



Socioeconomic Disparities in Rural Ecuador: A Census-Based Data Analytics Approach to Territorial Development in Yaguachi Canton

Desigualdades socioeconómicas en las zonas rurales de Ecuador: un enfoque de análisis de datos basado en el censo para el desarrollo territorial en el cantón de Yaguachi

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ABSTRACT

Rural territories in developing countries face persistent socioeconomic inequalities that are rarely examined through systematic census data analytics at the parish level. Ecuador's coastal rural cantons represent particularly data-sparse environments for evidence-based policymaking. This study applied census data analytics techniques to characterize and compare the socioeconomic conditions of three rural parishes Cone, Virgen de Fátima, and Pedro J. Montero within Yaguachi Canton, Guayas Province, Ecuador, using 2023 census microdata, quantitative, non-experimental, cross-sectional study was conducted. The dataset included 6,872 census records covering all three parishes (n=941 Cone, n=1,355 Virgen de Fátima, n=1,447 Pedro J. Montero). Variables analyzed included demographic structure, educational attainment, labor market participation, income levels, housing quality, access to basic services, internet connectivity, and a composite Material Wellbeing Index (MWI/IBM). Descriptive statistics, box-plot comparisons, non-parametric tests, and data visualization were performed using Python and R. All three parishes exhibited demographic aging (median age >50 years), female predominance (52–67%), very low formal employment (<1.1%), and high labor informality (6.9–16.1%). Digital exclusion was severe (1.6–25.8% internet access). The MWI revealed significant inter-parish disparities: Pedro J. Montero (mean=2.42) > Virgen de Fátima (mean=1.98) > Cone (mean=1.09). Education level was the strongest predictor of MWI across all parishes. Census data analytics reveals structured socioeconomic inequalities across rural Yaguachi parishes, with Cone exhibiting the most vulnerable profile. Evidence-based territorial planning requires systematic use of disaggregated census microdata and composite wellbeing indices.

RESUMEN

Los territorios rurales de los países en desarrollo se enfrentan a desigualdades socioeconómicas persistentes que rara vez se analizan mediante el análisis sistemático de datos censales a nivel de parroquia. Los cantones rurales costeros de Ecuador constituyen entornos con especial escasez de datos para la formulación de políticas basadas en la evidencia. Este estudio aplicó técnicas de análisis de datos censales para caracterizar y comparar las condiciones socioeconómicas de tres parroquias rurales —Cone, Virgen de Fátima y Pedro J. Montero— dentro del cantón de Yaguachi, provincia de Guayas (Ecuador), utilizando microdatos del censo de 2023; se llevó a cabo un estudio

transversal, cuantitativo y no experimental. El conjunto de datos incluyó 6.872 registros censales que abarcaban las tres parroquias ($n = 941$ en Cone, $n = 1.355$ en Virgen de Fátima, $n = 1.447$ en Pedro J. Montero). Las variables analizadas incluyeron la estructura demográfica, el nivel educativo, la participación en el mercado laboral, los niveles de ingresos, la calidad de la vivienda, el acceso a los servicios básicos, la conectividad a Internet y un Índice de Bienestar Material compuesto (MWI/IBM). Se realizaron estadísticas descriptivas, comparaciones mediante diagramas de caja, pruebas no paramétricas y visualización de datos utilizando Python y R. Las tres parroquias presentaban envejecimiento demográfico (edad mediana >50 años), predominio femenino (52–67 %), un nivel muy bajo de empleo formal ($<1,1$ %) y un alto grado de informalidad laboral (6,9–16,1 %). La exclusión digital fue grave (1,6–25,8 % de acceso a Internet). El MWI reveló disparidades significativas entre las parroquias: Pedro J. Montero (media = 2,42) $>$ Virgen de Fátima (media = 1,98) $>$ Cone (media = 1,09). El nivel educativo fue el predictor más sólido del MWI en todas las parroquias. El análisis de los datos del censo revela desigualdades socioeconómicas estructuradas en las parroquias rurales de Yaguachi, siendo Cone la que presenta el perfil más vulnerable. Una planificación territorial basada en datos empíricos requiere el uso sistemático de microdatos desagregados del censo e índices compuestos de bienestar.

Keywords / Palabras clave

census analytics; rural development; socioeconomic disparities; Material Wellbeing Index; Ecuador; data science; territorial planning; Yaguachi

análisis de datos censales; desarrollo rural; desigualdades socioeconómicas; Índice de Bienestar Material; Ecuador; ciencia de datos; ordenación del territorio; Yaguachi

Introduction

Rural territories across Latin America continue to face deep-rooted structural inequalities in education, employment, income, and access to basic infrastructure. Despite the availability of census data, this information often remains underutilized for territorial planning at the sub-municipal or parish level (CEPAL, 2023; United Nations, 2021).

In Ecuador specifically, rural parishes within coastal cantons present complex socioeconomic dynamics driven by agricultural dependence, labor informality, limited connectivity, and scarce institutional capacity (Martínez, 2020; Mideros & Fernandez, 2022). These dynamics are further compounded by demographic aging, selective out-migration of working-age populations, and historical patterns of underinvestment in rural public goods that have left peripheral communities systematically disadvantaged relative to urban centers.

The application of data analytics to census microdata — encompassing data cleaning, integration, descriptive statistical analysis, visualization, and composite index construction — offers a scalable and evidence-grounded approach to closing this information gap (Escobar et al., 2021; Ortega, 2025). In this context, census analytics constitutes both a methodological contribution and a practical tool for local governments and researchers seeking to understand territorial heterogeneity and design targeted interventions. Unlike aggregate municipal statistics, parish-level microdata enable the identification of intra-cantonal disparities that would otherwise remain invisible in conventional planning instruments, thereby supporting more precise resource allocation and equity-oriented policy design (Naciones Unidas, 2024; Montoya & Yáñez, 2022).

