



Risk Transfer for Populations in Precarious Urban Environments

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Abstract This study explores risk transfer options that precarious and marginal urban communities could use to protect themselves from future damages and losses generated by socio-natural hazards and disasters at the individual and community levels. The design is framed within an evidence-based disaster risk reduction (DRR) strategy and follows the case study research approach. We analyze the 2018 Neighborhood Approach for DRR programming evaluation carried out in four Latin American cities' informal settlements and review relevant risk transfer experiences aimed at vulnerable populations. We calculate the pure risk premium for the four cases selected, using a previous catastrophe risk assessment for earthquakes and landslides. We propose three risk transfer options based on our analysis: (1) voluntary collective insurance; (2) structural reinforcement with a comprehensive housing insurance; and (3) hybrid parametric insurance. Risk transfer mechanisms conventionally focus on residual risk management. Here, due to the precariousness of the analyzed urban settings, the proposed alternatives go beyond the management of just residual risk to positively impact the beneficiaries' quality of life and the reduction of the built environment's physical vulnerability in the short and medium terms. Our study proposes a prospective estimation of future risk despite the limitations of data availability. This study opens a window to new approaches and proposes a systematic process to design DRR policy aimed at the poor and vulnerable strata of society.

Keywords Case study research · Catastrophe risk assessment · Informal settlements · Risk transfer · Urban precariousness · Urban risk

1 Introduction

Fifty-five percent of the world's population lived in urban areas in 2018 and this figure is expected to increase to 66% by 2050 (UNDRR 2019). Most of this growth will take place in cities in Africa, Asia, and Latin America where the rate of expansion of informal settlements, or slums, is staggeringly high. In 2014, 880 million people lived in slums worldwide (UNDRR 2019). Urban planning capacities struggle to meet the growing needs of housing, compelling people to build houses on lands unsuitable for living, often in areas of high environmental fragility or exposed to socio-natural risks. Urban precariousness can be understood as household conditions of informal and marginal urban settlements that are characterized by deficiency in the quality of housing materials, lack of access to utilities (that is, electricity, water, and sanitation), and issues of tenure. These circumstances are frequently associated with poverty-ridden households, and to a lesser extent with households on the poverty line (Winchester 2008; Marin et al. 2018). Alongside the increase in socioeconomic and environmental vulnerabilities, the continuous and uncontrolled physical expansion and densification of urban areas causes further marginalization and pauperization of precarious communities (Gencer 2013). In the presence of natural and human-induced hazards, these factors accentuate the exposure and susceptibility factors, resulting in higher risk in urban informal environments (Gencer 2013). It is this concurrence of poverty and disaster risk that

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motivates a broader reflection on DRR strategies and decisive action from both development and disaster risk management actors.

Significant efforts have been made to reduce disaster risk in urban settings in the last two decades, but the strategy has largely focused on physical engineering works. Meanwhile, the link between the cycles of poverty induced by the constant presence of disaster risk conditions has not received the attention it deserves. Initiatives to reduce the financial losses that communities incur in the aftermath of disasters, especially in precarious urban settlements, lag behind. It is only in recent years that disaster risk management has grown to encompass compensatory financial strategies to address the risk that remains after an action geared to reduce exposure, susceptibility, or even a hazard's impact has been implemented. This remaining risk is called residual risk. Risk transfer is one type of compensatory financial approach to manage residual risk, which favors response and recovery after a disaster.

Across the globe, very few records of disaster risk transfer instruments for populations in precarious urban environments are found (Cummins and Mahul 2008). Most studies highlight microinsurance, a kind of risk transfer instrument generally associated with climate risks in the agricultural sector (Clarke and Grenham 2011). The low use of instruments in urban settings is explained by factors such as the cost of insurance in relation to the payment capacity of potential users, the incipient advancement in risk mitigation, the lack of awareness about available risk transfer instruments, and the absence of an enabling environment with sound policies and incentives (Prabhakar et al. 2015).

This study uses a case study research approach, analyzing four of the eight urban DRR projects that various nongovernmental organizations (NGOs) implemented in Latin American and Caribbean (LAC) countries between 2011 and 2016 under the Neighborhood Approach for DRR (NA-DRR) program. These projects were supported by the United States Agency for International Development's Office of Foreign Disaster Assistance (USAID/OFDA). The four case studies are located in the District of Independencia (Lima, Peru), Medellín (Colombia), Mixco (Guatemala), and Tegucigalpa (Honduras). These four projects provide an excellent real-life context to hypothetically apply hitherto unexplored risk transfer mechanisms in precarious urban communities where DRR measures had been implemented for earthquakes and landslides.

Although specially tailored for the study sites, the risk transfer instruments could also be used by other precarious urban settlements facing similar risks. The suggested mechanisms are meant to complement and support the

sustainability of programs aimed at reducing the physical and social vulnerability in precarious urban settlements.

