Urban Indicators

Risk analysis can further be disaggregated to metropolitan areas, which are usually made up of administrative units such as districts, municipalities, communes or localities. All of these have different risk levels and requirements to estimate potential damage and/or losses for the different types of infrastructure (i.e., buildings, public works, roads, etc.) that are exposed to hazard events. The estimation of a MCE for the city would allow us to evaluate in greater detail the potential direct damage and impacts to prioritize interventions and actions required to reduce risk in each area of the city.

The urban risk indicators are similar to those used at other levels but with the addition of two new indicators: the Index of Physical Risk and the Impact Factor. The former is based on hard data, while the latter is based on soft variables that depict social fragility and lack of resilience. In turn, these two indicators allow us to create a Total Risk Index, R_T, for each unit of analysis. These indicators require greater detail than that used at the national or regional level and they focus on urban variables (Cardona and Barbat, 2000; Barbat, 2003a; Barbat, 2003b). In other words, we have developed a methodology that combines the Disaster Deficit and the Prevalent Vulnerability indices used for the national and subnational analyses.

It is important to point out that different urban areas may be most affected by different phenomena (as shown by studies of seismic microzonation and flooding). In other words, risk and hazards vary greatly spatially (i.e. an urban center). This complicates the analysis because, strictly speaking, we would need to carry out different impact analyses for each section of an urban area. Yet, historical data can be used to identify the type of event that would cause the most critical impact on the city as a whole and use this estimate as a reference point.

In order to demonstrate the types of results that may be obtained with this methodology, we evaluated risk faced by the city of Bogota, Colombia. The choice was made based on the availability of risk studies as well as the ease with which the data could be obtained.[12] Earthquakes were chosen as the worst type of threat for the Bogota metropolitan area. A holistic evaluation of seismic risk was carried out, beginning with various scenarios of potential losses. The next step was the creation of indicators of damage and direct effects for each unit of analysis, which, in this case, is the locality or district. An indicator of physical risk (R_P) was obtained for each locality by taking into account potential deaths, number of persons injured, the extent of the area destroyed and the impact on vital infrastructure and services, including water, electricity, roads, and housing. An indirect impact factor $(1 + F)$, based on an aggravating coefficient F, was determined for each unit of analysis on the basis of indicators of social fragility and lack of resilience. The aggravating coefficient ranges between 0 and 1.

This coefficient is estimated for each locality by means of a series of nonlinear functions whereby the net values of the indicators are related to an impact factor. Each factor is also assigned a weight consistent with the Analytic Hierarchy Process (AHP).

Figure 23 presents the indicators and their weights, while figures 24 and 25 show the impact factor as a function of population density and public space, respectively. Figures 26 through 29 present the results of the holistic estimation of seismic risk for Bogota using these indicators.

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[12] Barbat and Carreño (2004b) present a detailed summary of the results.

Figure 23. Indicators of Physical Risk, Social Fragility and Lack of Resilience, with Related Weights

Ind	*Description*	*w*
F_{RF1}	Damaged area	31
F_{RF2}	Number of deceased	10
F_{RF3}	Number of injured	10
F_{RF4}	Ruptures in water mains	19
F_{RF5}	Rupture in gas network	11
F_{RF6}	Fallen lengths on HT power lines	11
F_{RF7}	Telephone exchanges affected	4
F_{RF8}	Electricity substations affected	4

>> **R_P** **Physical risk**

Ind	*Description*	*w*
F_{FS1}	Slums-squatter neighborhoods	18
F_{FS2}	Mortality rate	4
F_{FS3}	Delinquency rate	4
F_{FS4}	Social disparity index	18
F_{FS5}	Population density	18
F_{FR1}	Hospital beds	6
F_{FR2}	Health human resources	6
F_{FR3}	Public space/shelter facilities	4
F_{FR4}	Rescue and firemen manpower	3
F_{FR5}	Development level	9
F_{FR6}	Preparedness/emergency planning	9

