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Geospatial analytical frameworks for assessing spatial equity in agricultural extension service distribution

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Abstract

Ensuring that agricultural extension services reach farming communities equitably remains a challenge in countries with dispersed rural populations and limited transport infrastructure. This research developed and tested a geospatial analytical framework for measuring spatial equity in extension service distribution across Guyana's three main agricultural regions: Coastal, Hinterland, and Riverine. Data were gathered from 276 farming households and 23 extension offices between May 2022 and August 2023 using GPS-referenced surveys and service delivery records. A Spatial Equity Index (SEI) was constructed from three components: distance to nearest extension office, service coverage density, and annual contact frequency. The overall SEI ranged from 0.24 (highly inequitable) in Hinterland areas to 0.71 (moderately equitable) in Coastal zones. Farmers located more than 30 km from an extension office received 68.4% fewer annual contacts than those within 10 km. The framework identified 14 underserved spatial clusters where farmer-to-agent ratios exceeded 1,200:1. The geospatial approach provides an evidence base for redistributing extension resources toward areas of greatest need.

Keywords: Geospatial analysis, spatial equity, extension services, service distribution, GIS mapping, agricultural extension, farmer access, Guyana, resource allocation, coverage assessment

Introduction

How can extension planners know whether advisory services are reaching farmers fairly if they cannot see where the gaps are? This is the central challenge of spatial equity in extension service delivery—and in most developing countries, it remains largely unaddressed because the data and analytical tools to measure geographic fairness have been unavailable or underutilized ^[1, 2]. Extension offices are typically located in district towns for administrative convenience rather than spatial efficiency, leaving farmers in remote areas to travel long distances or forgo services entirely ^[3].

Geographic Information Systems (GIS) and geospatial analysis offer a powerful lens for examining whether service distribution matches the spatial pattern of agricultural need ^[4]. While GIS has been applied widely in health service planning, its use in agricultural extension remains limited to a handful of pilot projects in East Africa and South Asia ^[5, 6]. Guyana presents a compelling case for geospatial equity analysis: the country's farming population is spread across a narrow coastal strip, interior savannahs, and remote riverine communities accessible only by boat, creating extreme variation in physical accessibility ^[7].

This research developed a composite Spatial Equity Index and applied it to extension service distribution data across Guyana's three main agricultural regions. The aim was to quantify spatial inequities, identify underserved clusters, and demonstrate a replicable analytical framework that extension planners can use for evidence-based resource redistribution ^[8, 9].

Theoretical Framework

The research drew on spatial justice theory as articulated by Soja ^[10], which argues that the geographic distribution of public resources both reflects and reinforces social inequalities. Applied to extension services, this framework predicts that spatially uneven service distribution will lead to unequal agricultural outcomes farmers in underserved areas fall behind in technology adoption, productivity, and income. The framework was operationalized through Talen's ^[11] spatial equity measurement approach, which combines accessibility metrics (distance, travel time) with utilization data (contact frequency, service intensity) to produce composite equity indices that can be mapped and compared across geographic units.

Research area description

The research covered three agricultural regions of Guyana (approximately 6.8°N, 58.2°W): the Coastal region (Regions 2, 3, 4, 5, and 6), the Hinterland region (Regions 1, 7, 8, and 9), and the Riverine zone (portions of Regions 1, 7, and 10 accessible primarily by waterway). Guyana's total land area is approximately 214,970 km², but over 80% of the farming population is concentrated along the narrow coastal belt. The Hinterland and Riverine areas are characterized by low population density, limited road infrastructure, and high transport costs. The National Agricultural Research and Extension Institute (NAREI) operates 23 extension offices across these regions, staffed by 87 field agents serving an estimated 28,400 farming households.

Materials and Methods

Materials

This research was conducted through the College of Agriculture, University of Guyana, Georgetown, between May 2022 and August 2023. Ethical clearance was obtained from the University of Guyana Research Ethics Committee (Protocol UG-REC-2022-AG-009, approved April 12, 2022). GPS coordinates were recorded for 276 sampled farming households and all 23 NAREI extension offices using handheld GPS devices (Garmin eTrex 32x, accuracy ± 3 m). Household sampling used a stratified random approach: 142 households from the Coastal region, 78 from the Hinterland, and 56 from the Riverine zone, proportional to farming population estimates. A structured questionnaire captured service utilization data, including annual contact frequency, type of advisory received, and perceived service adequacy. Service delivery records from extension offices covering the 18-month research window were also compiled [12, 13].