Section 2 explains the concepts of risk transfer and financing, and presents secondary data on the catastrophe risk assessment of the four precarious urban settlements that serve as research cases for this study. Section 3 describes the study methods, including a literature review on risk transfer instruments and the financial calculation of insurance premiums. Section 4 presents and discusses the results based on the four neighborhoods' characterizations, the catastrophe risk estimates, and the revised financial strategies where different risk transfer instruments are proposed. The section elaborates on the analysis and contextualization of the results and addresses the limitations of the study.

2 Addressing Residual Risk and Precarious Urban Environments

This section introduces the concepts of risk transfer and financing now included by the United Nations (United Nations General Assembly 2016) in its disaster risk management strategy. It then presents secondary data from a previous study (Sarmiento et al. 2018) on the general features, physical and socioeconomic conditions, and on the landslide and earthquake risk assessments conducted in the four precarious urban settlements selected.

2.1 Disaster Risk Management and Disaster Risk Transfer

The concept of disaster risk management has taken on special strength in the last decade, moving further away from the traditional disaster management concept. Disaster risk management now refers to the implementation of policies and strategies to avoid the generation of new risk, as well as to reduce the current risk and manage the residual risk, so as to strengthen resilience and reduce future damages and losses (United Nations General Assembly 2016). For this concept to be translated into reality, it is essential that risk management actions be continuous and integrated into broader development policies and practices.

Disaster risk management incorporates different scopes: (1) prospective actions (aimed at preventing the development of new or greater disaster risks); (2) corrective actions (focused on the management of existing risk); and (3) compensatory actions (aimed at strengthening the social and economic recovery capacity). Risk transfer falls within the last category. Risk transfer initiatives must be complemented by additional risk reduction measures (Kunreuther 2013). Risk transfer, in itself, does not reduce

exposure and vulnerability to an event, but can be used as an efficient incentive for risk reduction (Botzen et al. 2019). Its purpose is to manage residual risk that persists after effective risk reduction measures have been implemented.

Although we tend to use the generic term “disaster risk transfer” there are actually three different and complementary approaches contained in the concept: (1) risk transfer; (2) risk retention; and (3) risk financing. Risk transfer involves financial instruments like market insurance, microinsurance, parametric insurance, reinsurance, and catastrophe bonds. Risk retention includes strategies such as emergency or contingency funds, budget reallocation, self-insurance, and the replacement of critical facilities. Finally, risk financing has instruments that include contingent loans and social safety nets. There are also other measures to seek financial protection at the individual and collective levels, involving the public and private sectors (Sarmiento 2008).

Given the scope of this study, we focus our attention on three financial instruments of the first category of risk transfer options: insurance, microinsurance, and parametric insurance. Insurance, better called “indemnity” insurance, is defined as “an operation by which a party, the insured, obtains from another party, the insurer, the promise for himself or for a third party to be indemnified in the event of a loss. The remuneration for this service is called premium. The insurer assumes a set of risks and compensates the insured or a third party in accordance with the laws of statistics” (Swiss Re 2005, p. 13). Within the context of risk transfer, private markets are interested in evaluating the possibility of using this type of financial instrument for populations in precarious urban environments. Microinsurance “is an insurance to which the low-income population has access, provided by a diversity of different entities, but which is managed according to generally accepted insurance practices” (IAIS 2011, p. 4). Parametric insurance, in comparison to the “indemnity” insurance, is understood as a contract with contingent and predefined payment (compensation), based on the behavior of a variable with a high correlation with the risk to be covered. The premium for this insurance is paid when a preestablished threshold is exceeded, without requiring a damage assessment (Martin 2018).

2.2 An Urban Disaster Risk Reduction Strategy: Neighborhood Approach (NA-DRR)

By mid-2011, USAID/OFDA began to promote programs aimed at DRR in marginalized and informal settlements in Latin America and the Caribbean. This NA-DRR strategy is designed to find practical and viable solutions for DRR in informal urban settlements through four priority sectors:

housing and settlements; economic recovery and market systems; water, sanitation, and hygiene; and the reduction of natural and technological risks. The participatory process and the risk reduction flexibility allow it to adapt to different local contexts, changing the focus from the individual and the household to the community (Sarmiento and Herard 2015).

2.3 Evaluation of the Effectiveness and Sustainability of the NA-DRR Strategy

In 2017–2018, USAID/OFDA assessed the effectiveness and sustainability of its NA-DRR program. The evaluation methodology was designed and framed as an evidence-based DRR strategy and sought to evaluate the performance and outcomes of eight projects in six LAC countries (Sarmiento et al. 2018; Sarmiento et al. 2019).

From the eight NA-DRR projects assessed, the present study selected four (Table 1) using two criteria: (1) communities exposed to earthquake and landslide risks for which studies and references were available; and (2) high level of precariousness (precariousness index ranging from 27.09–31.43) as identified by Sarmiento et al. (2018). Table 1 presents the general features of the four NA-DRR beneficiary communities and the associated demographic data from the 2018 study.

The four communities are precarious informal settlements, characterized by the absence of urban planning, major deficiencies in housing quality, and lack of access to utilities. The inhabitants are mostly engaged in the informal economy with means that barely ensure their survival. These neighborhoods are located in the peripheries of the four cities and are at a high level of exposure to various natural and human-induced threats, where seismic and landslide threats stand out.

