Ancient Mesoamerica (2023), **34**, e6, 1–9
doi:10.1017/S0956536123000081

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Compact Section: Ancient Maya Inequality

Quantitative analyses of wealth inequality at Classic period El Pilar: The Gini index and labor investment

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Abstract

Survey teams at the El Pilar Archaeological Reserve for Maya Flora and Fauna have mapped 70 percent of its 20 km^2 area and revealed the extent of settlement around the city center. Large-scale civic architecture, and the distribution of smaller ceremonial groups and minor centers, reflect the wealth and power of Maya rulers presiding over the largest Classic period city in the upper Belize River area. Previous analyses suggest disparities in wealth at El Pilar were more nuanced than the elite/commoner dichotomy commonly invoked for Classic Maya society. This article works to understand wealth inequality at ancient El Pilar by computing Gini coefficients from areal and volumetric calculations of primary residential units—the class of settlement remains most likely to represent ancient households. Presentation of Gini coefficients and their potential interpretations follows a discussion of settlement classification and residential group labor investment. We conclude by contextualizing these results within prior settlement pattern analyses to explore how disparities in wealth may have been distributed across the physical and social landscape.

Resumen

Los equipos de investigación en la Reserva Arqueológica El Pilar para la Flora y Fauna Maya han mapeado el 70 por ciento de su área de 20 km^2 y revelaron la extensión del asentamiento alrededor del centro de la ciudad. La arquitectura cívica a gran escala, y la distribución de grupos ceremoniales más pequeños y centros menores, reflejan la riqueza y el poder de los gobernantes mayas que presiden la ciudad más grande del período clásico en el área superior del río Belice. Análisis previos sugieren que las disparidades en la riqueza en El Pilar fueron más matizadas que la dicotomía élite/plebeyo comúnmente invocada para la sociedad maya clásica. Este artículo trata de comprender la desigualdad de riqueza en el antiguo El Pilar mediante el cálculo de los coeficientes de Gini a partir de cálculos de área y volumétricos de unidades residenciales primarias: la clase de asentamiento sigue siendo más probable que represente hogares antiguos. La presentación de los coeficientes de Gini y sus posibles interpretaciones sigue una discusión sobre la clasificación de asentamientos y la inversión laboral del grupo residencial. Concluimos contextualizando estos resultados dentro de los análisis de patrones de asentamiento anteriores para explorar cómo las disparidades en la riqueza pueden haberse distribuido en el panorama físico y social.

Introduction

The Classic Maya city El Pilar occupied an ecotonal location, where the karstic ridgelands of the greater Peten grade south to the alluvial bottomlands of the Belize River Valley and east to the coastal plain (Figure 1). The landforms characterizing each microenvironment provided different resources for agrarian communities, and control over this diverse resource base was likely a factor in the rise of El Pilar to dominance in the area. Even as agricultural produce and other goods flowed upwards to elites as tribute and taxes, farming households took advantage of the heterogeneous landscape and used favorable environmental conditions—especially fertile soil—to increase their wealth, as revealed by variable artifact assemblages from residences in different environmental zones surrounding the city (Horn III and Ford 2017; Lucero 2001).

The wealth commanded by rulers of El Pilar is palpable to contemporary visitors. More than 150 ha of monumental architecture, comprising royal palaces, temples, plazas, and administrative structures, extend over a 2 km stretch of

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Cite this article: Horn, Sherman III, Justin Tran, and Anabel Ford (2023) Quantitative analyses of wealth inequality at Classic period El Pilar: The Gini index and labor investment. *Ancient Mesoamerica* **34**, e6, 1–9. https://doi.org/10.1017/S0956536123000081