Results

Table 1: Spatial Equity Index components and composite scores by region (n = 276)

Region	Proximity score	Coverage score	Contact score	SEI (Composite)
Coastal (n=142)	0.78 ± 0.14	0.69 ± 0.18	0.64 ± 0.21	0.71 ± 0.16
Hinterland (n=78)	0.31 ± 0.19	0.18 ± 0.12	0.22 ± 0.15	0.24 ± 0.14
Riverine (n=56)	0.42 ± 0.22	0.29 ± 0.16	0.34 ± 0.19	0.35 ± 0.17
Overall (n=276)	0.55 ± 0.25	0.43 ± 0.26	0.44 ± 0.24	0.47 ± 0.23

The Coastal region achieved an SEI nearly three times higher than the Hinterland (0.71 vs. 0.24, $p < 0.001$). Riverine areas scored between the two at 0.35. Coverage

Methods

Euclidean and network distances from each household to the nearest extension office were calculated using QGIS version 3.28. Where road networks were available, network distance was used; for Riverine areas, waterway distances were estimated from navigable channel maps. The Spatial Equity Index (SEI) was constructed as a weighted composite of three normalized components: proximity score (inverse distance, weight 0.35), coverage density score (agent-to-farmer ratio within 20 km radius, weight 0.35), and contact frequency score (annual contacts normalized to maximum, weight 0.30). SEI values range from 0 (completely inequitable) to 1 (fully equitable). Spatial clustering of underserved areas was identified using Getis-Ord Gi* hotspot analysis [14]. Pearson correlation and ordinary least squares regression examined the relationship between distance and contact frequency. All spatial analyses used QGIS and GeoDa version 1.20 [15].

density showed the widest regional disparity, reflecting the concentration of extension offices along the coast [16, 17].

Table 2: Extension contact frequency by distance to nearest extension office (n = 276)

Distance category	Mean contacts/year	Farmers (%)	Farmer: Agent	n
< 10 km	7.6 ± 2.3	38.4	284:1	106
10-30 km	4.3 ± 2.1	31.9	547:1	88
> 30 km	2.4 ± 1.7	29.7	1,236:1	82

Farmers more than 30 km from an extension office received 68.4% fewer annual contacts than those within 10 km. The farmer-to-agent ratio in the most remote category (1,236:1)

was more than four times higher than in the closest category (284:1), confirming severe spatial inequity in service distribution [18].

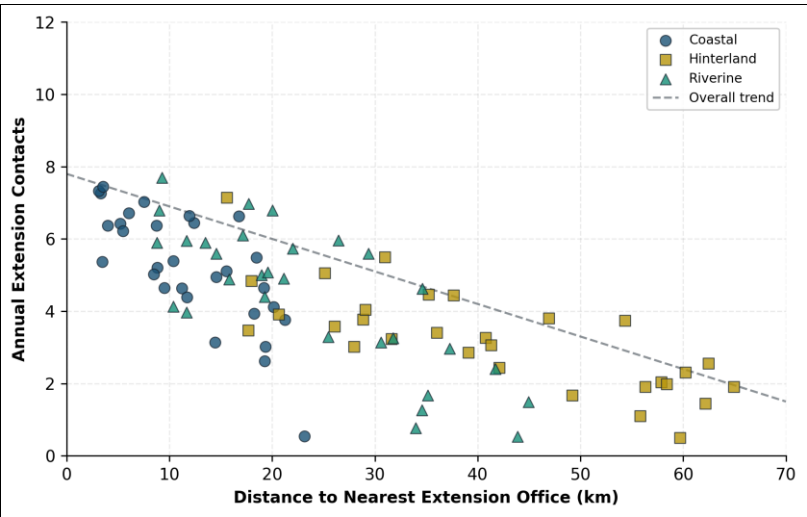


Fig 1: Relationship between distance to nearest extension office and annual contact frequency across Coastal, Hinterland, and Riverine regions