Table 1 gives information on the NA-DRR projects’ implementers, project length and budget, and general characteristics of the settlements. From the last, we can conclude that there is a high concentration of population, reflected in the reduced size of houses, the low availability of green areas (not built), and the limited availability of space per person. In all these indicators, the Medellín neighborhoods show by far the highest vulnerabilities.

The 2018 study also developed a precariousness index for the four communities, using data from household surveys and engineering inspections. The index is composed of three sub-indices: Legal, Physical, and Social (Table 2). Quintiles are used to create cut-off points, a statistical value of a data set that represents 20% of a given population. The first quintile represents the lowest fifth of the data, 1–20%; the second quintile, 21–40%; the third quintile, 41–60%; the fourth quintile, 61–80%; and the fifth quintile represents the highest fifth, 81–100%. Higher

Table 1 Neighborhood Approach – Disaster Risk Reduction (NA-DRR) Projects in select Latin American cities—general features

General features City	Peru Independencia, Lima	Colombia Medellín	Guatemala Mixco	Honduras Tegucigalpa
Project implementer	PREDES ^a	Global communities	Project concern international	GOAL ^b
Project duration	1 Oct 2014–31 Mar 2017	1 Oct 2014–31 Jan 2017	28 Sept 2012–30 Sept 2016	23 Sept 2013–23 Dec 2016
Total project budget (USD)	1,303,302	1,708,726	3,082,151	1,377,444
NA area (hectares)	11.2	95.7	8.1	59.3
NA built area (hectares)	8.1	131.0	4.8	53.4
Dwelling surface area (m ²)	119.3	67.8	122.9	100.8
Total dwellings	678	19,333	390	5300
Household members (average)	5	6	6	5
Total of individuals	3296	115,999	2298	27,718
Population density (people/ hectare)	295	1211	285	467
Square meter per person (m ²)	24.5	11.3	20.8	19.3

Data are presented in Sarmiento et al. (2018), and derived from approximately 44 household surveys conducted per study site in 2017–2018

^aCenter for Disaster Studies and Prevention (PREDES)

^bGOAL is an international humanitarian response agency established in Ireland

Table 2 Precariousness index of select communities with NA-DRR projects in Latin America. *Source:* Sarmiento et al. (2018)

Precariousness Index (0–100) City	Peru Independencia, Lima	Colombia Medellín	Guatemala Mixco	Honduras Tegucigalpa
Legal (0–30)	11.11	8.12	6.02	10.95
a. Issues with land use and land tenure (0–10)	1.27	2.12	3.27	3.26
b. Unplanned settlements/lack of compliance with urban planning & zoning (0–10)	3.33	2.22	2.22	1.11
c. Issues with building regulations/lack of compliance with building regulations (0–10)	6.51	3.78	0.53	6.59
Physical (0–40)	12.58	13.55	13.35	14.21
a. Issues with access to water, sewage, energy (0–10)	0.23	0.15	0.40	0.15
b. Deficient or poor housing conditions (0–10)	0.53	3.18	2.06	0.08
c. Overcrowding, environmental degradation (0–10)	4.09	3.64	5.08	5.61
d. Exposure to natural and human-induced hazards (0–10)	7.73	6.58	5.81	8.38
Social (0–30)	5.38	5.43	4.30	6.27
a. Issues with access to social infrastructure: health, education, cultural, commercial (0–10)	2.78	2.34	3.27	3.85
b. Marginalization (0–10)	0.91	0.68	0.48	0.45
c. Violence and illegal activities (0–10)	1.68	2.41	0.55	1.97
Informality/precarioussness Index (0–100)	29.07	27.09	23.67	31.43

values mean greater precariousness in the measured variable, the category, or the final index (Sarmiento et al. 2018).

The physical aspects of the community dwellings correspond to the highest level of precariousness, followed by the legal issues surrounding the dwellings' status. The

social category shows the lowest precariousness values for the communities. Among the four neighborhoods, the highest precariousness rate is seen in Tegucigalpa, followed by Independencia and then Medellín, with Mixco accounting for the lowest levels of precariousness (Table 2).

The spatial characteristics of each neighborhood are described in Table 1. The social characteristics of its inhabitants and the dwellings' legal and physical features described in Table 2 correspond to the status of these communities after the implementation of NA-DRR measures. There is still a residual risk that must be managed.

2.4 Disaster Risk Assessments

The 2018 evaluation included an analysis of the historical records of disaster events in the study areas. Two hazards were of particular concern: earthquakes and landslides, the former for their intensity of impacts recorded and the latter for their high frequency. A probabilistic risk modelling for earthquakes and landslides was conducted for the four settlements (Cardona 2018a; Sarmiento et al. 2018).

Hazard Evaluation The seismic risk curves for the study areas were constructed using the probabilistic seismic risk assessments from the 2019 *Global Assessment Report on Disaster Risk Reduction* (UNDRR 2019). Landslide susceptibility was considered in terms of the intrinsic characteristics of the site, as well as the triggering factors related to an external action on the static conditions of the site—for example, seismic acceleration, or cumulative rain. The probability of landslide occurrence was assigned to each susceptibility class to compute the hazard with different triggering factors (Cardona 2018a).