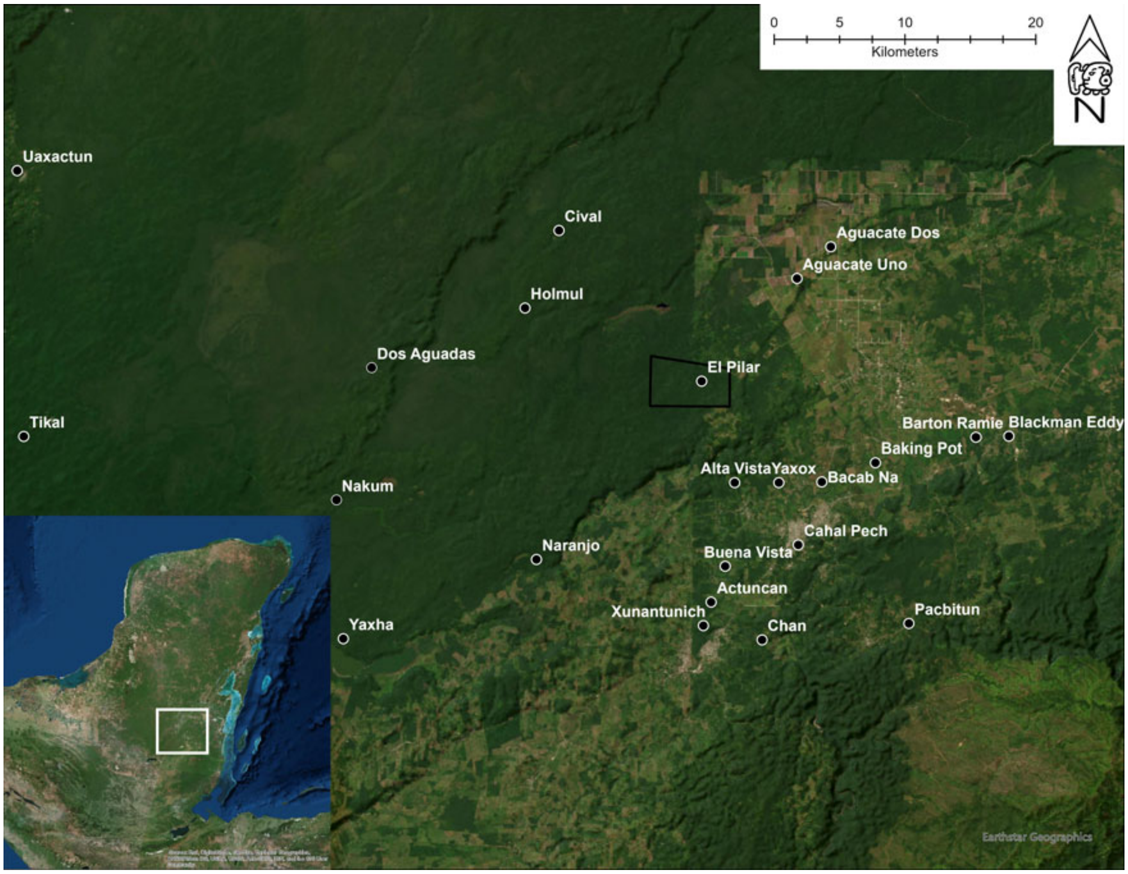

Figure 1. Map of upper Belize River area and eastern Peten, showing position of El Pilar and nearby Maya centers. Satellite imagery provided by Esri and Earthstar Geographics.

land in eastern Belize and western Guatemala. This downtown core is surrounded by dense residential settlement interspersed by smaller groups of civic architecture, with the minor centers Chorro and Kum squarely within the administrative orbit of the ruling elite (Figure 2; Ford and Horn III 2017, 2018; Horn III et al. 2020). The developmental trajectory of the El Pilar city center spans nearly 2,000 years, beginning in early Middle Preclassic times (ca. 1000 B.C.) as a small community center and rapidly expanding through the Late Preclassic (300 B.C.–A.D. 300) to become dominant in the upper Belize River area before falling into disrepair around A.D. 1000 (Horn III et al. 2023; Wernecke 2005).

Previous research at El Pilar suggests that substantial wealth inequality characterized city life. Apart from clear differences between elite and farmer households, initial surveys revealed variability in the size and number of structures that comprised non-elite residential groups. Calculations of residential labor investment show significant disparities in the manpower that different households could marshal for construction (Arnold and Ford 1980; Erasmus 1965; Folan et al. 2009).

Techniques for estimating area and volume, and the calculation of Gini indices for household groups based on these measurements, provide new ways to quantify inequality among non-royal households. Gini coefficients produce a global measure of inequality for a population by comparing each unit of analysis to every other comparable element (see Chase et al. 2023). The index ranges from zero to one, with zero representing perfect equality and one reflecting perfect inequality. Maya cities likely fall somewhere in between these extremes, with higher Gini values indicating more pronounced inequality among their inhabitants. We apply these methods to settlement pattern data from El Pilar to examine potential disparities in material wealth during the Classic period (Table 1).

Previous and current research at El Pilar

Regional survey by Anabel Ford and the Belize River Archaeological Settlement Survey (BRASS) led to the documentation of El Pilar in 1983–1984. Three BRASS survey transects, originating along the upper Belize River and traversing up to 10 km inland, recorded variable settlement distributions across different physiographic zones (Fedick and Ford 1990; Ford and Fedick 1992). Surveyors noted variability in the size and composition of residential groups across the landscape, which suggested that farming households differed in their abilities to secure extra-household labor when constructing their homes. These early data hinted at the pervasiveness of inequality in what we now recognize as the El Pilar polity.

Excavations at El Pilar in the late 1990s defined building corners and accessways, developed a chronology for major

