

# The influence of land tenure and dwelling occupancy on disaster risk reduction. The case of eight informal settlements in six Latin American and Caribbean countries



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## ABSTRACT

**Purpose:** This study seeks to understand how land tenure security and dwelling occupancy modes influence disaster risk reduction in precarious urban communities.

**Design/methodology/approach:** We conducted a comprehensive review of recent publications on the relationship between land tenure security, access to credit, housing improvements, and the expected outcome: safer housing and thus risk reduction. We used a database of surveys from a previous study conducted by the authors in eight informal settlements across six Latin American and Caribbean countries in 2017–2018. Bivariate correlation and Point-Biserial correlations analyses were conducted, using the stepwise variable selection for all regressions. This study assesses whether dwelling occupancy mode and land tenure situation predict the changes in disaster risk factors such as dwellings' physical conditions and occupants' social conditions.

**Findings:** Our extensive literature review reveals: (1) securing housing occupancy alone does not automatically address the issue of credit access, nor does it result in house improvement that lead to safer housing; and (2) households with land tenure or occupancy issues that are exposed to natural hazards are frequently excluded from aid distribution and post-disaster reconstruction programs which increases their vulnerability to future disasters. Our statistical analysis found a positive relationship between consolidated mode of occupancy and land tenure with disaster risk factors associated with housing conditions, particularly access to utilities (i.e., water, sewage, and energy).

**Originality/value:** Our study is the result of a systematic process framed within an evidence-based DRR evaluation strategy that brings forth the scope of measures to secure land tenure conditions and consolidate house occupancy modes as means to improve safety and quality of life in informal settlements that ultimately influence the susceptibility of communities to the impacts of natural hazards.

## 1. Introduction

Rapid urbanization worldwide has led to the uncontrolled growth of informal settlements characterized by lack of tenure security and basic services like access to utilities and city infrastructure. Furthermore, informal settlements tend to be located in areas exposed to natural hazards [1,29]. Governments, development agencies, and civil society constantly strive to improve the living conditions for the urban poor in informal settlements by providing land tenure security and access to basic services. Provision of *land tenure security* and *dwelling occupancy* to the urban poor is considered one of several significant steps in reducing vulnerability [8,10,25]. A positive relationship between strong land tenure rights and disaster risk reduction (DRR) is conventionally acknowledged [8]. In general, it is assumed

that securing land tenure rights will kick off a chain of events, opening doors for credit access to people formerly without one. This in turn may spark investments in housing improvement that may lead to safer housing and thus the desired final outcome—disaster risk reduction [9]. We use here the United Nations definition for Disaster Risk Reduction (DRR) “... is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development” [32].

As we begin our examination of the intricate relationship between secure land tenure and housing occupancy, and its implications on DRR, it is important to step back and emphasize the main purpose for such analyses. This study has two major objectives: (1) to review the existing literature on the relationship between land tenure security, credit access, and housing improvements that lead to the expected outcomes of safer housing and disaster risk reduction; and (2) to conduct a study on Latin American and the Caribbean region's informal settlements to assess whether land tenure

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status and dwelling occupancy modes are associated with two types of risk determinants: the physical conditions of the dwelling and the social conditions of its occupants. Our research ultimately seeks to benefit vulnerable groups of people whose rights and needs get lost or compromised in political, legal, and technocratic discussions. Often, the forest is lost for the trees in academic pursuits as well and hence a periodic reminder serves well. These vulnerable groups are low-income households comprising renters, squatters, migrants, and other populations who are frequently or consistently neglected or isolated from regular urban planning and disaster risk management processes and risk transfer measures [2,14]. According to Godschalk, “the poorest and most vulnerable communities within a city are the weakest links in its mitigation capacity” ([13]: 140). When a disaster occurs, these populations, already in situations of extreme fragility, now face a complex reality that reveals the existence of gaps and unresolved conflicts in the regulatory and institutional frameworks regarding land tenure and property rights relations in urban areas. These challenges often exacerbate existing vulnerabilities to human rights violations and economic exploitation [14].

Insecure land tenure increases disaster vulnerability even before disasters strike. For example, when insecure land tenure leads to eviction or loss of land, people lacking economic means, strong social networks, and employment alternatives could lose their livelihoods or housing or both. Insecure land rights and even the perception of insecurity of land tenure discourages people from making investments in housing improvements [25], compromising their ability to anticipate and prepare for disasters.

