"I built it with my own hands:" A method to assess heterogeneity of housing quality in consolidated informal settlements.

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Abstract

Because housing quality varies significantly in informal settlements, participatory slum upgrading must be based on fine-grained empirical analysis of design, structural quality, and materials used in self-help housing. Slum severity indices drawing on indicators defined by UN-Habitat have served to map precarious communities in large Global South cities. However, these assessments cannot capture the heterogeneity of self-built homes within consolidated informal settlements. Building on a case study of a consolidated informal settlement in Mexico City, this research presents a replicable model to measure the range of variability of housing quality by combining qualitative and quantitative methods. We used architectural observations and household surveys to construct a qualitative database of housing quality indicators identified by self-help builders. This fine-grained database allowed us to develop a housing quality index that revealed the heterogeneity of housing quality. We then conducted in-depth interviews that illuminated factors beyond household income that shape the consolidation of self-help buildings, including participation in community-based self-help efforts, apprenticeships, incorporation in social networks, and government assistance. By providing fine-grained documentation of self-help housing heterogeneity based on local knowledge, we contribute a globally applicable model to inform more empirically informed and locally appropriate approaches to participatory slum upgrading in informal settlements.

1. Introduction

After decades of rapid urbanization, consolidated informal settlements account for the most significant proportion of urban areas in the Global South (UN-Habitat, 2019). In the case of Latin America, most dwelling units that emerged more than 60 years ago still stand and function today (Ward et al., 2015), having undergone several phases of self-help consolidation and improvement. The original owners and their children still live in many of the original housing units (Ward et al., 2014). Because such a significant portion of the consolidated housing in informal settlements in the Global South is developed through self-help practices, global housing policy is increasingly calling for slum upgrading policies (Bredenoord et al., 2010). By engaging with local knowledge and drawing on the incremental methods of housing improvement developed by informal builders, participatory approaches to slum upgrading offer the most effective, democratic solutions to improving the living conditions of the urban poor in low-income settlements across the Global South (Kiefer & Ranganathan, 2020; Muchadenyika & Waiswa, 2018).

However, such participatory approaches to slum upgrading are complicated by the great variability of housing quality in consolidated informal settlements (Vaid, 2021). Since slum dwellers differ in their economic wherewithal and ability to improve their homes (Gilbert, 2007), consolidated informal settlements are often characterized by a patchwork pattern of housing clusters and individual homes in varying states of repair. For instance, in Mexico City, small pockets of informal settlements are located within relatively wealthy municipalities and even within new, state-funded housing developments on the current urban periphery (Connolly, 2009). Around 25% of the urban population in Latin America continues to live in a human settlement that can be classified as an informal settlement or "slum" (Murray & Clapham, 2015).

Because of the great heterogeneity of consolidated informal settlements, a central challenge for participatory upgrading is to identify the most precarious homes urgently needing upgrading assistance. Such quality assessments require careful attention to the variability of housing design, structural quality, and materials used for incremental housing improvement by residents in informal settlements. However, given data limitations and the lack of adequate training and resources on the part of municipalities, current slum severity assessment models tend to rely on remote sensing imagery and aggregated census data (MacTavish et al., 2023; Patel et al., 2014, 2020; Stoler et al., 2012). Given their inherent inaccuracies and insufficient resolution, such remotely sourced data fails to provide a nuanced picture of variation of housing quality at the community level. Furthermore, simplified assumptions of proxy values for housing quality lead to policy interventions that gloss over the heterogeneity of informal settlements. While such quantitatively based assessments of slum severity in the Global South may serve to identify low-income communities with high concentrations of self-help housing at the coarser metropolitan

scale (Patel et al., 2014; Roy et al., 2020), these assessments may gloss over the heterogeneous character of consolidated informal communities in large and economically diverse municipalities.

To address these significant methodological limitations in housing quality assessments in consolidated informal settlements in order to foster more equitable and empirically informed participatory approaches to slum upgrading, we propose a field-based approach that incorporates quantitative data with information collected through field observations, surveys, and ethnographic methods. To develop more effective policy and planning interventions, we argue that housing quality assessment should, in part, be based on local knowledge and the collaboration of local, informal builders in the development of quality indicators as well as housing improvement strategies. Our model thus represents a situated approach to housing quality assessment in consolidated settlements that emerges from lived experience and incorporates simple, accessible and participatory research methods that can be adjusted to particular contexts. By enlisting local builders and their families in primary data collection and holistic analysis of housing conditions, we seek to complement participatory approaches to slum upgrading by providing a more grounded and contextually relevant database as well as local support for future upgrading efforts.

To develop our model, we drew on field research to document variability of housing quality in the *colonia popular* (consolidated informal settlement) of Isidro Fabela in Mexico City. Isidro Fabela was founded in the 1960s on the southern fringe of Mexico City during a period of massive proliferation of informal settlements in Mexico and elsewhere in Latin America (Ward et al., 2015). As in the case of many older informal communities once located on the edge of the city, Isidro Fabela has been consolidated and incorporated into city service networks and now finds itself in a central urban location with prime access to transportation services and employment and education opportunities. Residents in "inner burbs" Ward et al. (2015) such as Isidro Fabela have

developed strong social networks and vibrant local economies that provide ready access to employment, goods, and services (Reyes, 2020).

However, while this colonia popular is in an advanced stage of consolidation, it still displays great heterogeneity in housing quality which in turn complicates policy efforts to support participatory slum upgrading strategies. To document the variability in housing conditions in Isidro Fabela, we simultaneously conducted household surveys (n=108), architectural observations and measurements, and in-depth interviews. The household surveys allowed us to document the number of buildings or housing units in the lot as well as the number of families who reside in these structures; the architectural observations and measurements served to document the structural state of buildings, such as the number of constructed floors and the apparent shortcomings of structures; while the ethnography conducted through intensive case studies of six individual properties helped us document the history of self-help construction in the lot. Our research drew on principles of participatory slum upgrading by including residents as research partners. Rather than relying on the UN-Habitat's slum indicators, this participatory approach allowed us to collectively identify with residents and self-help builders the most important criteria for self-help construction quality to be documented in the field, including the structure quality, the quality of decorative materials and facade finishes, the material quality of roofs, and earthworks for land leveling.

Following the fieldwork, we analyzed each of the structures in the 108 lots in accordance with the housing quality criteria developed jointly with residents. Using exploratory factor analysis, we developed a Self-help Housing Quality Index (SHQI) ranging from -2 (very low) to 3 (very high) which allowed us to classify the continuous result into five categories using bagged-cluster algorithm, a resampling version of hierarchical clustering. Since our indicators and data

draw on participatory methods and local knowledge coupled with systematic observations, the index reveals nuanced deficiencies in self-help housing that cannot be obtained solely through the use of census proxy data, surveys, satellite images, and external architectural documentation.