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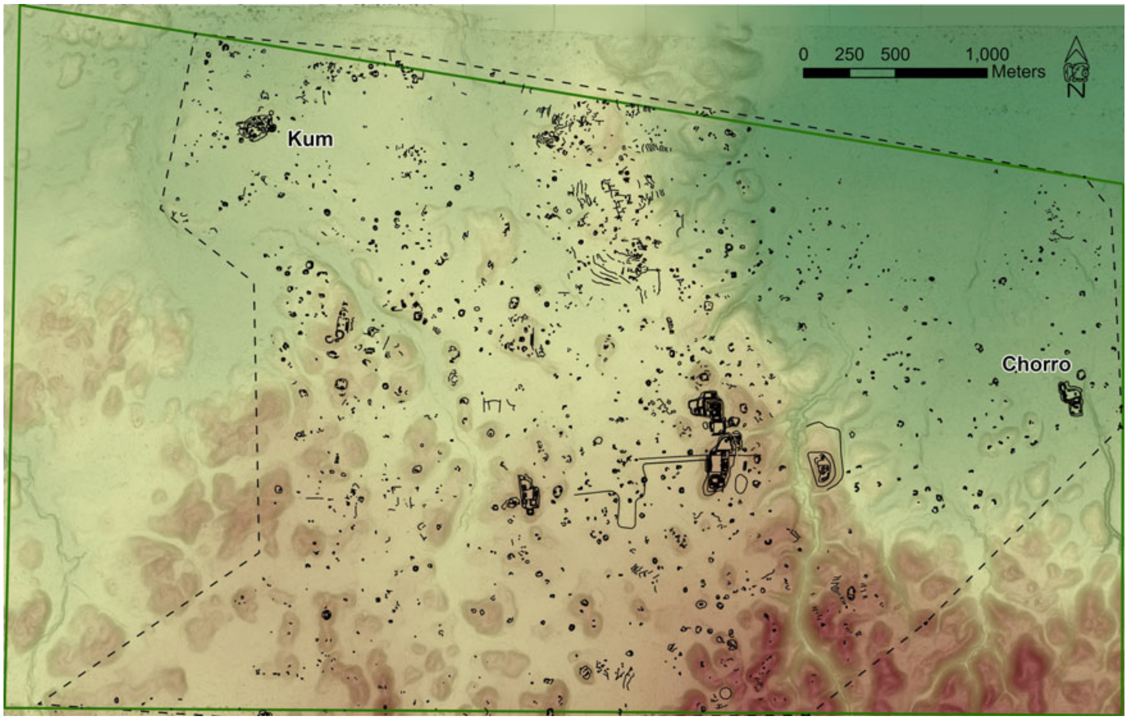

Figure 2. Map of El Pilar showing 2019 survey boundaries and recorded cultural features.

construction events, and consolidated a large residential compound near the monumental core. Household excavations in the center continued into the early 2000s, targeting smaller residences for comparative study (see summary in Ford and Horn III 2018). Data from these excavations suggested that at least two levels of wealth inequality were present at El Pilar: the well-known differences between ruling elites and their subjects, and lesser-defined disparities among city residents.

Current research consists of a full-coverage pedestrian survey of the 20 km^2 El Pilar Archaeological Reserve for Maya Flora and Fauna, which extends around the monumental core into Belize and Guatemala. Visualizations derived from aerial lidar scanning of the reserve in 2012 made detailed survey feasible (Ford 2014; Pingel et al. 2015), and project members use these topographic renderings, alongside traditional mapping methods, to record Maya settlement and landscape-modification features. At the time of this analysis, the project had surveyed 14 km^2 and recorded 2,506 features related to ancient Maya settlement at El Pilar. Exploration revealed three previously unknown civic architectural complexes, including two E-groups, an apparently fortified hilltop complex, and a concentrated zone of terraces and berms potentially related to intensified agricultural production. Surveyors also recorded numerous quarries, *chultunes* (underground storage pits), and small-scale depressions that were not visible in LiDAR imagery (Horn III and Ford 2019). Ancient Maya settlement remains, defined as mounds not part of ritual or civic architectural assemblages, comprised 38 percent ($n = 959$) of all mapped features. The subset of these mounds discussed below provided the inputs for Gini calculations.

Table 1. Settlement dataset for El Pilar Gini analysis.

Survey area	Residential structures	Residential groups	Occupation period
15.5 km^2	1444	613	Late Classic

Objects of analysis: Primary residential units and labor investment

Measures of household inequality must be based on comparable analytical units. As the articles in this Compact Special Section use architectural area and volume as proxies for household wealth, the architectural features included in the analyses should represent the principal living spaces of households. There is little consensus among archaeologists about what constellation of settlement remains actually represents a Maya household, however, which can complicate comparisons across projects. We therefore explain the analytical units used in our calculations and the reasoning behind our choices, as they may vary from other articles in this Compact Special Section.

We define three functional categories within the settlement remains at El Pilar (Figure 3): primary residential units (PRU), secondary residential units (SRU), and solitary range structures (SRS). Accurately gauging household wealth distribution requires selecting units that provide an “apples to apples” comparison—those we can confidently assign to a single residential group or family—and omitting others with different functions or that cannot be assigned to