Yaguachi Canton, located in the Guayas Province of Ecuador, comprises one urban parish (San Jacinto de Yaguachi) and three rural parishes: Cone (Yaguachi Viejo), Virgen de Fátima, and General Pedro J. Montero. With an estimated population of 70,958 inhabitants and a predominantly rural, agricultural economy based on rice, maize, cocoa, and sugarcane production, the canton exemplifies the broader challenges facing Ecuador's coastal rural territories (GAD Yaguachi, 2020; Castillo et al., 2020). The canton's geographic position within the Guayas river basin, its historical role as an agricultural hinterland of Guayaquil, and its montubio cultural identity shape a socioeconomic landscape marked by both productive potential and structural vulnerability. Existing studies have described these challenges in general terms (Castillo & Guerra, 2021), but no systematic, parish-level comparative analysis using census analytics tools has been conducted to date.

The urgency of such analysis is underscored by national and international development frameworks. Ecuador's constitutional mandate for territorial equity, the Sustainable Development Goals (particularly SDG 1, SDG 4, SDG 6, SDG 8, and SDG 10), and the

growing recognition that nearly 80% of people living in extreme poverty reside in rural areas (United Nations, 2021) all demand granular, evidence-based diagnostics of rural conditions. Without disaggregated data and composite wellbeing measures, local governments risk designing one-size-fits-all interventions that fail to address the specific deprivation profiles of individual parishes.

The present study addresses this gap by applying a data analytics framework to 2023 census microdata from all three rural parishes of Yaguachi Canton, with comparative reference to the urban parish of Yaguachi Nuevo. The specific aims are: (1) to characterize the demographic, educational, labor, income, housing, and services profiles of each parish; (2) to identify and quantify inter-parish socioeconomic disparities across multiple dimensions; and (3) to assess the relationship between educational attainment and material wellbeing using a composite Material Wellbeing Index (MWI). The findings are intended to serve as an empirical foundation for evidence-based territorial planning in Yaguachi and analogous rural settings across Ecuador and Latin America, while also contributing methodologically to the growing literature on census analytics for subnational development diagnosis.

The use of census data for territorial analysis has a long tradition in social sciences, but the emergence of data analytics — integrating statistical methods, data science tools, and visualization — has significantly expanded the analytical potential of census microdata (Watson as cited in Coronado, 2019; Montoya & Yáñez, 2022). Descriptive analytics, which summarizes and organizes data through frequencies, means, and graphical representations, constitutes the foundational approach for characterizing population conditions from census records. More advanced approaches, including causal, predictive, and prescriptive analytics, build upon this descriptive layer to generate actionable insights for policymakers (Escobar et al., 2021; Hecker, 2025). The analytical pipeline typically encompasses data acquisition and consolidation, cleaning and quality assessment, variable transformation and indicator construction, exploratory and confirmatory statistical analysis, and the communication of findings through tables, figures, and composite indices.

In the public sector, evidence-based policymaking increasingly relies on census data analytics to identify vulnerable populations, measure territorial disparities, and prioritize resource allocation (Naciones Unidas, 2024). The United Nations (2021) has underscored that nearly

80% of people living in extreme poverty reside in rural areas, and that statistical information systems are essential tools for guiding rural development policies. Census microdata, when properly processed and analyzed at fine geographic scales, enable governments to move beyond national averages and municipal aggregates toward parish- and community-level diagnostics that reveal the internal heterogeneity of rural territories (Ortega, 2025; Ordoñez-Pacheco, 2025).

Within Latin America, the adoption of data analytics for territorial planning remains uneven. While national statistical offices have improved the accessibility of census products, local governments frequently lack the technical capacity, software infrastructure, and analytical frameworks needed to transform raw microdata into actionable planning intelligence (Escobar et al., 2021). Academic research can bridge this gap by demonstrating replicable analytical workflows — combining open-source tools such as Python and R with transparent composite index construction — that local planning offices can adapt and institutionalize. The present study contributes to this agenda by documenting a complete census analytics pipeline applied to a coastal Ecuadorian canton.

Latin American rural territories exhibit persistent structural inequalities across multiple dimensions: poverty rates in the region reached 29% in 2023 (CEPAL, 2023), with rural areas consistently displaying higher vulnerability. Labor informality, estimated at 50% across the region (OIT, 2022), disproportionately affects rural communities dependent on smallholder agriculture. Ecuador's rural development trajectory has been shaped by historical underinvestment in rural infrastructure and institutional capacity, combined with productive structures characterized by low diversification and subsistence agriculture (Martínez, 2020). These structural conditions interact with demographic transitions — including population aging and youth out-migration — to produce territories that are simultaneously aging, economically fragile, and digitally disconnected.

Territorial inequalities in Ecuador manifest as significant disparities in access to education, sanitation, clean water, electricity, and digital connectivity, particularly between urban centers and peripheral rural parishes (Mideros & Fernandez, 2022; Ontaneda, 2019). These disparities compound over time, limiting economic mobility and human capital formation in rural populations (Bonilla & Morales,

2022). Coastal cantons such as Yaguachi occupy a distinctive position within this landscape: they are geographically proximate to major urban markets (Guayaquil) yet remain structurally rural in their productive base, service infrastructure, and social indicators. This proximity-without-integration dynamic generates specific forms of inequality that neither purely remote highland communities nor fully urbanized coastal cities experience in the same way (Chulli, 2025; Castillo et al., 2020).