Beyond the obvious factors that drive construction quality, including family size and residents' economic resources and capacities to invest in their homes (Bazant, 2003: 16), our research illuminated other important factors that also shaped the consolidation process, including social networks and government assistance. We found through our intensive case studies that collective self-help housing efforts coordinated by community leaders, especially women founders, were critical during the early years of the settlement. These collective efforts allowed self-help builders, known as *albañiles,* to develop construction knowledge and become a local source of expertise. The history of consolidation also illustrates the important role of publicly funded, low-cost training programs and technical assistance, as well as the significant contributions of community-based organizations in terms of channeling external assistance while guarding against divisive political cooptation.

Together, the insights from such life stories combined with the architectural observations, surveys, and traditional quantitative models allowed us to present a nuanced picture of informal housing development, accounting for the spatial heterogeneity in housing quality but also the range of historical experience of residents. Our approach addresses the limitations in commonly used housing quality assessment models, which are typically premised on proxy analysis of remote sensing imagery and census data. By more accurately visualizing the spectrum of self-built housing quality based on fine-grained data, our model may serve to strengthen participatory slum upgrading approaches in highly heterogeneous consolidated informal settlements. Furthermore, our model is based on simple field research methods that can be adjusted for specific geographies

and social contexts, making it replicable in consolidated informal settlements throughout the Global South.

2. Housing quality assessment models

Slum Severity Indices (SSI) have been used to identify concentrations of precarious informal housing in large metropolitan areas in the Global South, including in Mexico City (Connolly, 2009; Roy et al., 2020) and Mumbai and Kolkata in India (Patel et al., 2014, 2020). These studies tend to rely on the five indicators of slums developed by UN-Habitat (2003, 2009) that emerged from a world-wide synthesis of slum characteristics: inaccessibility to piped water and sanitation, overcrowding, substandard structural quality, and tenure insecurity. Although these generalized categories risk erasing local contexts, scholars generally concur that studies based on the UN-Habitat indicators are more accurate in identifying large concentrations of precarious communities than the assessments conducted by federal-level institutions, including in Mexico (Roy et al., 2020) and India (Patel et al., 2014, 2020). For example, in their work to assess slum severity in Mexico and Ghana, respectively, Roy et al. (2020) and Stoler et al. (2012) used indicators comparable to those proposed by the UN-Habitat (2003), such as the presence of dirt materials on floors or temporary structures.

To develop multidimensional indicators of slum severity, scholars have experimented with statistical techniques that rely on census data, as exemplified by regional assessments of slum severity in Accra, Ghana (Stoler et al., 2012) and Mexico City, Mexico (Connolly, 2009; Roy et al., 2020). To create multivariate indicators of informality, precariousness, or deprivation, Connolly (2009) applied cluster analysis techniques while Roy et al. (2020) resorted to dimension reduction techniques, such as Exploratory Factor Analysis. However, census data is sometimes inaccurate because some questions lead to binary interpretations of services provision. As a result,

these measures do not accurately assess the housing quality or the availability of basic services in informal communities (Satterthwaite, 2003). For instance, access to drinking water in the dwelling unit captures the connection to a distribution network but not the actual availability of water. Also, census data related to access to piped water and sewage is often aggregated at the neighborhood or municipal level (Patel et al., 2014, 2020; Roy et al., 2020), undermining the assessment of heterogeneity at the household level.

To address the data limitations of the national census and household surveys, scholars have incorporated more fine-grained housing data from national census and housing surveys to conduct housing insecurity assessments, notably in Mumbai and Kolkata, India (Patel et al., 2014, 2020) and the Greater Accra Metropolitan Area of Ghana (MacTavish et al., 2023). Drawing on insights from previous qualitative research in Mexico, Connolly (2009) incorporated additional variables for evaluating structural quality, including roof quality, which is one of the most complex construction systems in the context of Latin America's informal settlements (Caballero Moreno et al., 2019).

Nevertheless, even national household survey data aggregate information at the community level because of the complexity of data collection (Stoler et al., 2012). Due to the challenges posed by data aggregation, researchers such as Boateng and Adams (2023) have begun building SSIs based on data collected in the field. Although the indicators used by Boateng and Adamas (2023) in Ghana respond to the local conditions of precarious informal settlements at earlier stages of consolidation, their use of surveys in three informal Ghana communities resulted in more fine-grained and accurate data revealing housing heterogeneity at the community level. This recent work to expand the scope and accuracy of SSI has also incorporated housing insecurity dimensions associated with housing conditions, energy, and tenancy (MacTavish et al., 2023; Patel et al., 2014,

2020) and built environment measures such as flooding and sludge (Boateng and Adams, 2023), which provides a deeper understanding of housing conditions that are not well captured in censuses. Other scholars such as Stoler et al. (2012), Patel et al. (2020), and Roy et al. (2020) have attempted to counter the limitations of aggregated census data by comparing census data with land use and land cover data using high spatial resolution satellite imagery (MacTavish et al., 2023; Roy et al., 2020; Stoler et al., 2012). Their basic assumption is that the texture of the spectral response accounts for the degree of informality, and they argue in favor of the use of remote sensing to reduce costs and provide data with greater temporal granularity.

However, SSI measures still provide a simplistic picture of the complex nature of housing quality in Global South urban contexts, which differ greatly in their level and form of urbanization, economic development, and social policy. By solely considering physical and legal characteristics but disregarding critical social and housing dimensions, traditional SSI methods draw on conservative measures that obscure the heterogeneity of housing quality in informal settlements (Boateng and Adams, 2023; Patel et al., 2014, 2020). SSI studies often build on a limited understanding of self-help housing quality at the household level, and, by relying solely on quantitative measurers and structural assessments, overlook the implications of housing policy and housing assistance for self-help consolidation (Roy et al., 2020). Connolly (2009) and Boateng and Adams (2023) have called for qualitative methods, including ethnographic fieldwork and historical analysis of the process of self-help consolidation, to complement quantitative, metropolitan-scale models of slum severity. As Connolly argues (2009, p. 31), "Observing from a distance may produce questionable results."

Notably, assessments in Latin America leave out land tenure variables because of data limitations (Connolly 2009; Roy et al. 2020) and the complexity of examining inheritance topics

(Grajeda and Ward, 2012), which requires the researcher to engage in interviews with residents. Furthermore, current housing insecurity assessments methods reflect the dominant precarious conditions of informal settlements in some of the poorest region of the world (Boateng & Adams, 2023; MacTavish et al., 2023) rather than the multiplicity of conditions that characterize consolidated informal settlements. These limitations call for a new approach to slum severity analysis in consolidated informal settlements at advanced stages of self-help consolidation, especially in complex, heterogeneous and economically uneven metropolitan areas. Mixed-method assessments of housing quality in consolidated informal settlements can help document the needs of informal dwellers and reveal the implications of self-help housing policy assistance.