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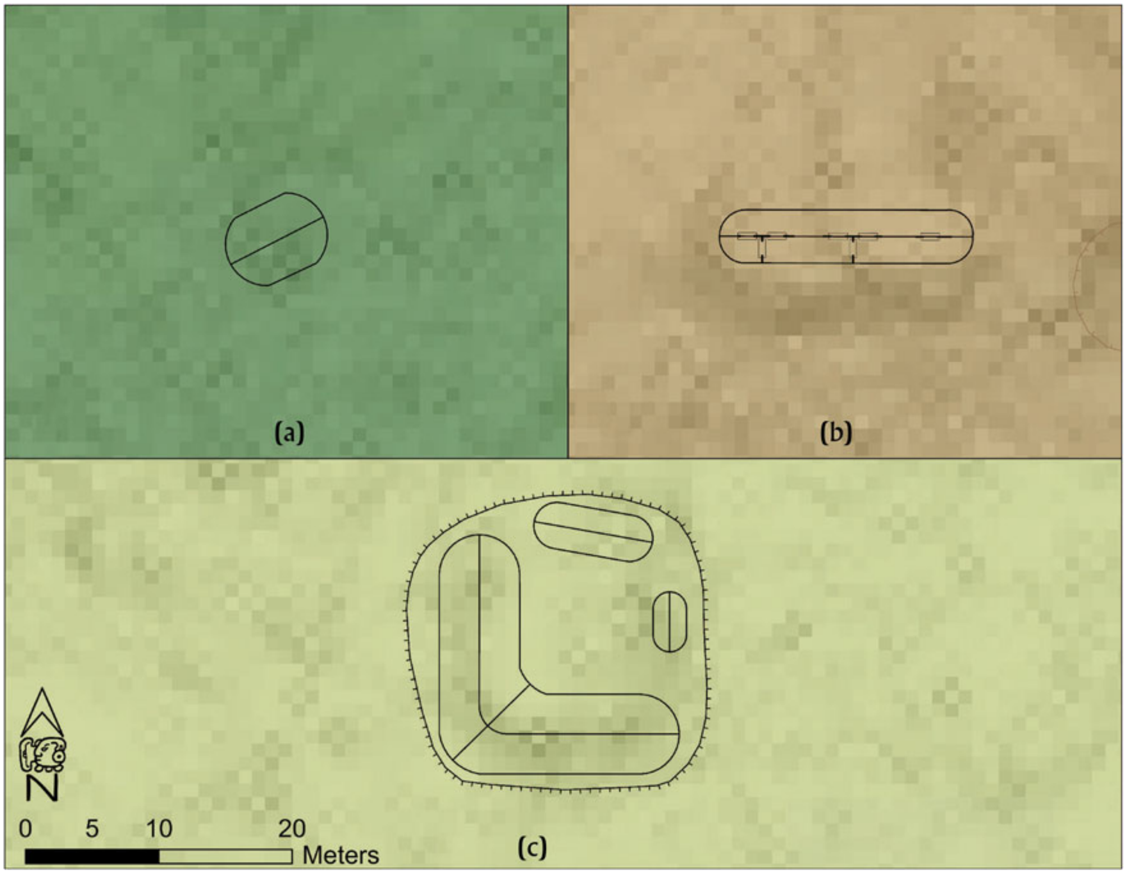

Figure 3. Examples of settlement units at El Pilar, 1:300 scale: (a) secondary residential unit (SRU); (b) solitary range structure (SRS); and (c) primary residential unit (PRU).

a particular household. Our Gini calculations include only PRUs, as these most closely approximate ethnographically and ethnohistorically known Maya households (see also Canuto et al. 2023). We include brief descriptions of other settlement units to explain our logic for excluding them.

SRUs consist of low, small mounds, usually found in isolation more than 20 m from larger settlement remains. Structures with these characteristics were likely field houses or outbuildings (Wauchope 1938), which provided farmers with a secondary residence while working in fields away from their household compounds (Ford and Nigh 2015; Zetina Gutiérrez 2007). Field houses, while providing necessary shelter for farmers away from their homes, could be expedient structures that would not necessarily reflect household wealth, and we cannot associate SRUs with specific primary residences. Small, ephemeral SRUs would skew Gini results and create inappropriate comparisons between permanently occupied dwellings and part-time, special use structures. For these reasons, we exclude SRUs from this analysis.

SRSs are recently identified settlement units that do not fit neatly into the PRU or SRU categories. They are large structures, 9–20 m long and more than 1 m high. Like most SRUs, these structures are isolated from surrounding settlement units and not associated with *plazuelas* (raised platforms) or other features of domestic architecture. Some SRSs consist of up to four rooms, arranged in a single file, as revealed by looter trenches and roof slumping, and most appear to be vaulted. The potential function of these structures is not clear; they may represent administrative buildings, collection facilities for taxes and tribute, or some other specialized purpose. They do not conform to our expectations of Maya residential architecture, however, and including SRSs in Gini calculations would be as incongruous as comparing farmer's residences to palaces. Although the labor invested in SRSs was considerable—and they certainly reflect some form of unequal wealth distribution at El Pilar—our doubts about their domestic nature precluded us from including them in Gini calculations.

A settlement unit must meet at least one of three criteria to be classified as a PRU: (1) consist of more than one structure with a combined labor investment greater than 500 person-days; (2) comprise a single structure built atop a *plazuela*; or (3) in the case of solitary mounds with no associated features, have a diagonal measurement less than or equal to 8 m, and a height of 1 m or more (Figure 4). Our criteria derive from the straightforward proposition that, based on ethnographic observations, traditional lowland Maya houses consist of at least two structures: one for general domestic functions, and one for cooking (e.g., Cook 2016; Redfield and Villa Rojas 1962; Zetina Gutiérrez and Faust 2011). In other words, archaeologists should look for both