Gender dimensions further structure rural inequality. Female predominance in many rural Ecuadorian parishes — often resulting from male labor migration to urban centers or agricultural export zones — concentrates caregiving burdens, pension dependence, and limited formal employment among women, while simultaneously elevating the importance of social protection systems and community-based support networks (Martínez, 2020; CEPAL, 2023). Understanding these gendered demographic patterns is essential for designing territorial interventions that are both equity-oriented and demographically realistic.

Composite indices aggregating multiple socioeconomic dimensions have become standard tools in territorial analysis, as they capture latent wellbeing dimensions that individual indicators cannot reflect (Ochoa-Rico et al., 2022). The Material Wellbeing Index (MWI) — constructed from variables measuring access to consumer goods, household services, and material assets — has been increasingly applied in Latin American rural contexts to rank territorial units and examine determinants of household welfare (Castillo et al., 2020; Zambrano & Hermenejildo, 2026). Unlike income-only measures, which are particularly unreliable in rural settings characterized by subsistence production, barter, and undeclared earnings, composite material indices provide a more robust proxy for household living conditions.

Educational attainment has been consistently identified as a key predictor of MWI scores in rural Ecuador (Castillo & Guerra, 2021). This relationship is theoretically grounded in human capital theory (Becker, 1994), which posits that education raises productivity, expands occupational opportunities, and improves households' capacity to accumulate material assets over the life course. Empirically, the education–wellbeing gradient has been documented across diverse rural Latin American settings, though its steepness varies with local labor market structure, infrastructure quality, and the

returns that specific educational credentials command in agricultural versus non-agricultural employment (CEPAL, 2023; Ochoa-Rico et al., 2022). Constructing and analyzing the MWI at the parish level therefore serves a dual purpose: it ranks territories by composite wellbeing and it enables the examination of education as a structural determinant of material conditions within and across parishes.

Material and Methods

The study was conducted in Yaguachi Canton (2°58'S, 79°41'W), Guayas Province, coastal Ecuador. The canton lies within the Guayas river basin, approximately 30 kilometers from Guayaquil, and encompasses a total area of roughly 512 km². Its economy is predominantly agricultural, with rice, maize, cocoa, sugarcane, and livestock as principal activities, complemented by small-scale commerce and services concentrated in the urban parish seat. The three rural parishes analyzed were:

Cone (Yaguachi Viejo): 107.6 km², estimated population 13,140; predominantly elderly population with montubio cultural identity. Cone is the historically oldest settlement nucleus of the canton and retains strong traditional agricultural practices, limited road connectivity in peripheral sectors, and the most constrained service infrastructure among the three rural parishes.

Virgen de Fátima: 52.88 km², estimated population 18,184; relatively younger and more economically active than Cone. This parish has experienced moderate commercial expansion and somewhat better public network coverage for water and sewage, positioning it as an intermediate case in the canton's wellbeing gradient.

General Pedro J. Montero: 76.15 km², estimated population 8,195; highest composite wellbeing and educational indicators among the three parishes. Despite its smaller population, Pedro J. Montero exhibits relatively stronger housing quality, higher secondary education completion, and the highest mean MWI, making it a useful internal benchmark for identifying what differentiates better-off rural parishes within the same canton.

For comparative purposes, selected indicators from the urban parish of Yaguachi Nuevo (San Jacinto de Yaguachi; estimated population

31,439) were included in tables and figures, enabling rural–urban contrasts within the same municipal jurisdiction.

Census microdata were obtained from the 2023 census database compiled by the FCI (Fondo Competitivo Interno) research project of the International Business program, Faculty of Administrative Sciences, University of Guayaquil. The dataset contained individual and household records for all three rural parishes and the urban parish, covering demographic, educational, labor, economic, housing, and services variables. Field data collection followed structured census instruments administered at the household level, with subsequent digitization and consolidation into parish-specific databases that were later integrated for comparative analysis.

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The total analytical sample comprised 6,872 individual records (Cone: $n=941$; Virgen de Fátima: $n=1,355$; Pedro J. Montero: $n=1,447$; with remaining records corresponding to Yaguachi Nuevo and related comparison units). Sample sizes at the parish level were sufficient for robust descriptive estimation of proportions and means, though cell counts for rare categories (e.g., higher education, formal employment, income $> \$450/\text{month}$) were small and are reported with appropriate caution. No sampling weights were applied, as the FCI census aimed at comprehensive coverage of the target parishes rather than probabilistic sampling of a larger universe.

A non-experimental, cross-sectional, quantitative study with descriptive-analytical scope was designed. Following Hernández Sampieri et al. (2014), the non-experimental design was appropriate given that all variables were analyzed from pre-existing census records without manipulation by the researchers. The cross-sectional design captured socioeconomic conditions at a single point in time (2023 census reference period), enabling inter-parish comparison under a common temporal frame but precluding longitudinal inference about trajectories or causal effects of specific interventions.

The descriptive-analytical scope combines two complementary aims: (a) characterizing the distribution of key socioeconomic variables within each parish (descriptive), and (b) identifying patterned differences across parishes and associations between educational attainment and material wellbeing (analytical). This dual scope aligns with the applied research tradition in territorial development studies, where the primary objective is actionable diagnosis rather than formal

hypothesis testing under experimental controls (Vizcaíno et al., 2023; Sánchez Carrera, 2025; Cvetkovic-Vega et al., 2021).