Thus, poverty, isolation from urban planning processes, and insecure land tenure form a potent combination in informal settlements leading to unsafe housing conditions unable to withstand hazards. This socio-economic vulnerability of communities adds to their vulnerability against future hazards. Land tenure and the dwelling occupancy modes are essential components of socio-economic vulnerability. In this paper we seek a nuanced understanding of disaster risk reduction as related to land tenure issues. We characterize the land tenure status of households using two types of risk determinants—the physical considerations of a dwelling and the social considerations of its occupants. We use data for the two risk determinants and for the land tenure status from households in eight informal marginalized communities across six Latin American and Caribbean (LAC) countries from our recent study on urban program evaluation [26]. By understanding the linkage between land tenure and the two risk determinants, we can explain how land tenure security reduces disaster risk, thereby increasing disaster resilience. We expect that our study on the influence of land tenure security and dwelling occupancy modes on disaster risk reduction will pave the path for a deeper comprehension of socio-economic resilience of communities.

This work is part of a series of studies resulting from the evidence-based urban DRR strategy for informal settlements defined by Sarmiento et al. [27]. This particular study focuses on the outcomes of the Building Resilience and Capacities for Emerging Disaster (BRACED) project implemented by Habitat for Humanity in Portland-Jamaica, building a set of evidences from the project's findings that will serve different stakeholders in their decisions on land tenure security, dwelling occupancy modes, and resilience.

The outline of the paper is as follows. In Section 3, we introduce the methodology for our study. This section comprises a literature review and survey analysis, along with the study hypotheses that explore the relationships between land tenure and dwelling occupancy with the two types of risk determinants: the physical considerations of the dwelling and the social considerations of its occupants. Section 4 explains the results of the statistical analysis, highlighting the main findings. The fourth section discusses the results and compares them against the current literature, indicating some of the study constraints and limitations. Finally, the conclusions.

## 2. Methodology

We conducted a literature review to study the relationship between land tenure security, credit access, and housing improvements that lead to the expected outcomes of safer housing and disaster risk reduction. We then

present our hypotheses and study variables. This is followed by a statistical analysis of a survey database to investigate the hypotheses to assess whether land tenure status and dwelling occupancy modes are associated with two types of risk determinants: the physical conditions of the dwelling and the social conditions of its occupants. We used a survey database from our recent previous study [26] in eight informal settlements across six Latin American and Caribbean countries. Bivariate correlation and Point-Biserial correlations analyses were conducted, using the stepwise variable selection for all regressions.

### 2.1. From land tenure and dwelling occupancy modes toward housing investment and disaster risk reduction

#### 2.1.1. Land tenure and dwelling occupancy modes

Land tenure and housing occupancy form a complex theme, involving a wide range of approaches and practices that usually fall within regulatory frameworks. However, more often than not land tenure practices are simply culturally accepted, responding to deeply embedded historical processes and contexts, so they vary considerably from country to country. Whether legally or customarily defined, land tenure is the relationship between people, as individuals or groups, with respect to land. In simple terms, “land tenure systems determine who can use what resources for how long, and under what conditions” ([12]:5). Land tenure refers to “the conditions under which land resources are held and used” ([17]: 38).

Land tenure and property rights (LTPR) is a common term used by development agencies to refer to “the systems that define and regulate how people, communities, and others gain access to natural resources, whether through formal law or informal arrangements” [8]. According to FAO [12] land tenure can be categorized into four types of property rights regimes: (1) private (individual, groups, commercial, non-profit); (2) communal (where each member has a right to use the community assets independently); (3) open access (specific rights are not assigned to anyone and no one can be excluded); and (4) state (property rights are assigned to some authority in the public sector). The four types of property regimes differ in “the nature of ownership, the rights and duties of owners, the rules of use and the locus of control” ([7]: 5).

Formal property rights are those that are explicitly acknowledged by the authority, and informal property rights are those that lack official recognition and are considered—in many instances—illegal. In some countries there is a third status, called “extra-legal”, where the rights are not against the law, but not recognized by the law either. Customary property held by indigenous communities falls into this category. In some cases, property rights can have different regimes vis-à-vis land and housing ownership: in the former, owners own the land and immovable property (e.g., house, building, etc.), and in the second, owners just own the immovable property and not the land [26].

It is common to find references in the literature for land tenure security, understanding it as “...the certainty that an individual's rights to land will be recognized by others and protected in cases of specific challenges; or, more specifically, the right of all individuals and groups to effective government protection against forced evictions” ([19]: vii). This security as certainty would also apply for housing occupancy [21].

Land administration—formal or informal—encompasses land tenure rules and how they are applied. This includes formalization, registration, rights transfer mechanisms, regulation enforcement, valuation and taxation, among others. Formal and informal mechanisms can coexist, generating ambiguities that hinder the definition of the legal status of land, local tenure practices prevailing in most cases [12].

Mitchell & Herrera [19] interpret access to land and housing as the “opportunities for temporary or permanent use and occupation of land for purposes of shelter, productive activity or the enjoyment of recreation and rest”. This access to use and uses of land can be obtained in four different ways: (1) direct occupation; (2) exchange (purchase or rental), (3) membership of family and kin groups or; (4) allocation by government, other land owners, or management authorities. This access encompasses both legal

and illegal modes of occupancy, 'direct occupation' being the most common beginning among informal settlements.