Exposure Evaluation Exposure corresponds to the assets susceptible to suffering damages in the event of disasters. The exposed assets in the study areas correspond to the dwellings and the infrastructure, which—though limited—holds considerable social value for the communities of the selected settlements susceptible to suffering damages from possible earthquakes and landslides. Information availability is one of the most important constraints in informal settlements. This evaluation required a field reconnaissance and field surveys supported with remote sensing data.

Disaster Risk Evaluation The four metrics calculated for the two hazards, seismic (Cardona 2018b) and landslides (Cardona 2018a), used in these assessments include: (1) Exceedance Probability (EP) Curve—the annual frequency with which a certain economic loss will be exceeded; (2) Average Annual Losses (AAL)—the expected losses per year; (3) Pure Risk Premium (PRP)—the cost that must be paid annually to cover the expected losses in the future; and (4) Probable Maximum Losses (PML)—the loss value for a given exceedance frequency, or for its inverse, the return period (Marulanda et al. 2014). Details of the probabilistic risk assessment methodology can be found in Cardona (1986) and Salgado-Gálvez et al. (2017).

3 Methodology

This research follows a case study research approach. This type of research constitutes an empirical inquiry that investigates a phenomenon within its real-life context, where one or several units are analyzed intensively with the purpose of elucidating features of a broader class of units (Gerring and McDermott 2007). Within the case study approach, we follow the counterfactual comparison variant, using experimental (hypothetical) interventions applied to similar units, analyzing and comparing the outcomes. The units are represented by the four precarious urban neighborhoods selected, and the broader class corresponds to urban informal settlements. The interventions fall within the DRR category and focus on the risk transfer mechanisms in particular.

We first use a comprehensive literature review method to identify case studies documenting successful experiences in the implementation of risk transfer mechanisms for vulnerable populations. Then, we proceed to calculate the pure risk premium based on the information extracted from the 2018 study, that is the physical and socioeconomic characterization and the catastrophe risk assessment conducted for each of the four cases.

3.1 Experiences in the Implementation of Risk Transfer Instruments for Vulnerable Populations

The extensive literature review included peer-reviewed articles and reports from public institutions, donor agencies, and the insurance industry in English and Spanish. The keyword search included: risk transfer, insurance, microinsurance, poor, vulnerable, *transferencia de riesgo*, *seguro*, *microseguro*, *pobre*, *vulnerable*. We used Google Scholar, Google, and PreventionWeb. The 7850 documents that were initially obtained were filtered in two stages. The first stage had three inclusion criteria: (1) details on instrument design and implementation; (2) indication of specific geographic area; and (3) targeting of vulnerable populations. Sixty-five documents met these three criteria. Documents in the second stage had two inclusion criteria: (1) indication of order of magnitude (affiliated coverage, accumulated premium value); and (2) implementation in the last 15 years. In total, 12 documents referring to 7 individual experiences were identified. Table 3 shows the main characteristics of the seven risk transfer experiences selected that met the inclusion criteria. The experiences comprise collective home insurance, individual and collective microinsurance, and parametric insurance. A major finding was the extremely limited reference to experiences in urban settings. Except for the solidarity collective

Table 3 Experiences in the implementation of risk transfer instruments for vulnerable populations

Case #	Geographical Scope	Initiative	Instrument	Target Population	Highlights
1	Manizales, Colombia	Solidarity Collective Insurance Marulanda et al. (2014)	Seismic risk insurance, with a 3% deductible. Other risks such as natural phenomena or events like strikes, riots, civil commotion, and acts of bad intent to third parties, with a deductible of 10%	Most vulnerable population located in the lowest socioeconomic strata	Through the payment of property tax, private homeowners can purchase voluntary insurance, which under certain conditions covers the most vulnerable population, through a cross-subsidy scheme
2	Ethiopia, Senegal, Malawi, and Zambia. Kenya and Zimbabwe are under test	Rural Resilience Initiative—R4 World Food Programme (2018)	Considers four risk management strategies: improved resource management through the creation of assets (risk reduction); insurance (risk transfer); diversification of livelihoods and microcredit (prudent risk taking); and savings (risk reserves)	Rural vulnerable households	It offers coverage to 57,000 farmers (300,000 people). By 2018, it is estimated that R4 made insurance payments of approximately USD 1.5 million in the five countries
3	India	Health scheme for farmers in the cooperative Yeshasvini, Karnataka Radermacher et al. (2005)	Health microinsurance. Discounts in surgery and hospitalization	Households below the rural poverty line	Association between the rural cooperative sector and the Cooperation Department of Karnataka. It offers coverage to 1.45 million users
4	Philippines Bulos and Portula (2016)	Tulay sa Pag-Unlad, Inc. (TSPI) Center for Agriculture and Rural Development, Inc. (CARD) Prudential Life Insurance Company (PPLIC) Life and General Insurance Cooperative (CLIMBS) MicroEnsure	Microinsurance—offers group and individual loans Financial products such as savings, loans, and insurance Offers a variety of life insurance products Life insurance for the lowest income population It offers life, health, climate, and natural disaster insurance	Small business owners, farmers, and others Farmers and small business owners Clients of microfinance institutions, rural banks, and other organizations in the Philippines Insurance cooperative, with more than 2000 primary cooperatives and federations throughout the Philippines	Life insurance is mandatory for credit holders. It offers coverage to 500,000 users Life insurance is mandatory for credit holders. It provides coverage to 7 million users Offers coverage to 60,000 users Provides coverage to 1.1 million users Provides coverage to 2 million users.
5	Guatemala	Insurance and Microinsurance COLUMNA Herrera and Miranda (2004)	Life insurance, linked to cooperative loans Fire insurance and other risks Life insurance to savings	Members of cooperatives, Owners of savings accounts	Approximately 90% of COLUMNA's clients are members of the 35 cooperatives. It covers geographically dispersed rural areas and work in agriculture and the informal economy

