Assembly areas as urban infrastructure: disaster governance, spatial equity, and the protection of public open space in seismically exposed cities

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Abstract

Disaster assembly areas - designated open spaces where populations gather following a major earthquake - represent a critical but neglected component of urban resilience infrastructure. Using Istanbul as a primary case study, this Perspective examines how assembly area provision has been systematically eroded through routine planning decisions made outside the disaster management apparatus. Our spatial analysis of 5,570 designated sites reveals a citywide per-capita provision of 2.98 m^2 - below the Sphere humanitarian minimum - with acute spatial inequality: districts carrying the oldest, most seismically vulnerable building stock simultaneously show the worst assembly provision, a double jeopardy condition affecting 31.7 per cent of Istanbul's 973 neighbourhoods. The pattern is not unique to Istanbul: comparative evidence from Kathmandu, Tehran, and Lima demonstrates that the commodification of urban open space under development pressure is a global phenomenon, consistently outpacing disaster governance frameworks. We argue that four shifts are required - statutory protection for designated sites, vulnerability-weighted spatial allocation, fitness-for-purpose verification, and community-level awareness - and that the fundamental barrier is not technical but institutional: the systematic disconnection between land-use planning and disaster management that allows assembly space to be quietly withdrawn from public use one planning amendment at a time.

On 23 April 2025, a magnitude 6.2 earthquake struck Istanbul, sending millions of residents into the streets. For many, the instinct was to head to a designated disaster assembly area - a park, a schoolyard, a public square. What they found, or failed to find, was the product of decades of decisions made long before the ground shook.

Istanbul sits astride the North Anatolian Fault, one of the world's most seismically active strike-slip systems. The 1999 Marmara earthquake killed over 17,000 people and triggered a generation of reform: building codes were tightened, emergency management was restructured, and a network of disaster assembly areas was formally established. Yet the April 2025 event revealed how fragile that legacy has become. Numerical gains in designated assembly space have masked a deeper erosion of urban resilience - one driven not by seismic hazard but by land use politics, and one that falls most heavily on those least able to bear it. Assembly areas sit at the intersection of urban planning, disaster governance, and social equity - and their story in Istanbul illuminates a pattern visible in rapidly urbanising cities worldwide: the gradual erosion of disaster-preparedness infrastructure in favour of short-term economic gain (Koren and Rus, 2019).

A disappearing public realm

Following the 1999 earthquake, approximately 496 sites across Istanbul were formally designated as disaster assembly zones. Within two decades, the Chamber of Civil Engineers (İMO) documented that 419 of those sites had been released for development (Kale, 2019) - converted into shopping centres, hotel complexes, and high-density residential projects. The transformation of Cumhuriyet Park into the Akmerkez mall, the former İETT garage into Kanyon, the Fire Brigade Square into City's Nişantaşı, the Ali Sami Yen Stadium site into Torun Center: these are not isolated planning failures but a systemic pattern (Figure 1). A 2024 report by the Istanbul Planning Agency identified 95 shopping malls (Istanbul Planning Agency [IPA], 2024) across the city built on plots previously designated as earthquake assembly areas, representing over 20,000 m^2 of former public open space - enough, the agency estimated, to have sheltered approximately 42,200 displaced residents. Istanbul is not an outlier. The conversion of disaster-preparedness commons to private commercial use is a pattern documented in cities across the seismically active world, driven by the same structural forces: development pressure on centrally located land, weak statutory protection for open space, and the systematic exclusion of disaster governance from routine land-use decision-making. What makes Istanbul distinctive is not the phenomenon itself but the completeness of the record - the degree to which the mechanism is traceable, documented, and quantifiable. It offers, in this sense, an unusually legible case study in how urban resilience is incrementally dismantled not by a single catastrophic decision but by the accumulation of individually defensible planning amendments (Pelling, 2003; Koren and Rus, 2019).

