Inequality in environmental risk exposure and procedural justice in the Matanza-Riachuelo River Basin

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Abstract: Using a capabilities-based perspective on socioenvironmental justice, this paper aims to contribute to the understanding of the interconnection between social equity and care for the earth in the case of the Matanza-Riachuelo – the most industrialized and contaminated river basin in Argentina. First, it uses a spatial regression model to analyse the correlation between multidimensional poverty and potential exposure to three types of environmental risks: environmental hazards of productive establishments, open-air waste dumps, and proximity to contaminated rivers and streams. Second, it analyses inequities in the processes of resettlement of households living in conditions of extreme environmental risk in informal settlements. It shows that higher poverty areas face greater risk of exposure to open-air waste dumps but lower risk of exposure to industrial and commercial environmental hazards. It also demonstrates how enhanced participation of households in decision-making on resettlement contributed to improved outcomes.

Key words**:** environmental justice, spatial analysis, multidimensional poverty, water contamination, Latin America.

Introduction

Sustainable human development involves the pursuit of both greater intra- and intergenerational social equity and care for the earth, and thus the reduction of socio-environmental injustices. While these central goals are clear, less is known about the interconnection between them at the micro territorial level and over time. What are the tensions and synergies between the pursuit of social equity and care for the earth?

The answer to this question depends at least in part on the initial distribution of environmental burdens and benefits. If the most disadvantaged groups face greater exposure to pollution, then environmental conservation and remediation policies would be expected to improve social equity, producing synergies between both objectives. The environmental justice literature provides a growing body of evidence from high income countries that low-income households, racial and ethnic minorities, and other disadvantaged groups face greater exposure to diverse environmental hazards (Schlosberg, 2007; Mohai et al., 2009; Banzhaf et al., 2019). The evidence for Latin America, however, is less extensive and the findings are mixed. While some studies on Mexico (Grineski et al., 2010; Lome-Hurtado et al., 2020) and Ecuador (Rodríguez-Guerra & Cuvi, 2019) show that socioeconomically disadvantaged groups face greater pollution exposure, other studies conclude that higher socioeconomic status groups face greater risks (see Grineski & Collins [2010] and Lara-Valencia et al. [2009] on Mexican cities; and Habermann et al., [2014] on São Paulo, Brazil).

The answer also depends on the distributional effects of environmental regulation and remediation policies. Although there are numerous theoretical arguments for why environmental policies are regressive (Fullerton, 2011), the empirical evidence is mixed (Bento et al., 2015; Vona, 2021). The distribution of outcomes depends critically on initial inequality (in deprivations, environmental amenities, and hazards) and on the extent to which different groups in society can participate in decision-making in environmental remediation processes (Banzhaf et al., 2019).

This paper analyses the case of the Matanza-Riachuelo River Basin (MRB), the most industrialized and polluted river basin in Argentina (ACUMAR, 2010a) and one of the most polluted worldwide (Blacksmith Institute & Green Cross Switzerland, 2013). While some research contends that disadvantaged households face greater exposure to environmental risk in the river basin due to the siting of industries along the river and the settlement of low-income households on nearby lands (Merlinsky, 2013), the existing literature has not examined systematically the correlation between different sources of environmental hazards and the level of deprivation of the population.

The integral environmental remediation plan for the MRB introduced in 2010 following a supreme court decision called for actions to improve quality of life; repair contamination of water, land, and air; and prevent future environmental damage. The policy that has impacted the most vulnerable households is the forced resettlement of households living in situations of high environmental risk in informal settlements (Ryan et al., 2019).

The paper aims to provide empirical evidence based on the case of the MRB on two factors that influence the multifaceted and complex relationship between social equity and care for the earth: the initial distribution of environmental harms and procedural justice in environmental remediation processes. First, it analyses the correlation between multidimensional poverty and three types of potential environmental risks in the MRB: environmental incidence of productive establishments, open-air waste dumps, and proximity to surface water pollution. Second, it analyses procedural justice in the process of resettlement of households exposed to high environmental risk in informal settlements, that is, it analyses how the voices of affected individuals have been represented in decision-making processes. The paper is structured as follows. Section two introduces the case of the MRB. Section three provides a brief theoretical framework drawing insights from the capability approach. Section four reports the results of the analysis of inequality in exposure to environmental risks. It shows that higher poverty areas face greater exposure to open-air waste dumps but lower risk of exposure to the environmental hazards of productive establishments. Section five analyses procedural justice in the household resettlement process in the City of Buenos Aires. It demonstrates how enhanced participation of households in decision-making on resettlement contributed to improved outcomes. Section six summarizes the paper's main conclusions and discusses its limitations and areas for continued research.

Environmental pollution and clean-up of the MRB

The MRB covers an area of 2,238 km^2, spans 14 municipalities of the Province of Buenos Aires (PBA) and nine districts of the City of Buenos Aires (CBA), and has a population of 4.7 million (10% of the Argentine total). The environmental contamination of the watershed is the result of more than 150 years of industrial waste disposal in the river, a severe deficit in sanitation services, open-air waste dumps, and inadequate regulation of urban land use and productive activities (Merlinsky, 2013; ACUMAR, 2010a). Close to 800,000 people live in more than 500 informal settlements in the river basin (ACUMAR, 2018a).

Around 5,500 productive establishments operate in the MRB in industries ranging from petrochemicals and electroplating to food processing, meatpacking, and tanneries. The discharge of industrial waste into the river exposes the population to toxic and carcinogenic substances such as chromium, benzene, toluene, and lead (Auyero & Swistun, 2008). Only 53% of the river basin's population are connected to the public sewerage network (ACUMAR, n.d.) and deficits in access are most severe in informal settlements (DGEC, 2015). As a result, it is estimated that 192,000 m^3 of untreated sewage (equivalent to 9,600 vacuum tanks) are discharged daily into the Matanza-Riachuelo River (ACUMAR, 2019a). Water pollution produces health risks (such as, gastrointestinal illnesses, parasites, and skin infections) for the 20% of households who are not connected to the public water system and depend on groundwater abstraction for domestic use or live close to contaminated rivers and streams. A 2010 survey identified 348 clandestine open-air waste dumps in the watershed, which proliferate disease-spreading vectors; contaminate surface and groundwater; and produce air pollution, odours, and green-house gas emissions (Ferronato & Torretta, 2019).

In 2004 residents of an informal settlement in the MRB presented a lawsuit against the national, provincial and city governments and 44 companies for the negative health impacts of environmental contamination. In 2006 the Supreme Court of Argentina took up the case; recognized the collective right to live in a healthy environment; and demanded that the national, provincial, and municipal governments develop an integral environmental remediation plan (ACUMAR, 2010a). The Matanza-Riachuelo Authority (ACUMAR), an autonomous interjurisdictional entity, was given the responsibility for coordinating, executing, and regulating the environmental remediation process. Remediation actions have included the clean-up of some open-air waste dumps; inspection of private enterprises; waste removal from riverbanks and waterways; investments in sewerage transport and treatment infrastructure, among others (ACUMAR, n.d.).

A capabilities framework for evaluating socioenvironmental injustice

The foundational idea behind the capability approach (CA) proposed by Amartya Sen (1993, p. 1) is that interpersonal comparisons of wellbeing should be evaluated not based on incomes or resources, but in the space of *capabilities*, defined as "the alternative combinations of things a person is able to do or be–the various 'functionings' he or she can achieve", such as being well nourished, healthy or educated. Capabilities form a better basis than income for evaluating social states because people's ability to convert resources into capabilities varies depending on individual, social and environmental characteristics (Robeyns, 2017). A person who uses a well for drinking water will be more vulnerable to contaminated groundwater than someone connected to the public water system. These differences are accounted for directly if wellbeing comparisons are based on capabilities but ignored if based on income. The CA also recognizes the interconnection between capabilities. The negative health outcomes produced by environmental degradation impact many other capabilities, like the ability to work or attend school (Auyero & Swistun, 2008). Holland (2008) argues that because of the total dependence of human capabilities on environmental conditions, the environment should be viewed as a 'meta-capability' necessary for all other capabilities and environmental entitlements as a matter of social justice.