Table 3 continued

Case #	Geographical Scope	Initiative	Instrument	Target Population	Highlights
6	El Salvador	Produce Seguro MiCRO (2018)	Parametric insurance that covers events such as excess rain, droughts, and earthquakes	Clients who acquire credits for productive activities: agriculture (livestock, sugarcane, fruit, basic grains, vegetables, banana, guisquil, loroco, or tomato), cosmetology, and grocery stores	Clients receive information on other DRR tools, such as family emergency plans
7	Guatemala	Esfuerzo Seguro Peinado (2018)	Parametric insurance that covers events such as excess rain, droughts, and earthquakes	Clients that manage productive and agricultural credit	Offered by Aseguradora Rural and Banrural. Insured persons receive training to manage their risks

insurance initiative implemented in Manizales (Colombia), the experiences obtained were predominantly drawn from rural initiatives. Regarding the latter, these cases were included because most of the informal settlements are generated in the cities' peripheries, in the rural–urban interface. This fact is reflected in the way of life of their inhabitants, the relation between different social groups, and in their interaction with the environment, where urban and rural practices overlap in a particular territory.

The Solidarity Collective Insurance in Manizales (Colombia) was the case study that suited best the purpose of our study. Specifically, it targeted vulnerable populations in precarious urban environments exposed to natural hazards. Manizales is a city of approximately 400,000 inhabitants. The city has a public policy for comprehensive DRR with a multi-hazard approach that has been evolving over the last three decades. This policy includes a voluntary collective insurance for risk transfer. Under this scheme, private homeowners can acquire voluntary insurance, based on the property's cadastral value, through the payment of property tax. The policy covers most of the vulnerable population (lowermost socioeconomic groups exempt from property tax) through a cross-subsidy scheme, where the pure risk premium increases in a non-significant way when the subsidy is included. According to Marulanda et al. (2014), if 10% of the housing owners in Manizales (who pay property taxes) decide to support the solidarity collective insurance geared to the inclusion of low-income households (who do not pay property taxes), the cost of their insurance premium would increase from 2.1 to 2.3%. If the participation of homeowners increases to 20%, the cost of their insurance premium would go from 2.0 to 2.1%. The insurance company shares a direct contractual relationship with the insured, expediting claim management by avoiding the need for intermediaries. The

insurance has a deductible of 3%. It covers seismic risk and other natural phenomena, as well as civil disturbances—for example, strikes, riots, civil commotion, malicious third-party acts, with a 10% deductible. The first layer of losses stemming from a disaster and the deductible for the exempt dwellings would be covered by the local government.

3.2 Pure Risk Premium

The values of the precariousness index (Sarmiento et al. 2018) and the catastrophic risk assessment were used to establish the magnitude of the pure risk premium (PRP) cost that would be required for a risk transfer instrument to insure the dwellings in the four selected cases.

Each hazard was independently analyzed to estimate the PRP outcomes. An integrated exercise for probable events and degrees of vulnerability of the portfolio's components was based on Marulanda et al. (2014). The probability density functions associated with the events and their vulnerability were aggregated to develop the respective exceedance probability curves, which yielded the AAL values. Based on our estimations, the PRP costs using AAL values for seismic events are USD 26,825 for Independencia, Lima, Peru; USD 557,896 for Medellín, Colombia; USD 61,122 for Mixco, Guatemala; and USD 174,245 for Tegucigalpa, Honduras (Table 4). The PRP costs using AAL values for landslide events are USD 21,639 for Independencia, Lima, Peru; USD 511,358 for Medellín, Colombia; USD 91,820 for Mixco, Guatemala; and USD 196,000 for Tegucigalpa, Honduras (Table 5).

The result obtained from the calculation of the PRP for earthquakes and landslides varies significantly in the different neighborhoods. To obtain a relative value that would allow for comparison, we calculated the value of the insurance premium per family unit (Table 6).