Since 2005, the Brazilian Census Bureau (IBGE) National Household Survey (Pnad) refers to different modes of housing occupancy as "dwelling occupancy modes" ([20]: p.17). These are arranged in six categories: (1) owned, paid; (2) owned, paying; (3) rented; (4) rent-free, ceded by employer; (5) rent-free, ceded by family and; (6) other tenure arrangement such as encroachments. More recently, Sarmiento et al. [26] measured housing occupancy regardless of the legal condition of land.

In this study, we distinguish five different dwelling occupancy modes: (1) Own house (fully paid); (2) Own house (paying for term); (3) Leased/rented property; (4) Housing provided for work, and; (5) Free housing. The last refers to rent-free occupancy in the sense of Mitchell & Herrera [19], where land access was ceded through membership of family (e.g., inheritance) or allocated by government, other land owners, or management authorities, regardless of the legal status [26].

### 2.1.2. Land tenure, welfare, investment, and credit access

The systematic review carried out by Lawry et al. [18] suggests that long-term programs and policy investments in perceived tenure security are "plausible channels" ([18], p.68) through which tenure recognition may contribute to welfare for those who receive title. Nyametso [21] reached similar conclusions in their study of the relationships between land tenure security, access to housing, and improved living and environmental conditions in Accra, Ghana. More recently, Morais and Oliveira Cruz [20] found a positive relationship between housing conditions and access to durable goods on homeownership and tenure in Brazil.

Evidence that security in tenure will lead landowners or households to invest in safer housing, or perhaps seek access to credit to do so, is mixed. Lawry et al. [18] conducted an extensive literature review to understand relationships between tenure security, registration, agricultural productivity, and investment, concluding that in the rural context tenure security alone is not a 'silver bullet' to assure the expected sequence of events and outcomes. The evidence for impact on investment from formalization of rights through land titling was mixed—meagre in some cases while increasing productivity and slowing forest loss in others. In the case of statutory recognition of customary land rights, the authors did not find any quantitative evidence of sufficient quality regarding investment or productivity outcomes. Gains in productivity and investment require long-term observation and may vary in significant ways, depending on variables such as access, performance, and markets. Most importantly, the authors found no effect of land tenure security on credit access. Land tenure reforms may also result in negative social impacts as socially and economically weak groups like women and the poor are further disadvantaged as changing laws continually fail to accommodate their rights [18].

According to Payne et al. [23], one of the main reasons to work on land titling among other tenure alternatives is because property titles can be used as collateral in accessing formal credit. Nevertheless, the same authors conducted an extensive literature review where no evidence was found that land titling significantly increased access to credit for low-income households. They argue several possible reasons for this: (1) resistance from the poor to borrow from banks, and from banks to lend to the poor; (2) a slum dwelling is not an attractive collateral; and (3) other strategies rather than titling could work better in accessing credit (i.e., micro-credit institutions and pro-poor banks).

Renters represent the demographic who do not have access to credit as homeowners do and consequently tend not to make investments in housing for lack of stake in property ownership. Studies in New Orleans have shown that this failure to mitigate disasters through housing improvement proved to be especially detrimental to renters in the wake of Katrina in 2015 (Burby et al. 2003 in [25]).

### 2.1.3. Land Tenure and Disaster Risk

Factors that affect disaster risk are a result of several underlying causes, influenced by power relations and the allocation and distribution of resources in society [5]. One salient risk determinant, poverty,

is closely linked to land tenure security. Land is an important asset supporting livelihoods, and insecure land or lost land could threaten livelihoods [28]. Reale & Handmer [25] carefully analyzed the Lower Ninth Ward in New Orleans following Hurricane Katrina, confirming that vulnerability is usually generated where a household owns few assets besides the land they occupy, or where costs for housing or land demand most of the household's income.

Since 2014, Habitat for Humanity (HfH) and Jamaica's Land Administration and Management Program (LAMP) have been developing a pilot activity in the community of Naggo Head in Portmore. This initiative aims to help communities exposed to disaster risk in acquiring a registered title. The project, based on empirical evidence, points to the positive cascade effect of land registration on credit access, housing improvement, and risk reduction, with one process leading to the next.