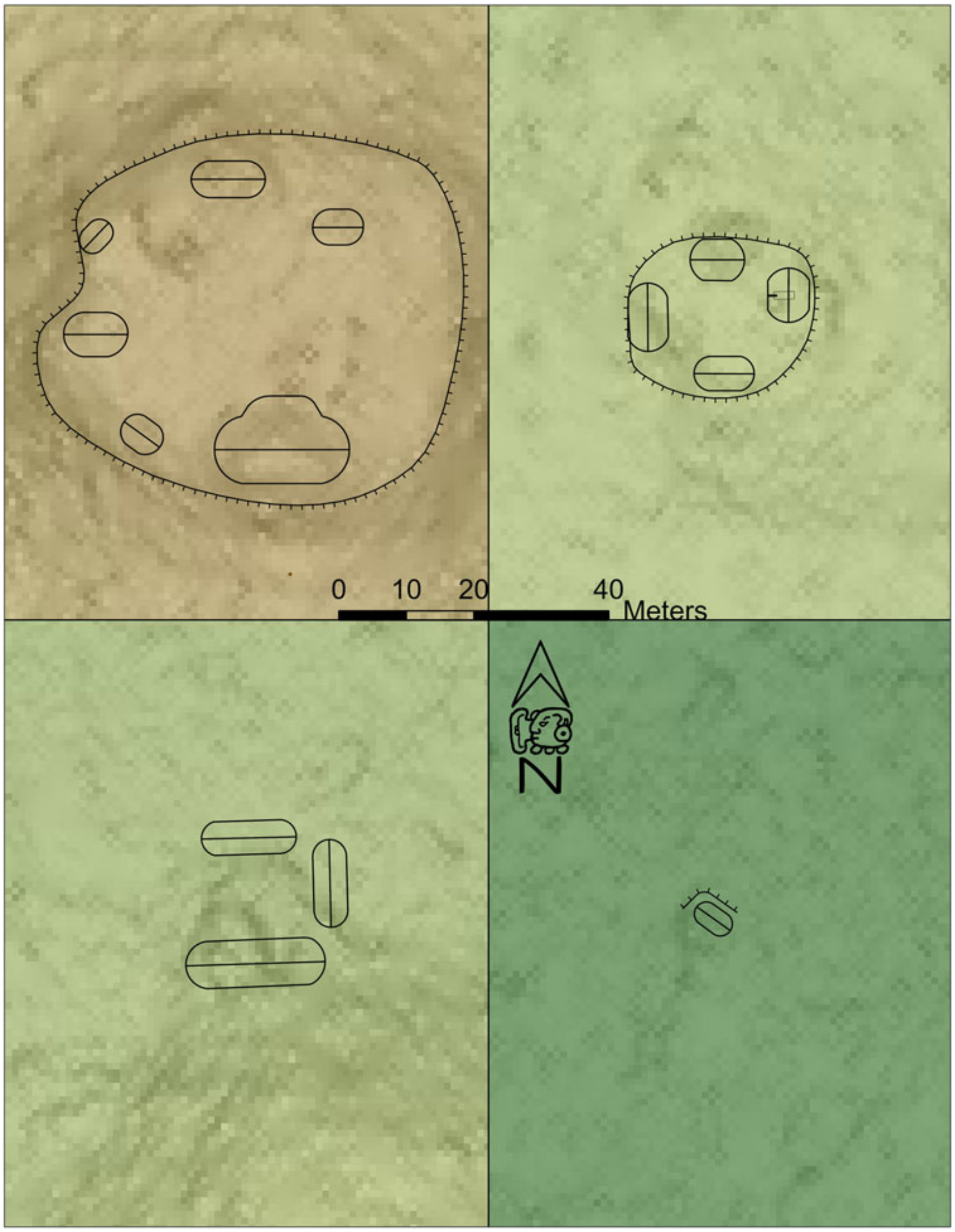

Figure 4. Examples of primary residential units (1:650 scale), showing variability in size, orientation, and composition.

domicile and kitchen, at a minimum, when defining the built environs of a household.

We include caveats to a simple "two structure" rule for identifying PRUs on the basis of field observations, traditional knowledge of Maya farmers, and the recognition that kitchen structures may be more ephemeral than sleeping quarters. Traditional Maya farmers sometimes build more than one structure in outfield areas (Narciso Torrres, personal communication 2022), to accommodate additional storage or replace a dilapidated field house, and these buildings tend to be small and constructed of perishable materials. We have occasionally encountered groups of small mounds, usually less than 20 cm high and with diagonals below 4 m, which more likely represent these types of structures than the residence of a household. At the opposite end of the spectrum, we would not expect ephemeral field houses to be built on *plazuelas* or to be so substantially constructed that their remains rise 1 m high above the forest floor. In these cases, we presume a kitchen was present but not detectable by surface survey (see Johnston 2004).

Labor investment estimates at El Pilar are based on a formula developed by Arnold and Ford (1980) for comparing differences among residential groups at Tikal. Diagonal measurements of structure footprints and their height class—defined as high (>1 m) or low (<1 m)—are the inputs for estimating labor investment for single structures. To calculate group labor investment, we combine individual structure estimates and use a group diagonal measurement to account for household compound size. The presence of a

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Table 2. Statistics for all Gini coefficient calculations, based on area, volume, and labor investment of PRUs.

