Flood Risk in the Buenos Aires-La Plata Metropolitan Area

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Keywords	Risk to floods, spatial vulnerability, Buenos Aires-La Plata Metropolitan Area
City Population	16,650,814
City Area	3,035.2 km^2
City GDP	94.7 billion USD
Climate Zone	Cfa (humid subtropical)
ARC3.3 Linkage	Equity, Development, and Informality Element

Introduction. The Buenos Aires-La Plata Metropolitan Area constitutes the largest urban agglomeration in Argentina, with an area of 3035 km^2 (CIPPEC, 2023) within the 2,780,085 square kilometers (km^2) of continental Argentina (IGN, 2023a). This urban extension includes the Autonomous City of Buenos Aires and conurbation of surrounding departments of Buenos Aires Province. It includes a total of 14 departments (Lomas de Zamora, Quilmes, Lanús, General San Martín, Tres de Febrero, Avellaneda, Morón, San Isidro, Malvinas Argentinas, Vicente López, San Miguel, José C. Paz, Hurlingham and Ituzaingó) and portions of 20 (La Matanza, Almirante Brown, Merlo, Moreno, Florencio Varela, Tigre, Berazategui, Esteban Echevarría, San Fernando, Ezeiza, Pilar, Escobar, General Rodríguez, Presidente Perón, San Vicente, Marcos Paz, Cañuelas, La Plata, Ensenada and Berisso). (INDEC, 2003; INDEC, 2023a).

The surface is intersected by multiple watercourses contributing to the La Plata basin. The altitude varies from 0 msl (some portions under 0 msl) and 35 msl. The data register records the average annual rainfall in the area at about 1210.4 mm (based on January 1991 and August 2023 empirical data) with an average of 111.6 rainy days (GCABA, 2023a). January is the month with the highest precipitation (132.2 mm) while June is the driest (56.4 mm). August experiences the fewest rainy days (8) and October shows the most (10.7). The 95th percentile of daily rainfall (R95pT), derived from climate simulations for 2015-2039 (from the Representative Concentration Pathways -RCP- 4,5-), indicates 182.6 days in average annual precipitation (Taylor et al., 2012; Sillmann et al., 2013).

The geomorphological and climatic conditions create a susceptible state for flooding caused by extreme precipitation events while nurtured by multiple anthropogenic problems, such as low availability of land for housing, reduced underground piping to collect rain, and the low capacity to prevent collateral disasters like tropical diseases, demographic dynamics, urban complexities, and social vulnerabilities based on economic poverty. A governmental way to integrally deal with the multiple challenges is the "Buenos Aires Resiliente" strategy. This strategy has been developed by the Buenos Aires Bureau, which implements the Autonomous City of Buenos Aires' official program (GCABA, 2018). It involves five pillars: diversity, gender, coexistence, innovation/talent, and opportunities; environment and sustainability; social and urban integration; safety and risk management. Three axes are considered: citizen participation, data/technology, and a metropolitan perspective. The "Buenos Aires Resiliente" strategy works to reduce the vulnerability and included the developing of the Social Vulnerability to Disasters Index (SVDI) as method for understanding territorial issues.

Resilience and vulnerability: the Social Vulnerability to Disasters Index (SVDI). As in environmental studies, risk refers to the potential for harm to life, health, property, and/or the environment (Park, 2007), while resilience implies the reduction of risk variables to disasters impacts based on a system's capacity to absorb unexpected perturbations and shocks (Holling, 1973). It implies further understanding of access to basic services and green spaces, linking urban, peri-urban and rural zones, and reducing deaths and economic losses from the hydric cycle, with a focus on vulnerable groups (United Nations, 2023).

We consider the existing inverse relationship between social vulnerability and resilience: while resilience increases, vulnerability decreases (SOPAC, 2004), whereby links to vulnerability can be identified through limitations in reducing social response to unfavorable conditions (Massachesi & Castro-Díaz, 2023). This has also been found

in preexisting structural conditions prior to climate disaster (Natenzon & Ríos, 2015). Referring to urban floods, resilience in cities refers to the set of strategies to avoid floods or to mitigate the impact in the disaster context (Visintini & Castro-Díaz, 2018; Rosenzweig et al., 2018). From a Latin American perspective (Castro-Díaz et al., 2019), it has been considered the basic meaning of social vulnerability to disasters and quantifiable from social conditions. Natenzon & Ríos (2015) developed the Social Vulnerability to Disasters Index (SVDI) containing ten variables for three dimensions: social (population under 15 years, population over 64 years, illiteracy, and childhood mortality), housing (overcrowded households, lack of access to drinking water supply, and lack of sewage service), and economic (unemployment, incomplete secondary education, and single parenthood). We used this method in the case study for analyzing departments with highest vulnerability.

