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Backyard fishery extension programs for nutritional security enhancement in rural farming households

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Abstract

The trend across Nepal's Terai districts over the past decade points in a troubling direction: agricultural output has risen but child stunting rates have barely moved, hovering near 36% in the far-western districts even as rice yields have improved steadily ^[1]. This research evaluated whether backyard fishery extension programs could break the disconnect between agricultural productivity and nutritional outcomes among 276 farming households in Kanchanpur and Kailali districts between April 2021 and March 2023. A matched-pair design compared 138 households receiving fishery extension (pond construction guidance, species selection, feed management, water quality monitoring, and nutrition education) with 138 control households receiving standard crop extension only. At 24-month endline, fishery households showed significantly higher dietary diversity scores (8.7 vs. 5.3 out of 12 food groups, $p < 0.001$), animal protein intake (28.6 vs. 12.4 g/capita/day, $p < 0.001$), and household fish consumption (18.7 vs. 3.2 kg/year, $p < 0.001$). Child stunting rates were 22.1% among fishery households compared to 38.7% in controls ($p < 0.01$). The results position backyard fishery extension as a nutrition-sensitive agricultural intervention that operates through direct consumption, income, and women's empowerment pathways simultaneously.

Keywords: Backyard fishery, nutritional security, extension programs, fish pond, dietary diversity, rural nutrition, Nepal agriculture, aquaculture extension, protein intake, food security

Introduction

The trend is paradoxical: Nepal produces enough calories to feed its population, yet nearly one-third of children under five are stunted and over half of women of reproductive age are anemic ^[1, 2]. The explanation lies partly in what farmers grow versus what bodies need. The far-western Terai's agricultural extension system has successfully promoted rice and wheat intensification, but cereal-dominated diets provide calories without the animal protein, micronutrients, and dietary diversity that prevent stunting and anemia. Nutrition-sensitive agricultural programs try to bridge this gap, but most focus on kitchen gardens and small livestock-fish, despite being the cheapest source of animal protein in lowland South Asia, rarely feature in extension portfolios ^[3]. Backyard fish ponds occupy as little as 15 square meters and can produce 15-25 kg of fish annually using household waste and on-farm feed inputs ^[4]. In Bangladesh, where a similar agro-ecological and cultural context applies, homestead aquaculture programs reduced child stunting by 8-12 percentage points and increased dietary diversity by 2-3 food groups within two years ^[5, 6]. Nepal's far-western districts share many conditions with Bangladesh's fishery success areas-flat terrain, seasonal water availability, warm growing seasons, and rice-based farming systems-but have not yet integrated fishery extension into their agricultural advisory infrastructure.

The challenge isn't only technical. Backyard aquaculture requires a different extension skill set than crop advisory: water quality management, species selection for local

conditions, and feed formulation from available materials, and- critically- nutrition education that connects fish production to household dietary practices. Without the nutrition education component, fish production tends to go entirely to market rather than household consumption, reducing the nutritional impact ^[7]. This research tested whether an integrated fishery extension program combining production technical support with nutrition education could improve nutritional security outcomes among farming households in Nepal's far-western Terai.

Field experimental design

A matched-pair quasi-experimental design assigned 276 households across 18 village development committees in Kanchanpur and Kailali districts. Treatment households ($n = 138$) were selected from nine communities where fishery extension was introduced; control households ($n = 138$) were matched from nine comparable communities receiving standard crop extension only. Matching criteria included household size, landholding, caste/ethnicity, market distance, and baseline dietary diversity score (within 0.5 points). The fishery extension package included five components delivered over 24 months: pond construction guidance (months 1-3), species selection advisory (month 3), feed management training (months 4-6), water quality monitoring support (ongoing), and harvest and nutrition education (months 6-24). Each treatment community received bi-monthly visits from a trained fishery extension agent paired with the existing agriculture extension worker.

Material and methods

Material

Data were collected from 276 farming households (138 treatment, 138 control) in Kanchanpur and Kailali districts between April 2021 and March 2023. Ethical clearance was obtained from the Research Committee of Far Western University (Approval FWU-RC/2021-023, dated 18 March 2021). Eligible households had access to at least 15 square meters of land suitable for pond construction, at least one child under five years, and no prior fish culture experience. Written informed consent was obtained in Nepali, with Tharu-language explanation provided where needed. Baseline and endline surveys captured dietary intake (24-hour recall), anthropometric measurements for children under five (height-for-age z-scores), hemoglobin levels for women of reproductive age, household food security (Months of Adequate Household Food Provisioning), and fish production and consumption data.