Although scholars recognize the significance of self-help housing policies for improving living conditions across the globe (Bredenoord & van Lindert, 2010), they highlight the challenges of implementation at the local level (Patel, 2013; Vaid, 2021). Governments have used self-help housing policy and assistance programs to establish clientelist relations with communities, which in turn have enabled political cooptation of residents and served to control grassroots community organizations (Deuskar, 2019, 2020). In light of these challenges, UN-Habitat has supported the 'Participatory Slum Upgrading Programme (PSUP)' for over two decades to help cities understand the needs of informal settlements while incentivizing residents' participation. However, despite the emphasis on participatory approaches to redevelopment based on collaboration between informal dwellers, governments, and stakeholders, participatory slum upgrading projects have been critiqued in India by De Geest & De Nys-Ketels (2019) and in South Africa by Kiefer & Ranganathan (2020). De Geest and De Nys-Ketels (2019) found that participatory slum upgrading projects have failed or not worked well because governments and stakeholders inconsistently implement community participation at the local level. When informal dwellers cannot influence

the design of PSUP projects, external stakeholders may implement cost-efficient proposals with designs and materials that do not respond to residents' housing, cultural, and family needs. However, when residents and grassroots community organizations actively participate in top-down PSUP proposals developed by external stakeholders, they are better able to voice their needs and even contest misguided strategies, thus ensuring that the self-housing improvement approaches are effective and serve to improve their communities (De Geest & De Nys-Ketels, 2019; Kiefer & Ranganathan, 2020).

Another challenge is to ensure continuity of housing policy, which depends on the capacity of governments but also on the involvement of community-based organizations in self-help housing programs. Community-based organizations can help facilitate resident engagement and representation, including of those most vulnerable, to sustain comprehensive PSUP projects over time (De Geest & De Nys-Ketels, 2019; Kiefer & Ranganathan, 2020; Muchadenyika & Waiswa, 2018). As reported by Zapata Campos et al. (2022), grassroots community organizations have supported informal dwellers in Latin America in developing their self-help construction knowledge and legal insights to resist political cooptation. This important connection between community organizing and self-help housing practices, which is a common feature of informal settlements globally, underscores the importance of incentivizing the participation of all residents in housing quality assessments. Housing quality assessments based on local, self-help construction knowledge and experiences of community-based organizations can ensure that participatory housing upgrading policies are better targeted and more strongly supported by residents.

3. Case Study

Since the 1990s, federal Mexican institutions including the Consejo Nacional de Población (CONAPO) and Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL) have conducted slum severity assessment drawing on quantitative analysis of census data developed by the Instituto Nacional de Estadística y Geografía (INEGI) (CONAPO, 2011; CONEVAL, 2020). However, the scale of the census data obscures the heterogeneity of housing quality in large and complex metropolitan regions at the community and household levels. Although INEGI recently has expanded its census questionnaire to include questions that explore not only the *availability* of primary essential resources, such as piped water, but also questions about the *frequency* of access to services, data granularity is lost because the sample of this fine-grained census questionnaire only allows inferences at the municipal scale. In order to develop a participatory assessment model that integrates qualitative and quantitative data for more fine-grained analysis of housing quality, we chose to conduct our field research in Isidro Fabela, a representative colonia popular where proxy variables of household income—share of informal workers (62%), workers' education levels (20%), and car ownership (40%)—resemble the average values in the Mexico City Metropolitan Area. While previous regional assessments of slum severity had classified housing quality in the community as high (Connolly, 2009; Roy et al., 2020), our field observations in 2017 prior to initiating our study suggested that the community, in fact, exhibited significant variability in housing quality.

4. Materials and methods

Our assessment of self-help housing quality in Isidro Fabela progressed in four phases. After developing the building quality criteria jointly with residents and self-help builders, we conducted field assessments between January and November 2017 to develop a fine-grained database of self-help housing quality, which served as the basis for our subsequent statistical analysis and

classification of housing quality. Third, we chose six in-depth case studies representing the range of heterogeneity to validate our classifications and uncover further socio-economic drivers of housing quality. Finally, in 2022, we reviewed satellite imagery and conducted walks in the community to follow up on our previous field assessment. Our work revealed that nearly all the surveyed buildings remained structurally unchanged since 2017 except for a few minor improvements to the façade finishing.

4.1 Developing Assessment Criteria

Our field work was premised on developing co-productive relationships of trust with residents and self-help builders, which allowed us to develop housing quality assessment criteria that more adequately represent the heterogeneity of housing quality in the community. We worked most closely with local albañiles, who contributed their practical experience and understanding of the strength and limitations of various self-help design solutions, structural qualities of building elements, and durability of materials typically used in local construction. Some residents allowed us to enter their homes and showed us structural deficiencies, such as severe drainage issues that led to the erosion of structures, that are typically not included in census data or in surveys and architectural observations. Drawing on this participatory approach, we identified the following indicators to document in our observations and surveys: 1) earth works, 2) the quality of structures, 3) the material quality of roofs, 4) the staircase quality, 5) the sewer system, and 6) the quality of decorative materials on facades. While we documented the quality of the sewer system (finding that half of the houses have a low-quality system), in the final instance this indicator did not meet the statistical requirements to allow it to be incorporated into the index.

4.2 Conducting Field Assessments

Our architectural observations and household surveys were conducted of a random sample of parcels derived from the property tax database of the district of Tlalpan. This file provided the polygons of the 1,710 lots of Isidro Fabela along with the size of each lot, the constructed area, and the approximate year of land regularization, allowing us to conduct a simple random sampling of residential lots. The sample size (n=108 parcels) was large enough to ensure a 95% level of confidence, and a margin of error of 9%.

Our field assessments methods included architectural observations combined with household surveys that asked residents about housing and living conditions. [First Author] initially used satellite images as a reference to locate self-built homes in the community for purposes of architectural observation. Following this, a self-help quality observation sheet served as a guide to systematically document the apparent quality of structures, building systems, such as foundations and roofs, and the state of decorative materials, based on observations from outside the buildings during systematic walks through the community.

The household survey drew from previous research on incremental housing quality based on the characteristics of construction materials (Bazant, 2003; Connolly, 2009). In addition, based on our participatory development of housing quality criteria jointly with local self-builders, we incorporated additional factors that drive the variability of self-help construction quality into our survey, such as roof, wall, and floor materials, and a comprehensive description of sewage disposal. We included questions about years of residence, as previous scholars have found that incremental housing quality in Mexico City is positively correlated with the age of the building (Bazant, 2003; Connolly, 2009).

4.3 Initial Analysis of Fieldwork Data

Our field research revealed that Isidro Fabela is a very dense community with a population of 230 people per hectare, a density more than twice that of the Mexico City metropolitan area. Contrary to the assumption that informal settlements face high levels of overcrowding, only 6.1% of the households in Isidro Fabela exceed the occupancy of 2.5 people per room. Our research indicates that self-help builders develop or adapt, on average, three separate housing units in which three different households reside. As a result of the continuous process of consolidation, most of the original dwellers and/or their adult children have remained in the community. On average, survey respondents have lived for 53 years in Isidro Fabela. Twenty percent of the surveyed houses were still owned by the original settlers, while 73 percent of the surveyed lots were owned by the adult children or grandchildren of the original settlers. These findings concur with the observations of Grajeda & Ward (2012), who documented the inheritance of self-help buildings by second and third-generation residents in Isidro Fabela.

