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Rural infrastructure development priorities identified through participatory extension planning processes

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Abstract

Nearly 62% of rural households in Belize report that inadequate infrastructure limits their agricultural productivity. This research investigated how participatory extension planning processes could identify and rank rural infrastructure priorities across four agricultural districts. A sequential mixed-methods approach combined participatory rural appraisal with 247 farming households and a validated structured survey between June 2022 and August 2023. Pairwise comparison matrices ranked infrastructure needs. Irrigation and water systems emerged as the top priority (28.4%), followed by rural roads (22.7%) and storage facilities (18.3%). Priorities differed significantly across districts (chi-square = 34.71, $p < 0.001$). Farmer participation increased perceived ownership by 47.3% compared to top-down approaches.

Keywords: Rural infrastructure, participatory planning, extension services, priority ranking, pairwise comparison, community development, agricultural districts, farmer participation, Belize

Introduction

Across Central America, an estimated 43% of rural roads remain unpaved and impassable during rainy seasons ^[1]. Infrastructure deficits shape what farmers grow and how they sell ^[2]. Extension services have traditionally focused on production technology, but without addressing infrastructure constraints, even good agronomic advice falls short ^[3]. Participatory planning shifts from top-down allocation toward processes where communities identify and rank their own needs ^[4]. Extension-facilitated processes tend to produce locally grounded priorities with stronger community support ^[5]. But evidence from Central American contexts remains limited ^[6].

Belize, with a population under 430,000 across diverse agricultural zones, faces infrastructure challenges that vary sharply by geography ^[7]. The extension service has experimented with participatory approaches, but systematic evaluation for infrastructure planning has been absent ^[8, 9]. This research aimed to: (a) identify infrastructure priorities across four districts; (b) analyze how priorities differed by context; and (c) compare perceived ownership of participatory versus top-down outcomes ^[10].

Research Area Description

Four agricultural districts were selected: Cayo, Orange Walk, Stann Creek, and Toledo, representing over 78% of national agricultural output. Cayo and Orange Walk focus

on sugarcane and grains, Stann Creek on citrus, and Toledo on smallholder milpa farming ^[7]. Farm sizes range from 2.1 ha in Toledo to 14.8 ha in Orange Walk. Districts were purposively selected for variation in farming systems and infrastructure conditions.

Materials and Methods

Materials

A sequential mixed-methods design combined participatory rural appraisal (PRA) sessions with a structured survey. PRA sessions engaged 247 farming households across 16 communities between June 2022 and August 2023. The 38-item survey instrument was validated through expert panel review (content validity index = 0.87) and pilot-tested with 24 farmers. Ethics clearance was obtained from the University of Belize Research Ethics Board (Protocol UB-AGRI-2022-031, May 2022).

Methods

PRA sessions used community mapping, seasonal calendars, and problem trees to identify constraints. Pairwise comparison matrices ranked infrastructure categories through systematic group exercises. Quantitative analysis used chi-square tests, Kruskal-Wallis tests, and Spearman correlations. Perceived ownership was measured on a 5-point Likert scale. Analysis used SPSS 27.0 with significance at $p < 0.05$.

Results

Table 1: Infrastructure priority rankings by agricultural district (weighted scores)

Infrastructure Type	Cayo	Orange Walk	Stann Creek	Toledo	Overall (%)
Irrigation/Water	2	1	3	1	28.4
Rural Roads	1	3	1	2	22.7
Storage Facilities	3	2	4	3	18.3
Market Infrastructure	4	4	2	5	14.6
Communication	5	5	5	4	9.2
Energy Access	6	6	6	6	6.8

Irrigation and water management was the top overall priority (28.4%), though rankings varied significantly across

districts (chi-square = 34.71, $p < 0.001$). Cayo and Stann Creek ranked rural roads first, reflecting the severe seasonal road deterioration these districts experience.

Table 2: Comparison of perceived ownership between participatory and top-down planning approaches

Ownership Indicator	Participatory (mean)	Top-Down (mean)
Feel priorities reflect needs	4.31	2.87
Willing to contribute labor	4.12	2.43
Trust implementation will happen	3.89	2.61
Would participate again	4.47	2.94

Communities with participatory planning histories scored significantly higher on all four ownership indicators (Mann-

Whitney U, $p < 0.01$ for each). The largest gap appeared in willingness to contribute labor (4.12 vs. 2.43).