However, obtaining property titles alone will not address the issue of access to credit, and further, reduce risk [11]. What is clear and can be stated with confidence is that lack of land tenure combined with exposure to natural hazards may result in an exclusion from aid distribution and post-disaster reconstruction programs, making communities across the globe more vulnerable to future disasters. This was starkly evident in the aftermath of the 2010 Haiti earthquake where the recovery efforts for the >1.5 million displaced people were obstructed by a chaotic land registration system, competing claims over land and property, and lack of legal security [16]. In Sri Lanka, after the devastating 2004 tsunami, the reconstruction process was severely complicated by lack of land tenure, among other factors. Ill-planned recovery solutions like a buffer zone created along the coastline to purportedly provide protection from further disasters led to housing discrimination against the undocumented outside the buffer zone. Fishermen were forced to relocate inland which severely impacted their livelihoods [6]. More than a third of the population of Leyte and Eastern Samar in the Philippines affected by the 2013 Typhoon Haiyan comprised the extremely poor living in informal settlements. These communities with insecure forms of tenure faced higher risk of eviction upon their return and in their efforts to repair and rebuild their homes [22]. In sum, secure land tenure is critical in assuring restoration of shelter and livelihoods and reducing the risks of precariousness in communities [8].

## 2.2. Hypotheses and variables

Our first hypothesis explores how land tenure and dwelling occupancy modes are related to housing improvement. We assume that housing improvement can be evidenced through the state of its physical considerations.

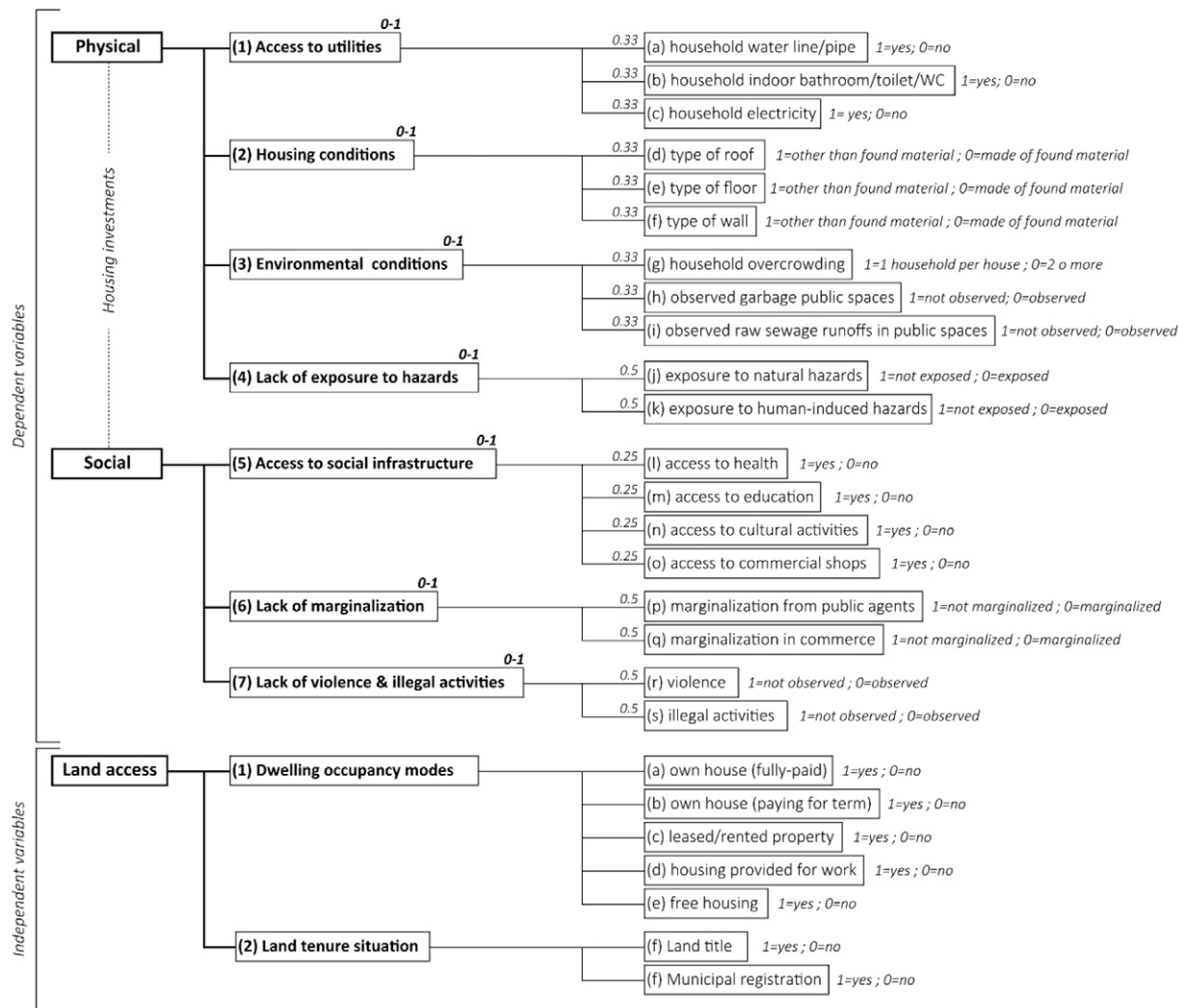
**Hypothesis A.** Securing land tenure and dwelling occupancy predict better physical conditions for dwellings.