For decades, the original residents had been forced to reside in precarious buildings that lacked basic infrastructure, including water, electricity, solid waste management, and stormwater drainage (Bazant, 2003). The volcanic soil of Isidro Fabela prevented the construction of a drainage system via self-help construction, as this would have required specialized earth-moving machinery. According to the residents, it was not until 2002, 40 years after the founding of Isidro Fabela, that the Mexico City government built a stormwater pipeline. However, there is still no sewage system, leading many residents to informally connect their sewers to the stormwater drains. Our research revealed that most lots have only one bathroom to serve all residents, but because of the lack of a drainage system self-help builders are unable to build additional toilets. Most residents

use septic tanks that drain into cracks in the volcanic soil, despite data from INEGI (2010)[1] that indicates that nearly 94 percent of the households have access to sewage. This reveals the inaccuracies of census data and the importance of conducting a community-based assessment of housing quality to reveal precarity.

Our surveys indicated that self-help builders over time have replaced discarded and temporary materials with durable materials to construct foundations, walls, and floors. In 103 out of the 108 lots documented, columns were made of reinforced concrete (known as *castillos*) to strengthen the structure, and in 88% of the lots, self-help builders had utilized brick for the walls while the rest had used concrete blocks. INEGI data also indicate that 98% of Isidro Fabela's dwelling units have cement floors (INEGI, 2010), which in most cases were added in a later phase of consolidation. However, our observations show that only 42% of the lots have buildings with concrete roofs while 32% had buildings with sheet metal roofs, 22% with asbestos roofs, and 4% with plastic sheeting, most likely due to the lower cost of these unstable roofing materials.

4.4 Developing a Self-help Housing Index

The data gathered through the architectural observations and household surveys allowed us to construct a housing quality index using exploratory factor analysis, a statistical technique similar to principal component analysis (PCA). While both statistical techniques permit the use of a set of continuous factors as normal standard variables, the explicit assumption of the existence of latent factors in factor analysis allowed us to understand and validate what constructs underlie the data

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[1] We use the INEGI (2010) census as a reference because the most current census (2020) has a significantly lower response rate than that of 2010, given the data collection challenges imposed by the restrictions of the COVID-19 pandemic.

(Wang et al, 2009). Roy et al. (2020) used exploratory factor analysis (EFA) to develop a slum severity index in Mexico City with data aggregated at the census tract scale. We also explored other methods of classification, but the results were more challenging to interpret given the lack of separability in crispy classes. While Connolly (2009) opted to use the k-means classification algorithm, this is sometimes more difficult to interpret and prone to bias given the initial solution of centers. We also tried fuzzy set and mixture models with similar difficulties related to lack of identification of low intra-cluster variance. Ultimately, the exploratory factor analysis proved its functionality both in terms of data reduction and measures validation.

Many of the original variables in our dataset were categorical, as they describe quality of construction systems, such as roofs, facades, structure size efficiency, and so on. This required us to group the original qualitative variables on a Likert-like scale to obtain ordinal variables with five categories. Although we originally tested 11 variables, only seven indicators related to housing quality were significant for the self-help housing index, whose distribution is shown in Figure 1. However, to apply any statistical model, it is essential to verify the behavior of the data. In the case of exploratory factor analysis, the correlations between the input variables must be moderate because otherwise, we would increase the standard errors of the factor loadings. We verified the data behavior using the Kaiser-Meyer-Olkin statistic, a sample adequacy measure, finding that all the construction quality variables identified in the field research were significant for the self-help housing quality analysis.
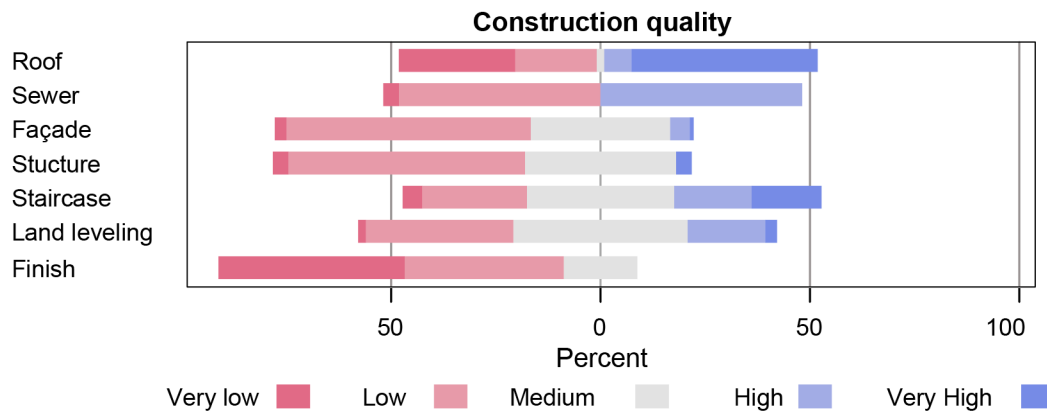
Figure 1. Input variables for the Self-Help Housing Quality Index (SHQI) for Isidro Fabela, Mexico City. Source: Authors.