Schlosberg (2012) asserts that the CA offers a means for bridging the gap between abstract notions of justice and real-life situations of injustice, as well as concrete standards for making comparisons across location and scale. He proposes broadening the approach to encompass the importance of recognition of people and their ways of life, drawing on the work of Fraser (1996) and Young (2002). Nonrecognition devalues and stigmatizes people, makes them invisible, and limits their ability to participate in creating more just circumstances. Incorporating recognition helps bring attention to the social, political, and economic forces that produce injustice and how impediments to participation in political processes can be redressed. Schlosberg also identifies aspects of recognition related to place, which are especially relevant to the case of the MRB, such as the spatial variation in disadvantage, contextual factors that produce inequalities, people's and communities' attachment to place, and the interconnection between humans and ecological systems.

In the context of climate adaptation, Holland (2017) asserts that policies should be evaluated in terms of the extent to which vulnerable populations have the political capability (or agency) to determine how they live and influence policy decisions. She draws a distinction between instances of public consultation with affected communities (a weak form of participation) and having the real capability for political control over one's environment. She contends that having the political power to shape decisions means "being able to formally control the decision rules and procedures according to and with which adaptation decisions are made" (p. 397).

In the analysis that follows we use the concepts of capabilities and agency as the basis for comparing social states across space and time. To analyse the spatial distribution of exposure to environmental risks, we use a multidimensional poverty index in the space of capabilities, instead of an income-based poverty measure. Research has shown that while multidimensional and income poverty are positively correlated, the association is weaker and there is less overlap in terms of who is identified as poor in relatively higher poverty areas (Macció & Mitchell, 2023). In our analysis of household resettlement, we assess the extent to which people living in different communities participated in the processes of change that impacted their lives. We do not aspire to present an integral evaluation of socioenvironmental justice in the MRB, but rather seek to analyse empirically two specific factors which the literature suggests will influence the interconnection between social equity and care for the earth at the micro territorial level.

Inequality in exposure to environmental risks

This section focusses on distributive justice, analysing the correlation between multidimensional poverty and three sources of environmental risk at the census tract level, the smallest available level of observation. The universe of analysis includes the census tracts whose geographic centre is located within the hydrographic limits of the CMR or in the Dock Sud sector, in accordance with ACUMAR (2019b).

Spatial analysis methods

This section explains the following aspects of the spatial analysis methodology: measurement of exposure to each type of environmental risk, measurement of multidimensional poverty and statistical methods used to analyse the correlation between multidimensional poverty and each measure of environmental risk exposure.

Measurement of environmental risk exposure

The environmental risk generated by industrial, service, and commercial establishments is proxied by the Environmental Incidence Level (EIL).[1] This indicator has the advantage that it is calculated by ACUMAR based on the legal declarations on the productive activities of all registered establishments. Unregistered establishments face risk of closure and fines. The EIL for the 5,574 registered establishments in 2019 – the first year for which data are available for all registered establishments – ranges from 5.5 to 87, with an average 31.9. Approximately one-third of registered establishments have EIL ≥ 40, the threshold above which there is significant risk of adverse environmental impact (ACUMAR, 2018b).

Following Bolin et al. (2002), we estimate the environmental risk associated with exposure to industrial, commercial, and service establishments for census tract *d* (ERE_{dr}) using the cumulative hazard density method. We first construct a buffer of radii *r* around each of the *J* establishments (see Chakraborty et al., 2011) and then calculate ERE_{dr} as the sum of the intersected areas (between these buffers and the census tract) weighted by EIL_j, divided by the area of census tract *d*.[2] We compute the ERE_{dr} for two radii: 500 and 1000 meters.

$$ERE_{dr} = \sum_j area_{jdr} * EIL_j \, (1/area_d) \tag{1}$$

Our measure of the environmental risk of open-air waste dumps is based on geographically referenced data on the location of 139 waste dumps identified in a 2017 baseline survey (ACUMAR, n.d.).[3] We estimate the radius of impact of each waste dump using three concentric doughnut buffers: 100, 200, and 300 meters for micro waste dumps; 250, 500, and 750 meters for regular waste dumps; and 500, 1000, and 1500 meters for macro waste dumps. As in the case of productive establishments, the environmental risk faced by people in census tract *d* ($ERWD_d$) is computed as the weighted sum of the intersected areas of *k* waste dumps divided by the census tract's area. The buffer size and corresponding weights (1, 0.5, and 0.33 from closest to farthest) are based on (UIDET, 2017).

$$ERWD_d = [\sum_k \sum_{r=1}^{3} area_{kdr} * weight_r] * (1/area_d) \tag{2}$$

To measure the environmental risk associated with proximity to contaminated waterbodies, we use the Surface Water Quality Index (SWQI), a composite index based on the comparison of ten measures of water quality collected at 35 monitoring stations (PH level, dissolved oxygen, phosphate content, etc.) with normative standards for passive recreational activities (ACUMAR, 2019b). As the SWQI increases with water quality, (100-SWQI) increases with the level of pollution. For each census tract we calculated the shortest distance between its centre and the middle line of the closest river or stream (s_d^w) and determined its corresponding subbasin. Then we measured each census tract's environmental risk associated with proximity to contaminated surface water as:

$$ERSW_d = (100 - SWQI_d) * (1/s_d^w) \qquad (3)$$

where $SWQI_d$ is the average value of the index at the monitoring station within the sub-basin corresponding to census tract d during 06/2013-05/2014, the first period with valid measurements for all sub-basins.

Measurement of multidimensional poverty

To measure deprivation we construct a multidimensional poverty index (MPI) using the Alkire and Foster (2011) method,[4] consisting of the following steps: (i) define a list of d wellbeing indicators grouped by dimension; (ii) for each indicator j set a minimum cut-off z_j and weight w_j such that the sum of the weights equals one; (iii) for each household and indicator create a binary indicator of deprivation, $g_{ij}^0 = 1$ if household i is deprived in indicator j and otherwise $g_{ij}^0 = 0$; (iv) calculate the deprivation score for household i as the weighted sum of deprivations $c_i = \sum_{j=1}^{d} w_j g_{ij}^0$; and (v) set the poverty threshold, k. Households with $c_i \geq k$ are identified as poor. This information can then be used to construct the multidimensional headcount $H = q/n$ (the number of poor people divided by the total population) and the adjusted headcount $M_0 = H * A$, where $A = \sum_{i=1}^{q} c_i / q$ is the poverty intensity (the average weighted share of deprivations of the multidimensionally poor). M_0 increases when an additional person becomes multidimensionally poor or when any poor person becomes deprived in another indicator.

We used a specialized census software (REDATAM+7) to construct H and M_0 at the census tract level based on household level data from the 2010 National Census (INDEC, 2010).[5] Appendix A, Table A1, presents the indicators, indicator cut-offs and weights used to construct our MPI. If a household is identified as poor, all members are considered poor, and the poverty measures refer to the level of poverty of the population. The indicator is comprised of four dimensions: housing, access to water and sanitation services, education, and economic and social inclusion. The dimensions and indicators were selected based on the CA literature and data availability. We apply equal weights to all dimensions and all indicators within each dimension. The poverty threshold is set at one-third of all weighted indicators, meaning that households must be deprived in more than one full dimension to be multidimensionally poor. The results of robustness analysis of the effects of altering these MPI parameters are discussed in section 4.