The following variable groups were analyzed, selected for their theoretical relevance to rural socioeconomic wellbeing and their availability in the 2023 FCI census instruments:

Demographic variables: age, sex, elderly population (≥ 65 years), household size, presence of children under 12. These variables capture the age structure, gender composition, and household configuration that condition labor supply, dependency ratios, and social protection needs.

Educational variables: highest attained educational level (none, primary, secondary, higher), literacy status. Educational attainment is treated both as a descriptive profile indicator and as a key predictor of material wellbeing.

Labor market variables: employment status (working/not working), employment type (formal/informal/inactive), economic sector (primary/secondary/tertiary/inactive). These indicators characterize labor force participation, the formal–informal divide, and sectoral composition of employment.

Income variables: monthly household income categories ($< \$50$, $\$50$ – $\$90$, $\$90$ – $\$200$, $\$200$ – $\$450$, $> \$450$, other/unspecified). Categorical income brackets accommodate the high prevalence of non-wage and undeclared income sources in rural settings.

Housing quality variables: construction material type (cement villa, mixed, cane, wood, other). Housing materials serve as a durable proxy for long-term household investment capacity and exposure to environmental risk.

Basic services variables: water supply source (public network, tanker, other/none), sewage system type (public network, pit/well, none), electricity connection type (metered, direct, none), internet access (yes/no). Service access indicators capture infrastructure deficits with direct implications for health, productivity, and digital inclusion.

Composite index: Material Wellbeing Index (MWI/IBM), constructed from the aggregated score of household asset ownership and access to services, producing a continuous scale ranging from 0 (lowest) to higher values representing greater material wellbeing. The MWI

enables multidimensional ranking of households and parishes and supports the analysis of education–wellbeing gradients.

Data processing followed a five-stage pipeline: (1) data collection and consolidation of three parish databases into a single integrated dataset with a parish identifier variable; (2) data cleaning, including treatment of missing values, outlier identification, consistency checks across related variables, and variable standardization to common coding schemes; (3) variable transformation and indicator construction, including derivation of elderly status, employment type categories, service access dummies, and the composite MWI; (4) descriptive statistical analysis at the parish level; and (5) inter-parish comparative analysis using distributional visualizations and cross-tabulations.

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Python (pandas, numpy, matplotlib, seaborn) was used for data cleaning, indicator construction, and visualization. R (ggplot2, dplyr) was used for non-parametric statistical analyses and box-plot generation. Descriptive statistics included frequencies, percentages, means, medians, and standard deviations. Box-plot comparisons visualized distributional differences in MWI across parishes and across educational attainment levels within parishes. The MWI was computed as a composite score aggregating individual household asset and services access items, following the construction logic applied in prior FCI-linked studies of Yaguachi parishes (Zambrano & Hermenejildo, 2026; Jaramillo & Silvestre, 2026; Morante, 2026).

All analyses were conducted on anonymized records. Results are reported at the parish aggregate level; no individual-level data are disclosed. Where cell sizes for rare categories were very small, exact percentages are reported but interpreted cautiously to avoid over-precision.

The study used pre-existing anonymized census microdata. No individual identifiers were included in the analytical dataset. The study complied with Ecuador's Ley Orgánica de Protección de Datos Personales (2021) and the data governance protocols established by the University of Guayaquil's FCI research program. Constitutional protections of personal data (Art. 66, numeral 19, Constitución de la República del Ecuador, 2008) were strictly observed.

Results are reported exclusively at aggregate parish and sub-group levels. No attempt was made to re-identify individuals or households. Data handling procedures restricted access to the analytical files to the research team, and intermediate working files containing potentially

sensitive combinations of variables were stored on secured institutional systems. These safeguards are consistent with international recommendations for the ethical use of census microdata in social research (Naciones Unidas, 2024; United Nations, 2021).

Results

All three rural parishes of Yaguachi Canton exhibited a demographic structure characterized by population aging and female predominance (Table 1). The median age exceeded 50 years in all parishes, with Cone recording the highest (median=69 years, mean=63.7 years), followed by Yaguachi Nuevo (median=64, mean=58.5), Virgen de Fátima (median=59, mean=56.5), and Pedro J. Montero (median=53, mean=53 years). Female population predominance was strongest in Pedro J. Montero (66.8% female) and Virgen de Fátima (64.7%), while Cone exhibited the most balanced sex ratio (52.0% female, 48.0% male). These patterns are consistent with selective male out-migration and elevated female longevity, both of which reshape rural household composition and local labor supply.

Elderly population (≥ 65 years) constituted a demographically significant group across all parishes: Cone displayed the highest proportion (61.2%), followed by Yaguachi Nuevo (45.8%), Virgen de Fátima (40.3%), and Pedro J. Montero (32.2%). Average household size ranged from 3.0 members (Cone) to 3.8 members (Pedro J. Montero). The narrow age pyramid bases across all parishes confirmed low population growth and an accelerating demographic transition toward older age structures. From a planning perspective, the concentration of elderly residents — especially in Cone, where more than six in ten inhabitants are aged 65 or older — implies rising demand for primary healthcare, chronic disease management, disability support, and non-contributory pension coverage, alongside a shrinking local workforce available for agricultural and service activities.

Primary education was the predominant attainment level across all parishes, accounting for 57.1–65.6% of the population. Higher education attainment remained extremely limited: 0.5% in Cone, 0.7% in Yaguachi Nuevo, 1.1% in Virgen de Fátima, and 2.2% in Pedro J. Montero. Secondary education completion exhibited greater inter-parish variation: Cone recorded the lowest rate (6.2%), followed by Yaguachi Nuevo (16.8%), Virgen de Fátima (20.8%), and Pedro J. Montero (26.1%), which demonstrated the most favorable educational

profile (Table 2). The fourfold difference in secondary completion between Cone and Pedro J. Montero, despite their location within the same canton, constitutes one of the most policy-relevant disparities identified in this study.