Based on the exploratory factor analysis, we next developed a Self-help Housing Quality Index (SHQI) spectrum ranging from -2 (very low) to 3 (very high). Figure 2 shows that the density distribution of the housing quality index is almost three-modal and asymmetrical, with two peaks. The first peak at low values reflects the low quality of most houses surveyed, while the second, lower peak is due to the higher values in a few indicators. The red line depicts the position of the six intensive case studies discussed below. Since the SHQI is a normal standard variable, the average value of the SHQI is 0 with a range that fluctuates between (-1.91) and (3.04). To facilitate the interpretation of the index, we classified the continuous result into five categories using bagged-cluster algorithm, a resampling version of hierarchical clustering (Figure 3). This means that the lot with the lowest construction quality score can be classified as "very low" quality, whereas the one with the highest score is "very good" quality. The distribution of SHQI among the 108 examined self-built dwelling units is as follows: 33.3% can be classified as medium-quality, 58.3% as low-quality, 4.6% as high quality, and 2.8 % as low-quality.
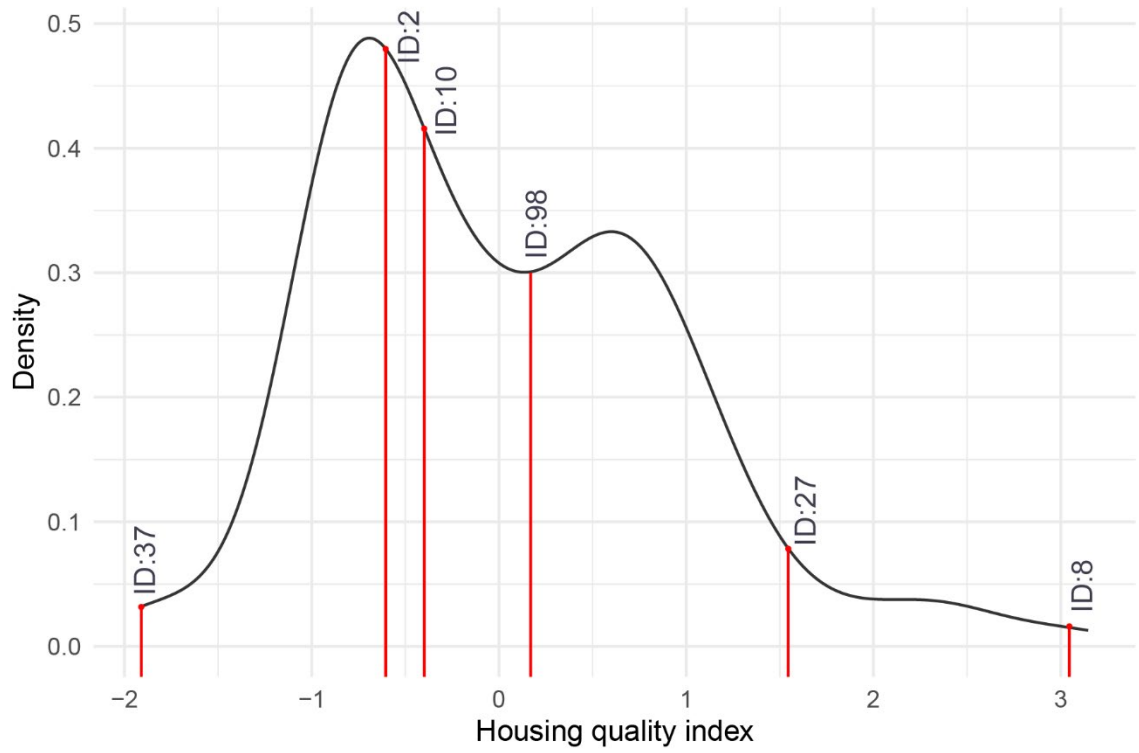
Figure 2. Histogram of self-help housing quality. Note: ID 37 (Ana's lot), ID 2 (Lucio's lot), ID 10 (Raul's lot), ID 98 (Ernesto's lot), ID 10 (Miguel's lot), and ID 8 (Graciela's lot).
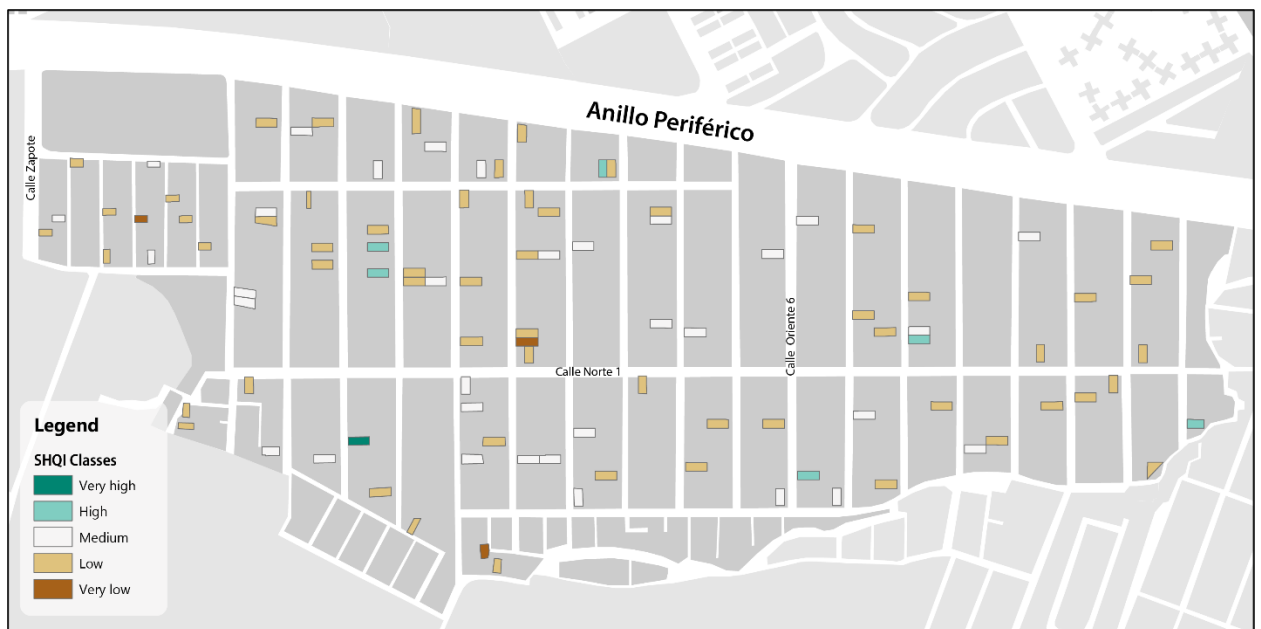

Figure 3. Heterogeneity of housing quality in Isidro Fabela, Mexico City. Source: Authors.

4.5 Testing the classification through intensive case studies

In order to test the validity of the SHQI, we adapted the intensive case studies methodology developed by Ward et al. (2014) and conducted further architectural assessments and interviews with heads of households in six lots representing each class of housing quality. These lots had all been previously surveyed in person and found to be exemplary representations of the different classes of housing quality. Furthermore, residents in these lots had expressed interest in participating in further qualitative research.

To conduct the in-depth case studies, [First Author] worked with two planning students from Universidad Autónoma Metropolitana at Xochimilco. One researcher took pictures of living spaces while [First Author] conducted interviews with heads of households and a third researcher took thorough notes. The goal was to document the incremental self-help construction process of the lot; the number of rooms, upper floors, or additional housing units; any structural deficiencies; and the type of materials used to construct walls, floors, and roofs. In addition, the interviews explored whether and how residents had engaged with self-help consolidation efforts of social leaders and community-based organizations in the first decades of consolidation and the extent to which residents had benefited from government assistance to incremental housing.

In addition to testing the self-help housing quality index, the intensive case studies also served to deepen our understanding of the variability of housing quality and the socio-economic drivers of self-help consolidation in Isidro Fabela. The intensive case studies revealed the role of collective self-help efforts in developing construction knowledge and the significance of state-funded low-cost training programs and technical assistance during the community's early years. In addition, the case studies showed the significant role played by female founders in developing

social networks, which were critical for channeling external assistance while protecting vulnerable residents against political manipulation and cooptation.

To illustrate the "very low" SHQI class, we selected the house of Ana, which, according to our architectural observations, had the most deteriorated structural conditions (Figure 4). Although Ana and her family have occupied the lot for 50 years, they have not completed any significant structural improvements to their home. The ground floor is more than four meters below the level of the street, the dwelling unit does not have its own walls, and the roof simply rests on the neighbor's walls and the volcanic stone on the other side of the lot. This building reflects the characteristics of initial structures in shantytowns, revealing the existence of pockets of deep poverty in Isidro Fabela and the inability of some families to gather the necessary resources to incrementally improve their homes.

Figure 4. Ana''s lot: Very low-quality SHQI class. Photo: [First Author].