Land tenure and dwelling occupancy modes form the independent variables of our study. The physical conditions considered for analyses of **Hypothesis A** are the dependent variable in our study. The four physical conditions of dwellings are: (1) Access to utilities; (2) Housing conditions; (3) Environmental conditions; and (4) Exposure to hazards. Each physical condition is a composite variable that contains sub-elements (see Fig. 1) as described in the Informality and Precariousness Index (IPI) proposed by Sarmiento et al. [26]. The sub-elements correspond to the variables originally collected as categorical and dichotomous (yes/no) in the 2018 study.

We acknowledge that not all housing investments can be attributed to the occupants alone. Investments from exogenous sources (i.e., municipality, civil society, international donors, etc.) are also likely. In our study, the relationship between dwelling occupancy and housing conditions (the proxy for dwelling investment) does not discriminate the source of the investment.

Our second hypothesis explores other co-factors involved in the type of land tenure and dwelling occupancy mode:

**Hypothesis B.** Securing land tenure and dwelling occupancy predict better social conditions for its occupants.



**Fig. 1.** Organization of dependent and independent variables: Physical and social considerations of households, land tenure situation, and dwelling occupancy modes *Note: \*Free housing ceded through membership of family and kin groups (e.g., inheritance), or by allocation by government, other land owners, or management authorities. It also considers other tenure arrangements such as encroachments and occupation. \*\*Land tenure situations were collected as dichotomous variables: (f) land title; and (g) municipal registration. The land title is often associated with a property rights regime within a national legal system while the municipal registration refers to land registration (different from titling) on the municipal or regional cadastral system.* Source: Authors, based on Sarmiento et al. [26].

The social conditions of occupants are defined as dependent variables for this study and are represented by the composite and continuous variables used in the IPI by Sarmiento et al. [26]. These are: (5) Access to social infrastructure; (6) Marginalization, and; (7) Violence and illegal activities.

The independent variables in this study, as described in the IPI by Sarmiento et al. [26], are the: (1) dwelling occupancy mode, and (2) land tenure status (Fig. 1).

### 2.3. Study data

We used the survey data gathered by Sarmiento et al. [26] for their evaluation of the Urban Disaster Risk Reduction (DRR) programming carried out in Latin America and the Caribbean, supported by the United States Agency for International Development’s Office of U.S. Foreign Disaster Assistance (USAID/OFDA). The surveys were conducted in 2017–18 in eight projects operating in six countries: Colombia, Guatemala, Haiti, Honduras, Jamaica, and Peru. These projects had applied USAID’s Neighborhood Approach for DRR (NA-DRR) to find practical and workable solutions for DRR in densely populated informal urban settlements.

#### 2.3.1. Sample

The surveys targeted the head of a household or spouse in each of the eight neighborhoods. It was assumed that the NA-DRR projects benefitted an average 100 households per neighborhood, totaling a population size of 800 households. The estimated sample size was obtained using the sample size calculator, Raosoft Inc. [4], with a margin of error of 3.94% and a 95% confidence level, resulting in  $n = 320$ . The survey process was completed with an average of 44 surveys per project, and a total of 349 surveys. Each survey consisted of 39 questions grouped into four sub-topics: social cohesion, DRR, urban informality, and Life Satisfaction Analysis (LSA). A preceding section in the survey included georeferencing, information on demographics and socioeconomic aspects of household respondents, and a rapid inspection of housing physical conditions. The study design went through the Institutional Review Board (IRB) review and registration, under the “exempt” category.

#### 2.3.2. Statistical analyses

Statistical analyses were conducted in SPSS (Version 24) for Windows (SPSS, Inc., Chicago, IL, USA). We began by conducting Point-Biserial correlations between the dwelling occupancy modes and land tenure situation

and: 1) existing physical conditions (**Hypothesis A**); and 2) existing social conditions (**Hypothesis B**). Once significant associations were established, we conducted multivariable linear regressions to determine whether the independent variables (dwelling occupancy mode and land tenure situation) predict the dwellings' physical conditions and the social conditions of their occupants. Stepwise variable selection method was utilized [15]. Fit statistics (i.e.,  $F$ ,  $R^2$ , and adjusted  $R^2$ ) and predictor coefficients (i.e., unstandardized, standardized, 95% confidence intervals, and part correlations) are reported.