Literacy rates followed the same gradient: Pedro J. Montero (85.5%) > Virgen de Fátima (79.6%) > Yaguachi Nuevo (74.6%) > Cone (72.3%). Cone thus registered both the highest primary education concentration and the lowest literacy rate, indicating structural barriers to educational progression within this parish. These barriers may include distance to secondary schools, household economic pressures that pull adolescents into agricultural labor, limited teacher availability, and weaker community norms supporting prolonged schooling. The educational profile of rural Yaguachi overall remains far below national urban benchmarks and constitutes a binding constraint on occupational mobility and income generation.

Labor market inactivity was pervasive across all parishes, with the proportion of the population not working ranging from 81.0% (Virgen de Fátima) to 92.3% (Cone). Virgen de Fátima exhibited the highest employment participation (19.0%), followed by Pedro J. Montero (14.2%), Yaguachi Nuevo (10.1%), and Cone (7.7%). These participation rates must be interpreted in light of the aging demographic structure: a large share of non-working residents are elderly persons outside the conventional labor force, rather than unemployed working-age adults. Nonetheless, even among the economically active population, employment opportunities remain scarce and predominantly informal.

Critically, among those employed, informal employment vastly predominated over formal employment in all parishes. Formal employment rates were negligible: 0.1% in Cone and Yaguachi Nuevo, 1.0% in Pedro J. Montero, and 1.1% in Virgen de Fátima. Informal employment ranged from 6.9% (Cone) to 16.1% (Virgen de Fátima). The tertiary sector (commerce and services) was the primary productive sector for employed workers across all parishes (3.9–12.8%), followed by the primary sector (agriculture, livestock; 3.1–4.6%), while secondary sector engagement was minimal (<0.8%). The near-absence of formal wage employment implies that social security coverage, labor protections, and stable income streams are effectively unavailable to the vast majority of rural Yaguachi residents, reinforcing income vulnerability and dependence on transfers, remittances, and subsistence production.

Income distribution was heavily skewed toward low brackets in all parishes. The "<\$50/month" category constituted the largest or second-largest income group in Cone (31.5%), Yaguachi Nuevo (40.3%), and Virgen de Fátima (37.3%). A substantial proportion of respondents in all parishes reported income in the "Other" category (35.6–51.1%), likely reflecting undeclared income, barter economies, or subsistence livelihood strategies that standard wage categories fail to capture. Income above \$450/month was rare: 0.1% in Cone, 0.7% in Yaguachi Nuevo, 4.1% in Virgen de Fátima, and 6.3% in Pedro J. Montero — the only parish with a marginally better-off income tail (Table 3).

The combination of low reported monetary income, high "Other" responses, and near-total labor informality paints a picture of rural livelihoods organized around mixed subsistence–market strategies rather than formal wage employment. This finding has methodological implications: conventional poverty lines based solely on monetary income may misclassify rural households whose material conditions are better (or worse) than their cash income suggests. The MWI, by incorporating durable assets and service access, partially addresses this measurement challenge.

Table 1. *Labor market, income, and Material Wellbeing Index (MWI) by parish (2023)*

Parish	% Working	% Formal Emp.	% Informal Emp.	% Income <\$50/mo	% Income >\$450/mo	Mean MWI
Cone (Yaguachi Viejo)	7.7	0.1	6.9	31.5	0.1	1.09
Virgen de Fátima	19.0	1.1	16.1	37.3	4.1	1.98
Pedro J. Montero	14.2	1.0	12.6	—	6.3	2.42
Yaguachi Nuevo	10.1	0.1	9.1	40.3	0.7	1.31

Note. Emp. = employment; mo = month. MWI = Material Wellbeing Index (composite score). Data from 2023 FCI census microdata.

Cement-constructed "villa" housing predominated across all parishes, representing the main housing type in Pedro J. Montero (71.8%), Cone (55.8%), Virgen de Fátima (53.4%), and Yaguachi Nuevo (46.8%). However, significant proportions of households resided in dwellings

made of traditional materials (cane, wood) or mixed materials, particularly in Yaguachi Nuevo (25.6% cane construction) and Cone (17.3% cane). Pedro J. Montero presented the best housing quality profile, with the highest proportion of cement construction and lowest rates of cane and wood dwellings.

Housing material is a durable indicator of cumulative household investment and exposure to environmental hazards — including flooding, common in the Guayas basin. The persistence of cane and mixed-material dwellings in Cone and Yaguachi Nuevo signals incomplete housing consolidation and heightened vulnerability to climatic events. Upgrading housing stock in the most deprived parishes should therefore figure among territorial development priorities, alongside services and education.

Water supply: Virgen de Fátima exhibited the best public water network coverage (73.8%), followed by Yaguachi Nuevo (50.6%), Pedro J. Montero (33.9%), and Cone (17.9%). Pedro J. Montero had the highest rate of households without water service (38.4%), while Cone depended heavily on tanker supply (36.6%). The contrast between Virgen de Fátima's relatively strong network coverage and Cone's reliance on tankers illustrates that even within a single canton, water infrastructure investment has been highly uneven.