Statistical methods

Regression analysis provides a framework for testing the statistical significance of the correlation between each measure of environmental risk exposure and multidimensional poverty measured at the census tract level, while controlling for the effects of confounding variables. We use the following spatial autoregressive model (SARAR) because the results of local Moran's I tests indicated that the measures of environmental risk exposure and multidimensional poverty display strong positive spatial autocorrelation and the results of the Lagrange Multiplier test indicated there is spatial autocorrelation in the residuals (see Anselin, 1996).

$$ER_d = \alpha + \rho W_1 ER_d + \beta X_d + \gamma Y_d + \varepsilon$$

$$\varepsilon = \lambda W_2 \varepsilon + \mu \quad (4)$$

where ER_d is one of the three measures of environmental risk of census tract d, X_d is the MPI of census tract d and β is the coefficient of interest. Y contains control variables which may be correlated with the level of deprivation, such as population density and municipality dummies.[6] This model considers spatial autocorrelation in the dependent variable, by adding an additional explanatory variable ($W_1 ER_d$), which accounts for the influence of the geographic unit's neighbours, and for spatial autocorrelation in the error term, by adding a term ($W_2 \varepsilon$) which represents the structure of the spatially dependent error term. ρ and λ are the coefficients of these terms. The spatial weights matrices (W_1 and W_2), were defined using a distance-based measure (row standardized based on the inverse distance between the centroids of the census tracts), considered appropriate when there is considerable variation in census tract size (Chakraborty, 2009). In the MRB, census tract areas range from 0.01 km^2 in the CBA to 45 km^2 in the semi-rural upper basin. Finally, μ is a stochastic error term. The parameters are estimated using the maximum likelihood method.

Spatial analysis results

The heat maps in Figures 1-4 exhibit substantial variation in the geographic concentration of exposure to environmental risk by census tract. Exposure to the environment risk of productive establishments (Figure 1) is highest in the densely populated lower basin and relatively low throughout the middle and upper basins. Risk of exposure to open-air waste dumps (Figure 2) tends to follow the course of the Matanza-Riachuelo River and coincide with the location of informal settlements. Risk of exposure to surface water pollution (Figure 3) naturally is highest adjacent to rivers and streams and in the highly contaminated lower basin. The map of the adjusted MPI (Figure 4) shows that poverty is highest in informal settlements and in areas farthest from the city centre. The census tracts with the lowest poverty rates tend to have the *highest* risk of exposure to industrial and commercial environmental hazards.

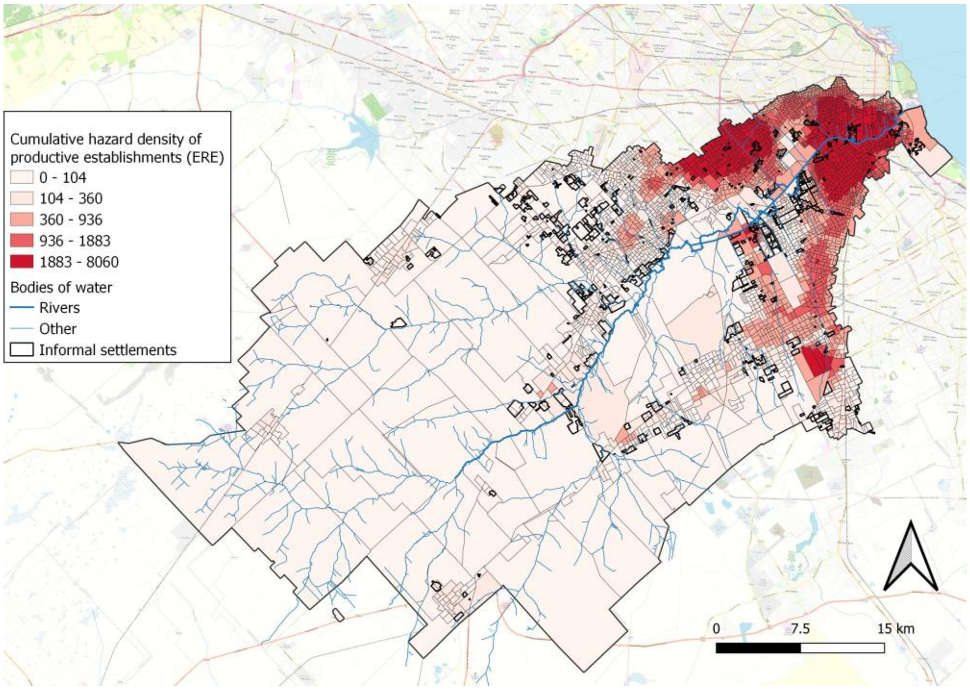

Figure 1. Cumulative hazard density of production establishments.

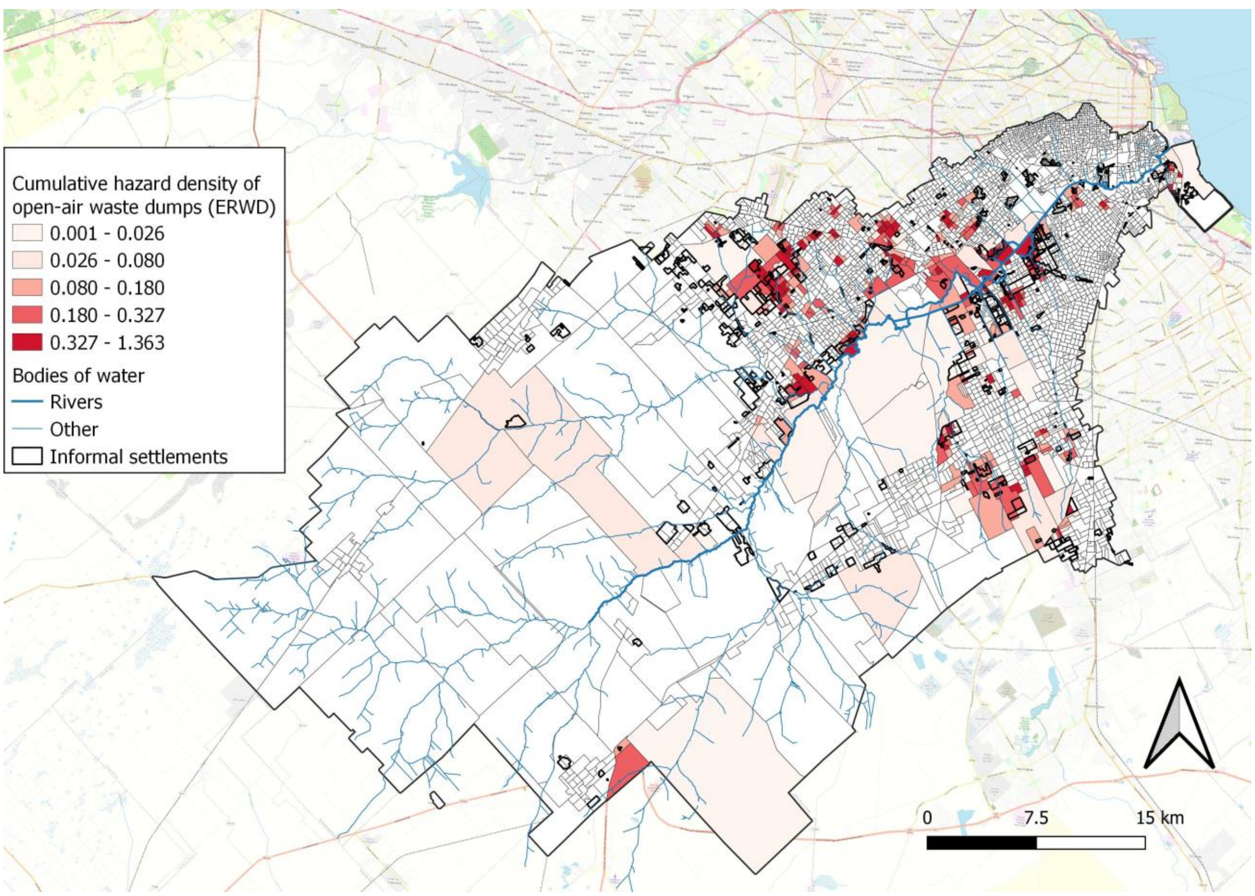

Figure 2. Cumulative hazard density of open-air waste dumps.