Lucio's home represents the "low" SHQI class (Figure 5). On his lot, there are now two separate buildings: the original building in the rear and a new two-story unit in the front. Each of the two buildings are divided into two housing units, allowing four families to live on his lot. A serious limitation of Lucio's lot is that he reused the asbestos roof from the original construction on the new addition. And, as in the case of Ana's husband, Lucio did not participate in the community-based construction efforts, leaving his home more than two meters below the street level. While Lucio hired local self-help builders, the construction reflects design shortcomings, including dark living spaces and a lack of plaster to protect the walls from erosion.

Figure 5. Lucio''s lot: low-quality SHQI class. Photo: [First Author].

To illustrate the "medium" SDQI class, we chose Raul's lot (Figure 6). Raul is a community leader and contrary to Ana's husband and Lucio, he participated in collective self-help efforts and received building materials through a Mexico City self-help program in the 1980s. Although Raul hired local self-help builders to complete the construction, he supervised both the design and the actual construction. On his lot, we documented columns that were 45 cm wide, which is more than double the size of standard columns used for this purpose. This illustrates a rather typical problem in self-help construction: builders sometimes design structures that are larger than necessary to make sure they can resist earthquakes and support the load of additional

upper floors. By wasting construction materials, self-help consolidation may in some cases be more expensive than construction by contractors (Bazant 2003, p. 43).

Figure 6. Raul''s lot: medium quality SHQI class. Photo: [First Author].

Ernesto's lot illustrates housing units classified as "medium" quality (Figure 7). Because of his experience as a skilled bricklayer who has led the construction of buildings in Isidro Fabela and other communities in Mexico City, Ernesto was able to build a relatively high-quality structure, but with limitations in the design. Ernesto's story serves to illuminate the co-production of empirical knowledge through the consolidation efforts of self-help builders.

According to Ernesto, his interest in construction started in the late 1960s when, as a child, he assisted his father on construction projects. Ernesto later gained valuable construction skills by working with his neighbors and family members during *faenas*, communal self-help housing efforts led by grassroots community-based organizations, to develop new roads and streets. Ernesto proudly said as he showed us the ongoing construction of the upper floor of his self-help building: "I built it with my own hands." However, Ernesto's lot illustrates another common shortcoming of self-help housing. Because self-help structures grow incrementally, self-help builders have difficulty designing adequate interior staircases to access new upper structures. In Ernesto's case, he uses a deteriorated piece of wood as a ramp to access the third floor of the building.

Figure 7. Ernesto's lot: medium quality SHQI class. Photo: [First Author].

Miguel's lot illustrates the "high" quality SHQI class and also reveals the significant role of women in organizing the community-based faenas (Figure 8). While men invested their sweat equity in collective self-help construction efforts, women formed neighborhood associations to take advantage of the self-help housing policies of the 1980s, negotiating the delivery of in-kind assistance, building materials, and construction tools. As in the case of Ernesto, Miguel learned the craft of blacksmithing from his father and made a living from it. Miguel is well-known in the community for his building skills, and he helped build many of the self-help structures in Isidro Fabela. While it is true that the shortcomings of self-help consolidation are often due to a lack of technical training, we learned from the interviews with Ernesto and Miguel that some self-help

builders have extensive construction knowledge, often acquired while working with formal construction practitioners such as civil engineers on large projects.

Figure 8. Miguel and Celia''s lot: good quality SHQI class. Photo: [First Author].

Because of his construction skills, Miguel's house was built with great attention to structural building codes and the columns were carefully designed to support the roofs. Celia, Miguel's wife, proudly stated that he took a course on self-help construction taught by architects at the Mexico City government complex in the 1990s. As she recounted, Miguel drew the blueprints of the housing unit in class while Celia designed the form and size of the living spaces because she knew her family's housing needs better than anyone else. Based on the rough drawings of the living spaces, the engineers teaching the course provided recommendations for the structural design, including the roofing beams.

Finally, Graciela's lot illustrates the highest SHQI class (Figure 9). Mario, Graciela's husband, is a topographic engineer while Graciela was a leader of the neighbor associations that organized faenas. Also, the economic status of Graciela's family has allowed them to invest in self-help housing improvement. Nevertheless, despite these investments in their housing unit, Graciela and Mario (as well as the other five cases presented here) do not have clean land titles, making it hard to transfer the land or sell their properties.

Figure 9. Graciela''s lot: high-quality SHQI class. Photo: [First Author].

Ultimately, these six cases provide a qualitative illustration of the range of self-help consolidation in Isidro Fabela but also serve to explain the reasons for the range in quality, and hence, more broadly, the heterogeneity of low-income communities. While not determinant factors, housing quality correlated significantly with homeowners' access to social networks, their

level of participation in collective infrastructure work, and their active learning through formal or informal apprenticeships. Through such apprenticeships, some residents learned self-help construction skills by assisting other builders during the communal efforts to develop infrastructure and improve housing units. Also, active participation in social networks allowed some residents to obtain building materials through state-run self-help housing programs, technical assistance provided by architects from the Mexico City government in the late 1970s and 1980s, and access to formal and informal training via courses or participation in construction projects (Table 1).

Case Study	SHQI Class	Incremental Housing Efforts		State Program Provisions	
		Participation in collective housing work	Learning through apprenticeships	Delivery of materials	Technical assistance
Ana	Very low				
Lucio	Low				
Raul	Medium	X		X	
Ernesto	Medium	X	X		
Miguel	High	X	X	X	X
Graciela	High	X	X	X	X

Table 1. Additional factors that contribute to incremental housing quality found in intensive case studies.

5. Results

Our assessment of housing quality complements earlier quantitative indexes of housing quality in Mexico City (Connolly, 2009; Roy et al., 2020) by illuminating a broader spectrum of housing quality variation in socially diverse colonias populares and demonstrating the prolonged continuity of self-help improvement efforts. By coupling architectural observations and household surveys in 108 lots of a representative colonia popular in Mexico City, we were able to develop a dataset of indicators of building quality than is more fine-grained than the aggregated data

available from the national census. The most critical variables included in the proposed SHQI are related to the façade finishing and structure quality, with loadings higher than 0.7, but other variables such as roofs, land leveling, and the quality of the stairs were also statistically significant. Our index of self-help housing quality revealed that almost all self-built homes can be classified as low-to-medium quality, which contrasts with previous studies relying on census data that have categorized housing quality in Isidro Fabela as high (Connolly, 2009; Roy et al., 2020). In fact, only a handful of housing units can be classified as of good quality.

Our intensive case studies allowed us to validate our quantitative analysis while providing a deeper understanding of the history of communal self-help consolidation and the implications of organizing efforts to improve the community's infrastructure. The interviews allowed us to discuss the connections between building quality and the assistance provided by the Habitat Program in the late 1970s, where architects provided technical assistance to residents and self-help builders of informal settlements, as exemplified by Miguel and Celia's case. Also, residents like Raul benefitted from the in-kind support of the Habitat Program, which provided building materials for the construction of complex building systems. Intensive case studies helped document residents' lived experience of self-help consolidation and the factors that drive or undermine building quality over time.