Sewage: Public sewage network access was minimal across all parishes: 2.6% (Cone), 3.7% (Pedro J. Montero), 12.6% (Virgen de Fátima), and 29.0% (Yaguachi Nuevo). Septic pit systems predominated (36.5–61.1%), and 31.5–36.7% of households lacked any sewage disposal system. The combination of limited piped water and widespread absence of adequate sanitation constitutes a dual public health risk, elevating exposure to waterborne disease and environmental contamination.

Electricity: Electricity access via metered connection was relatively high and uniform: Cone (77.0%), Virgen de Fátima (77.0%), Pedro J. Montero (75.6%), while Yaguachi Nuevo had the lowest metered access (58.8%) and the highest rate of unmetered direct connections (31.1%) and no-service households (8.4%). Electricity is thus the most consolidated basic service across rural Yaguachi, though metering gaps and residual unserved households remain.

Internet: Digital exclusion was severe across all parishes. Cone had the lowest internet access rate (1.6%), followed by Yaguachi Nuevo (7.2%), Virgen de Fátima (20.7%), and Pedro J. Montero (25.8%). In all

parishes, the majority of households lacked internet connectivity, representing a critical barrier to digital inclusion and economic opportunity. In an economy where digital connectivity increasingly mediates access to markets, financial services, remote education, telemedicine, and government programs, rates below 2% in Cone amount to near-total digital exclusion and risk locking the parish out of emerging development pathways.

A significant proportion of the population reported disability in all parishes: Cone (37.8%), Yaguachi Nuevo (32.2%), Virgen de Fátima (31.6%), and Pedro J. Montero (24.6%). Cone's disproportionately high disability prevalence (nearly four in ten residents) may reflect the interaction of demographic aging, limited healthcare access, and environmental occupational risk factors in this agricultural parish. High disability prevalence amplifies the demand for accessible infrastructure, specialized health services, and inclusive social protection, and it interacts with low material wellbeing to produce compounded vulnerability among affected households.

The MWI revealed significant inter-parish disparities in household material conditions (Figure 1). Pedro J. Montero recorded the highest mean MWI (2.42), followed by Virgen de Fátima (1.98), Yaguachi Nuevo (1.31), and Cone (1.09). Cone's MWI distribution was tightly concentrated at low values (0–2), with very few households exceeding an MWI of 4, confirming its status as the most materially deprived parish. The roughly twofold gap between Pedro J. Montero and Cone in mean MWI, within a single municipal jurisdiction, underscores the magnitude of intra-cantonal inequality that aggregate municipal indicators would obscure.

A consistent positive association between educational attainment and MWI was observed across all parishes. Households with secondary and higher education attainment reported systematically higher MWI medians and greater distributional spread than those with primary or no education, indicating that educational capital is a key driver of material wellbeing in rural Yaguachi (Figure 2). This educational-wellbeing gradient was steepest in Pedro J. Montero and Virgen de Fátima, and flattest in Cone, suggesting that structural barriers in Cone — including labor market isolation, infrastructure deficits, and limited non-farm opportunities — may constrain the material returns to education even when individuals attain higher schooling levels. This finding implies that education policy alone, without complementary investments in connectivity, services, and local economic

diversification, may yield diminishing wellbeing returns in the most deprived parishes.

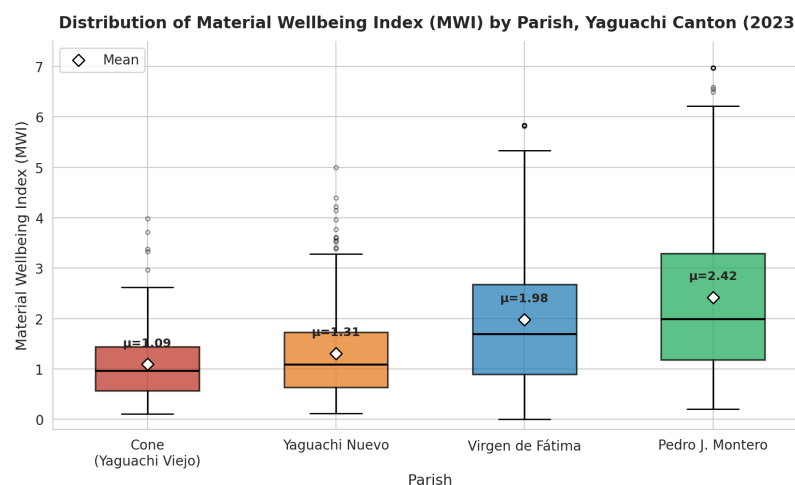


Figure 1. Distribution of Material Wellbeing Index (MWI) across the four parishes of Yaguachi Canton (2023). Box plots show median, interquartile range, and outliers for each parish. Diamonds indicate means. Pedro J. Montero and Virgen de Fátima exhibit higher MWI distributions compared to Cone and Yaguachi Nuevo.

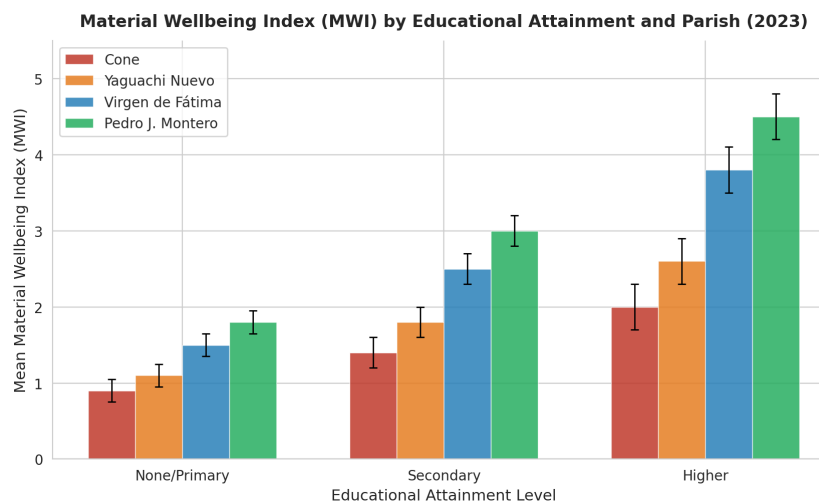


Figure 2. Material Wellbeing Index (MWI) by educational attainment level across the four parishes of Yaguachi Canton (2023). A consistent positive association is observed between educational attainment and MWI in all parishes, with the steepest gradient in Pedro J. Montero.