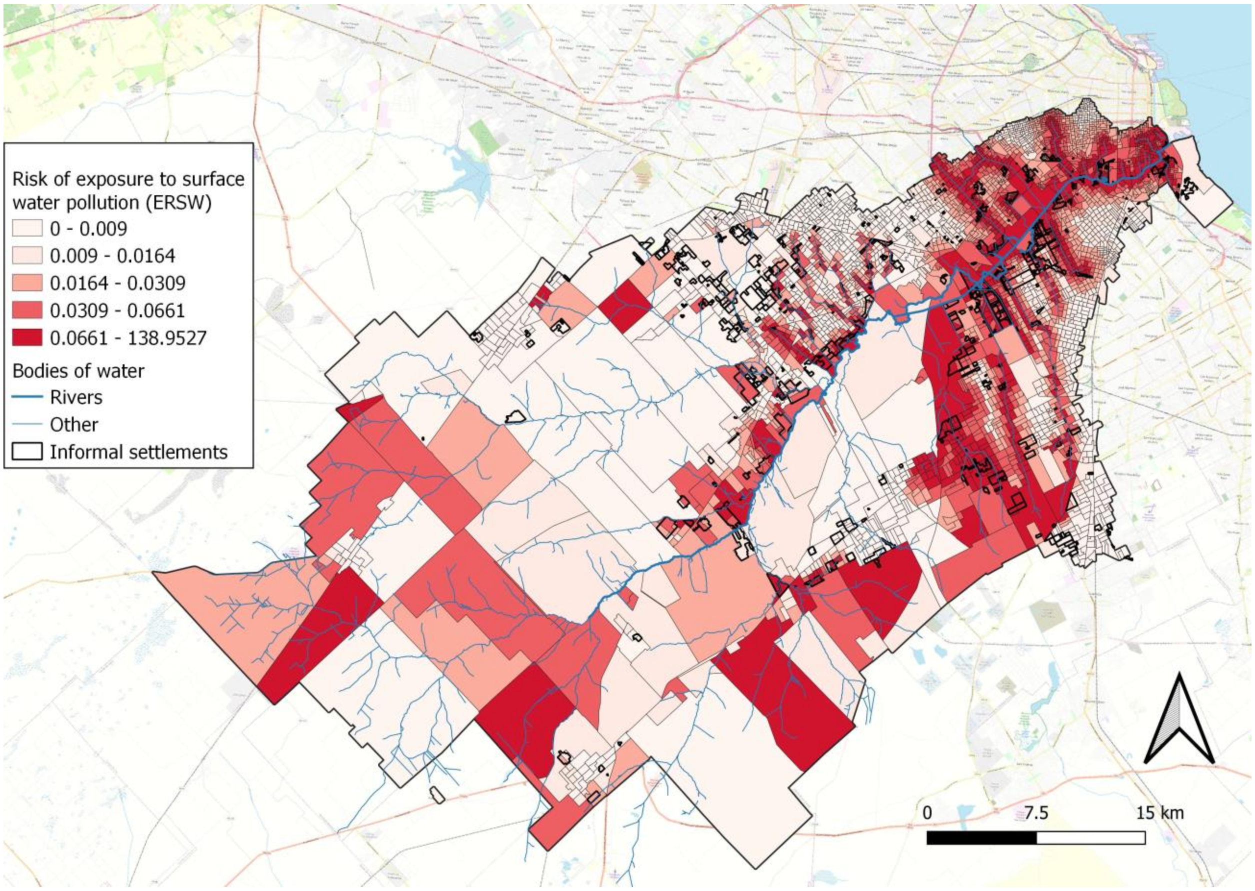

Figure 3. Risk of exposure to surface water pollution.

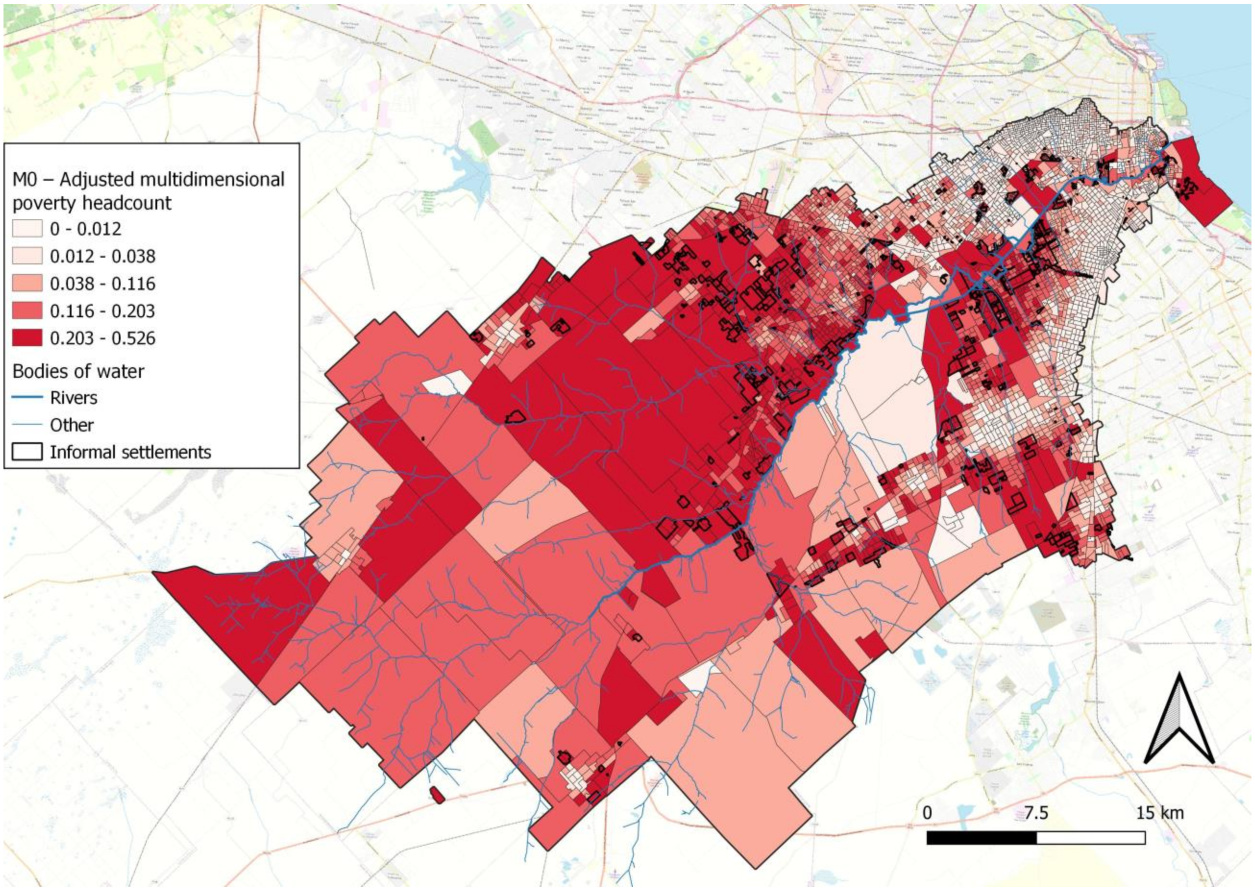

Figure 4. M0 – Adjusted multidimensional poverty headcount.