Table 4 Catastrophe risk assessment and pure risk premium costs—seismic events. *Source:* Adapted from Cardona (2018a)

Country	Peru		Colombia		Guatemala		Honduras	
City	Independencia, Lima		Medellín		Mixco		Tegucigalpa	
Peak Ground Acceleration, PGA (for 1500-year return period) (cm/s ²)	252		249 for Pinal sector and 363 for Llanaditas, Santo Domingo Savio, and Compromiso sectors		415		210 for Sector 1 and 159 for Sector 2	
Exposed Value (USD)	21,214,537		403,425,000		17,102,603		211,353,121	
Average Annual Losses (AAL) (USD)	26,824.53		557,895.62		61,121.89		174,245.39	
Pure Risk Premium (PRP)	1.26‰	USD 26,825	1.38‰	USD 557,896	0.36‰	USD 61,122	0.82‰	USD 174,245

The pure risk premium (PRP) calculation does not include other operating costs

Table 5 Catastrophe risk assessment and pure risk premium costs—landslides. *Source:* Adapted from Cardona (2018a)

Country	Peru		Colombia		Guatemala		Honduras	
City	Independencia, Lima		Medellín		Mixco		Tegucigalpa	
Susceptibility Class	High and very high susceptibility to the occurrence of landslides		Areas with high, moderate, and low susceptibility to the occurrence of landslides		Moderate susceptibility to landslides; small areas with very high susceptibility		Areas with high and low susceptibility to the occurrence of landslides	
Exposed Value (USD)	21,214,537		403,427,349		17,102,602		211,353,115	
Average Annual Losses (AAL) (USD)	21,638.83		511,357.88		91,820.13		196,000.00	
Pure Risk Premium (PRP)	1.02‰	USD 21,639	1.27‰	USD 511,358	5.37‰	USD 91,820	0.93‰	USD 196,000

The pure risk premium (PRP) calculation does not include other operating costs

The PRP cost per household as a percentage of household monthly income varies from 8 to 66%. The lowest values coincide with larger populations in Medellín and Tegucigalpa, while Mixco has the higher PRP costs per household for both seismic and landslides risks. Mixco also has the highest seismic and landslide risks among all cities studied.

4 Results and Discussion

In the LAC region, as across the world, the difference between economic losses and insured losses from natural hazard-induced disasters, called the insurance protection gap (IPG), is now a significant concern. The IPG is defined as the difference between the amount of insurance coverage that would be socially and economically beneficial and the real insurance market—what is actually purchased (The Geneva Association n.d.). The values of the IPG as a factor of the real market (4.67 for Peru, 2.6 for Colombia, 6.2 for

Guatemala, and 2.9 for Honduras) (Fundación MAPFRE 2018) show an important gap in the insurance coverage in the countries analyzed, which will undoubtedly affect the viability of the possible risk transfer options that may be proposed. The confluence of a favorable macroeconomic and financial environment, as well as stronger efforts to increase the financial inclusion of informal communities, will be required to close this insurance gap,

For financial inclusion, it is critical to focus on access to products that offer protection against basic risks (life, health, accidents, property, and liability) for groups excluded (or insufficiently served) in a society—for example, coverages and exclusions that seek to simplify the products, making the premium payment process more flexible, with basic and expedited procedures for compensation claims. Additionally, the means for bringing about insurance products to the users can be simplified. Players such as micro-financiers, community service providers, and NGOs have greater capacity to reach out and better adapt to the conditions of the marginalized

Table 6 Pure risk premium per household

City	Peru Independencia, Lima	Colombia Medellín	Guatemala Mixco	Honduras Tegucigalpa
Total Households	678	19,333	390	5300
Pure Risk Premium (PRP)—Seismic (USD)	26,824	557,895	61,121	174,245
PRP Cost per Household—Seismic (USD)	39.56	28.86	156.92	32.88
PRP Cost per Household—Seismic (% monthly income)	15	9	44	8
Pure Risk Premium (PRP)—Landslide (USD)	21,638	511,357	91,820	196,000
PRP Cost per Household—Landslide (USD)	31.91	26.45	235.74	36.98
PRP Cost per Household—Landslide (% monthly income)	12	9	66	9

Official monthly minimum wage for 2018: Peru USD 262.35; Colombia USD 308; Guatemala USD 357.18; and Honduras USD 395.48 (obtained from WageIndicator.org)

Fig. 1 Ideal risk transfer features. *Source:* Adapted from Prabhakar et al. (2015)

Ideal Risk Transfer Features		Corresponding Risk Transfer Features	
		Case Study	Features
A. Address a variety of hazards		Collective Insurance – Manizales	A, B, C, F, G, H, I
B. Reduce disaster impact on income and socioeconomic development		R4 Initiative – Ethiopia	B, C, D, E, F, G, H, I
C. Contribute to residual risk coverage		Farmers' Cooperative – India	C, G, H, I
D. Help affected communities re-establish their livelihood activities		Insurance – Philippines	A, B, C, D, F, G, H, I
E. Promote risk mitigation		COLUMNA – Guatemala	A, B, C, D, F, G, H, I
F. Reduce government resources burden associated to disaster response and recovery		Produce Seguro – El Salvador	A, B, C, D, E, F, G, H, I
G. Cost-effective		Esfuerzo Seguro – Guatemala	A, B, C, D, E, F, G, H, I
H. Opportunity for public-private partnerships			
I. Scalability			

populations while simultaneously reducing expenses and keeping costs at reasonable levels.