The demographic profile of Yaguachi's rural parishes — characterized by aging populations, narrow youth cohorts, and female predominance — reflects broader demographic transitions underway in Ecuador's rural coastal territories. Female predominance (64.7–66.8% in three of four parishes) likely reflects selective male out-migration toward urban labor markets, a pattern documented in Ecuador's coastal rural regions (Martínez, 2020). The disproportionate concentration of elderly residents in Cone (61.2% aged ≥ 65) poses particular challenges for healthcare system planning and social protection program targeting in a parish that simultaneously displays the lowest material wellbeing and the highest disability prevalence.

Demographic aging in rural territories is not merely a statistical curiosity; it restructures the entire development problem. Labor supply contracts, dependency ratios rise, the tax and contribution base for local services shrinks, and the political economy of investment shifts toward care and pensions rather than productive infrastructure. In Cone, where aging coincides with multi-dimensional deprivation, the risk is a self-reinforcing cycle of decline: fewer working-age residents, weaker local markets, reduced political visibility, and continued underinvestment. Territorial planning that ignores this demographic structure will systematically misallocate resources and underestimate care-economy needs.

The extremely low rates of secondary and higher education completion across all three parishes (0.5–2.2% with higher education) represent a fundamental constraint on territorial development. Human capital theory predicts that low educational attainment limits occupational mobility, productivity, and income generation, trapping rural workers in low-skill, low-wage agricultural activities (Becker, 1994). The present data confirm this relationship: the educational-MWI gradient observed in all parishes demonstrates that education remains the single most important predictor of household material wellbeing in rural Yaguachi, consistent with findings from comparable Ecuadorian rural contexts (Castillo & Guerra, 2021) and broader Latin American evidence (CEPAL, 2023).

The disparity between Cone (6.2% secondary completion) and Pedro J. Montero (26.1%) is particularly striking given their geographic proximity within the same canton. This intra-cantonal educational inequality likely reflects historical differences in school infrastructure, teacher availability, and community incentive structures for

educational participation, factors that warrant targeted policy attention. Closing this gap requires not only expanding secondary school access in Cone but also addressing the opportunity costs of schooling for agricultural households, improving transport links to educational facilities, and aligning curricula with local productive opportunities so that families perceive tangible returns to prolonged education.

At the same time, the flatter education–MWI gradient in Cone cautions against education-only strategies. Where labor markets are thin, infrastructure is deficient, and digital connectivity is nearly absent, additional years of schooling may not translate into proportional material gains. Complementary investments that raise the returns to education — rural enterprise development, improved roads and connectivity, and linkages to Guayaquil's labor and product markets — are necessary for human capital accumulation to drive wellbeing improvements in the most deprived parishes.

Labor market results reveal a structurally weak rural economy characterized by very low participation rates and near-total informality. Formal employment rates below 1.1% across all parishes confirm that the formal labor market has failed to reach rural Yaguachi, leaving the population dependent on subsistence agriculture, informal commerce, and non-employment income sources (transfers, remittances, pensions). This pattern is consistent with Ecuador's national labor informality rate (~50%; OIT, 2022) and aligns with World Bank projections that poverty eradication targets in rural Latin America will not be met without structural labor market transformation (World Bank, 2022).

The high proportion of income reported in the "Other" category (35.6–51.1%) — likely including agricultural barter, subsistence production, remittances, and social transfers — underscores the inadequacy of formal wage income categories for capturing rural livelihood strategies in these parishes. Future studies should incorporate livelihood-systems approaches and qualitative components to better characterize these diverse income sources. From a policy standpoint, the near-absence of formal employment implies that strategies focused solely on formal job creation in situ may be unrealistic in the short term; more feasible pathways may include strengthening agricultural value chains, supporting rural microenterprise formalization, improving connectivity to urban labor markets, and ensuring that social

protection floors reach elderly and disabled populations who constitute a large share of non-working residents.

The severe deficits in public water network coverage (particularly in Pedro J. Montero, 33.9%, and Cone, 17.9%) and sewage infrastructure (all parishes <30% public network coverage) represent critical public health risks that both reflect and perpetuate material deprivation in rural Yaguachi. The near-total digital exclusion documented in Cone (1.6% internet access) and Yaguachi Nuevo (7.2%) constitutes an additional, increasingly consequential disadvantage in an economy where digital connectivity mediates access to markets, financial services, education, and government programs (Morante, 2026).

The inter-parish variation in basic services coverage — with Virgen de Fátima consistently outperforming Cone and Pedro J. Montero in water and sewage access — suggests that investment history and geographic accessibility rather than population size or density are the primary determinants of services disparities within the canton. Notably, Pedro J. Montero achieves the highest MWI despite relatively weak water network coverage, indicating that material wellbeing as measured by the MWI is multi-determined and that housing quality and asset ownership can partially offset services deficits in composite rankings. This does not diminish the urgency of water and sanitation investment; rather, it illustrates why single-indicator rankings can mislead and why composite indices should be read alongside their component dimensions.