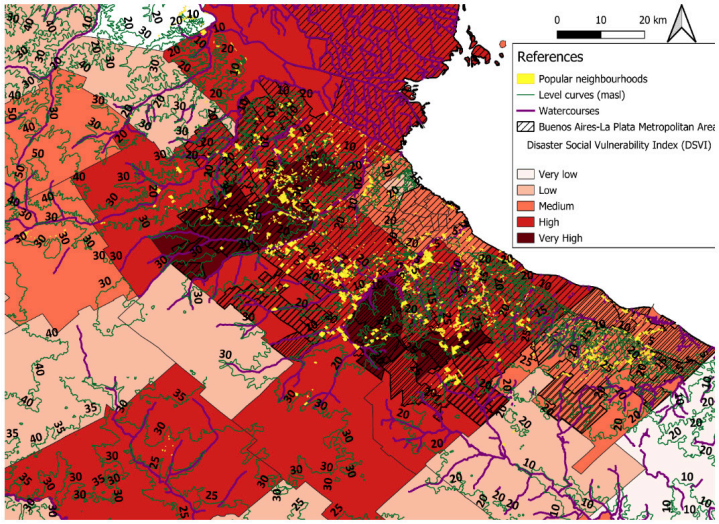

Figure 1. *Great Buenos Aires and Great La Plata Metropolitan Area and surroundings, level courses, SVDI, watercourses and Popular neighbourhoods. Source: authors based in GCABA (2023a), GPBA (2023), IGN (2023a), Natenzon (2015), and Ministerio de Salud y Desarrollo Social de la Nación (2019)*

Figure 1 shows the Buenos Aires-La Plata Metropolitan Area, divided by department (gray polygons) within the Province of Buenos Aires and City of Buenos Aires. The darkest red areas represent highest Social Vulnerability to Disaster Index (DSVI) values. According to DSVI measurements in Argentina, the geographical units with the highest vulnerability in this agglomeration are the Departments of Moreno, Malvinas Argentinas, Ezeiza, General Rodríguez, José C. Paz, Presidente Perón, and Almirante Brown. Of 514 total geographical units in Argentina, thirteen show highest DSVI values, while seven of them are located in the Buenos Aires-La Plata Metropolitan Area.

Given the meteorological conditions (see Section 1), these departments are at highest risk for climate disasters, though other administrative units might be extremely impacted as seen on April 2nd and 3rd, 2013, where widespread flooding occurred across the agglomeration, with 275 mm of precipitation in the City of Buenos Aires (GCABA, 2023a) and 392.2 mm in La Plata and surroundings (UNLP, 2013) resulting in 89 deaths (Chesini et al., 2019).

Popular Neighborhoods in the Buenos Aires-La Plata Metropolitan Area. The demographic context of social vulnerability in Buenos Aires-La Plata Metropolitan Area for 5,671,711 households (INDEC 2023a; INDEC, 2023b) is remarkable due to the existence of 581,276 residents in informal settlements (106,786 households in the seven departments registered as "high vulnerability" by the SVDI) according to data from the National Register of Popular Neighborhoods (RENABAP) (RENABAP, 2023). These informal settlements are recognized as "popular neighborhoods" and defined by a minimum of eight families, where at least a half of them lack either formal land tenure titles or present difficulties to access to two out of three housing services: drinking water supply, sewage, and legal electricity connection (Ministerio de Salud y Desarrollo Social de la Nación, 2019). Most of these neighborhoods are situated within regions exhibiting high to very high social vulnerability (Figure 1).

Conclusions. As Buenos Aires – La Plata Metropolitan Area is located on terrain susceptible to extensive flooding due to the interplay of geomorphological and climatic conditions, several torrentiality simulations (Taylor et al., 2012; Sillmann et al., 2013), as well as the rain empirical data (GCABA, 2023b), and the factual vulnerability (described in this text), exhibit areas highly susceptible to negative impacts from climate change. The region has experienced climate events resulting in fatalities (Chesini et al., 2019), spurring current adaptive responses like rainfall water control infrastructure as well as social interventions to improve employment access and education. The Buenos Aires-La Plata Metropolitan Area faces high risk to urban flooding due to heavy summer rainfall overwhelming drainage infrastructure. These floods severely impact over 580,000 marginalized residents of informal settlements lacking adequate housing, services, and resilience. According to the Disaster Vulnerability Index, seven metro departments exhibit acute social vulnerabilities driven by poverty, unemployment, and inadequate infrastructure.

Flooding disasters like the 2013 extreme rainfall event have massively disproportionate impacts on these vulnerable communities. Their precarious circumstances leave them far less equipped to cope with and recover from floods. There is thus a clear spatial correlation between highly vulnerable neighborhoods and lack of resilience to absorb and bounce back from flooding shocks. In response, the city's "Buenos Aires Resiliente" strategy focuses on upgrading housing and infrastructure and addressing risk factors in informal settlements to bolster metro-wide resilience. Crucially, resilience building requires tackling the root drivers of social marginalization that magnify disaster vulnerability (Ebru et al., 2018; Leal Filho et al., 2021).

Effective climate adaptation necessitates infrastructure to mitigate extreme rainfall, but its feasibility requires prioritizing actions that reduce social vulnerability.

Flood resilience to confront vulnerability and climate change requires developing multiple adaptation strategies, including drainage infrastructure to contain rainfall and factors linked to household infrastructure, healthcare access, formal education, and employment directly tied to income. All of this needs an integral plan among the geographical units involved in the urban space through a metropolitan outlook.

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Additional Data

- **Population Density:** 5,486 people/km^2
- **Gross National Income (GNI):** 12,890 USD (Higher-Middle Income) [2023]
- **Gini Coefficient:** 40.7 [2022]
- **Human Development Index (HDI):** 0.849 (Very High) [2022]
- **Type of Climate Intervention:** Adaptation