>> **F** **Aggravating Coeff.**

>> $$R_T = R_P(1+F)$$

Figure 24. Factor of physical risk as a Function of Population Density

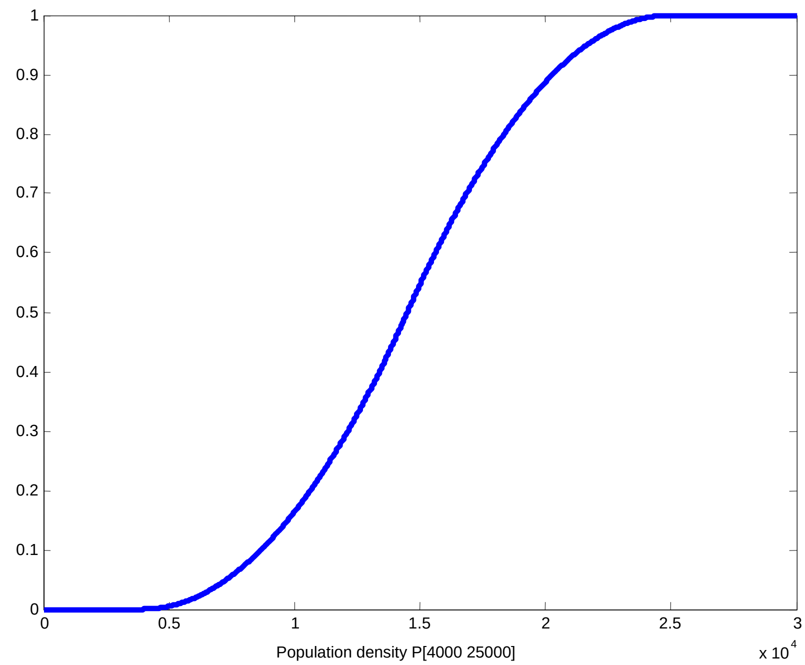


Figure 25. Factor of social fragility as a Function of Public Space Available

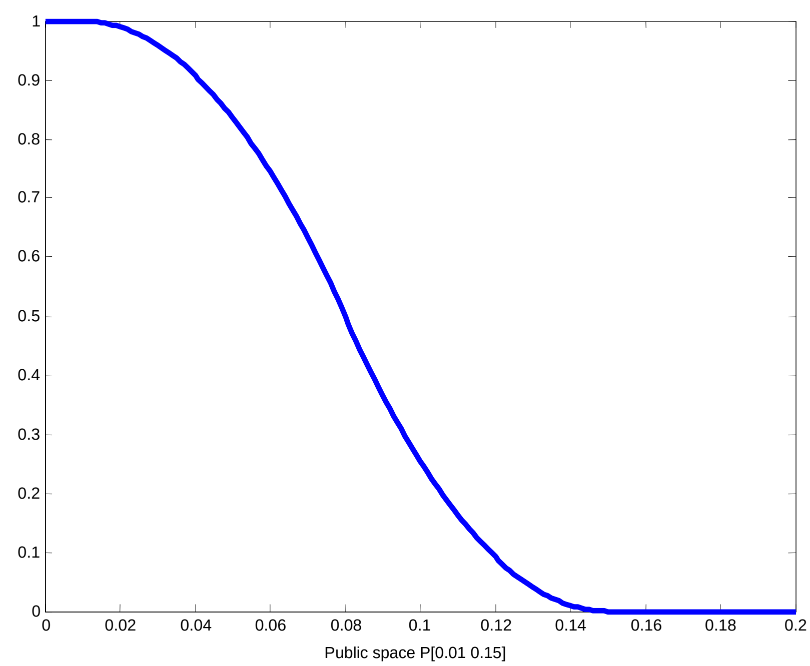


Figure 26. Physical Risk Index for the Localities of Bogota

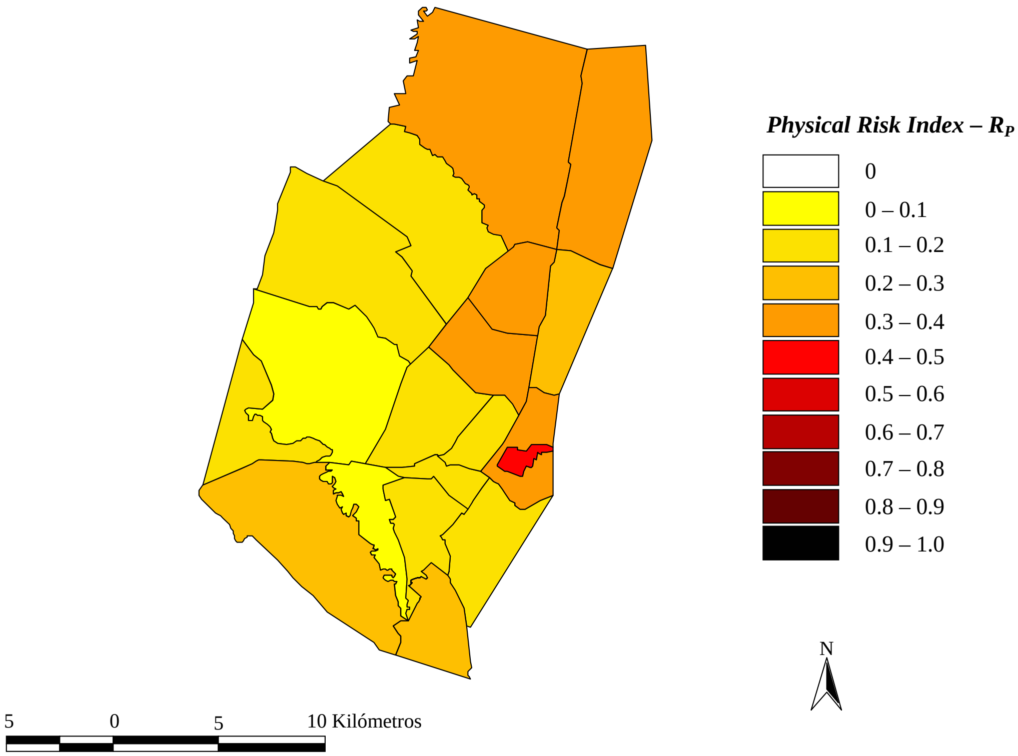


Figure 27. Values and Ranking of the Localities According to the Physical Risk Index