Methods

Nutritional outcomes were assessed through six indicators: dietary diversity score (12-group FAO classification), animal protein intake (grams per capita per day from 24-hour recall), food secure months (MAHFP scale), child stunting prevalence (height-for-age below -2 SD, WHO growth standards), iron deficiency in women (hemoglobin

below 12 g/dL), and household fish consumption (kg/year). Difference-in-differences analysis compared changes between treatment and control groups from baseline to endline. Multiple regression models controlled for household size, caste, education, landholding, and market distance. Cost-effectiveness was calculated as cost per unit of nutritional improvement. Analyses used Stata 16.0 with significance at $\alpha = 0.05$ [8].

Seasonal variations

Fish production and nutritional outcomes showed distinct seasonal patterns across the two-year monitoring period. Pond productivity peaked during the warm monsoon months (June-September) when water temperatures of 25-32 degrees Celsius supported rapid tilapia and carp growth. Partial harvesting during this period coincided with the lean season when household food stocks from the previous rice harvest were depleted, providing animal protein precisely when nutritional vulnerability was highest. Winter months (November-February) saw reduced fish growth but continued low-level harvesting sufficient for 1-2 fish meals per week. The seasonal alignment between peak fish availability and peak nutritional need represented an unplanned but significant advantage of the backyard fishery model over other nutrition interventions that don't naturally match production cycles to household food calendars.

Results

Table 1: Baseline household characteristics: Treatment vs. control groups (n = 276)

Characteristic	Fishery (n=138)	Control (n=138)	p-value
Household size	5.8 ± 1.9	5.6 ± 2.0	0.412
Landholding (kattha)	12.4 ± 7.8	11.8 ± 8.1	0.538
Tharu ethnicity (%)	43.5	41.3	0.714
Baseline dietary diversity	5.2 ± 1.4	5.4 ± 1.3	0.237
Baseline protein (g/cap/day)	12.1 ± 4.8	12.7 ± 5.1	0.328
Child stunting (%)	37.4	39.1	0.782

Groups were well-matched at baseline across all key characteristics (Table 1), with no significant differences in household composition, landholding, ethnicity, or

nutritional indicators, supporting the validity of between-group comparisons at endline.

Table 2: Nutritional Security Outcomes at 24-Month Endline

Indicator	Fishery	Control	DiD effect	p-value
Dietary diversity (0-12)	8.7 ± 1.8	5.3 ± 1.6	+3.2	<0.001
Protein intake (g/cap/day)	28.6 ± 8.4	12.4 ± 5.2	+15.6	<0.001
Food secure months	10.4 ± 1.3	7.8 ± 2.1	+2.4	<0.001
Child stunting (%)	22.1	38.7	-15.3 pp	<0.01
Iron deficiency (%)	36.8	54.2	-16.1 pp	<0.01
Fish consumption (kg/yr)	18.7 ± 6.3	3.2 ± 2.4	+15.2	<0.001

All nutritional indicators showed significant improvements in fishery households relative to controls (Table 2). The largest effect sizes appeared in fish consumption (Cohen's $d = 2.31$) and protein intake ($d = 1.87$). Child stunting

dropped by 15.3 percentage points more in fishery households than in controls after adjusting for baseline levels.