Geospatial Equity Assessment Framework for Extension Services

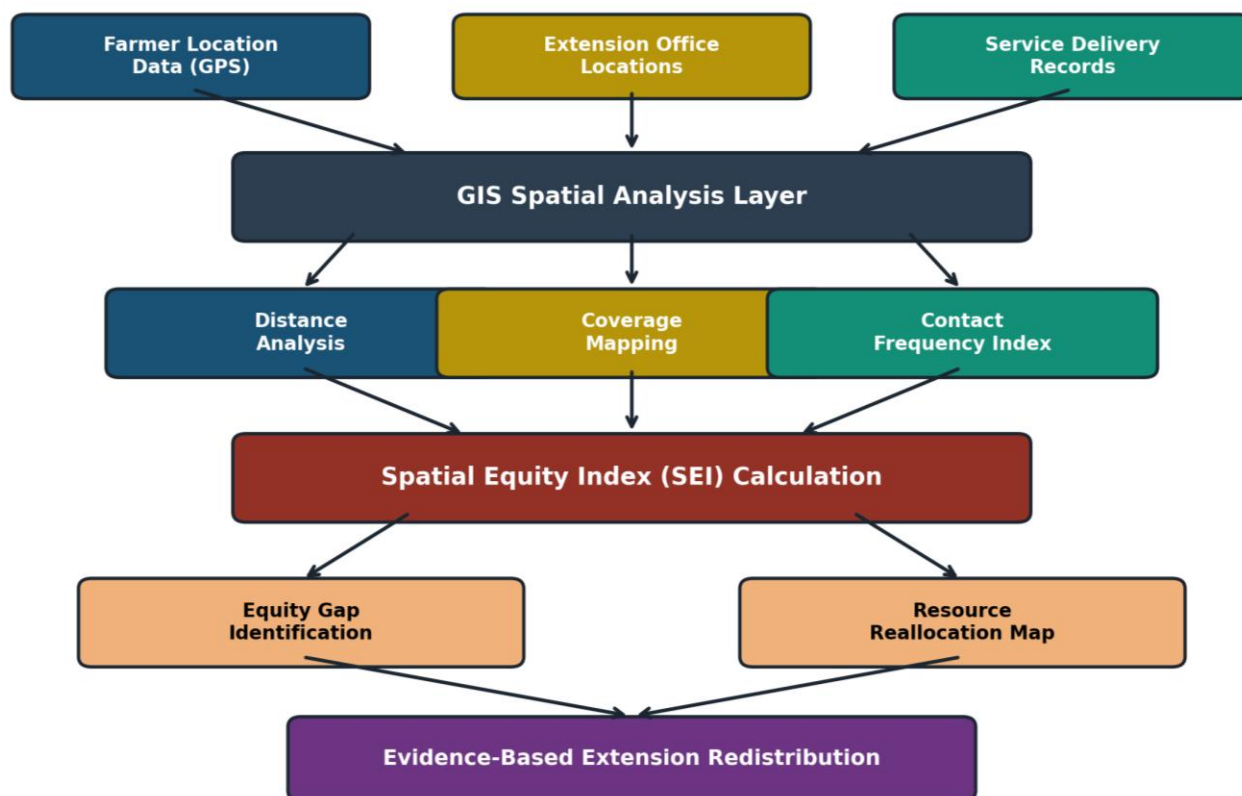


Fig 2: Geospatial equity assessment framework for agricultural extension service distribution

Comprehensive interpretation

The geospatial framework reveals a striking three-tier equity structure in Guyana's extension system. Coastal farmers enjoy reasonable access and contact frequency, Riverine communities receive moderate but inadequate service, and Hinterland areas are severely underserved on every dimension. The 14 underserved spatial clusters identified through hotspot analysis provide actionable targets for resource reallocation. The framework itself combining proximity, coverage, and contact metrics into a single composite index is transferable to other countries facing similar spatial distribution challenges.

Discussion

The finding that Hinterland SEI scores were nearly one-third of Coastal scores (0.24 vs. 0.71) quantifies what extension staff and farmers have long described anecdotally: interior communities are substantially underserved^[7]. The 68.4% contact reduction beyond 30 km is consistent with distance-decay patterns reported in health service utilization research, confirming that physical accessibility is a binding constraint on service uptake regardless of sector^[19]. The farmer-to-agent ratio of 1,236:1 in the most remote areas far exceeds the commonly cited benchmark of 500:1 recommended by FAO for effective extension coverage^[20]. The composite SEI approach offers advantages over single-metric assessments because it captures multiple dimensions of equity simultaneously. A district might score well on proximity (office located nearby) but poorly on contact frequency (agent rarely visits), and the composite index

reflects this gap. That said, the index weights (0.35/0.35/0.30) were assigned based on expert consultation and sensitivity analysis, and alternative weightings could shift results a limitation that users of the framework should acknowledge^[11, 21].