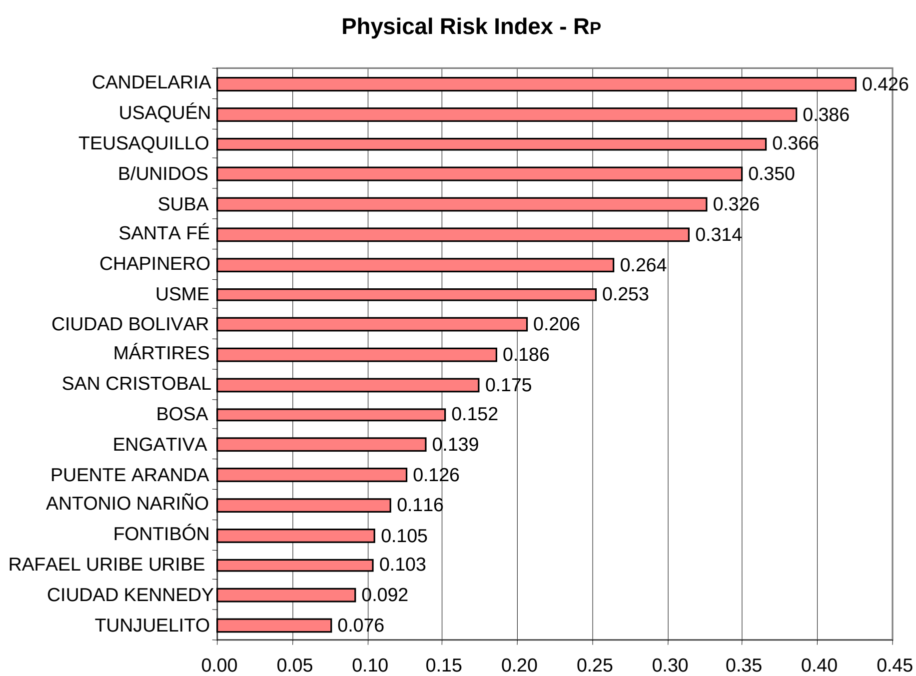


Figure 28. Total Risk Index for the Localities of Bogota

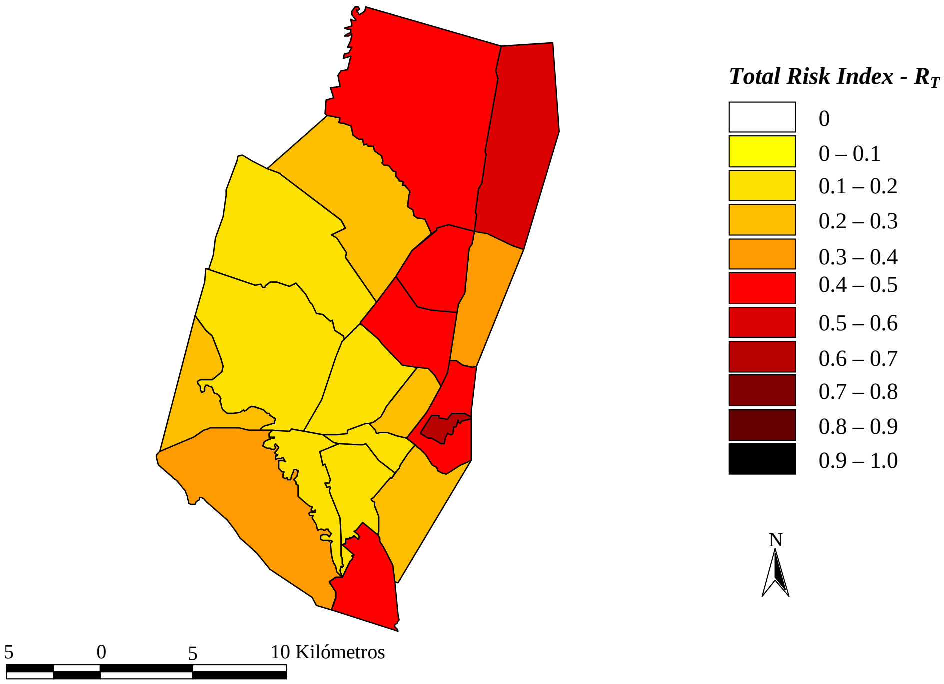
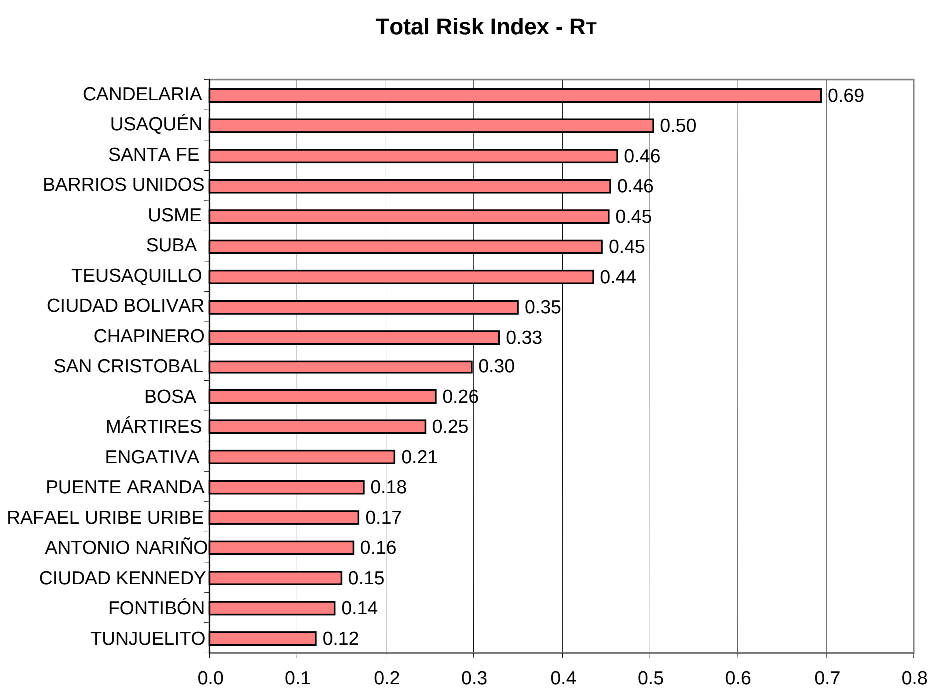


Figure 29. Values and Ranking of the Localities According to the Total Risk Index



The Risk Management Index, including its component indicators (identification of risk, risk reduction, disaster management, and financial protection and governance) was estimated with the assistance of experts from the *Dirección de Prevención y Atención de Emergencias* [Directorate of Emergency Prevention and Response] of Bogota as well as outside experts. As is the case with other indicators, the weights used are consistent with the AHP.

Table 24 shows the RMI for Bogota. Figure 30 shows the results of the analysis for each one of Bogota's localities for 2003, which was obtained following the same procedures as for the city as a whole.

Table 24. The Risk Management Index for Bogota

Indicator	1985	1990	1995	2000	2003
RMI_{RI}	4.6	13.9	35.6	56.2	67.1
RMI_{RR}	11.0	13.9	13.9	46.1	56.7
RMI_{DM}	4.6	8.3	8.3	24.0	32.3
RMI_{FP}	4.6	57.5	54.8	57.6	61.4
$RMI_{average}$	**6.2**	**23.4**	**28.1**	**46.0**	**54.4**

Figure 30. Ranking of Localities According to the RMI