	Area			Volume			Labor investment
Basic statistics	Individual structures	Group structures	Whole group	Individual structures	Group structures	Whole group	Whole group
Gini	0.42	0.42	0.42	0.42	0.42	0.42	0.42
"Corrected" Gini	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Sample size	1444.00	613.00	613.00	1444.00	613.00	613.00	613.00
Mean	41.67	41.67	41.67	41.67	41.67	41.67	41.67
Range	269.40	269.40	269.40	269.40	269.40	269.40	269.40
Standard deviation	36.28	36.28	36.28	36.28	36.28	36.28	36.28
Coefficient of variation	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Box-n-whisker data (not standard)							
Minimum	2.02	2.02	2.02	2.02	2.02	2.02	2.02
Lower median	17.61	17.61	17.61	17.61	17.61	17.61	17.61
Median	29.82	29.82	29.82	29.82	29.82	29.82	29.82
Upper median	52.32	52.32	52.32	52.32	52.32	52.32	52.32
Maximum	271.42	271.42	271.42	271.42	271.42	271.42	271.42
Confidence interval ("Corrected" Gini)							
Lower Gini	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Higher Gini	0.44	0.44	0.44	0.44	0.44	0.44	0.44

plazuela is a modifier in the formula that increases group labor investment. As this formula contains elements of the areal and volumetric calculations included in the comparative Gini index analyses used by authors in this Compact Special Section, but is somewhat different from each of those, we include it as an additional metric for comparing wealth inequality among PRUs.

Gini coefficient results

Our analysis includes only PRUs that have been groundtruthed, mapped, and processed in our geodatabase, which limits our sample to data obtained through the 2019 field season. These results are therefore preliminary, as we recorded additional PRUs in 2022 that have not yet been fully analyzed, and LiDAR imagery for the remaining 2 km^2 of unsurveyed territory suggests more will be discovered. Our sample size of 613 PRUs, accounting for about 64 percent of settlement remains, is robust, however, and it provides an important starting point for comparisons with the complete dataset. Data from Gini coefficient analyses are presented in Table 2 and discussed below.

Gini indices produced by areal and volumetric inputs vary considerably (see Thompson et al. 2023). There is more variation among the wealth metrics in the area calculations (0.42–0.56), and all of these Gini coefficients are significantly lower than those based on volume (0.72–0.80). Potential sources of variation within these categories are not clear, but given our use of PRUs as the units of analysis, the "whole group" metric is best suited for interpreting wealth inequality among households at El Pilar (see also Thompson et al. 2021). Interestingly, the coefficient for labor investment was the lowest of the three metrics of inequality among whole group units.

Discrepancies in the Gini indices produced by different measurements of whole group wealth raise methodological and interpretive questions. Although all three metrics indicate an unequal distribution of wealth among households, the degree of inequality they suggest varies considerably. For example, the coefficient derived from labor investment estimates (0.43; Figure 5) is roughly similar to Gini indices from area estimates at other lowland Maya cities (Chase 2017:Table 2; Thompson et al. 2021:Table 5), but it is significantly lower than the area and volume Ginis generated from the El Pilar dataset. This could be due to an underestimation of labor needed to build raised *plazuelas* or in some other component of the formula, but it may also represent a closer approximation of wealth inequality than either the volume or area measures. As it derives from a different dataset, our labor investment Gini is not directly comparable to the area Ginis it most closely resembles from other Maya centers, although it provides another potential avenue for multiproxy