At the same time, our research also revealed the possible limitations of such field assessments. Our household survey questions were not effective in exploring linkages between housing quality, tenancy, and government subsidies for housing upgrading. Given the sensitivity of some survey questions, participants may not know or refuse to discuss tenancy issues or their access to government assistance over time. As a result, land tenure did not appear to influence the self-help housing quality assessment. This finding concurs with Gilbert's (2002) argument that

housing quality is influenced more by perceptions of residents' security than formal land titling. Likewise, access to housing improvement credits provided by the government did not influence self-help housing quality.

6. Conclusions and discussion

Traditional, quantitative slum severity models gloss over the diversity of housing quality because of its limited metrics and the insufficient resolution of census data, limiting the ability to detect the most vulnerable individual housing units in consolidated informal settlements. Scholars including MacTavish et al. (2023) and Stoler et al. (2012) argue that the use of high spatial resolution satellite images can be a viable alternative for the classification of precarious informal communities, under the assumption that differences in pixel texture are associated with construction deficiencies. We recognize the importance of such remote sensing data, as this can undoubtedly reduce costs and allow rapid characterization of large, urbanized regions. However, it is also necessary to recognize the limitations of this approach: most of these studies only show differences between neighborhoods rather than within neighborhoods, and an image will not illuminate the level of housing consolidation beneath the visible part of the structure.

Instead, our methodology draws on the premise that informal settlements are profoundly heterogeneous communities (Gilbert, 2007) where residents have differential access to resources to incrementally improve their homes. Our research illustrates a mixed-methods approach to examining the variation of self-help housing quality that may serve as a reference for consolidated informal settlements across the globe. By combining surveys and architectural observations with intensive case studies, we captured the complex shortcomings and advantages of self-help housing, documented the lived experiences of consolidation efforts (Connolly 2009), and revealed the wide

spectrum of housing quality in the community. Because community participation at the local level is often unfulfilled even in projects inspired by participatory slum upgrading approaches (De Geest & De Nys-Ketels, 2019; Kiefer & Ranganathan, 2020), our research provides insights on how planners can support the inclusion of informal dwellers in housing quality assessment. We see urban planners as the facilitators of the housing upgrading process between residents, governments, and stakeholders, as well as advocates for participation of informal dwellers and community organizations in assessing the needs for housing upgrading, thus allowing for the implementation of more comprehensive, better targeted, and locally supported slum upgrading projects (Kiefer & Ranganathan, 2020). Ultimately, our work highlights the significance of such mixed-methods approaches for developing appropriate, participatory upgrading policies, particularly in aging informal settlements that comprise most of the affordable housing stock on a global level (Bredenoord & van Lindert, 2010). Since such communities display great heterogeneity in housing quality (Gilbert, 2007), participatory slum upgrading must be based on careful, fine-grained assessments to identify precarious self-help buildings at the community level.

To contribute to such empirically based yet participatory slum upgrading, we have proposed a housing quality index that derives from local knowledge, empirical observations, household surveys, and statistical analysis, thus modeling an approach to housing quality assessment that is directly relevant for informal settlements that have experienced lengthy periods of consolidation. Since the index derives from fine-grained data collected through participatory fieldwork, it serves to assess the current state of consolidated self-built homes, document the variability in housing quality within communities, and identify the homes that are in most need of urgent assistance.

In employing a mixed-method approach to investigate the variability of housing quality in informal settlements, our research drew on methods similar to those deployed by Vaid (2021), Boateng and Adams (2023), and Connolly (2009). Vaid (2021) conducted in-depth interviews and focus groups in India while Boateng and Adams (2023) and Connolly (2009) used the insights from previous qualitative research to enhance the variables in their quantitative models in Ghana and Mexico, respectively. However, we suggest that our study expands on the use of qualitative research methods in assessing housing quality, in part because of our integration of observations with surveys, and in part through our participatory development of housing quality measures together with local self-help builders. We built relationships of trust with the residents, which allowed us to engage community leaders, knowledgeable self-help builders, and even residents experiencing high poverty and exclusion in our participatory research. We contend that these qualitative approaches permitted us to not only document but also experience first-hand the inadequacies of self-help housing, such as overflowing latrines and unsafe staircases, from inside people's homes. Such deficiencies cannot be detected by available census data or satellite images.

Beyond such fine-grained empirical documentation and analysis of current housing quality, however, it is necessary to understand the social, historical, and political factors that shape consolidation efforts on the household level. Our approach, therefore, included intensive case studies that served to document other drivers of housing quality, including the ability of families to accumulate economic resources to invest in housing improvements, shared learning through collective housing improvement efforts, and the opportunity to work with other self-help builders. The intensive case studies also revealed that the effort of community leaders, especially women, in negotiating in-kind support from state housing programs was a significant factor in shaping housing quality. This finding concurs with previous research on housing quality in consolidated

informal communities in Buenos Aires, Argentina (Zapata Campos et al., 2022), which identified community organizing as a significant driver of consolidation, and the work of Mitlin & Mogaladi (2013) which highlighted the contributions of women as the managers of collective resources in South Africa.   However, our research also found that many households were unable to engage in faenas and other community-based efforts, depriving them of an opportunity to learn self-help constructions skills. That is to say, while housing quality assessments should include resident participation, such as our collaborative development of housing quality indicators in Isidro Fabela, participatory slum upgrading approaches must also be based on community knowledge and engagement. Technical assistance may serve to address deficiencies of self-help buildings to improve the safety and health of residents in low-quality housing units, but only if such programs are designed with community members in ways that target those most in need (Vaid, 2021).

By shedding light on the heterogeneity of this consolidated informal settlement in Mexico City, our research supports the emerging understanding of the diversity of housing conditions in consolidated informal settlements. The wide spectrum of housing quality in old informal settlements belies the binary narrative of slums which is so commonly reproduced by policymakers, instead revealing that self-help consolidation is a sustainable form of housing production that has allowed most families in Isidro Fabela to improve their homes over the past five decades (Gilbert, 2007; Perlman, 2010). However, the case of Isidro Fabela also underscores that for vulnerable families, self-help housing improvement is an extremely slow process that requires government assistance and the participation of civil society, NGOs, local universities, and donors (Bredenoord et al., 2010; De Geest & De Nys-Ketels, 2019; Kiefer & Ranganathan, 2020). This case study thus serves as a reference for examining housing quality variation in other Global South cities with large proportions of consolidated informal settlements. By providing more

nuanced and empirically based documentation of housing quality in such heterogeneous settlements, participatory approaches to slum upgrading may allow founders and their families to remain in the communities that they developed over time while increasing the availability of affordable housing stock in the central city.