Table 1 presents summary statistics of the variables included in the regression models and Table 2 the results of the estimation of six SARAR models for each of two MPIs. The results indicate that there is a negative and statistically significant association between both MPIs and risk of exposure to industrial and commercial environmental hazards (p-value<0.01 for all models). This means that contrary to some predictions, when examining the entire MRB we do not find evidence of disproportionate siting of productive establishments close to high poverty areas. When we analyse only productive establishments with $\text{EIL} > 40$ (columns 3 and 4), the size of the MPI coefficients decline, but they continue to be negative and statistically significant. The coefficient on population density is negative and statistically significant but only when buffers of radii 0.5 km are used. In contrast, higher levels of multidimensional poverty are associated with greater exposure to open-air waste dumps (p-values<0.01 in all models). Finally, we do not find a statistically significant association between risk of exposure to surface water pollution and multidimensional poverty.

Table 1. Descriptive statistics of variables included in the regression models

	Mean	Std.Dev.
Cumulative hazard density productive establishments (buffer 0.5 km)	279.52	385.27
Cumulative hazard density productive establishments (buffer 1 km)	1,113.39	1,330.06
Cumulative hazard density productive establishments EIL>40 (buffer 0.5 km)	87.93	135.50
Cumulative hazard density productive establishments EIL>40 (buffer 1 km)	350.48	440.58
Cumulative hazard density open-air waste dump	0.03	0.10
Risk if exposure to surface water pollution	0.14	2.61
Multidimensional poverty headcount (*H*)	0.24	0.22
Adjusted multidimensional headcount (M_0)	0.11	0.10
Population density (population per km^2)	13,900.30	21,244.00

Notes: Sample size is 3,633 census tracts in the MRB.

Table 2. Results of the spatial autoregressive models

	Exposure to environmental hazards all productive establishments		Exposure to environmental hazards all productive establishments (EIL>40)		Exposure to open-air waste dumps	Exposure to surface water contam.
	Buffer 0.5k	Buffer 1k	Buffer 0.5k	Buffer 1k		
	(1)	(2)	(3)	(4)	(5)	(6)
Models with multidimensional poverty headcount (H)						
Constant	390.09	549.11	91.16	117.89	-0.007	0.006
	[467.99]	[3,194.43]	[116.67]	[870.40]	[0.020]	[0.212]
H	-137.34***	-270.13***	-32.66***	-70.20***	0.061***	-0.001
	[20.89]	[43.34]	[8.59]	[16.77]	[0.010]	[0.231]
Pop. density	-285.77**	-265.07	-135.40**	-78.76	-0.041	2.613
	[145.18]	[300.77]	[59.74]	[116.43]	[0.072]	[2.129]
ρ	0.994***	0.998***	0.991***	0.998***	0.828***	-0.006
	[0.004]	[0.001]	[0.006]	[0.002]	[0.040]	[0.110]
λ	0.994***	0.998***	0.990***	0.998***	0.876***	-0.068
	[0.004]	[0.001]	[0.006]	[0.002]	[0.034]	[0.113]
LM test spat. error	781.65***	1884.69***	394.67***	1378.56***	154.35***	4.11**
LM test spat. lag	231.73***	339.47***	202.76***	353.75***	7.12***	3.84**
Models with adjusted multidimensional headcount (M_0)						
Constant	382.17	554.83	89.53	120.18	-0.006	-0.000
	[469.44]	[3,205.04]	[116.74]	[870.83]	[0.020]	[0.211]
M_0	-269.13***	-540.32***	-64.68***	-142.06***	0.129***	0.053
	[43.05]	[89.30]	[17.69]	[34.55]	[0.020]	[0.486]
Pop. density	-293.07**	-276.70	-136.99**	-81.39	-0.040	2.601
	[145.22]	[300.77]	[59.73]	[116.40]	[0.072]	[2.128]
ρ	0.994***	0.998***	0.991***	0.998***	0.830***	-0.006
	[0.004]	[0.001]	[0.005]	[0.002]	[0.039]	[0.110]
λ	0.994***	0.998***	0.990***	0.998***	0.874***	-0.068
	[0.004]	[0.001]	[0.006]	[0.002]	[0 .034]	[0.113]
LM test spat. error	753.45***	1848.32***	385.09***	1363.05***	155.49***	4.18**
LM test spat. lag	240.35***	347.83***	207.46***	360.20***	6.80***	3.91**

Notes: Robust standard errors in brackets. All regressions are based on 3633 census tract observations and include municipality (PBA) or comuna (CBA) dummies. *** p<0.01, ** p<0.05, * p<0.1.

We conducted three types of robustness tests (results provided in Appendix B). First, we replicated regression models (1) and (3) using buffers of 1.5 and 2 kilometres. The sign and statistical significance of the coefficients on both MPIs did not change. Second, we repeated regressions (1) and (2) using only the establishments classified as 'polluting agents' (PA) in March 2018, the earliest available data.[7] For this analysis we did not weight by EIL so as to obtain estimates that are independent of the EIL measure. The regression coefficients on both MPIs continue to be negative and statistically significant at the 1% level. Third, we examined the robustness of the results to changes in the poverty threshold k and indicator weights used to construct the MPI.[8] For regressions (1) through (5), the coefficients on H and M_0 continue to have the same sign and statistical significance level and for regression (6) the coefficients continue to be not statistically significant.

The resettlement process and procedural justice

This section focuses on procedural justice in the resettlement process. We examine the relationship between the quality of participatory processes and resettlement outcomes in the City of Buenos Aires during 2011-2021.

Background and qualitative methods

The integral environmental remediation plan called for improving the habitat of the population living in informal settlements in the MRB, prioritizing the most vulnerable (ACUMAR, 2010a). It gave precedence to the resettlement of households living in dwellings bordering the Matanza-Riachuelo River, in settlements on open-air waste dumps, and in other highly polluted areas. The relocation of households in proximity to the river sought to reduce exposure to polluted river water, permit river access, and transform the coastal zone into public space. A framework agreement signed in 2010 between ACUMAR and the national, provincial, and municipal authorities identified 17,771 households for resettlement (ACUMAR, 2010b). The responsibility for implementing the policy was delegated to the municipalities, and within the CBA, to the Housing Institute (HI).

Our analysis is based on site visits and semi-structured interviews conducted by the authors between February and December 2022 with 20 people involved in the environmental remediation and resettlement process and the analysis of public documents, judicial resolutions, and the academic literature. The interview participants included delegates of community organizations representing resettled households, civil society organization leaders, employees of the HI, public defenders, an architect involved in the waterfront project design, the director of a large private enterprise operating in the watershed, and public officials of the Ministry of Public Works and of the principal state-owned water and sanitation enterprise operating in the MRB (AySA). The interviews with people involved in the resettlement process focussed on four main questions: 1) How did affected households participate in the resettlement process? 2) Which life dimensions were most impacted by resettlement and how? 3) What were the strengths and limitations of the resettlement process? 4) How did the experiences differ across households and informal settlements? The rest of the interview questionnaires were designed to gain a greater understanding of the overall remediation process. Although the qualitative analysis (based on interview notes and recordings) did not involve formal data coding, the interviews were an essential component of the research process. The participants provided a nuanced account of the context and personal experiences, helped us to better understand other data sources, and often suggested new sources of data and bibliography, enabling an iterative learning process combining desk research and fieldwork.