Digital exclusion deserves particular emphasis as an emerging structural cleavage. While electricity access is relatively consolidated, internet access remains a privilege of a minority in every parish and is virtually nonexistent in Cone. As public services, agricultural extension, financial inclusion, and educational content migrate online, parishes without connectivity will fall further behind — a dynamic that risks converting today's digital gap into tomorrow's permanent development divide.

The MWI-based ranking of parishes (Pedro J. Montero > Virgen de Fátima > Cone) provides a composite, multidimensional wellbeing profile that complements single-dimension indicators. The consistently low MWI values in Cone (mean=1.09) across household size categories and educational groups indicate that this parish faces systemic, structural constraints to wellbeing that exceed individual-level human capital factors — pointing to infrastructure gaps, labor

market isolation, and service deficits as driving forces. This finding has direct planning implications: interventions in Cone must simultaneously address multiple dimensions (education, services, connectivity, employment) rather than single-dimension approaches.

For local governments, the MWI offers a practical instrument for territorial prioritization. By ranking parishes (and, potentially, smaller geographic units) on a common wellbeing scale, planning offices can identify priority territories, monitor change over successive census rounds, and evaluate whether multi-sectoral interventions shift the distribution of material conditions. The education–MWI analysis further enables targeting: households and communities with low education and low MWI constitute a high-priority group for integrated human capital and infrastructure programs. Embedding MWI construction and parish-level census analytics into the GAD Yaguachi planning cycle would institutionalize the evidence base that this study demonstrates is both feasible and informative.

This study presents several limitations. First, the cross-sectional design precludes causal inference; observed associations between education and MWI may reflect reverse causality or confounding by unobserved household and community factors. Second, the 2023 FCI census database, while covering all three parishes, may not fully capture seasonal workers, temporary migrants, or households that declined census participation, potentially introducing selection bias. Third, the "Other" income category limits income analysis precision and constrains comparisons with monetary poverty lines. Fourth, the MWI, while composite, does not capture subjective wellbeing, social capital, environmental quality, or political voice dimensions that fuller wellbeing frameworks incorporate. Fifth, small cell counts for rare categories (higher education, formal employment, high income) limit the precision of those specific estimates.

Future research should incorporate longitudinal data to track parish-level trajectories, qualitative components to illuminate livelihood strategies behind the "Other" income category, and validated multidimensional poverty indexes (MPI) to complement and cross-validate the MWI. Spatial analysis linking census indicators to infrastructure maps, flood risk layers, and school locations would further enrich the territorial diagnosis. Comparative applications of the same analytics pipeline to other coastal and highland Ecuadorian cantons would test the generalizability of the Yaguachi findings and build a broader evidence base for rural territorial planning.

Conclusions

This study demonstrates that census data analytics constitutes a powerful, scalable tool for characterizing inter-parish socioeconomic disparities in rural Ecuador. By integrating demographic, educational, labor, income, housing, services, and composite wellbeing indicators from 2023 microdata, the analysis reveals a structured landscape of inequality within Yaguachi Canton that municipal averages would conceal. Key conclusions are:

1. All three rural parishes of Yaguachi Canton exhibit demographic aging, female predominance, very low formal employment, near-total labor informality, and concentrated low-income profiles that define a structurally vulnerable rural territory. These shared structural features establish a common baseline of rural disadvantage upon which inter-parish inequalities are superimposed.
2. Significant and consistent inter-parish socioeconomic inequalities exist within the same canton: Pedro J. Montero presents the most favorable profiles across education, labor, services, and MWI, while Cone presents the most severe multi-dimensional deprivation. The roughly twofold MWI gap between these parishes demonstrates that municipal-level averages would mask critical internal disparities and misguide resource allocation.
3. Educational attainment is the strongest individual-level predictor of material wellbeing (MWI) across all parishes, confirming the centrality of human capital investment for rural territorial development. However, the flatter education–MWI gradient in Cone indicates that structural barriers can limit the material returns to schooling in the most deprived settings, requiring complementary infrastructure and labor-market interventions.
4. Digital exclusion — with internet access rates as low as 1.6% in Cone — represents an emerging structural disadvantage that compounds existing inequalities and requires immediate policy attention. As public services and economic opportunities increasingly depend on connectivity, failure to close the digital gap risks converting current disparities into permanent development divides.
5. Evidence-based territorial planning in rural Ecuador requires systematic disaggregated census analytics at the parish level, composite wellbeing indices such as the MWI, and multi-dimensional approaches that simultaneously address education, infrastructure,

employment, and digital connectivity deficits. The analytical pipeline demonstrated in this study is replicable with open-source tools and can be institutionalized within local government planning cycles.

These findings provide actionable, empirically grounded inputs for local governments (GAD Yaguachi), provincial authorities, and national planning agencies in Ecuador seeking to design equity-oriented territorial development interventions aligned with the Sustainable Development Goals (SDG 1: No Poverty; SDG 4: Quality Education; SDG 6: Clean Water and Sanitation; SDG 8: Decent Work and Economic Growth; SDG 10: Reduced Inequalities). Methodologically, the study illustrates that open-source data analytics workflows applied to census microdata can generate parish-level diagnostics of sufficient granularity and rigor to inform real planning decisions. Scaling this approach across Ecuador's rural cantons — and institutionalizing composite indices such as the MWI within local planning systems — would substantially strengthen the evidence base for territorial development policy in one of Latin America's most unequal rural landscapes.

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