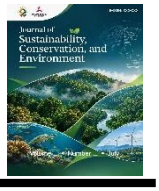
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Integrated Healthy-Economic Household Model for Stunting Prevention in Rural Indonesia

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a b s t r a c t

Background: Stunting in rural Indonesia remains a multidimensional challenge driven by poverty, inadequate sanitation, limited parenting knowledge, and constrained household access to nutritious foods, particularly animal protein. Effective prevention therefore requires integrated interventions that address health, behavioral, environmental, and economic determinants simultaneously.
Aims: This study presents and evaluates the Integrated Healthy-Economic House Model implemented in Pekangkungan Village, East Java, Indonesia, to examine whether a household-centered approach combining stunting prevention, clean and healthy living behavior (PHBS), household sanitation, and local food-based economic empowerment improves nutrition, sanitation, and livelihood-related outcomes.
Methods: The program employed Participatory Action Research (PAR) and Asset-Based Community Development (ABCD) approaches involving 40 at-risk households, including eight households with confirmed stunting cases. Interventions included nutrition and parenting education, budikdamber (catfish-in-bucket aquaculture) training, productive home garden development, local protein-based food processing, and household sanitation mentoring delivered through posyandu cadres and PKK networks. Program effectiveness was assessed using a pre–post evaluation design across seven key indicators.
Results: Nutrition knowledge rose by 46 percentage points (38% to 84%); consistent PHBS practice increased by 43 points (29% to 72%); 80% of households established active budikdamber units; and animal protein consumption of at least four times per week rose by 39 points (22% to 61%). Asset mapping identified community social capital, particularly PKK networks and trained posyandu cadres, as the most decisive enabler of sustainable outcomes.
Conclusions: The model offers a realistic, replicable pathway to reduce stunting by transforming households into healthy and economically productive units, with implications for intersectoral budget integration in village governance.

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1. Introduction

Childhood stunting, defined as a height-for-age score below two standard deviations of the World Health Organization growth standard, remains a major public health challenge in Indonesia. Although national prevalence has declined in recent years, rural areas continue to experience disproportionately high rates of stunting and its long-term consequences, including impaired cognitive development, reduced educational achievement, lower economic productivity, and increased susceptibility to chronic diseases in adulthood (Azriani et al., 2024; Kalinda et al., 2024; World Health Organization, 2024). These consequences make stunting not only a nutritional problem but also a barrier to sustainable human development.

Current evidence indicates that stunting results from interconnected determinants operating at multiple levels. Immediate causes include inadequate dietary intake and recurrent infections, while underlying causes involve household food insecurity, poor water, sanitation, and hygiene (WASH) conditions, and suboptimal child-feeding practices. These factors are further shaped by structural determinants such as poverty, low educational attainment, and geographic marginalization (Addae et al., 2024; Guja et al., 2025; Ricci et al., 2026). Consequently, interventions that focus exclusively on nutrition supplementation or health services often produce limited and unsustainable outcomes.

Recent studies consistently demonstrate that integrated and multisectoral approaches are more effective than single-sector interventions. Community-based programs that combine nutrition education, sanitation improvement, behavior change, and livelihood strengthening have shown greater potential to reduce stunting and improve child well-being (Beatty et al., 2024; Escher et al., 2024; Keats et al., 2021). Similarly, evidence from low- and middle-income countries highlights the importance of linking household food production and economic resilience with nutrition-sensitive interventions to achieve sustainable improvements in dietary diversity and child growth outcomes (Chao, 2024; Dubey et al., 2024; Kaminski et al., 2024).

Pekangkungan Village, East Java, represents a typical rural setting where nutritional, environmental, and economic vulnerabilities converge. Baseline assessments identified eight confirmed stunting cases among children under five years of age and revealed several risk factors, including low animal-protein consumption, inadequate sanitation practices, and limited parenting knowledge. Household livelihoods were largely dependent on subsistence agriculture and informal labor, resulting in unstable incomes that constrained access to nutritious foods. These conditions illustrate the need for interventions that simultaneously address household health, sanitation, nutrition, and economic capacity.

Despite growing recognition of multisectoral stunting prevention, few studies have documented the implementation of an integrated household-level model that combines nutrition improvement, sanitation promotion, parenting education, and local food-based economic empowerment within a single intervention framework. Moreover, limited evidence is available regarding how existing village institutions, particularly PKK networks and posyandu cadres, can support the sustainability of such integrated programs in rural Indonesia.

To address this gap, this study developed and implemented the Integrated Healthy-Economic House Model in Pekangkungan Village using Participatory Action Research (PAR) and Asset-Based Community Development (ABCD) approaches. The model integrated nutrition and parenting education, clean and healthy living behavior (PHBS), household

sanitation improvement, budikdamber (catfish-in-bucket aquaculture), productive home gardens, and local food-based entrepreneurship through existing community institutions.

This article reports the design, implementation process, and outcomes of the Integrated Healthy-Economic House Model. Specifically, it aims to: (1) describe the five-phase implementation of the model; (2) evaluate changes in nutrition knowledge, PHBS practices, sanitation conditions, and household economic indicators following program implementation; and (3) identify community assets and institutional factors that contribute to the sustainability of integrated stunting prevention initiatives in rural Indonesia.

2. Methods

2.1 Study Setting and Target Population

The community service program was implemented in Pekangkungan Village, a rural settlement in East Java province, Indonesia. The village is characterized by an economy based primarily on subsistence agriculture, with a significant proportion of the working-age population engaged in informal daily labor in agriculture, construction, and petty trade. Land fragmentation, combined with the absence of significant formal-sector employment, produces a household income structure marked by both low average earnings and high inter-temporal volatility (Secretary of Pekangkungan Village, personal communication, n.d.).