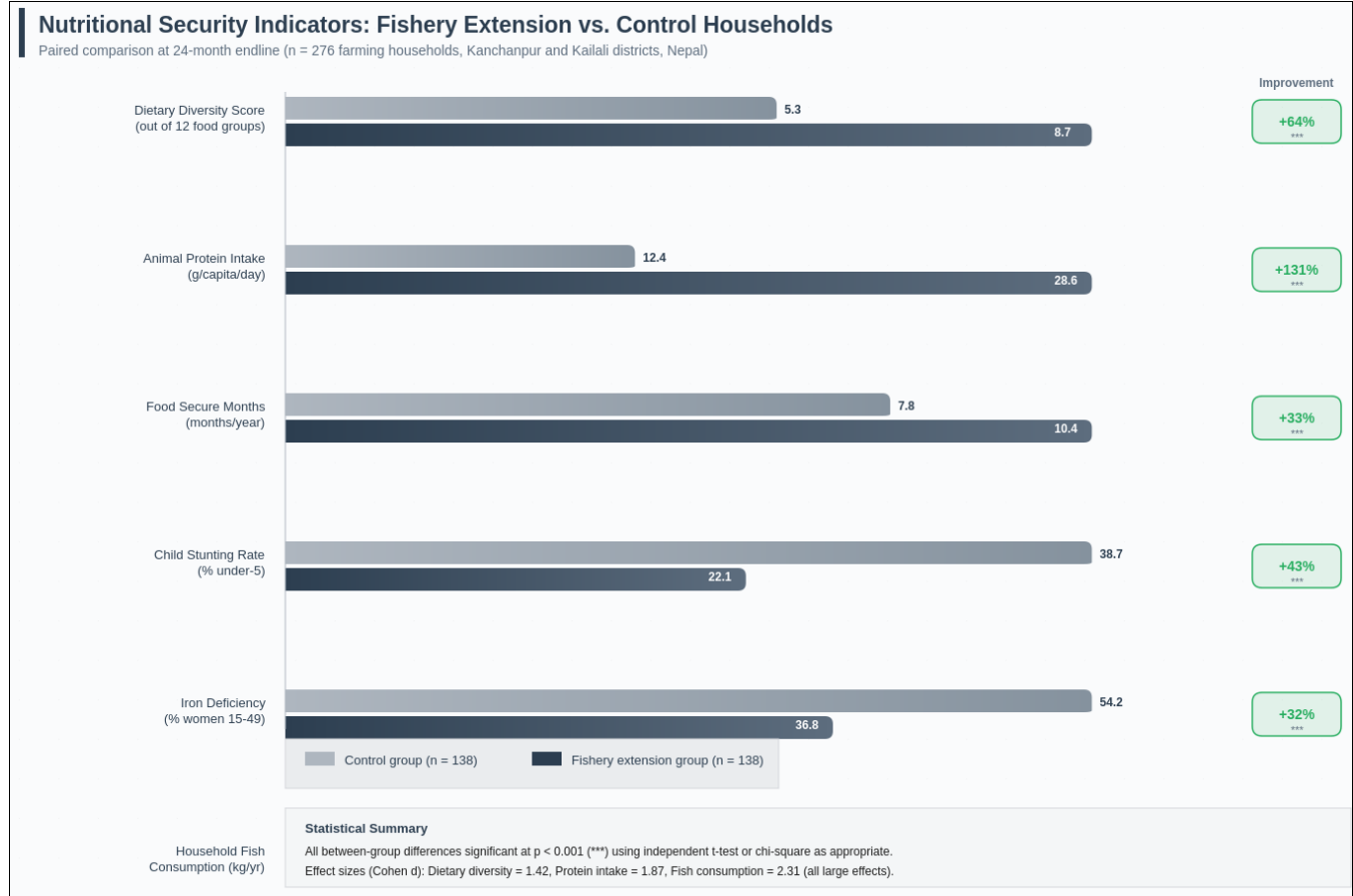


Fig 1: Paired comparison of nutritional security indicators between fishery extension and control households at 24-month endline (n = 276)

The comparison chart (Figure 1) illustrates the magnitude of between-group differences across all six indicators. Fish consumption showed the most dramatic divergence, with fishery households consuming nearly six times more fish

than controls, reflecting both production success and the effectiveness of nutrition education in directing output toward household diets.