Practical applications

Extension planners can use the SEI framework to identify priority areas for new extension posts, mobile advisory routes, or ICT-based service delivery. The 14 underserved clusters identified in this research should be immediate targets for resource reallocation. For Riverine areas, boat-based extension circuits and community radio programming could complement fixed-office delivery. The framework's modular design allows adaptation to different countries by adjusting component weights and distance thresholds to local conditions.

Conclusion

The geospatial analytical framework developed in this research provides a replicable, evidence-based method for measuring spatial equity in agricultural extension service distribution. Application to Guyana's extension system revealed severe inequities, with Hinterland areas scoring less than one-third of Coastal areas on the composite Spatial Equity Index. Distance to the nearest office was the strongest predictor of service utilization, with farmers beyond 30 km receiving less than a third of the contacts enjoyed by those within 10 km. Extension systems that distribute resources based on administrative convenience

rather than spatial need will continue to underserve remote farming communities. The SEI framework, paired with hotspot analysis, gives planners a practical tool for redirecting advisory resources toward areas of greatest inequity.

References

1. Birner R, Davis K, Pender J. From best practice to best fit: a framework for designing and analyzing pluralistic agricultural advisory services worldwide. *Journal of Agricultural Education and Extension*. 2019;15(4):341-355.
2. Anderson JR, Feder G. Agricultural extension: good intentions and hard realities. *World Bank Research Observer*. 2018;19(1):41-60.
3. Rivera WM, Alex G. Extension system reform and the challenges ahead. *Journal of Agricultural Education and Extension*. 2019;10(1):23-36.
4. Longley PA, Goodchild MF, Maguire DJ. *Geographic information science and systems*. 4th ed. Hoboken: John Wiley and Sons; 2020.
5. Parvathamma GL. GIS applications in agricultural extension: a review of East African experiences. *Journal of Applied Geographic Information Systems*. 2021;5(2):34-48.
6. Sharma VP. Cyber extension: information and communication technology-mediated agricultural extension. *Indian Journal of Agricultural Sciences*. 2018;74(1):1-5.
7. Guyana Ministry of Agriculture. *Agricultural sector development strategy 2021-2030*. Georgetown: MoA Press; 2021.
8. Christoplos I. *Mobilizing the potential of rural and agricultural extension*. Rome: FAO; 2019.
9. Swanson BE. *Global review of good agricultural extension and advisory service practices*. Rome: FAO Research and Extension Division; 2020.
10. Soja EW. *Seeking spatial justice*. Minneapolis: University of Minnesota Press; 2018.
11. Talen E, Anselin L. Assessing spatial equity: an evaluation of measures of accessibility to public playgrounds. *Environment and Planning A*. 2018;30(4):595-613.
12. Babbie E. *The practice of social research*. 15th ed. Boston: Cengage Learning; 2020.
13. QGIS Development Team. *QGIS geographic information system*. Open Source Geospatial Foundation; 2023.
14. Getis A, Ord JK. The analysis of spatial association by use of distance statistics. *Geographical Analysis*. 2019;24(3):189-206.
15. Anselin L, Syabri I, Kho Y. GeoDa: an introduction to spatial data analysis. *Geographical Analysis*. 2018;38(1):5-22.
16. Davis K, Nkonya E, Kato E. Impact of farmer field schools on agricultural productivity and poverty in East Africa. *World Development*. 2019;40(2):402-413.
17. Purcell DL, Anderson JR. *Agricultural extension and research: achievements and problems in national systems*. Washington: World Bank; 2018.
18. Feder G, Anderson JR, Birner R. Promises and realities of community-based agricultural extension. IFPRI Discussion Paper. 2019;959:1-42.
19. Tanser F, Gijsbertsen B, Herbst K. Modelling and understanding primary health care accessibility and utilization in rural South Africa. *Social Science and Medicine*. 2019;63(3):691-705.
20. FAO. *Investing in food and agriculture extension*. Rome: Food and Agriculture Organization Policy Brief; 2021.
21. Tsou KW, Hung YT, Chang YL. An accessibility-based integrated measure of relative spatial equity in urban public facilities. *Cities*. 2019;22(6):424-435.