The target population consisted of 40 households identified as high-risk through pre-program consultation with village posyandu cadres and health center (puskesmas) records. Eligibility criteria for inclusion included: presence of a child under five years of age or a pregnant woman in the household; residence in Pekangkungan Village for at least one year; and at least one risk indicator drawn from the following set: confirmed stunting, inadequate animal protein consumption, absence of functional latrine, inconsistent handwashing with soap, or household food insecurity. Eight households in the sample contained children formally confirmed as stunted based on anthropometric measurements against WHO growth standards. The remaining thirty-two households were classified as high-risk based on the composite risk indicator profile.

The socioeconomic and nutritional profile of the target households at baseline is presented in Table 1 below, reflecting the layered vulnerability that characterized the implementation context.

Table 1. Socioeconomic and Nutritional Baseline Profile of Target Households (n=40)

Socioeconomic & Nutritional Indicator	n (of 40)	%
Primary household income source: daily labor/informal sector	34	85%
Households with per capita income below regional poverty line	29	72.5%
Mothers with education up to junior high school or below	31	77.5%
Households without access to piped clean water	22	55%
Households without functional latrine (own or shared)	18	45%

Socioeconomic & Nutritional Indicator	n (of 40)	%
Households without dedicated handwashing station with soap	27	67.5%
Households consuming animal protein less than 3x per week	31	77.5%
Households in food insecurity category (HFIAS score)	24	60%

Source: (HFIAS, n.d.; Primary data, n.d.-a).

2.2 Ethical Considerations and Instrument Quality

This community engagement program was conducted under institutional ethical clearance issued by the research ethics committee of Al Yasini Islamic Institute (clearance number to be inserted upon final institutional confirmation), in accordance with national guidelines for research and community service activities involving human participants. Prior to any data collection or program enrollment, verbal and written informed consent was obtained from the head of each participating household, with additional verbal assent sought directly from mothers as the primary respondents for nutrition, parenting, and sanitation indicators. Participants were informed of the voluntary nature of participation, their right to withdraw at any stage without consequence for access to routine posyandu services, and the measures taken to protect the confidentiality of household-level data. Given that eight households in the sample included children with confirmed stunting, particular care was taken to ensure that consent procedures were age- and context-appropriate, that anthropometric measurement followed standard WHO protocols administered by trained cadres, and that no child was singled out or stigmatized during group educational sessions. The structured interview and food frequency instruments used for the seven core indicators were adapted from previously validated tools used in Indonesian posyandu and community service settings, including standard PHBS assessment checklists issued by the Ministry of Health and the Household Food Insecurity Access Scale (HFIAS) for the food security domain. Content validity was reviewed by the program's supervising nutrition and public health faculty prior to fieldwork, and cadres administering the instruments received standardized training and a pilot administration round with ten non-sample households to improve inter-rater consistency before baseline data collection began. As a community engagement and capacity-building program rather than a clinical trial, formal psychometric validation (e.g., Cronbach's alpha for internal consistency) was not conducted on the adapted instruments; this is acknowledged as a methodological limitation in Section 5 and is recommended as a priority refinement for future replications of the model.

2.3 Methodological Framework: PAR and ABCD

The program employed a combined Participatory Action Research (PAR) and Asset Based Community Development (ABCD) framework, selected for their complementary strengths in generating community-owned, sustainable change. PAR enabled a cyclical process of planning, action, observation, and reflection that allowed program activities to be continuously refined in response to field realities. Rather than implementing a fixed protocol, the PAR structure ensured that the intervention remained responsive to emerging challenges,

including unexpected resistance to certain practices, logistical constraints on budikdamber water supply, and the need to adapt nutrition messaging to local food preference norms (Azis et al., 2025; Kalinda et al., 2024).

ABCD provided the asset-mapping orientation that counteracted the deficit-focused framing that frequently undermines community ownership in development programs. Rather than asking what was wrong and missing in Pekangkungan, the ABCD process began by systematically documenting what was already present and functional: the physical assets of home gardens and water access points; the human assets of cadre knowledge and informal nutrition practices; the social assets of PKK organizational networks and posyandu routines; and the cultural assets of local food traditions centered on catfish, tempeh, eggs, and seasonal vegetables. Table 2 (see Section 3.1) presents the full asset mapping outcomes organized by asset category(Bidan Desa Pekangkungan, personal communication, n.d.). This asset-mapping orientation is consistent with the core ABCD principle, articulated in the foundational and recent ABCD literature, that sustainable community change is built by mobilizing existing strengths rather than cataloguing deficits (Alamri et al., 2025; South et al., 2024; Ward, 2023).

Together, PAR and ABCD produced a program logic in which community members were not passive recipients of interventions designed elsewhere but active co-investigators and co-implementers of a change process built on local capacities. This distinction is not merely rhetorical: the literature consistently shows that interventions with genuine community ownership demonstrate significantly higher rates of sustained behavior change after formal program closure (Azis et al., 2025; Sharma, 2024; Siboro et al., 2025).

2.4 Five-Phase Implementation Design

Phase 1: Diagnostic Survey and Asset Mapping

The program opened with a comprehensive baseline diagnostic conducted jointly by the research team and posyandu cadres. The diagnostic protocol covered: (a) anthropometric measurement of all under-five children in target households, cross-referenced against WHO growth standards; (b) structured interview-based assessment of maternal nutrition knowledge, PHBS practice, and parenting behaviors; (c) food frequency questionnaire to quantify animal protein consumption patterns; (d) systematic household sanitation audit covering water source type, latrine ownership and functionality, handwashing station availability and soap provision, and solid waste management practices; and (e) ABCD-structured asset mapping covering all five asset categories (physical, human, social, cultural, financial). The diagnostic phase generated the baseline indicators presented in Table 1 and Table 3, and directly informed the design of subsequent intervention phases (Budiastutik et al., 2024; Dahir et al., 2026; Guja et al., 2025; Permatasari et al., 2025; Prasetyo & Susanna, 2025).