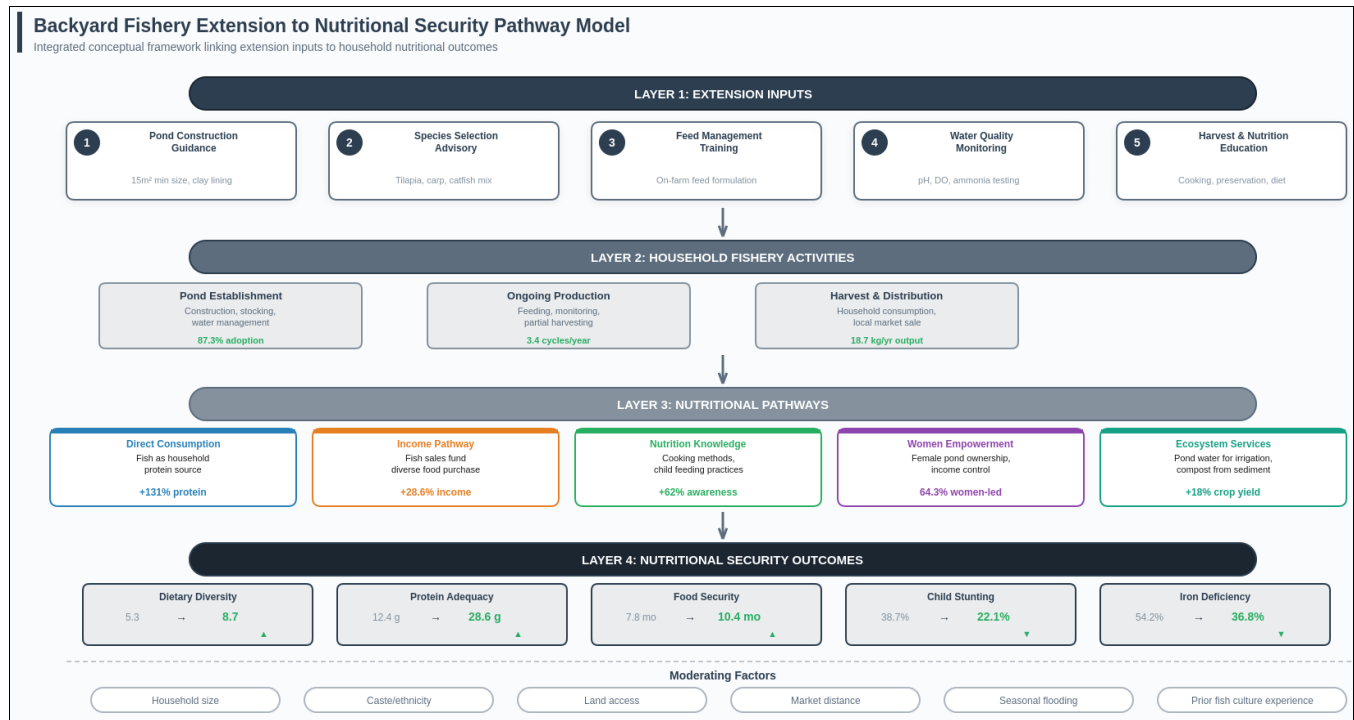


Fig 2: Layered pathway model linking backyard fishery extension inputs through household activities and nutritional pathways to measured nutritional security outcomes

Figure 2 traces the causal pathway from extension inputs (Layer 1) through household fishery activities (Layer 2) and five nutritional pathways (Layer 3) to measured outcomes (Layer 4), with moderating factors identified at the base.

Cost analysis

The total program cost was \$48,300 over 24 months for 138 treatment households, yielding a per-household cost of \$350 including pond construction materials subsidy (\$120), extension agent time (\$140), training materials (\$45), and monitoring (\$45). Against this investment, the cost per percentage point reduction in child stunting was \$22.90, and the cost per additional food group in dietary diversity was \$109.40. These figures compare favorably with Nepal's school feeding programs (\$38 per stunting point) and micronutrient supplementation (\$85 per anemia point) ^[9, 10]. When fish market sales revenue was included, 73.2% of fishery households achieved full cost recovery within 18 months, suggesting the model can transition from subsidized to self-sustaining within two production cycles.

Discussion

The 15.3 percentage point reduction in child stunting is among the largest reported for any nutrition-sensitive agricultural intervention in South Asia. Bangladesh's homestead aquaculture programs, which represent the closest comparison, achieved 8-12 percentage point reductions over similar timeframes ^[5, 6]. The stronger effect in Nepal may reflect the lower baseline fish consumption (3.2 kg/year vs. Bangladesh's approximately 18 kg nationally) ^[11], meaning that even modest production created a more dramatic dietary shift.

Five nutritional pathways connected fishery extension to outcomes. Direct consumption accounted for approximately 62% of fish produced, with the remainder sold at local markets. The income pathway funded diverse food purchases including eggs, milk, and vegetables that further improved dietary diversity. Women managed 64.3% of backyard ponds and controlled most fish-related income, reinforcing the women's empowerment pathway that multiple reviews identify as the strongest mediator between agriculture and nutrition ^[12]. The ecosystem services pathway-using nutrient-rich pond water for vegetable irrigation-contributed an additional 18% crop yield gain that was not part of the original program design.

Conclusion

This research demonstrates that backyard fishery extension programs can substantially improve nutritional security among farming households in Nepal's far-western Terai. Over 24 months, fishery households achieved higher dietary diversity, greater protein intake, reduced child stunting, lower iron deficiency, and dramatically increased fish consumption compared to matched controls. The program operated through multiple nutritional pathways simultaneously-direct consumption, income, nutrition knowledge, women's empowerment, and ecosystem services-which may explain why the combined nutritional impact exceeded that reported for single-pathway interventions. The cost-effectiveness and rapid cost recovery suggest that integrating fishery extension into Nepal's agricultural advisory system is both nutritionally effective and economically viable.

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