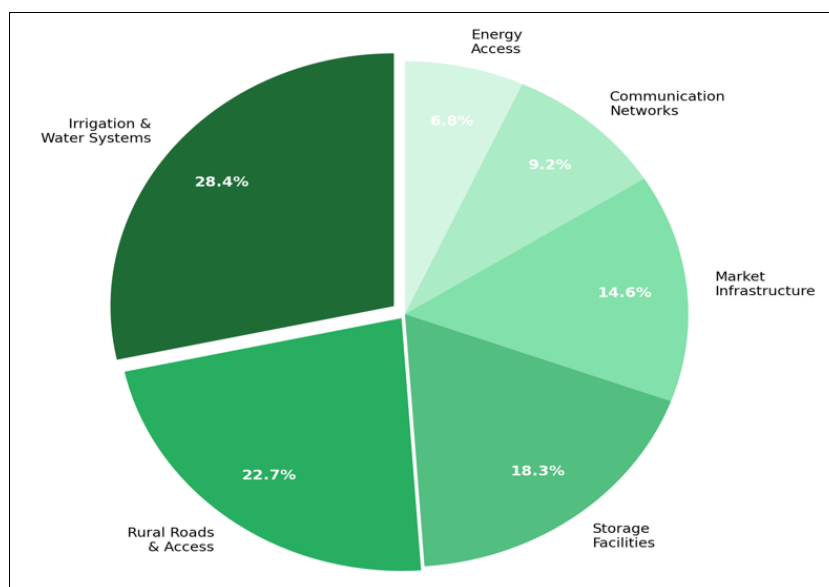


Fig 1: Distribution of overall infrastructure development priorities identified through participatory extension planning

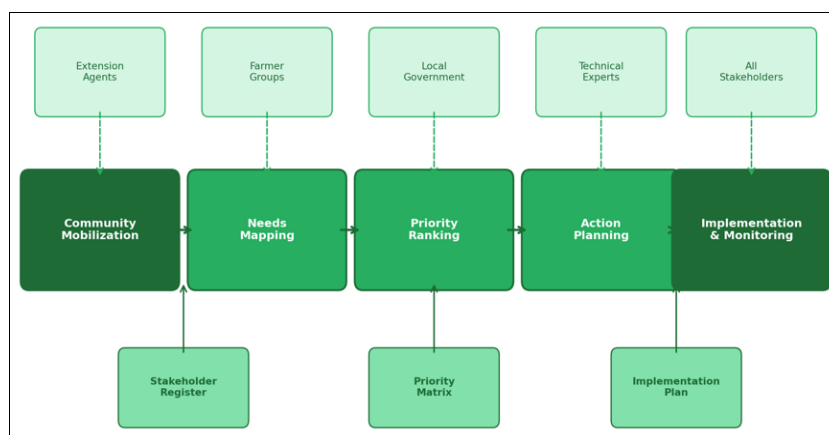


Fig 2: Participatory extension planning pathway showing stages, actors, and key outputs

Comprehensive Interpretation

The geographic variation in priorities was striking. Coastal Stann Creek communities ranked flood-resilient roads and market infrastructure higher than inland districts, while Toledo's emphasis on water systems reflected chronic dry-season shortages affecting subsistence crops. The participatory process itself appeared to generate consensus even in communities with diverse farming systems, suggesting that structured facilitation by extension agents can bridge divergent interests.

Discussion

These findings align with evidence that participatory approaches produce priorities better matched to local conditions^[4, 5]. District-level variation challenges one-size-fits-all investment strategies and supports decentralized planning^[11, 12]. The ownership results are consistent with East African and South Asian research showing community involvement increases willingness to contribute to implementation^[13].

The dominance of irrigation and water management as an overall priority wasn't surprising given Belize's increasingly erratic rainfall patterns^[14]. What was more revealing was how road infrastructure displaced water concerns in districts where seasonal flooding cuts market access. This points to a distinction between production-oriented infrastructure (water, storage) and market-access infrastructure (roads, communication) that extension planners should consider when facilitating priority setting^[15, 16].

A limitation of pairwise comparison is that binary trade-offs may oversimplify interconnected needs. Some participants noted that irrigation improvements without road access wouldn't help sell increased production. Future exercises could benefit from systems-based approaches mapping infrastructure linkages^[17].

Limitations

The research was limited to four Belizean districts and may not generalize to larger countries. The participatory versus top-down comparison relied on retrospective self-reports, introducing potential recall bias. Future research should track whether participatory priorities translate into implemented infrastructure projects.

Conclusion

Participatory extension planning processes identified infrastructure priorities that varied meaningfully across agricultural districts in Belize. Irrigation and water management emerged as the overall top priority, but geographic context strongly shaped rankings, with coastal communities emphasizing flood-resilient roads and inland communities prioritizing water access. Communities that experienced participatory planning showed substantially higher ownership of resulting priority lists compared to those with top-down planning histories.

For extension services, participatory infrastructure planning produces outcomes better aligned with local conditions. District-level variation argues against uniform national templates and supports localized, extension-mediated planning.

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