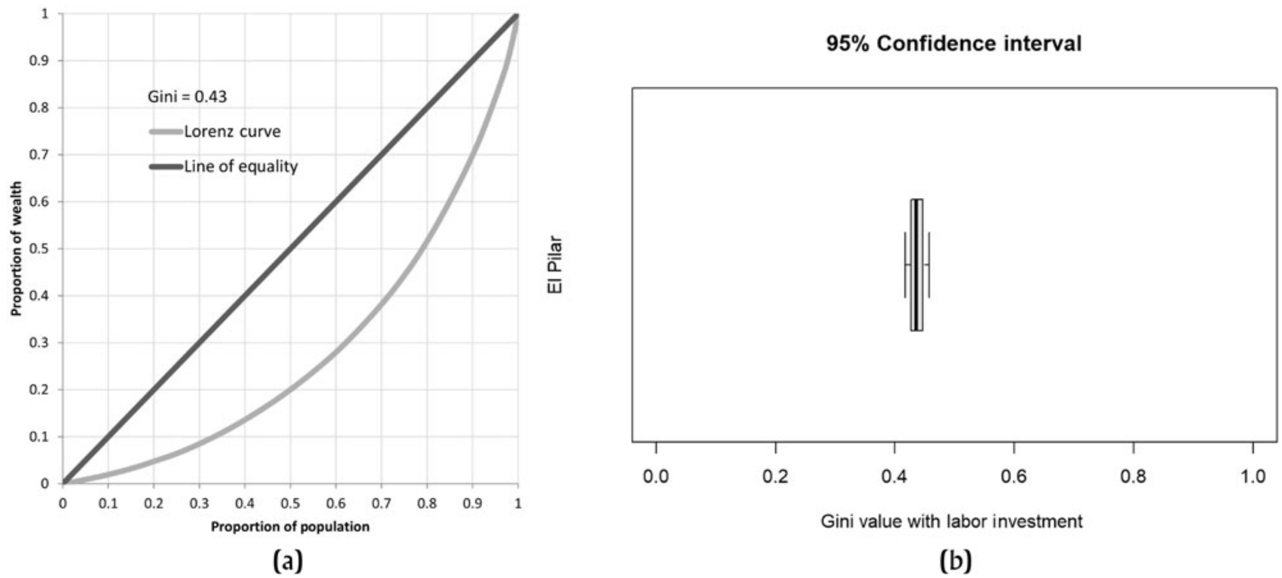

Figure 5. Gini coefficient and Lorenz curve of labor investment estimates of PRUs: (a) Lorenz curve and Gini; (b) confidence interval of Gini coefficient.

approaches to material wealth distribution for future comparisons (see Munson et al. 2023; Walden et al. 2023).

The area Gini (0.56; Figure 6) indicates greater disparities in wealth among households and is closer to previously reported volume Ginis, rather than area Ginis, from Ix Kuku'il (area = 0.40; volume = 0.59), Uxbenka (area = 0.38; volume = 0.54), and Caracol (area = 0.34; volume = 0.60), among other Maya sites (Chase 2017:Table 2; Thompson et al. 2021: Table 5). Area measurements would seem to offer a less complete measure of household wealth, as they overlook the labor necessary to build taller buildings and platforms. Measuring area, however, is somewhat more straightforward than estimating volume, especially when considering the hilltop locations many Maya residences were built on and the processes by which volume accumulates over time in longer-lived residences (Hutson 2016:151–152; see also Hutson et al. 2023; Munson et al. 2023).

The Gini coefficient computed from whole group volume (0.8; Figure 7) indicates an extremely unequal distribution of wealth among households at El Pilar. Such concentration of resources in the hands of the few has no parallels in previously published studies of lowland Maya cities, which suggests additional scrutiny is warranted in interpreting this number. Many of the largest PRUs included in this sample were built atop small hillocks or ridges, and the polygons used to define these groups may have encompassed sections of natural topography that inflated volumetric values (see also Canuto et al. 2023).

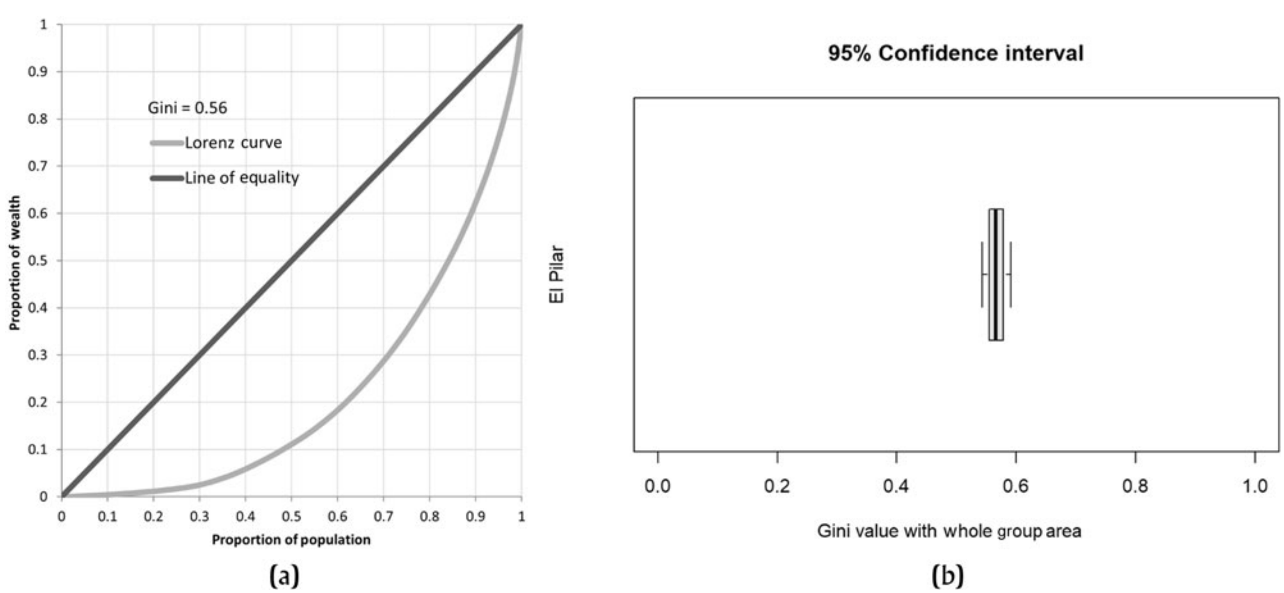

Figure 6. Gini coefficient and Lorenz curve of areas of PRUs: (a) Lorenz curve and Gini; (b) confidence interval of Gini coefficient.