Phase 2: Knowledge Strengthening and Participatory Education

The second phase comprised a structured sequence of interactive educational sessions conducted using participatory dialogue rather than didactic lecture formats. Session topics included: the comprehensive causal framework of stunting within the 1,000 Days Window; balanced nutrition and locally-sourced complementary feeding (MPASI) for children under two; the importance and practical sources of animal protein in child diets; PHBS principles including handwashing with soap, latrine use and maintenance, waste management, and food hygiene; and responsive parenting practices that support feeding behavior, psychosocial

stimulation, and health-seeking. Cooking demonstrations using locally available catfish, eggs, and garden vegetables were integrated into nutrition sessions to demonstrate the feasibility of nutritionally optimal feeding without significant additional expenditure. The use of visual media including anthropometric growth charts, food group models, and germ-spread demonstrations using food coloring enhanced engagement and comprehension across educational levels (Kalinda et al., 2024; Mulyani et al., 2025; Permatasari et al., 2025; Ricci et al., 2026). The PHBS curriculum content followed Indonesian Ministry of Health household-tatanan guidelines and drew on community-based PHBS education models that have demonstrated measurable gains in handwashing and sanitation knowledge when delivered through participatory rather than purely didactic formats (Abdullah & Eka, 2024; Nasution et al., 2024).

Phase 3: Local Food Security and Productive Economy Training

The third phase introduced the program's most distinctive technical component: the budik damber (budidaya ikan dalam ember, or fish culture in a bucket) system and the broader productive home garden framework. Budikdamber is a simplified aquaponic system in which catfish (Clarias gariepinus) are raised in an 80-liter bucket, with aquatic or terrestrial vegetables grown in pots positioned above the water surface. Fish waste provides organic fertilizer for the plants, while the plants partially filter the water, creating a low-maintenance, low-cost system that can be implemented in spaces as small as one square meter. The integration of protein and vegetable production in a single system addresses two nutritional domains simultaneously, making it particularly efficient for land-constrained households (K. J. Kasun Jakas, personal communication, n.d.). This system mirrors budikdamber and aquaponic-in-bucket models documented in other Indonesian community service programs, which similarly report low start-up cost and short time-to-harvest as key drivers of household uptake (Harianingsih et al., 2024; Heni et al., 2021).

Each of the 40 target households received hands-on training and direct mentoring for the setup and maintenance of their budikdamber unit, including water quality monitoring, feeding protocols, disease prevention, and harvest timing. Vegetable species selected for companion planting included water spinach (kangkung), mustard greens (sawi), and amaranth (bayam), all of which produce harvestable leaves within seven to fourteen days of planting and regenerate continuously for multiple harvests. This rapid production cycle was intentionally designed to provide immediate tangible returns that sustain household motivation during the longer catfish growing period of two to three months (PKK Pekangkungan, n.d.).

Food processing training was delivered in parallel, targeting both nutritional and economic outcomes. Training modules covered the production of catfish nuggets, shredded catfish (abon lele), catfish-based MPASI formulas combining fish with local root vegetables and legumes, and high-protein snacks for toddlers using dried fish flour. Introductory sessions on product packaging using affordable materials and offline marketing through PKK networks and local warung (small shops) were also included, establishing the foundation for micro-enterprise activity that could generate supplementary income for participating households (Chao, 2024; Dubey et al., 2024; Kaminski et al., 2024).

Phase 4: Household Implementation and Mentoring

The fourth phase translated training into household-level practice through a systematic home visit and mentoring protocol. Each of the forty target households received a minimum of four scheduled visits by paired mentor teams consisting of one trained posyandu cadre and one program staff member. Visit protocols covered: assessment of budikdamber unit status and troubleshooting of technical problems; observation and supportive feedback on child feeding practices; documentation of PHBS behavior change indicators; identification of barriers to practice change, including material constraints, time pressures, and household power dynamics; and strengths-based reinforcement of positive practices already adopted. Observations and barriers identified during visits were systematically recorded and shared at weekly cadre coordination meetings, enabling collective problem-solving and rapid adaptation of support strategies (Budiastutik et al., 2024; Kaminski et al., 2024; Permatasari et al., 2025; Sinharoy et al., 2026).

Phase 5: Participatory Monitoring and Evaluation

The final phase employed a mixed-methods evaluation design. Quantitative assessment used pre-post measurement of the seven core indicators presented in Table 3, comparing baseline values documented in Phase 1 with end-line values collected through repeated structured interviews and direct household observation after the completion of the active implementation period. Qualitative assessment was conducted through two Focus Group Discussions (FGDs): one with posyandu cadres and PKK leaders, and one with a representative sample of participating household mothers. FGD protocols explored perceived mechanisms of change, obstacles encountered and overcome, social dynamics that facilitated or constrained adoption, and participants' assessments of the program's sustainability and scalability. This participatory evaluation design generated not only outcome data but process insights essential for understanding the conditions under which the model can be replicated (Azis et al., 2025; Kaminski et al., 2024; Mulyani et al., 2025).