Building on the importance of insurance emphasized by Prabhakar et al. (2015), we list a set of ideal risk transfer features (Fig. 1) and analyze the seven risk transfer experiences selected (Table 3) against them. With the exception of case 3 (India), all the cases address at least seven of the nine ideal risk transfer features.

We propose three decision options for risk transfer aimed at poor and vulnerable urban communities (Table 7). These are based on the reviewed experiences, the ideal risk transfer instruments, and the systematic catastrophe risk assessment carried out in the four cases under study.

Option 1 uses the Solidarity Collective Insurance approach; as described in Fig. 1, it fulfills five out of the nine ideal risk transfer instrument features (A, B, C, F, H). Option 2 is built on risk mitigation measures and complemented with a risk transfer feature, and complies with six of the ideal risk transfer features (A, B, C, E, F, H). Option 3 implies higher participation, involving

communities in activities that could generate work opportunities, embracing six of the ideal risk transfer features proposed (A, B, C, D, F, H). Two of the ideal risk transfer instrument features, cost-effectiveness (G) and scalability (I), are addressed only partially in this study because their calculation requires further data not currently available.

4.1 Decision Option 1: Collective Voluntary Insurance

The collective insurance, like the one implemented in Manizales (Marulanda et al. 2014), helps the local government access key resources for low-income households, as well as recover and improve disaster risk management at the local level.

The District of Independencia (Lima, Peru) and the municipality of Mixco do not even appear in the insurance market reports; this severely limits the development of a financial inclusion strategy for property insurance. However, the insurance markets register a greater penetration in

Table 7 Risk transfer options proposed

Risk Transfer Mechanism	Main Risk Transfer Features	Common Risk Transfer Features
Option 1—Collective Insurance	Focus on handling residual risks Based on the principle of solidarity (not paid by the user, but by the citizens voluntarily)	Address a variety of hazards Reduce disaster impact on income and socioeconomic development
Option 2—Structural Retrofitting + Individual Insurance Coverage	Handles residual risks Built on risk mitigation measures	Reduce government resources burden associated to disaster response and recovery Opportunity for public–private partnerships
Option 2—Hybrid Parametric Insurance Coverage	Handles residual risks Maintenance of mitigation works Livelihoods generation	

the municipalities of Tegucigalpa and Medellín. In the case of these two cities, the properties that could benefit from a collective voluntary insurance premium represent an average of 3.4% of the total cities' insured value. Using the same rate of participation (10%) of registered private properties as described by Marulanda et al. (2014), the total insured value of the properties in the Tegucigalpa and Medellín projects is estimated to be USD 683 million and USD 1304 million, respectively. Using the data from Fasesolda (Association of Colombia's Insurers), the housing insurance market in Medellín for 2017 was estimated to be USD 10 million (Arias 2017). However, this amount is still significantly lower than what is required to cover the insurance for the project's beneficiary neighborhood, let alone the other depressed neighborhoods of the city as a whole, making this insurance modality unfeasible. This financial protection option was conceived with the comprehensive risk management project Manizales (Colombia) template in mind. Insurance data for Tegucigalpa were not available. We can conclude that this approach has limited viability for the neighborhoods under study.

4.2 Decision Option 2: Credit for Structural Retrofitting with Comprehensive Housing Insurance

This option is based on housing retrofits financed by low-interest loans and covered by insurance at a cost of 1% of the insured value (100% of the commercial value of the property). Table 8 shows the cost analysis of retrofitting in the study areas using the structural improvement costs for the city of Medellín, Colombia.¹ This intervention includes

¹ In Medellín, housing physical interventions are regulated by the city at three levels: (1) Healthy improvement: bathroom, kitchen, and roof: USD 3700; (2) Structural improvement: beams, columns, and new walls: USD 4800; and (3) Replacement: demolish and rebuild the house: USD 6140 (Mayor's Office of Medellín 2013). We used the

retrofitting in addition to improvements in bathrooms and kitchens.

The basis for calculating the insurance premium costs for options 1 and 2 is the same. The main difference is who undertakes the cost of the premium, where the scale factor plays a critical role. For Option 1, the 22,501 houses in Manizales that do not pay property taxes (due to precariousness) represent 19.9% of the total private insurable buildings, but only 3.85% of the total insurable value. In that option, those who assume the cost of the premiums of the tax-exempt precarious homes are the homeowners that pay property taxes. The greater the participation of voluntary homeowners, the lower the value of their individual contribution, in this option the scale factor is definitive for the financing of the collective insurance.

In Option 2, the payment of the premium is taken directly by the owner of the building to be insured (financed, co-financed, or subsidized), and can be implemented on a smaller scale. This situation increases its feasibility. Option 2 is a comprehensive risk management option that goes beyond the risk transfer measure described in Option 1. Along with the benefit of house retrofitting, it offers a quality structural improvement that meets environmental sanitation requirements and contains an aesthetic and quality of life component. The physical intervention can be financed at different subsidy levels. A co-financing scheme in which the dwelling's owner contributes at least 10% could lead to a subsidy of 17% for Medellín (the lowest among the four cities studied) and up to 24.6% for Mixco (the highest of the four cases). The costs of physical interventions vary significantly from one city to another. However, the studies carried out in Medellín by the Mayor's Office and Build Challenge (Mayor's Office of Medellín 2013) offer an order of

Footnote 1 continued
structural improvement cost of USD 4800 for the estimates in this study.