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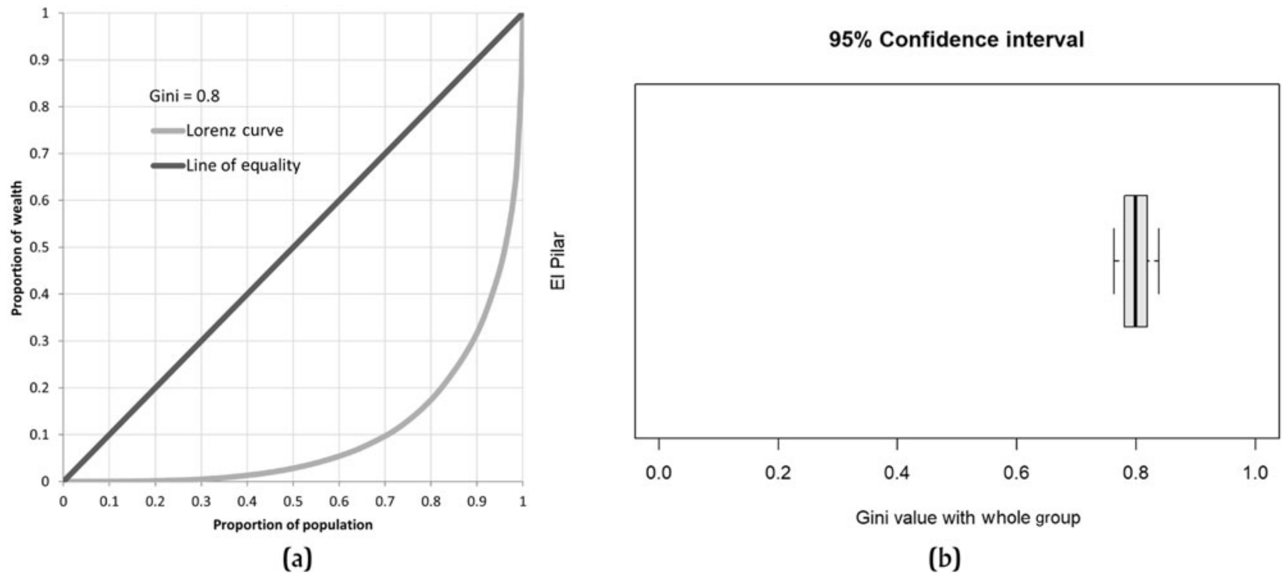

Figure 7. Gini coefficient and Lorenz curve of volumes of PRUs: (a) Lorenz curve and Gini; (b) confidence interval of Gini coefficient.

Discussion and conclusion

The conflicting Gini coefficients yielded from different inputs, and the potential confounding factors associated with each measure, foreclose the possibility of a single interpretation of wealth distribution based on this analysis. As noted above, every Gini index indicates that some degree of inequality existed among the inhabitants of El Pilar. Disparities in wealth are lowest with the labor investment measure, which is surprising, given the highly skewed frequency distribution of PRU labor investment estimates. Gini coefficients for volumetric measures are greater than those based on area, which mirrors findings at other lowland Maya centers (Chase 2017; Thompson et al. 2021). Higher Gini coefficients for whole group area and volume than those calculated elsewhere in the Maya Lowlands suggest that El Pilar was something of an outlier in terms of household wealth inequality.

Deciding which Gini provides the closest approximation for wealth distribution at El Pilar is problematic, as few data exist to clarify this issue. Better understanding of material wealth disparities will require multiproxy measures. Household artifact assemblages could provide an additional line of evidence to corroborate the use of one measure over another (Peterson and Drennan 2018), as could burial data (Munson and Scholnick 2022), but the excavated sample from El Pilar is currently too small for a robust comparative study. Using house size measures allows for greater comparability among ancient cities with robust survey data when such multiproxy approaches are not feasible.

Attempts to examine wealth distribution at the intracenter level, such as within the neighborhoods at Chunchucmil (Hutson and Welch 2021) and centers in southern Belize (Thompson et al. 2021), also prove difficult at El Pilar. Spatial methods to identify El Pilar neighborhoods have met with limited success (Thompson et al. 2022), and labor investment data argue against a concentric-zone model of elite residences clustering near the monumental city center (Horn III et al. 2020). An alternative approach taken by Marken (2023) assessed inequality within El Perú-Waka' at the urban core, near periphery, and far periphery, rather than among specific neighborhoods. The spatial distribution of household wealth within the city continues to be a research focus, despite somewhat ambiguous results from preliminary analyses.

The Gini coefficients from PRUs document an unequal wealth distribution among the inhabitants of El Pilar, although the true scale of this inequality is difficult to ascertain from a single proxy. Completing the survey and refining settlement data may resolve the issues discussed above and provide a clearer picture of variable household prosperity at Classic period El Pilar.

Acknowledgments. We thank the directors and staff of the Institute of Archaeology, Belize, and the Instituto de Antropología e Historia, Guatemala, for permissions to conduct the research on which this article is based, and for their continuing support of fieldwork at El Pilar. Funding for this research was provided by supporters of Exploring Solutions Past: The Maya Forest Alliance, to whom we express our utmost gratitude.

Competing interests declaration. The authors declare no competing interests in the publication of this research.

Data availability statement. All data used in this publication are housed at the MesoAmerican Research Center at the University of California, Santa Barbara, and can be made available to researchers upon request to the corresponding author.

Funding statement. No outside funding was provided for the publication of this research.

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