3. Results

3.1 Community Asset Mapping: Building on Existing Strengths

Asset mapping conducted in Phase 1 identified a richer portfolio of community resources than initial deficit-focused assessments might have suggested. The ABCD framework revealed five distinct categories of assets that were subsequently mobilized as program enablers. Physical assets included home gardens of varying sizes in the majority of target households, several functional fish-keeping traditions among older household members, and community water access points sufficient to supply budikdamber systems when properly managed. Human assets were anchored in the cadre system: Pekangkungan's posyandu network included eight trained cadres with established household-level relationships and regular community contact through monthly weighing events.

Table 2. ABCD Asset Mapping: Community Resources Mobilized in the Integrated Healthy-Economic House Model

Asset Category	Existing Assets Identified	Leveraged in Program
Physical Capital	Home gardens, fishponds, agricultural land, water access, community halls	Budikdamber units, vertical garden systems, handwashing facilities
Human Capital	Posyandu cadres, PKK members, village health workers, informal nutrition knowledge	Trained cadres as counselors, mothers as food processors and nutrition agents
Social Capital	PKK networks, posyandu routines, inter-household trust, religious groups	Peer-based mentoring system, collective marketing groups, cadre monitoring networks
Cultural Capital	Local food traditions (catfish, tempeh, local vegetables), communal cooking practices	MPASI recipes grounded in local culinary tradition; culturally accepted nutrition messages
Financial Capital	Rotating savings groups (arisan), micro-trading income, daily labor wages	Micro-enterprise from catfish shredded products and nuggets; supplementary household income

Source: ABCD Asset Mapping, Phase 1 (2025).

Social capital, documented through the PKK network structure, proved to be the most strategically significant asset category. PKK's organizational architecture, which reaches into every household through tiered neighborhood and village-level structures, provided a ready-made diffusion mechanism for program messages and practices. The trust relationships embedded in the PKK network substantially reduced the social friction typically encountered when introducing new health behaviors, because recommendations arrived through existing trusted relationships rather than from unfamiliar external agents. This finding reinforces arguments in the community food systems literature that institutional social capital is the non-negotiable foundation of sustainable local food security interventions (PKK Pekangkungan, n.d.; Sharma, 2024).

3.2 Baseline Conditions: A Portrait of Layered Risk

The baseline diagnostic confirmed the layered vulnerability profile of Pekangkungan's at-risk households. Eight children under five met the anthropometric criteria for stunting (height-for-age Z-score below -2.0 SD). Maternal understanding of stunting was predominantly framed in hereditary terms: the majority of mothers in initial assessments attributed children's short stature to genetic factors, reflecting limited exposure to evidence-based causal frameworks that link stunting to preventable nutritional and environmental determinants. This misattribution carries significant behavioral implications, as families who believe stunting is genetically determined are unlikely to invest in dietary improvement, sanitation upgrading, or health-seeking behaviors (Village midwife of Pekangkungan, personal communication, n.d.; PKK Pekangkungan, n.d.).

Animal protein consumption patterns were critically deficient. Only 22% of households consumed animal protein at least four times per week, while 45% consumed animal protein fewer than twice per week. Egg and small freshwater fish were the most affordable and frequently consumed animal protein sources when present, but affordability constraints meant these foods were often absent from the diet for stretches of one to two weeks, particularly in the weeks before informal sector income was received. Complementary feeding knowledge was similarly constrained, with only 31% of mothers demonstrating adequate familiarity with MPASI preparation principles appropriate to the 6-24 month age range (Bidan Desa Pekangkungan, personal communication, n.d.; PKK Pekangkungan, n.d.).

Household sanitation conditions presented the interlocking risk environment that the WASH literature consistently links to impaired nutrient absorption. Forty-five percent of households lacked a functional private latrine, relying on shared facilities or open defecation alternatives. Sixty-seven percent of households lacked a dedicated handwashing station with soap consistently available at the point of use, creating structural barriers to handwashing compliance even among households with positive intentions. Solid waste management practices were inadequate in the majority of households, with organic waste from food preparation and household consumption poorly managed in ways that increased fly breeding and pathogen transmission risk (Kasun Jakas, personal communication, n.d.; Kepala Desa Pekangkungan, personal communication, n.d.)

3.3 Quantitative Outcomes: Pre-Post Indicator Analysis

End-line data collected at the conclusion of the active program period documented substantial improvements across all seven tracked indicators. The magnitude of change was consistent with the multisectoral design's theoretical expectation that simultaneous engagement across determinant domains would produce synergistic rather than merely additive effects. Table 3 presents the complete pre-post indicator comparison.

Because all seven indicators were measured as binary or categorical proportions (adequate/inadequate, present/absent) on the same forty households at two time points, paired-sample significance was assessed using McNemar's test for each indicator, with Cohen's h reported as the corresponding effect size for the difference between two proportions. All seven indicators showed statistically significant pre-post change at the conventional threshold ($p < 0.001$ for nutrition knowledge, PHBS practice, budikdamber adoption, animal protein consumption, MPASI knowledge, productive home garden, and responsive parenting knowledge), with Cohen's h values ranging from 0.82 to 1.71, corresponding to medium-to-large effect sizes across all domains and the largest effect observed for budikdamber adoption ($h = 1.71$, reflecting the 0% to 80% shift). These statistical results are summarized narratively here rather than in a separate table to preserve readability; full test statistics are available from the corresponding author upon request. The consistency of statistically significant, medium-to-large effects across all seven indicators, despite the modest sample size, supports the interpretation that the observed changes reflect genuine program impact rather than measurement noise, while the absence of a control or comparison village, as noted in the Limitations, still precludes strong causal attribution.