References

Bazant, J. (2003). *Viviendas progresivas: construcción de vivienda por familias de bajos ingresos*. Trillas. Mexico City

Boateng, G. O., & Adams, E. A. (2023). A multilevel, multidimensional scale for measuring housing insecurity in slums and informal settlements. *Cities*, *132*, 104059. https://doi.org/10.1016/j.cities.2022.104059

Bredenoord, J., & van Lindert, P. (2010). Pro-poor housing policies: Rethinking the potential of assisted self-help housing. *Habitat International*, *34*(3), 278–287. https://doi.org/10.1016/j.habitatint.2009.12.001

Caballero Moreno, W. G., Alegre, I., Armengou-Orús, J., & Aguado, A. (2019). Self-construction in informal settlements: a multiple-criteria decision-making method for assessing sustainability of floor slabs in Bucaramanga, Colombia. *Journal of Housing and the Built Environment*, *34*(1), 195–217. https://doi.org/10.1007/s10901-018-9606-5

CONAPO. (2011)*. Índice de marginación por entidad federativa y municipio, 2010*. Mexico City.

CONEVAL. (2020). *Informe de la pobreza multidimensional 2008-2018. Una década de medición multidimensional de la pobreza en México.* Mexico City.

Connolly, P. (2009). Observing the evolution of irregular settlements: Mexico City's colonias populares, 1990 to 2005. *International Development Planning Review*, *31*(1), 1–35.

De Geest, F., & De Nys-Ketels, S. (2019). Everyday resistance: exposing the complexities of participatory slum-upgrading projects in Nagpur. *Housing Studies*, *34*(10), 1673–1689. https://doi.org/10.1080/02673037.2018.1562056

Deuskar, C. (2019). Clientelism and Planning in the Informal Settlements of Developing Democracies. *Journal of Planning Literature*, *34*(4), 395–407. https://doi.org/10.1177/0885412219842520

Deuskar, C. (2020). Informal urbanisation and clientelism: Measuring the global relationship. *Urban Studies*, *57*(12), 2473–2490. https://doi.org/10.1177/0042098019878334

Gilbert. (2007). The return of the slum: does language matter? *International Journal of Urban and Regional Research*, *31*(4), 697–713.

Gilbert, Alan. 2002. "On the Mystery of Capital and the Myths of Hernando de Soto. " International Development Planning Review 24 (1): 1–19. https://doi.org/10.3828/idpr.24.1.1.

Grajeda, E. D., & Ward, P. M. (2012). Inheritance and Succession in Informal Settlements of Latin American Cities: A Mexican Case Study. *Latin American Research Review*, *47*(4), 139–162. https://doi.org/10.1353/lar.2012.0057

INEGI. (2010). Censo de Población y Vivienda 2010.

Kiefer, K., & Ranganathan, M. (2020). The Politics of Participation in Cape Town's Slum Upgrading: The Role of Productive Tension. *Journal of Planning Education and Research*, *40*(3), 263–277. https://doi.org/10.1177/0739456X18761119

MacTavish, R., Bixby, H., Cavanaugh, A., Agyei-Mensah, S., Bawah, A., Owusu, G., Ezzati, M., Arku, R., Robinson, B., Schmidt, A. M., & Baumgartner, J. (2023). Identifying deprived "slum" neighbourhoods in the Greater Accra Metropolitan Area of Ghana using census and

remote sensing data. *World Development*, *167*, 106253.

https://doi.org/10.1016/j.worlddev.2023.106253

Mitlin, D., & Mogaladi, J. (2013). Social movements and the struggle for shelter: A case study of eThekwini (Durban). *Progress in Planning*, *84*, 1–39. https://doi.org/10.1016/j.progress.2012.12.001

Muchadenyika, D., & Waiswa, J. (2018). Policy, politics and leadership in slum upgrading: A comparative analysis of Harare and Kampala. *Cities*, *82*, 58–67. https://doi.org/10.1016/j.cities.2018.05.005

Murray, C., & Clapham, D. (2015). Housing policies in Latin America: overview of the four largest economies. *International Journal of Housing Policy*, *15*(3). https://doi.org/10.1080/14616718.2015.1055090

Patel, A., Koizumi, N., & Crooks, A. (2014). Measuring slum severity in Mumbai and Kolkata : A household-based approach. *Habitat International*, *41*, 300–306. https://doi.org/10.1016/j.habitatint.2013.09.002

Patel, A., Shah, P., & Beauregard, B. E. (2020). Measuring multiple housing deprivations in urban India using Slum Severity Index. *Habitat International*, *101*(March), 102190. https://doi.org/10.1016/j.habitatint.2020.102190

Patel, S. (2013). Upgrade, rehouse or resettle? An assessment of the Indian government's Basic Services for the Urban Poor (BSUP) programme. *Environment and Urbanization*, *25*(1), 177–188. https://doi.org/10.1177/0956247812473731

Perlman, J. (2010). Favela - Four Decades of Living on the Edge in Rio de Janeiro. In *Oxford University Press* (Issue 12).

Reyes, A. (2023). Housing and transportation: The relationship between residential location,

local retail economies, and commutes of low-income families in Mexico City. *Journal of Planning Education and Research*, *43*(4), 1020-1030.

Roy, D., Bernal, D., & Lees, M. (2020). An exploratory factor analysis model for slum severity index in Mexico City. *Urban Studies*, *57*(4), 789–805. https://doi.org/10.1177/0042098019869769

Satterthwaite, David. 2003. "The Millennium Development Goals. " Environment and Urbanization 15 (2): 10–24. https://doi.org/https://doi.org/10.1177/095624780301500.

Stoler, J., Daniels, D., Weeks, J., Stow, D., Coulter, L., & Finch, B. (2012). Assessing the utility of satellite imagery with differing spatial resolutions for deriving proxy measures of slum presence in Accra, Ghana. *GIScience and Remote Sensing*, *49*(1), 31–52. https://doi.org/10.2747/1548-1603.49.1.31

UN-Habitat. (2019). *Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable.* Nairobi.

UN-Habitat. (2003). The challenge of slums: global report on human settlements 2003. https://unhabitat.org/the-challenge-of-slums-global-report-on-human-settlements-2003

Vaid, U. (2021). Delivering the promise of 'better homes'?: Assessing housing quality impacts of slum redevelopment in India. *Cities*, *116*(May), 103253. https://doi.org/10.1016/j.cities.2021.103253

Ward, P. M., Huerta, E. J., & Di Virgilio, M. (2015). Housing policy in Latin American cities: A new generation of strategies and approaches for 2016 UN-HABITAT III. In *Housing Policy in Latin American Cities: A New Generation of Strategies and Approaches for 2016 UN-HABITAT III*. https://doi.org/10.4324/9781315773001

Ward, P. M., Jiménez Huerta, E. R., & Virgilio, M. M. Di. (2014). Intensive Case Study

Methodology for the Analysis of Self-Help Housing Consolidation, Household

Organization and Family Mobility. *Current Urban Studies*, *02*(02), 88–104.

https://doi.org/10.4236/cus.2014.22010

Zapata Campos, M. J., Kain, J.-H., Oloko, M., Scheinsohn, M., Stenberg, J., & Zapata, P. (2022).

Residents' collective strategies of resistance in Global South cities' informal settlements:

Space, scale and knowledge. *Cities*, *125*, 103663.

https://doi.org/10.1016/j.cities.2022.103663