Table 8 Option 2, credit for structural retrofitting with comprehensive housing insurance

City	Peru Independencia, Lima	Colombia Medellín	Guatemala Mixco	Honduras Tegucigalpa
Exposed value (USD)	21,214,537	403,425,000	17,102,603	211,353,121
Total housing	678	19,333	390	5300
Value per housing unit (USD)	31,285	20,867	43,909	39,879
Physical intervention cost ^a (USD)	4800	4800	4800	4800
Cost of the annual premium (USD)	313	209	439	399
Cost of the monthly premium (USD)	26	17	37	33
Annual premium as % of intervention	6.52	4.35	9.15	8.31

^aPhysical intervention costs include structural retrofitting and other housing improvements

magnitude to guide those interested, advance the cost analysis, and inform feasibility studies under specific local conditions.

4.3 Decision Option 3: Hybrid Parametric Insurance

The third option is an innovative hybrid approach built on a parametric insurance. We suggest a hybrid approach in the case of NA projects—one where the insurer pays the total/partial premium of a parametric policy subject to community participation. This involves the community committing itself to a number of man-hours to carry out works that ensure the sustainability of the program—for example, maintenance of a community garden, cleaning of drainage channels. This innovative idea could well be adopted by the private sector. This would effectively fit the realm of corporate social responsibility and earn tax benefits at the same time for its social cause.

Given that the evaluated projects have already been completed, it is assumed that the projects' implementers no longer have the resources, are not able to assume the cost of collective risk insurance, or even consider it inconvenient to generate a contingent risk as it could be interpreted as a legal liability.

Emulating the R4 Initiative in Ethiopia (see Table 3), we propose schemes in which a community benefiting from a NA-DRR program (which has budgetary restrictions) receives a parametric policy. This policy could cover a percentage of their homes' value, their livelihoods, or public infrastructure where networks or local associations operate, such as *comedores populares* (communal dinners), *juntas de acción comunal* (community action boards), *grupos de vecinos* (neighborhood groups), and *asociación de vasos de leche* (neighborhood association that manages milk supply to school-age children). These community-based mechanisms significantly contribute to the sustainability of the NA-DRR program's achievements with an emphasis on the collective benefit. To make the policy

attractive, it is proposed to design a hybrid parametric financial instrument as a social transfer mechanism that includes the coverage of some basic needs, such as environmental sanitation.

Likewise, it is of the utmost importance that the community be able to access relevant information regarding the costs and benefits of the policy to understand its scope, be consistent with its use, and facilitate its subsequent renewal.

4.4 Challenges and Limitations

Accessing recent and reliable information on marginalized and vulnerable urban populations is a major challenge. The prospective risk management approach proposed here involves uncertainties that arise from the assessment of the severity and frequency of hazardous events. This study is a work in progress, and the results are not only partial, but are also the first step in a methodological process that must be consolidated in the long term (Cardona 2018a, b).

This study constitutes a significant advance in measuring and characterizing a reality of high complexity: precarious urban informal settlements. The effort corresponds to a systematic process framed within an evidence-based urban DRR evaluation strategy, and the case study research approach—an effort that must be continued through the dissemination of the methodologies used. This would allow for refining the proposed metrics and consolidating the body of knowledge necessary to inform public policy decisions and practices aimed at improving the living conditions of marginal communities that inhabit informal settlements and increase their resilience to disasters.

5 Conclusion

The uncontrolled urban growth worldwide urgently demands a new approach that allows for the integration of comprehensive risk management within the processes of

sustainable development. Funding and risk transfer strategies should be an essential component of these measures. This study presents evidence-based, viable risk transfer options for precarious urban informal settlements in four case study sites facing earthquake and landslides risks. We recommend and suggest the collective voluntary, structural retrofitting credit for comprehensive housing, and hybrid parametric insurance for addressing the residual risk in urban informal settlements for comprehensive risk management. The credit for structural retrofitting with comprehensive housing insurance option transcends the management of residual risk, reducing the physical vulnerability of the built environment with a positive short-term impact on the population's quality of life.

The study confirms the low insurance culture in developing countries, where there is a poor understanding of the concept of insurance—on the part of the population in general and even more so in marginal sectors of society. Any initiative undertaken will require a rigorous process of insurance literacy, accompanied by a series of practices that reinforce, by demonstration, the short-term benefits and those associated with post-disaster recovery. For this, we must ensure that risk transfer instruments are increasingly feasible, accessible, and sustainable.

This study's findings are framed within a complex problem of urban informality and precariousness exposed to socio-natural risks. Yet the work constitutes an effort that can inspire a change in public policies for other segments of society with greater capabilities and resources in urban environments to achieve more effective and comprehensive disaster risk management.

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