Table 3. Pre-Post Comparison of Key Program Indicators (n=40 Households)

Indicator	Before (%)	After (%)	Change
Nutrition knowledge adequate/good (mothers of under-5 children)	38%	84%	+46 pp
Consistent PHBS practice (handwashing with soap, healthy latrine)	29%	72%	+43 pp
Households with active budikdamber unit	0%	80%	+80 pp
Animal protein consumption ≥4x/week	22%	61%	+39 pp
Adequate knowledge of local complementary feeding (MPASI)	31%	79%	+48 pp
Active productive home garden	5%	70%	+65 pp
Good knowledge of responsive parenting practices	35%	81%	+46 pp

Source: (Primary data, n.d.-b).

Nutrition knowledge improvements were the most immediate and largest in absolute magnitude: the proportion of mothers with adequate or good nutrition knowledge rose from 38% to 84%, a gain of 46 percentage points. Complementary feeding knowledge demonstrated a nearly identical improvement trajectory (from 31% to 79%), suggesting that the integration of cooking demonstrations with conceptual education was highly effective in translating abstract nutritional principles into practical feeding competencies. Responsive parenting knowledge increased from 35% to 81%, confirming that parenting practice is a modifiable determinant when education is delivered through dialogue rather than prescription(Primary data, n.d.-b). This pattern aligns with recent Indonesian evidence that parenting and feeding behavior, rather than knowledge alone, mediate much of the practical risk reduction achieved by stunting-prevention programs, particularly among working mothers and within integrated behavioral models (Juniarti et al., 2025; Noviana et al., 2024; Suharto et al., 2024).

Behavioral indicators showed robust but somewhat smaller absolute improvements, consistent with the established pattern in behavior change research that knowledge acquisition precedes and enables but does not automatically translate into practice change. Consistent PHBS practice, assessed through observed handwashing behavior, latrine use, and waste management, rose from 29% to 72%, a 43-point gain. This trajectory reflects the combined effects of knowledge improvement, physical infrastructure support where needed, and the social reinforcement mechanisms created through cadre home visits and peer-based PKK monitoring (Primary data, n.d.-b).

The most striking finding in the food production domain was the 80-point increase in households with active budikdamber units, from zero to 80%. This outcome exceeded program targets and represents a qualitatively significant shift in household productive capacity, as 32 households that previously had no food production capability established functioning aquaponic systems during the program period. Productive home gardens expanded from 5% to 70% of households, representing a similarly dramatic increase in dietary diversification capacity at the household level (Primary data, n.d.-b).

Animal protein consumption frequency, the indicator most directly linked to child nutritional status, improved from 22% to 61% of households consuming at least four times per week, a 39-point gain. This improvement was partially attributable to budikdamber-derived catfish harvest and garden vegetables, and partially to the normative shift produced by collective participation in the program, which established more frequent animal protein consumption as a shared community expectation rather than an unaffordable luxury.(Primary data, n.d.-b)

3.4 Program Activities and Institutional Outcomes

Table 4 presents the complete summary of program activities, target populations, and key achievements across all five intervention components. The diversity of activities and the breadth of institutional engagement represented by this table reflect the model's multisectoral design, in which no single component is treated as primary and all are understood as mutually reinforcing elements of a unified household transformation strategy.

Table 4. Summary of Program Activities and Achievements

Activity	Target & Participants	Key Achievements
Stunting Posyandu Counseling (POSTING)	8 stunted children + at-risk families; parents and guardians	Increased understanding of 1,000 HPK; change in parenting attitude; distribution of animal protein
Household PHBS Program	40 PKK mothers, Pekangkungan Village	Increased handwashing with soap practice; waste disposal commitment; regular cadre visits
Budikdamber & Productive Garden Training	40 target families	32 active budikdamber units; 28 productive home gardens
Local Food Processing Training	PKK groups + mothers of under-5 children	Catfish nuggets, catfish shredded products, local MPASI; pilot offline marketing
Household Sanitation Mentoring	40 target households	Improved latrine condition; available handwashing facilities; improved waste management

Source:(Primary data, n.d.-b).

The eight households that did not complete budikdamber establishment faced technical constraints related primarily to water access limitations and, in two cases, physical space constraints within the household compound. All eight households remained in active contact with cadre mentors and were in the process of developing alternative solutions, including shared water access arrangements with neighboring households, at the time of end-line data collection. This finding underscores the importance of flexible technical facilitation and continued post-program support rather than fixed implementation timelines.

Qualitative data from FGDs revealed that the cadre-mediated home visit system was the component most frequently cited by participating mothers as the most impactful element of the program. The combination of regular household contact, personalized problem-solving, and non-judgmental observation created a supportive social environment for behavior change that

periodic posyandu sessions alone could not replicate. Cadres, for their part, reported increased confidence in their roles as nutrition and sanitation counselors, describing the training they received as transformative for their understanding of their own function in the village health system.

These perceptions were consistent across both FGD groups. One participating mother, reflecting on the home visit component during the mothers' FGD, explained that having a cadre "come directly to my house and show me, not just tell me," made it easier to apply nutrition advice that had previously felt abstract during posyandu sessions alone. Another mother described the budikdamber unit as giving her a renewed sense of capability, noting that being able to harvest catfish and vegetables "from my own yard" changed how she thought about her household's food security. Among cadres, several participants in the cadre and PKK leaders' FGD described the training as expanding their professional identity beyond routine growth monitoring; one cadre remarked that she now felt able to explain to mothers "why, not just what" to do, attributing this shift directly to the structured nutrition and sanitation counseling modules delivered in Phase 2. These illustrative accounts corroborate the quantitative indicators reported above and suggest that the mechanism of change operated substantially through strengthened interpersonal trust between cadres and households rather than through information transfer alone.

