection–intake stunting pathway (Adzura et al., 2021; Bakara, 2023; Febria et al., 2023).

In summary, the research suggests that stunting among stilt-house communities in the Kahayan River Basin is caused by both direct factors such as poor diet and infectious diseases and indirect factors, including environmental sanitation, cultural practices, economic conditions, and food security. To effectively reduce stunting rates in these riverine areas with complex ecological and social challenges, it is essential to implement multisectoral interventions that focus on improving nutrition, sanitation, health services, educational outreach, and cultural awareness.

CONCLUSION AND SUGGESTION

The findings of this study indicate that ecological factors influence the nutritional status of children under five experiencing stunting in floating-house settlements along the Kahayan River Basin, Palangka Raya City, both directly and indirectly. Direct effects on stunting were observed from dietary intake and infectious diseases, while environmental sanitation and cultural influences exerted indirect effects through their impact on dietary intake and disease incidence. Food security was not found to have a significant association with stunting in this population. The ecology-based stunting prevention model developed for this context emphasizes improving dietary intake and mitigating infectious diseases by advancing environmental sanitation and promoting hygiene-related cultural practices, supported by adaptive health services and robust economic protections.

Recommendations center on prioritizing environmental sanitation initiatives, including clean water provision, enhancement of sanitation infrastructure, promotion of hygienic behavioral change, and effective waste management. Further longitudinal research is advised to evaluate the sustained impact of this ecology-based intervention on stunting prevalence within the Kahayan River floating-house settlements and comparable environments. The model has been formalized into a policy brief, with suggested integration into regional development planning instruments such as the RPJMD and Strategic Plans of local government agencies. Adoption of this approach should involve collaboration across health, environmental, housing and settlement, social, and community empowerment sectors.

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