### 3. Results

#### 3.1. Descriptive statistics

Table 1 summarizes the descriptive statistics associated with the independent variables (predictors): occupancy modes and land tenure situation; and the dependent variables (outcomes): physical dimension of housing investments (**hypothesis A**) and the social dimension (**hypothesis B**). Because of the reduced  $N$  in two of the independent variables under municipal registration, we grouped the five variables in three categories: 1) Own the house (full and paying); 2) leased/rented property; and 3) Free or work provided house.

Table 2 presents the point-biserial correlations between dependent and independent variables.

Based on the outcomes of the correlations, we decided to focus our statistical analysis on 4 of the 7 dependent variables, specifically from physical conditions: 1) Access to Utilities and 2) Housing Conditions and from social conditions: 3) Access to Social Infrastructure and 4) Lack of Marginalization.

#### 3.2. Results of the multivariable linear regression

Table 3 shows the outcomes of a multivariable linear regression using physical conditions as the dependent variable.

The outcomes of the multivariable linear regression (Table 3) were analyzed using the two dependent variables selected.

**Table 1**  
Descriptive statistics for study variables.

Predictors	n (%) <sup>a</sup>	
Occupancy		
Owning house in full or paying	279 (79.9%)	
Leased/rented	50 (14.3%)	
Free or work-provided house	20 (5.7%)	
Tenancy		
Land title	179 (53.0%)	
Municipal	224 (70.7%)	
Outcomes	M (SD) <sup>b</sup>	
<b>Hypothesis A</b> Physical Conditions	Access utilities	0.848 (0.310)
	Housing conditions	0.703 (0.242)
	Environmental conditions	0.529 (0.266)
	Lack of exposure to hazards	0.224 (0.323)
<b>Hypothesis B</b> Social Conditions	Access to social infrastructure	0.689 (0.208)
	Lack of marginalization	0.938 (0.174)
	Lack of violence and illegal activities	0.798 (0.299)

<sup>a</sup> Valid percent (i.e.,  $n$  divided by data available).

<sup>b</sup>  $n$  ranged from 325 to 349.

#### 3.2.1. Access to utilities

The overall regression model was statistically significant  $F(3,308) = 26.44, p < .001$ . The coefficient of determination ( $R^2 = 0.204$ ) indicated that 20.4% of the variance in 'access to utilities' was predicted by the model (adjusted  $R^2 = 0.196$ ). The stepwise variable selection method retained three of the five predictors. Results indicated that 'having the house registered at the municipal cadastral,' 'owning a house in full or paying,' and 'having land title,' predicted higher 'access to utilities' values. The squared part correlations ( $sr^2$ ) indicated that the variance in access to utility uniquely predicted by each variable was as follows: 'having the house registered at the municipal cadastral' (8.6%); 'owning house in full or paying' (1.6%); and 'having land title' (1.4%).

#### 3.2.2. Housing conditions

The overall regression model was statistically significant  $F(1,312) = 11.03, p < .01$ . The coefficient of determination ( $R^2 = 0.034$ ) indicated that 3.4% of the variance in 'housing conditions' was predicted by the model (adjusted  $R^2 = 0.031$ ). The stepwise variable selection method retained one of the five predictors. Results indicated that 'leased/rented property' predicted higher 'housing conditions' values.

Table 4 shows the outcomes of a multivariable linear regression using social conditions as dependent variable.

The outcomes of the multivariable linear regression (Table 4) were analyzed using the two dependent variables selected.

#### 3.2.3. Social infrastructure

The overall regression model was statistically significant  $F(1,309) = 6.17, p < .05$ . The coefficient of determination ( $R^2 = 0.02$ ) indicated that 2.0% of the variance in 'Social Infrastructure' was predicted by the model (adjusted  $R^2 = 0.016$ ). The stepwise variable selection method retained one of the five predictors for the physical conditions. Results indicated that 'having the house registered at the municipal cadastral' predicted higher 'Social infrastructure' values.

#### 3.2.4. Lack of marginalization

The overall regression model was statistically significant  $F(2,309) = 4.95, p < .01$ . The coefficient of determination ( $R^2 = 0.031$ ) indicated that 3.1% of the variance in 'lack of marginalization' was predicted by the model (adjusted  $R^2 = 0.025$ ). The stepwise variable selection method retained two of the five predictors for the physical considerations. Results indicated that 'having land title' predicted lower 'lack of marginalization' values and 'owning a house in full or paying' predicted higher 'lack of marginalization' values. The squared part correlations ( $sr^2$ ) indicated that the variance in 'lack of marginalization' uniquely predicted by each variable was as follows: 'having land title' (2.3%), and 'owning house in full or paying' (1.4%).

The outcomes of the multivariable linear regression are in the range of 'low' and 'very low' for 'having land title' and 'owning house in full or paying', respectively. Even though the outcomes are positive, they do not sufficiently explain the variance in the social conditions of the dwellings' occupants.