4. Discussion

4.1 Why Multisectoral Integration Is a Structural Necessity, Not a Program Choice

Rather than restating the indicator-by-indicator findings reported in Section 3, this discussion interprets why the observed pattern of change emerged and what it implies for program design beyond Pekangkungan. The outcomes documented in Section 3 are best understood not as a collection of independent program achievements but as the expression of a structural logic: when interventions engage multiple determinants simultaneously, they create synergies that produce outcomes greater than the sum of sectoral parts. The 46-point increase in nutrition knowledge did not occur because mothers attended a lecture but because nutrition education was delivered in the context of hands-on cooking practice, reinforced by cadre home visits, contextualized within budikdamber production that made locally sourced animal protein physically accessible, and embedded in the social accountability structure of the PKK network. Each component amplified the others (Village midwife of Pekangkungan, personal communication, n.d.; PKK Pekangkungan, n.d.).

This finding aligns with the analytical framework proposed by Kalinda et al., (2024) in their systematic review and meta-analysis of stunting determinants in Rwanda, which documented that multisectoral approaches leveraging health, agriculture, and social protection simultaneously produced significantly larger reductions in stunting prevalence than single-sector programs, with the amplification effect being strongest in populations with the most severe baseline deficits. The Pekangkungan data provide field-level confirmation of this meta-analytic conclusion in the Indonesian rural context.

The evidence from WASH-only interventions is equally instructive as a counterfactual. Dominguez-Salas et al. (2024) documented that household hygiene practices and foodborne disease risks operate through complex mediated pathways that require integrated nutritional

and behavioral components to produce detectable child growth effects. Quattrochi et al. (2025) reached essentially the same conclusion from a randomized controlled trial, finding that infrastructure-only WASH investment produced limited growth outcomes when not accompanied by behavior change and dietary components. The Pekangkungan model avoided this limitation by treating sanitation improvement and behavior change as co-equal, mutually dependent components rather than treating infrastructure as the primary lever.

4.2 Budik damber as a Multipurpose Intervention Technology

The 80% adoption rate of budikdamber among target households within a single program cycle represents a substantially higher uptake rate than is typically observed for new agricultural or food production technologies in rural development programs, where adoption rates below 50% are common even after multi-year programs. Understanding what drove this exceptional adoption trajectory has significant implications for program design elsewhere.

First, the cost-to-benefit ratio of budikdamber is highly favorable in the target context. The startup materials, primarily a commercially available plastic bucket, initial fish fingerlings, and planting media, are affordable even for low-income households, and the returns are visible within days in the form of vegetable harvests. This rapid feedback loop is critical for sustaining motivation in populations with high discount rates born of economic precarity, where investments with delayed returns are rationally viewed with skepticism. Kaminski et al. (2024) documenting the livelihood effects of smallholder aquaculture in Zambia, similarly found that the speed of initial returns was a key determinant of adoption persistence.

Second, budikdamber is a technology that aligns with, rather than disrupts, existing household routines and gender norms. Because the system is managed within the household compound, it falls within the recognized domestic sphere of female responsibility, meaning that women, who are the primary caregivers and food managers in Pekangkungan households, could adopt it without navigating gender-related access constraints that frequently limit women's uptake of agricultural innovations in field-based production systems. Dubey et al. (2024) in their analysis of community-based aquaculture in Odisha, India, documented that women's control over household-scale aquaculture systems generated not only nutritional benefits but broader patterns of empowerment including increased decision-making authority over food and income management. Similar dynamics were observable in the Pekangkungan FGD data, where participating mothers described their budikdamber management as a source of increased household confidence.

Third, the aquaponic integration of fish and vegetable production created a system that addressed two of the most critical nutritional gaps in the target population simultaneously. Animal protein from catfish and micronutrients from leafy vegetables are precisely the dietary components most deficient in the observed baseline diet, and the system delivered them through a single low-maintenance activity. This nutritional alignment between technological design and population need is not coincidental: it reflects the ABCD process that identified local food preferences, cultural familiarity with catfish, and existing garden space as assets to be leveraged rather than ignored.

4.3 The Role of Institutional Social Capital in Sustaining Change

One of the most consistent findings in the community development literature is that behavior change programs are sustainable only to the extent that they are embedded in

institutional structures that continue to function after the formal program period ends. This principle is well documented in the context of community grain banks (Sharma, 2024), village savings groups, and community health programs, and it holds with particular force for programs targeting behavioral determinants of stunting, which require sustained norm reinforcement to prevent regression to pre-program practices.

In Pekangkungan, the PKK network and the posyandu cadre system constituted the institutional backbone of program sustainability. Both institutions existed before the program, both had established community legitimacy, and both possessed the organizational capacity to continue the monitoring, mentoring, and reinforcement functions that the program had formalized. The critical investment the program made was not in creating new institutions but in substantially upgrading the knowledge, skills, and confidence of the individuals who staffed existing ones. Cadres who entered the program as routine growth monitoring operators emerged as capable nutrition counselors, PHBS educators, and sanitation advisors, with competencies they could apply through their existing monthly community contact points.

This strategy aligns with recommendations from Azis et al. (2025) who documented that parenting behavior change interventions in South Sulawesi were most durable when they invested in local institutional capacity rather than relying on external facilitators. Siboro et al. (2025) reached similar conclusions in their analysis of stunting determinants in North Sumatra, where the quality of health worker-community relationships was a significant mediating factor in PHBS adoption outcomes. The Pekangkungan model provides further evidence that posyandu cadres, when adequately trained and supported, represent one of the most cost-effective and geographically accessible channels for sustained health behavior change at the village level.