Participatory processes and outcomes

A civil society organization leader recalled a day in 2010 when families living in precarious wooden shacks along the Riachuelo River brought her a judicial order, demanding the elimination of 'obstacles' from the riverbanks and giving residents a 48-hour notice before their dwellings would be demolished.[9] These families were soon moved to a housing complex located in the most economically depressed area of the city nine kilometres from their neighbourhood of origin. The complex housed families from multiple neighbourhoods; was still under construction; lacked adequate connections to water, sanitation, electricity, and gas; had severe structural problems (cracks in walls and water infiltrations); and had not been formally inspected by the municipal government (AGN, 2013; Ryan et al., 2019).

Accounts of similar experiences during the first stage of resettlement (2011-2013) are documented in the literature. Ryan et al. (2019) found that households relocated in 2011 from the *Magaldi* settlement experienced a deterioration in mobility, connectivity, and access to schools and public health centres. The government provided little pre- and post- resettlement support to households and the workshops convened by the HI during this stage were irregular and used to inform rather than involve families in decision-making (Ryan et al., 2019; Chellillo et al., 2014a). Although a supreme court resolution of December 2012 formally recognized the right of affected households to participate in the process, it did not introduce mechanism to guarantee that right (Bercovich et al., 2014). The resettlement of households from two other small settlements (*Luján* and *El Pueblito*) during this period had similar characteristics (Chellillo et al., 2014a).

As the resettlement process advanced, the affected households increasingly obtained support from civil society organizations and public entities, such as the National Ombudsman, the General Advisors on Guardianship of the CBA, and the Office of the Public Defender of the CBA (OPD-CBA) (Chellillo et al., 2014b). The OPD-CBA set up local offices providing interdisciplinary support services to affected residents and in 2014 presented the case to the supreme court.[10] The normative framework used to defend the right to participation drew on national and international laws and agreements (Bercovich et al., 2014). The National Constitution of 1994 and the General Environment Law of 2002 recognize the right to information and participation in all decision processes regarding the environment. The 2018 Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters regulates rights to information, participation in decision-making processes, and access to justice in matters related to the environment and establishes mechanisms to render these rights effective (CEPAL, 2018).

By 2015-2017, when households were moved from a small settlement bordering the Riachuelo River (*Villa 26*) some improvements had been introduced in the process (Ryan et el., 2019). The HI began holding meetings with the households selected for resettlement to discuss financial planning for repayment for the housing units and reach agreements on the use of common spaces (Ryan et al., 2019). Inter-ministerial working groups were formed between the Ministries of Education, Housing, Health, and Human Development to coordinate actions to ensure access to public services during the transition to new housing.[11] However, the highly structured forms of consultation used by the HI to identify preferences for predefined alternatives did not allow for substantive political engagement by affected households (Ryan et al., 2019). The public authorities who participated in the meetings often were unable to provide technical information, lacked mandates to make commitments or did not respect the agreements reached with households (Chellillo et al., 2014b). Although two of the three complexes built to house these families were close to the neighbourhood of origin, all had numerous deficiencies, such as water infiltrations and electrical problems (Ryan et al., 2019).

A more substantive form of participation was achieved in the resettlement of households during 2019-2021 from the *Villa 21-24*, the city's largest informal settlement in terms of population and geographic area (DGEC, 2015). In this neighbourhood when the HI first attempted to conduct a neighbourhood census the residents impeded the entry of social workers until they could organize elections for delegates to represent the affected households (Scharager, 2016). Delegates demanded to oversee the census and worked to establish two instances of participation: weekly assemblies (forums for discussion and debate among residents) and working group sessions with the authorities responsible for implementing the resettlement policies.[12]

A principal demand of the body of delegates was to relocate families to housing complexes in the vicinity of the neighbourhood of origin. They argued that the uprooting of households from their community would disrupt access to local civil society organizations (e.g. community kitchens), public service providers (e.g. health centres) and neighbours, which together provided an essential support network. The neighbourhood also had intrinsic value associated with a common identity forged by years of shared struggle.[13] When authorities of the HI claimed there was no vacant land in the area to build the housing complexes, a group of delegates identified nearby abandoned lots and buildings and presented their proposal at a working group session. Following a large demonstration and blockade of the city centre's largest avenue, the Legislature of the CBA approved a law declaring the identified land of public interest and subject to expropriation (Scharager, 2016). According to interview participants, the body of delegates was also successful in reaching an agreement with the HI on the use of traditional methods to construct the new housing complexes, the contracting of neighbourhood cooperatives, and the provision of housing to the extended families of households selected for resettlement.

What seems to differentiate the experience in the *Villa 21-24* with that of the smaller informal settlements is the long history and strength of civic and political engagement in the neighbourhood. According to a civil society organization survey conducted during 2011-2013 in seven of the city's informal settlements, the *Villa 21-24* had the highest level of civil society organization density and rate of participation in local organizations (Mitchell, 2016). Since the 1970s, its neighbourhood assembly played an active role in conveying to government the community's collective demands and gaining access to basic public services.[14] While external civil and public entities (especially the OPD-CBA) provided legal counsel to affected households in all of the city's informal settlements, only this neighbourhood, which had a long tradition of political representation, was able to exert sufficient political influence to shape the resettlement process. This neighbourhood's experience aligns more closely with Holland's (2017) description of a 'transformative process' in that it fostered the institutionalization of decision rules and procedures for resettlement. The agreements reached in this community's working group sessions formed the basis for the adoption of protocols setting standards for resettlements throughout the MRB (ACUMAR, 2017).

Nevertheless, although this neighbourhood achieved expanded participation in decision-making processes, it does not come close to satisfying Schlosberg's (2012) definition of having the political capability for 'control over one's environment'. Interview participants emphasized the slow pace of progress and remaining challenges. By 2021, more than a decade after the process had begun, only three-fourths of the households initially targeted for resettlement in the CBA had been relocated to new housing (AGN, 2021; ACUMAR, n.d.). Moreover, even the newest housing complexes located close to the neighbourhoods of origin have multiple deficits, including structural problems, gas leakages, sewerage overflow, poor maintenance, and lack of mechanisms to ensure long-term sustainability.[15] The representative organization delegates we interviewed spoke of improvements in dwelling quality, security, tenancy and access to public services but also of the negative economic impact of now having to pay for public services and mortgage quotas, reduced ties with their neighbourhood of origin, and conflicts with neighbours over the maintenance of common spaces.

This case also demonstrates that the strength of participatory processes depends on the political will of the government in power. Residents were able to exhort influence through civic action when the HI had a receptive leader, but progress stalled following a change in authority in 2021.[16] The quality and experience of the team working on resettlement deteriorated and resources were diverted to urbanization policies in informal settlements outside of the MRB.[17] In 2021 the HI abandoned the area leaving piles of debris from demolished dwellings and unfinished renovations in dwellings damaged by the demolitions. During fieldwork, we visited homes with holes in the ceiling and cracks in ceiling beams due to unfinished housing repairs.