## 4. Discussion

The current study aimed to review the literature on the relationship between land tenure security, credit access, and housing improvements that lead to the expected outcomes of safer housing and disaster risk reduction, and to examine whether securing land tenure and dwelling occupancy are associated with two types of risk determinants: the physical conditions of the dwelling and the social conditions of its occupants.

The literature review revealed that obtaining property titles alone will not address the issue of access to credit, and further, reduce risk. However, lack of land tenure combined with exposure to natural hazards may result in an exclusion from aid distribution and post-disaster reconstruction programs, making communities more vulnerable to future disasters.

**Table 2**  
Correlations for dwelling occupancy modes, land tenure, and physical and social dimensions of housing investments.

			Access to utilities	Housing conditions	Environmental conditions	Lack of exposure to hazards	Access to social infrastructure	Lack of marginalization	Lack of violence and illegal activities
Occupancy Mode	Owning house in full or paying	Pearson Correlation	0.183**	-0.043	-0.153**	0.031	0.098	0.074	0.053
		Sig. (2-tailed)	0.001	0.421	0.004	0.571	0.070	0.167	0.345
		N	347	349	348	333	345	346	325
	Free or work-provided house	Pearson Correlation	-0.145**	-0.105	0.082	-0.019	-0.139**	-0.018	-0.029
		Sig. (2-tailed)	0.007	0.050	0.128	0.735	0.010	0.734	0.597
		N	347	349	348	333	345	346	325
Leased/Rented Property	Pearson Correlation	-0.113*	0.119*	0.120*	-0.023	-0.021	-0.073	-0.041	
	Sig. (2-tailed)	0.035	0.026	0.025	0.673	0.704	0.175	0.467	
	N	347	349	348	333	345	346	325	
Land Tenure	Land title	Pearson Correlation	0.283**	0.011	-0.068	-0.036	0.111*	-0.131*	-0.096
		Sig. (2-tailed)	0.000	0.839	0.213	0.520	0.043	0.017	0.088
		N	336	338	337	325	334	336	316
	Registration at municipal cadastral	Pearson Correlation	0.408**	-0.138*	-0.006	-0.003	0.142*	-0.052	0.069
		Sig. (2-tailed)	0.000	0.014	0.909	0.954	0.012	0.361	0.236
		N	315	317	316	306	314	314	297

\*  $p < 0.05$ .  
\*\*  $p < 0.01$

Additionally, secure land tenure is critical in assuring restoration of shelter and livelihoods and reducing the risks of precariousness in communities.

The multivariable linear regression showed that the more consolidated the mode of occupancy and land tenure situation, the better the housing conditions, particularly access to utilities (i.e., water, sewage, and energy). Our study results are congruent with the literature reviewed. Another

**Table 3**  
Multivariable linear regressions using physical conditions.

	Unstandardized beta			Standardized beta	Sig. $p$	Part correlation	
	B	95% CI	SE			$\beta$	sr
<b>Access to utilities</b>							
(Constant)	0.540	0.456–0.625	0.043		0.000		
Municipal Registration	0.226	0.149–0.304	0.039	0.326	0.000	0.293	0.086
Owning house Having Land title	0.113	0.024–0.202	0.045	0.132	0.013	0.127	0.016
	0.082	0.012–0.152	0.036	0.129	0.022	0.117	0.014
Fit statistics	$R^2 = 0.204$ ; Adj $R^2 = 0.196$ ; $F(3,308) = 26.244$ , $p < .001$						
<b>Housing conditions</b>							
(Constant)	0.692	0.665–0.719	0.014		0.000		
Leased/Rented Property	0.137	0.056–0.218	0.041	0.185	0.001	0.185	0.034
Fit statistics	$R^2 = 0.034$ ; Adj $R^2 = 0.031$ ; $F(1,312) = 11.032$ , $p < .01$						

**Table 4**  
Multivariable linear regressions using social conditions.

	Unstandardized beta			Standardized beta	Sig. $p$	Part correlation	
	B	95% CI	SE			$\beta$	sr
<b>Social infrastructure</b>							
(Constant)	0.641	0.599–0.684	0.022		0.000		
Municipal Registration	0.064	0.013–0.115	0.026	0.140	0.014	0.140	0.020
Fit statistics	$R^2 = 0.02$ ; Adj $R^2 = 0.016$ ; $F(1,309) = 6.168$ , $p < .05$						
<b>Lack of marginalization</b>							
(Constant)	0.917	0.867–0.967	0.025		0.000		
Having Land title	-0.055	-0.095–0.015	0.020	-0.156	0.007	-0.152	0.023
Owning house	0.059	0.005–0.113	0.028	0.123	0.033	0.121	0.014
Fit statistics	$R^2 = 0.031$ ; Adj $R^2 = 0.025$ ; $F(2,309) = 4.949$ , $p < .01$						

interesting result is that dwellers leasing or renting tend to have better housing conditions (i.e., roofing, floor, and walls). This observation aligns with Aravena et al. [3]’s research which explains ‘leasing out’ as an income-generation strategy that implies an initial investment to introduce that asset—either a room or house—into the informal market.