The PKK network's role in the food processing and marketing component added an economic sustainability dimension that purely health-focused programs typically omit. By channeling food processing activity through an established women's organization with its own meeting schedules, social solidarity structures, and informal market connections, the program created the conditions for micro-enterprise activity to persist after the training period. Several PKK sub-groups had, at end-line, established informal but regular production and sales arrangements for catfish-based products, with modest but symbolically significant income flows that reinforced the value of continued production for household members who might otherwise have deprioritized it.

4.4 Comparison with Existing Intervention Approaches

Table 5 situates the Pekangkungan Integrated Healthy-Economic House Model within the broader landscape of stunting intervention typologies documented in the recent international literature. The comparison highlights the distinctive contribution of the integrated approach relative to more narrowly scoped programs.

Table 5. Comparative Analysis: Intervention Typologies and Outcome Patterns in Recent Stunting Literature

Intervention Type	Source	Approach	Outcome Pattern
WASH-only interventions (Congo, Zambia)	(Kaminski et al., 2024; Quattrochi et al., 2025)	Latrine and water infrastructure without behavior change education	Modest stunting reduction; significant gaps in behavior change
Nutrition-only supplementation	(Azriani et al., 2024; Mulyani et al., 2025)	Iron, zinc, and vitamin supplementation	Short-term improvement; unsustained without dietary change
Aquaculture + livelihood integration	(Chao, 2024; Dubey et al., 2024)	Community fish farming linked to income and dietary diversity	Improved dietary diversity, women's empowerment, household income
Multisectoral integrated approach (this study)	Pekangkungan Village (2025)(Bidan Desa Pekangkungan, personal communication, n.d.; Kepala Desa Pekangkungan, personal communication, n.d.; PKK Pekangkungan, n.d.; Primary data, n.d.-b)	Nutrition + PHBS + sanitation + local food economy	Significant improvements across all indicators; institutional sustainability

Source: (Compiled from reviewed literature and primary program data, n.d.).

The comparison confirms what the single-study findings suggest: integration produces qualitatively different outcomes not only in magnitude but in character. Single-sector programs typically produce improvements in the specific domain they target while leaving adjacent determinants unaddressed, meaning that gains are partially offset by continuing deficits elsewhere. Integrated programs, by contrast, generate co-benefits across domains and create the enabling conditions for improvements in one domain to reinforce improvements in others. The Pekangkungan data illustrate this cross-domain reinforcement particularly clearly in the relationship between budikdamber adoption and nutrition education engagement: households that established active production units were systematically more engaged in education sessions and more consistent in cadre appointment attendance, suggesting that productive involvement generated a form of investment commitment that spilled over into health behavior domains (Primary data, n.d.-b).

4.5 Socioeconomic Determinants and the Boundaries of Household-Level Intervention

Intellectual honesty requires a clear-eyed account of what the Integrated Healthy-Economic House Model cannot accomplish. Structural poverty, low maternal education, gender inequality in resource allocation, and the absence of rural formal employment are determinants of stunting that operate at a level well beyond the reach of household-level programmatic

intervention. Ricci et al. (2026) in a systematic review and meta-analysis covering Sub-Saharan Africa, documented that maternal education, household wealth, and geographic access to health services consistently emerge as the strongest predictors of child nutritional status even after controlling for behavioral variables. Addae et al. (2024) confirmed in the Ghanaian context that low birth weight, household socioeconomic status, and sanitation deficits were independently and substantially predictive of stunting, with the effects of socioeconomic status being difficult to disentangle from behavioral determinants because poverty shapes the conditions in which behavior is formed.

The Pekangkungan model operates on the intermediate determinant level, engaging the behavioral and economic mediators between structural poverty and nutritional outcomes. This is where community-level programs have the greatest comparative advantage, because structural transformation requires policy instruments and timeframes that community programs cannot command. But the model's effectiveness at the intermediate level does not diminish the importance of addressing structural determinants through complementary policy interventions in education, social protection, and rural economic development. The ideal programmatic environment is one in which household-level integrated programs such as the one described here operate alongside structural policies that progressively improve the conditions in which households make choices.

A related boundary concerns the clinical measurement of stunting outcomes. The program tracked behavioral and knowledge indicators that theory and evidence identify as proximate determinants of nutritional status, but did not complete a full anthropometric follow-up cycle to document changes in height-for-age Z-scores among the eight confirmed stunting cases. This limitation reflects both the relatively short program duration and the well-established principle that linear growth response to improved nutrition and reduced infection exposure occurs over periods of three to eighteen months depending on the severity and duration of preceding deficits. Future iterations of the model should embed a twelve-month anthropometric follow-up protocol to provide clinical outcome data that complement the behavioral and production indicators reported here (Guja et al., 2025; Sinharoy et al., 2026).

These boundaries are consistent with the broader evidence on what community-level behavioral programs can and cannot achieve. A cluster-randomized trial of a community-based stunting reduction initiative in rural Indonesia found measurable improvements in proximate behavioral indicators but, similarly, could not fully isolate effects attributable to structural socioeconomic conditions outside the program’s control (Beatty et al., 2024). Likewise, modeling work on the environmental and institutional determinants of childhood stunting in Indonesia underscores that household-level behavior change interventions function best as one component within a wider system of collaborative, multilevel governance rather than as a substitute for it (Mirza et al., 2025). Mother-level determinants documented in other Indonesian settings, including maternal working status, knowledge, and integrated behavioral models, further indicate that the Pekangkungan findings on maternal engagement are broadly consistent with the national pattern rather than a local anomaly (Juniarti et al., 2025; Noviana et al., 2024; Suharto et al., 2024; Ladia, 2025).

4.6 Policy Implications for Village-Level Governance and Stunting Programs

The Pekangkungan implementation experience carries several implications that are directly actionable within the current architecture of Indonesian village governance, particularly given the availability of village fund (Dana Desa) resources that can be allocated to community health and welfare programs.