An additional problem is the inequality in treatment of households living in situations of environmental risk. The process has focussed on the resettlement of the 17,771 households identified in the 2010 framework agreement, which represent less than 10% of the population in informal settlements and 25% of the population at very high environmental risk according to a study on socio-environmental vulnerability in the MRB (ACUMAR, 2018a).[18] Proximity to the river has been the main targeting criteria used in the CBA, even though households living in other sectors of the informal settlements often are exposed to similar levels of environmental risk (associated with contaminated land and flooding risk) as those living close to the river.[19]

Conclusion

This paper has sought to examine the relationship between social equity and care for the earth in the case of the Matanza-Riachuelo River Basin, Argentina. The analysis of inequality in exposure to environmental risks indicates that there is a negative and statistically significant association between multidimensional poverty and risk of exposure to industrial and commercial environmental hazards and a positive and statistically significant correlation with exposure to open-air waste dumps. Both results are robust to variations in the criteria used to measure environmental risk exposure and multidimensional poverty. The correlation between multidimensional poverty and risk of exposure to surface water pollution is not statistically significant.

The finding that *lower* poverty areas face greater risk of exposure to productive establishment hazards runs counter to the generalized perception in the case of the MRB (Merlinsky, 2013) and research conducted in high-income countries (Banzhaf et al., 2019). By highlighting this result, we do not refute the real health risks faced by communities located close to highly contaminating industries. Further research is needed to understand the negative health impacts of industries on specific neighbourhoods. The results, however, are consistent with research in some Latin American countries showing that more affluent groups face disproportionate risk from industrial hazards (Grineski & Collins, 2010; Lara-Valencia et al., 2009). Grineski and Collins (2010) suggest that this result is likely related to the sociospatial pattern of urbanization in Latin America in which economic elites and businesses tend to locate in city centres, which have superior access to urban and transport infrastructure, and socially marginalized groups live in less developed peripheral areas. Consistent with this explanation, in recent decades in Greater Buenos Aires the most marginalized households have occupied the underdeveloped outer fringes of the city with limited urban infrastructure, whereas the most affluent groups have traditionally lived in the city centre. This result is also likely explained by the concentration of productive establishments in the southern zone of the CBA and neighbouring municipalities such as Avellaneda, which are relatively close to the city centre. Further inquiry is needed to understand the extent to which this sociospatial pattern of environmental risk exposure found in several Latin American cities holds for other contexts across the Global South.

The finding of a positive correlation between exposure to open-air waste dumps and multidimensional poverty is not surprising given the waste management problems in informal settlements and that many residents of these neighbourhoods depend on urban recycling as a source of income. A policy implication is that priority should be given to waste dump clean-up policies as they produce positive synergies between the promotion of social equity and environmental restoration. Such policies would need to include actions to create employment opportunities for households who depend on urban recycling as a livelihood strategy.

The quantitative analysis, however, was constrained by data limitations, and leaves a set of issues to be addressed further. High poverty areas may face greater threats of exposure to other types of hazards not studied in this paper due to lack of data, such as contaminated soil. In addition, the decline in size of the coefficients on the MPIs when we restrict the analysis to establishments with $\mathrm{EIL} \geq 40$ suggests that if we were to focus on the most contaminating industries the results may attenuate or even reverse. The lack of a statistically significant correlation between multidimensional poverty and our measure of surface water pollution may be due to lack of precision in measuring this source of risk. In addition, we do not consider the accumulative effect of multiple environmental risks and we only study the spatial correlation between environmental risks and multidimensional poverty (and not causal relationships), due to lack of data.

The analysis of procedural justice in the resettlement process illustrated that enhanced local participation in decision-making processes produced more favourable outcomes in terms of the expansion of capabilities of affected households, a result which is broadly consistent with the environmental justice literature (see the literature cited in Banzhaf et al., 2019). The first stage of resettlement was void of opportunities for participation. Households were uprooted from their neighbourhoods of origin and experienced a deterioration in connectivity and access to public services. In the second stage, the public housing authority began to incorporate some highly structured, top-down participatory exercises, which did not enable affected households to shape policy design. The informal settlement which was able to exert the most substantive influence over decision-making processes had a long history of political and civic engagement. In that community, through active political contestation, involving public demonstrations of force, the organization representing affected households negotiated relocation to housing complexes close to their neighbourhood of origin. This experience points to the importance of understanding the value of affiliation with communities of origin and attachment to place. The achievement of a more transformative form of participation demanded the combination of external legal support and an active grassroots civil society sector with experience in political engagement, as well as the political will of government authorities.

The findings point to the need for policies to foster civic participation and access to legal expertise and programmes, which accompany families during all stages of resettlement and consider the potential impacts on multiple life dimensions. This case also highlights the need to measure and disseminate data on the distribution of environmental risks and on the potential impact of regulatory and remediation policies, as access to information can help increase the bargaining power of communities.

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Appendix A

Table A1: Dimensions, indicators, indicator cut-offs, weights of the MPI.

Dimension	Indicator	Deprived if…	Weights
Housing	Overcrowding	Household has > 3 people per room.	0.083
	Housing materials	Dwelling has a dirt or loose brick floor or precarious roof.[1]	0.083
	Insecure tenancy	Households which i) own their dwelling but not the land, ii) live in an occupied or borrowed dwelling, or iii) have other precarious situations.	0.083
Basic Services	Lack of improved water source	Households with i) water piped to outside of dwelling but within the plot or outside the plot or ii) source of water is a manual pump, well, transport by cistern, rainwater, river, canal, stream or ditch.	0.125
	Lack of proper sanitation	Households with i) toilet or latrine not connected to piped sewer system or septic tank; ii) shared bathroom with another household, iii) no toilet.	0.125
Education	Adult schooling	Households in which any member ages ≥ 20 did not achieve a minimum schooling level for their age.[2]	0.125
	School attendance	Households in which any child or adolescent (ages 5-17) does not attend school.	0.125
Economic and social inclusion	Adult unemployment	Households in which any member over age 29 is unemployed.	0.125
	Excluded youth	Households in which any member ages 18-29 is out of school, unemployed or inactive.	0.125

Appendix B

Table B1: Robustness tests of spatial autoregressive models of environmental risk of productive establishments with variations in buffer size and of exposure to polluting agents.

	Exposure to environmental hazards all productive establishments		Exposure to environmental hazards productive establishments (EIL>40)		Exposure to polluting agents	
	Buffer 1.5k	Buffer 2k	Buffer 1.5k	Buffer 2k	Buffer 0.5k	Buffer 1k
	(1)	(2)	(3)	(4)	(3)	(4)
Models with multidimensional poverty headcount (H)						
Constant	-4844.94	-18325.74	-688.25	-2751.76	1.090	-0.056
	[9,928.48]	[23,214.33]	[2,575.72]	[5,169.17]	[2.940]	[23.669]
H	-358.83***	-402.58***	-80.06***	-84.49***	-0.778***	-1.553***
	[66.23]	[91.83]	[24.08]	[31.62]	[0.200]	[0.391]
Pop. density	273.93	941.81	113.18	197.85	-1.933	-0.562
	[459.47]	[637.04]	[167.07]	[219.38]	[1.391]	[2.713]
Ρ	0.999***	0.999***	0.999***	0.999***	0.991***	0.998***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.005]	[0.002]
Λ	0.999***	0.999***	0.999***	0.999***	0.992***	0.998***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.005]	[0.002]
LM test spat. error	2593.606***	3069.838***	2105.615***	2480.071***	255.198***	1019.292***
LM test spat. lag	377.535***	416.748***	455.612***	571.341***	92.365***	173.738***
Models with adjusted multidimensional headcount (M_0)						
Constant	-4758.84	-18075.97	-662.27	-2700.39	1.041	-0.110
	[9,899.67]	[23,047.85]	[2,570.41]	[5,146.33]	[2.937]	[23.646]
M_0	-737.11***	-851.48***	-168.16***	-180.90***	-1.523***	-3.069***
	[136.42]	[189.12]	[49.60]	[65.13]	[0.412]	[0.805]
Population density	263.11	935.54	111.66	197.05	-1.975	-0.637
	[459.34]	[636.75]	[167.01]	[219.30]	[1.391]	[2.712]
Ρ	0.999***	0.999***	0.999***	0.999***	0.991***	0.998***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.005]	[0.002]
Λ	0.999***	0.999***	0.999***	0.999***	0.992***	0.998***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.005]	[0.002]
LM test spat. error	2563.530***	3047.073***	2091.028***	2465.131***	249.159***	1016.063***
LM test spat. lag	385.783***	425.724***	462.878***	579.876***	95.632***	176.804***