Despite finding important correlations between homeownership, land tenure, and access to utilities, no other statistically significant evidence was found on how consolidated occupancy modes and land tenure are associated with other dimensions of physical and social investments.

One interesting observation is that ‘having a municipal registration’ predicted 8.6% of the variance in ‘access to utilities’ vs. ‘having a title’ that only predicted 1.4% of the variance. This finding is consistent with other studies that show how in some cultures the ‘perceived’ tenure security is preferred over the legal land title, and people with higher perceived tenure security invest more money in their dwellings than people with lower perceived tenure security—the latter probably because of the fear of eviction ([24,30,31]).

Overall, the results of the current study support **Hypothesis A**: securing land tenure and dwelling occupancy are associated with better physical conditions for dwellings, particularly access to utilities. The results also underscore the complexity of the relationship as it explains only a portion of the variance in the house’s physical conditions, an outcome consistent with other studies on the subject [21]. The second **Hypothesis B** is statistically positive, though the low values obtained do not fully explain the variance in the outcomes. The models obtained for social conditions showed a relatively low proportion of variance, and limited to the variable of

marginalization, where households with land title predict higher values of perceived marginalization than households that own the house.

There is no significant evidence showing that consolidated modes of occupancy and land tenure would produce comprehensive improvements in housing and environmental conditions, nor result in reduced exposure to natural and human-induced hazards. This finding leads us to recommend that efforts to acquire tenure security for vulnerable communities should simultaneously and proactively seek to incorporate measures and investments, albeit small, in housing improvements that mitigate disaster risk. The Habitat for Humanity project in Jamaica offers an excellent example of how in the process of providing tenure security in vulnerable communities, retrofitting investments (addition of brackets, hurricane straps) were made in the households exposed to hurricane risk. These development measures go hand in hand with short-term disaster risk reduction efforts and are a step forward in comprehensively reducing vulnerability of informal settlement communities. It is important to keep in mind that land tenure practices are context driven and vary considerably from country to country.

## 5. Conclusions

A careful literature review reveals: 1) secure housing occupancy alone does not automatically address the issue of credit access, nor does it result in housing improvement; and 2) households with land tenure or occupancy issues and exposed to natural hazards frequently get excluded from aid distribution and post-disaster reconstruction programs, increasing their vulnerability to future disasters. Our statistical analysis found that the more consolidated the dwelling occupancy and land tenure, the better the housing conditions, particularly the access to utilities (i.e., water, sewage, and energy).

Our study is the result of a systematic process framed within an evidence-based DRR evaluation strategy. It brings forth the scope of measures geared to secure land tenure conditions and consolidate housing occupancy modes and their impact on access to utilities, and the undoubtedly concomitant contribution to the improvement in quality of life for communities in informal settlements. In addition, access to utilities is per-se a risk factor, which strongly influences the susceptibility of communities to the impacts of natural hazards. Ultimately, securing land tenure and dwelling occupancy leads to strengthening community resilience.

The level of variable desegregation used and the statistical analysis, driven by the variable access to utilities, confirmed the hypothesis—securing land tenure and dwelling occupancy predict better physical conditions for dwellings. However, it was not possible to demonstrate association between securing land tenure conditions and dwelling occupancy with other critical aspects of physical conditions such as hazard exposure, environmental conditions, nor with physical dwelling features such as identifiable structural conditions of walls and roofs. The results for the second hypothesis—securing land tenure and dwelling occupancy predict better social conditions for dwellings' occupants—show the complexity of the relationships among the predictors and outcomes as the former only explain a small portion of the variance in the latter.

An important factor to keep in mind is that investments in dwellings cannot be attributed exclusively to programs that secure land tenure and dwelling occupancy. These investments are part of a common process used by informal occupants to claim rights over land.

Projects designed to secure land tenure conditions and consolidate housing occupancy modes should include basic and low-cost retrofitting investments to reduce vulnerability and increase disaster resilience in informal settlement communities exposed to natural hazards.

We recommend robust longitudinal studies to demonstrate other DRR implications associated with measures aimed at securing land tenure and housing occupancy. For now, we have sufficient evidence to show that households exposed to socio-natural hazards and with issues of land tenure and housing occupancy are frequently excluded from development assistance, post-disaster aid distribution and reconstruction programs, deepening their fragile socio-economic conditions and making them even more vulnerable to future disasters.

## Declaration of competing interest

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

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