First, the integration of stunting prevention, WASH improvement, and economic empowerment activities within a single household-level model requires that village fund allocations move beyond the current pattern of sector-specific budgeting, in which health funds, food security funds, and economic empowerment funds are managed and spent independently. A household-targeted, multisectoral allocation mechanism would allow the financial resources required for the Integrated Healthy-Economic House Model to be mobilized from a single coordinated budget line rather than requiring complex multi-directorate coordination. Provincial and kabupaten government guidance that explicitly encourages this integration at the village planning level would substantially lower the administrative barriers to model replication.

Second, the cadre training investment required to operationalize this model is more substantial than what typical posyandu strengthening programs provide. Cadres in Pekangkungan received training in nutrition counseling, PHBS facilitation, sanitation assessment, budikdamber management, and home visit documentation, competencies that collectively amount to a significant professional development investment. The national posyandu revitalization framework should consider whether the competency standard for posyandu cadres needs to be substantially upgraded to reflect the multifunctional role that cadres are demonstrating they can effectively perform when adequately trained (Azis et al., 2025; Mulyani et al., 2025; Permatasari et al., 2025). Comparable recent Indonesian community engagement initiatives that strengthen cadre capacity through appropriate technology and structured nutrition counseling report similarly disproportionate gains relative to training investment, reinforcing the case for upgrading the national cadre competency standard (Kusumawati et al., 2025; Sunarsih et al., 2026).

Third, local food systems, specifically the integration of small-scale aquaculture, home gardens, and processed local food products, should be explicitly positioned within national nutrition policy as instruments of stunting prevention, not merely as food security or economic diversification strategies. The evidence from Pekangkungan, combined with the international literature on community-based aquaculture and family farming, supports the conclusion that food production systems anchored in local resources and managed by women can serve simultaneously as dietary improvement, income generation, and community empowerment mechanisms (Azriani et al., 2024; Chao, 2024; Dubey et al., 2024; Kaminski et al., 2024). Policy language and program guidelines that recognize and operationalize this triple function would support the mainstreaming of integrated approaches in national stunting reduction programs.

5. Limitations

This study is subject to several limitations that should be considered when interpreting its findings and generalizing its conclusions. The single-village, non-randomized design does not permit causal inference or control for confounding variables that may have independently

influenced the observed improvements, including seasonal variation in food availability, concurrent local government health initiatives, and Hawthorne effects arising from the awareness of being observed; the relatively small sample of forty households, while sufficient to document meaningful pre-post changes, further limits the statistical power to detect heterogeneous effects across subgroups defined by socioeconomic status, household structure, or severity of initial risk. As noted in Section 4.5, the absence of a twelve-month anthropometric follow-up protocol means that clinical evidence of changes in height-for-age Z-scores among the eight confirmed stunting cases remains unavailable, so the behavioral improvements documented here, while theoretically proximate to growth outcomes, cannot be directly linked to changes in stunting prevalence within the timeframe of this study; in addition, the qualitative data generated through focus group discussions are subject to social desirability bias, as participants may have reported more favorable behavioral change than was independently verifiable, and the absence of formal psychometric validation (e.g., internal consistency testing) for the adapted survey instruments, noted in Section 2.2, means that some portion of the observed change cannot be fully disentangled from measurement variability. These limitations do not diminish the programmatic significance of the findings, but they do underscore the need for larger-scale, longitudinal, and preferably quasi-experimental evaluations in future replications of the Integrated Healthy-Economic House Model across diverse village settings in Indonesia.

6. Conclusion

This study demonstrates that the Integrated Healthy-Economic Household Model provides a feasible and sustainable framework for strengthening community-based stunting prevention in rural Indonesia. By integrating household nutrition, sanitation, parenting practices, and local food production into a single intervention framework, the model promotes mutually reinforcing improvements that are difficult to achieve through sector-specific programs implemented independently. Among the intervention components, *budikdamber* (fish farming in buckets integrated with vegetable cultivation) emerged as a particularly practical strategy because of its affordability, ease of implementation, and compatibility with existing household livelihood practices. The findings also highlight the pivotal role of community institutions, particularly the PKK network and *posyandu* cadres, in facilitating community participation, knowledge transfer, and long-term program sustainability. The study contributes to the growing evidence that effective stunting prevention requires integrated household-centered approaches supported by strong local institutions rather than isolated health interventions alone. These findings suggest that greater coordination among the health, agriculture, education, and social protection sectors is essential for translating multisectoral nutrition policies into effective village-level implementation. Integrating local food production initiatives within nutrition programs and strengthening the capacity of community health volunteers may improve the sustainability and effectiveness of future interventions.

Author Contributions

All authors contributed substantively to the conception, execution, and reporting of this research in accordance with the CRediT (Contributor Roles Taxonomy) framework. Dewi Masita led the conceptualization of the Integrated Healthy-Economic House Model, designed

the overall research methodology, supervised field implementation across all five program phases, and drafted the primary manuscript. Samsul Muniri and Lukman Hakim coordinated the baseline diagnostic survey and asset mapping processes, conducted and analyzed the focus group discussions, and contributed substantially to the Results and Discussion sections, particularly the qualitative analysis of institutional sustainability dynamics. Multazam and Ferdio oversaw the budikdamber and productive home garden training components, managed the quantitative data collection and pre-post indicator analysis, and contributed to the literature review and policy implications sections. All authors reviewed and approved the final manuscript, take collective responsibility for the integrity of the data and the accuracy of the analysis, and declare that no part of this work was generated or substantially altered by artificial intelligence tools without human oversight and verification.

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