Notes: Robust standard errors in brackets. All regressions are based on 3633 census tract observations and include municipality (PBA) or comuna (CBA) dummies. *** p<0.01, ** p<0.05, * p<0.1

Table B2: Results of robustness tests of the results of the spatial autoregressive models with variation in the parameter k and the weighting structure used to construct the multidimensional poverty measures.

	Exposure to environmental hazards all productive establishments		Exposure to environmental hazards all productive establishments (EIL>40)		Exposure open air waste dumps	Exposure to surface water contamination
	Buffer 0.5k	Buffer 1k	Buffer 0.5k	Buffer 1k		
	(1)	(2)	(3)	(4)	(5)	(6)
Coefficients Poverty Headcount (H)						
Original	-137.34***	-270.13***	-32.66***	-70.20***	0.061***	-0.001
	[20.89]	[43.34]	[8.59]	[16.77]	[0.010]	[0.231]
Alternative values of k						
0.25	-118.44***	-231.29***	-26.86***	-56.73***	0.054***	-0.048
	[19.13]	[39.71]	[7.86]	[15.37]	[0.009]	[0.194]
0.375	-143.10***	-290.33***	-33.69***	-75.35***	0.074***	0.047
	[24.91]	[51.65]	[10.23]	[19.98]	[0.012]	[0.280]
0.5	-208.47***	-453.72***	-52.37***	-121.29***	0.127***	0.246
	[43.77]	[90.69]	[17.96]	[35.06]	[0.021]	[0.550]
Alternative weighting structure of dimension weights						
Housing 0.5	-153.15***	-287.54***	-37.48***	-75.50***	0.062***	-0.016
	[22.14]	[45.96]	[9.10]	[17.79]	[0.011]	[0.257]
Public services 0.5	-109.51***	-230.48***	-25.60***	-59.66***	0.047***	0.001
	[18.81]	[39.01]	[7.72]	[15.09]	[0.009]	[0.197]
Education 0.5	-132.94***	-261.88***	-30.72***	-65.33***	0.063***	-0.042
	[21.20]	[44.00]	[8.71]	[17.03]	[0.010]	[0.214]
Inclusion 0.5	-203.21***	-386.64***	-43.93***	-88.29***	0.111***	-0.094
	[36.43]	[75.59]	[14.96]	[29.24]	[0.017]	[0.407]
Coefficients Adjusted MPI (M0)						
Original	-269.13***	-540.32***	-64.68***	-142.06***	0.129***	0.053
	[43.05]	[89.30]	[17.69]	[34.55]	[0.020]	[0.486]
Alternative values of k						
0.25	-260.40***	-519.67***	-60.97***	-132.48***	0.126***	-0.020
	[41.94]	[87.01]	[17.23]	[33.67]	[0.020]	[0.448]
0.375	-269.81***	-555.25***	-64.57***	-146.21***	0.146***	0.131
	[47.98]	[99.50]	[19.70]	[38.48]	[0.023]	[0.551]
0.5	-337.70***	-741.24***	-84.97***	-199.86***	0.212***	0.427
	[72.42]	[150.03]	[29.72]	[58.00]	[0.035]	[0.916]
Alternative weighting structure of dimension weights						
Housing 0.5	-292.72***	-563.80***	-70.46***	-149.14***	0.130***	0.025
	[44.71]	[92.76]	[18.38]	[35.89]	[0.021]	[0.535]
Public services 0.5	-186.99***	-399.09***	-44.73***	-105.04***	0.091***	0.061
	[33.57]	[69.60]	[13.78]	[26.92]	[0.016]	[0.365]
Education 0.5	-264.93***	-531.39***	-62.25***	-136.07***	0.137***	-0.032
	[42.44]	[88.05]	[17.43]	[34.07]	[0.020]	[0.445]
Inclusion 0.5	-426.66***	-808.95***	-98.00***	-190.00***	0.221***	-0.126
	[74.97]	[155.54]	[30.79]	[60.16]	[0.036]	[0.849]

Notes: The table only presents the estimated coefficients on H and M0. Robust standard errors in brackets. All regressions are based on 3633 census tract observations and include municipality (PBA) or comuna (CBA) dummies. *** p<0.01, ** p<0.05, * p<0.1

[1] $EIL = LE + R + EG + Ru + Ri + Di + Lo$, where LE is a score measuring liquid effluents, R solid waste, GE gaseous effluents, Ru primary products employed in production, Ri diverse risks (explosion, fire, noise, vibration, and chemical substances), Di the establishment's scale and Lo location-related risks (ACUMAR, 2018b).

[2] This approach assumes that environmental risks are distributed homogeneously in space. Although this assumption is not realistic, we cannot use dispersion models, which consider air and water currents and geographic features, due to lack of data on each establishment's emissions.

[3] This survey identified 118 micro, 19 regular and 2 macro waste dumps. Micro dumps have between 15 and 500 m^3 of waste, regular dumps between 500 and 15,000 m^3 and macro dumps more than 15,000 m^3 (UIDET, 2017).

[4] While most environmental justice research uses income-based measures of social equity, some recent studies use multidimensional measures (Barnes et al., 2019; Li et al., 2018).

[5] This census is the most recent source of spatially disaggregated data for measuring multidimensional poverty. As the MPI is comprised mostly of indictors of structural poverty it evolves slowly and, therefore, 2010 data should provide an adequate measure of the spatial variation in deprivation in the years for which environmental risk exposure data are available (2013-14, 2017 and 2019).

[6] *Comuna* dummies used in the CBA.

[7] ACUMAR declares establishments PA when their negative impact on the air, earth, water, or environment in general has been proven or when it has been shown to not comply with regulations on liquid effluents (Art. 24 of ACUMAR, 2019c).

[8] We re-estimated H and M_0 using three alternative values of k (0.25, 0.375 and 0.5) and four alternative weighting structures (sequentially increasing the weight of one dimension to 0.5 and distributing equally the remaining weights).

[9] Based on an interview with an NGO leader on March 31, 2022.

[10] Based on interviews with three current or former OPD-CBA lawyers on April 25^{th} and May 20^{th}, 2022.

[11] Based on interview with a former Housing Institute employee, February 16, 2022.

[12] Based on interview with a representative organization delegate, April 21, 2022.

[13] Based on interview with a representative organization delegate, April 21, 2022.

[14] Based on interview with a representative organization delegate, April 21, 2022.

[15] Based on interview with a representative organization delegate, April 21, 2022.

[16] Based on an interview with an NGO leader on March 31, 2022.

[17] Based on interview with a representative organization delegate, April 21, 2022.

[18] Estimates assume an average household size of four.

[19] Based on interviews with an NGO leader on March 31, 2022 and with a delegate on April 21, 2022.