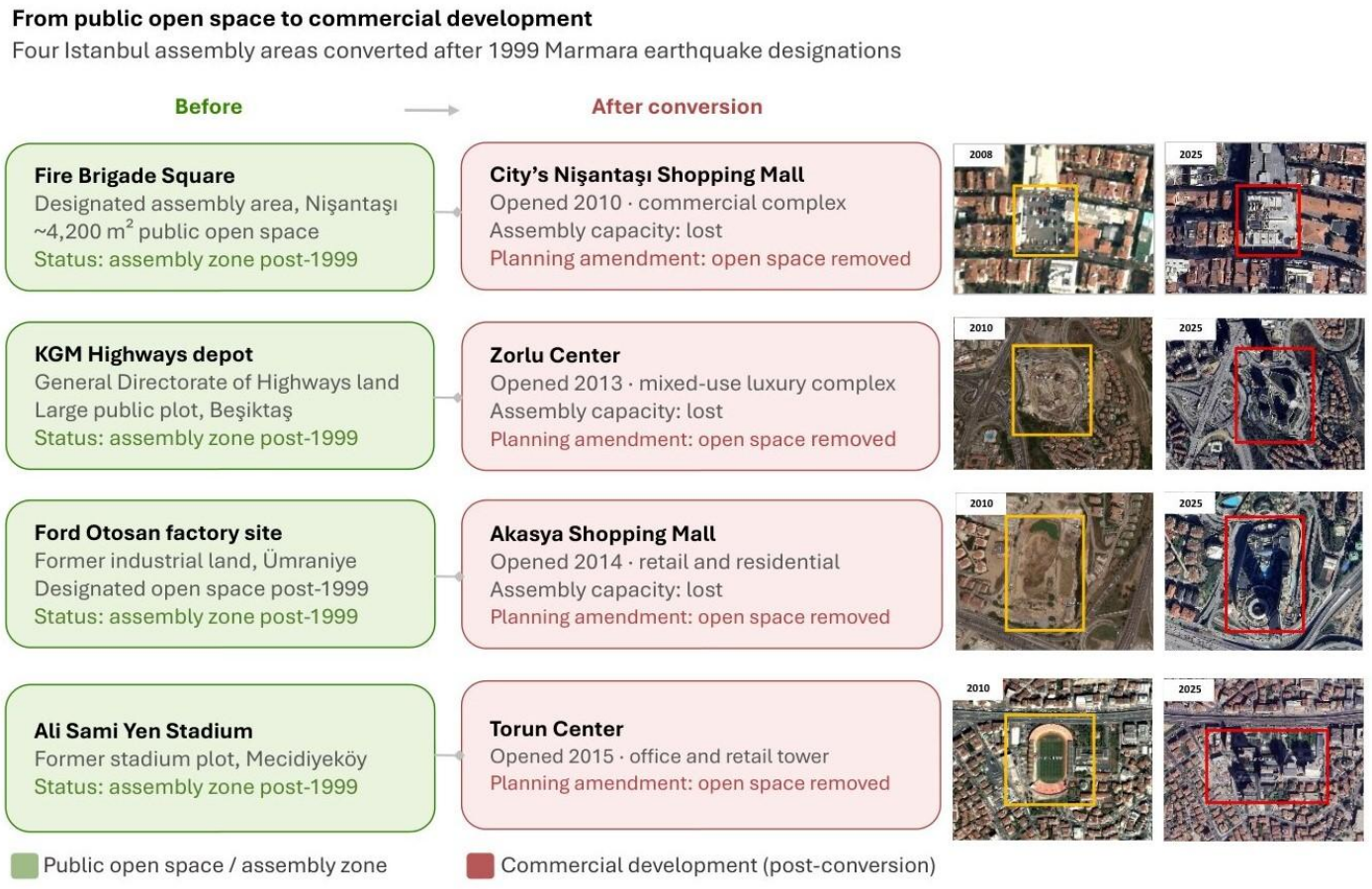

Figure 1. Spatial transformation of four disaster assembly areas in Istanbul following the 1999 Marmara earthquake. Each site was formally designated as a public assembly zone after 1999 and subsequently released for commercial development through planning amendments. Left panels show the designated open space; right panels show the post-conversion state. Images: Google Earth (dates to be confirmed).

The institutional response has been to designate new areas rather than recover lost ones. By 2020, the Disaster and Emergency Management Authority (AFAD) reported 3,021 assembly areas across Istanbul (AFAD, 2020). Following the April 2025 earthquake, a rapid re-designation exercise pushed that figure above 5,500. Our spatial analysis of data from AFAD, derived from publicly available datasets accessed via the Turkish e-Government portal (AFAD via e-Government Gateway, 2025), together with data from the Istanbul Metropolitan Municipality and district-level sources, conducted in May 2025, confirmed 5,570 designated sites (Istanbul Metropolitan Municipality [IMM], 2025). The composition of this expanded network raises serious questions. Roughly 59% of designated areas are recreational open spaces - parks and gardens - which is appropriate (IMM, 2025). More surprising is the inclusion of shopping mall plazas, building forecourts, and car parks: the very land uses that displaced the original assembly zones are now being pressed back into emergency service, their facades designated as temporary shelter areas while their forecourts serve as gathering points.

The Istanbul case illustrates a dynamic that extends well beyond the city, and evidence from other seismically exposed megacities is sobering. In Kathmandu Valley, 888 open spaces were inventoried before the 2015 Gorkha earthquake; a 2020 International Organisation for Migration assessment found that roughly half had since been reduced, encroached upon, or rendered unusable - including designated sites occupied by ministerial buildings (IOM, 2020). Kathmandu now has approximately 0.25 m^2 of open space per person, and Lalitpur district only 0.06 m^2 - figures that make Istanbul's inadequacy look modest. In Tehran, open space shortage is identified among the highest-ranked seismic risks in the city's historical districts, where it compounds a vulnerability profile defined by deteriorated building stock and high population density (Kamranzad et al., 2020; Parizi et al., 2024). In Lima, facing a 270-year seismic gap on one of the world's most active plate boundaries, around 80 per cent of housing has been built without regulatory input, and the country's foremost disaster risk organisation has long identified the near-total absence of assembly areas in informal settlements as among the most acute pre-disaster deficits (PREDES, 2009; INDECI, 2017). Table 1 compares these four cities across key dimensions. What is consistent is not a specific institutional failure but a structural one: in each city, assembly space is treated as residual - accommodated when convenient, surrendered when profitable, and never protected as infrastructure (Koren and Rus, 2019; Pelling, 2003).

Table 1. Assembly area provision in four seismically exposed megacities

City	Population	Assembly/open space provision	Designation system	Legal protection status
Istanbul, Türkiye (this study; AFAD 2025)	~16 million	2.98 m^2 per person citywide; <1.5 m^2 in worst districts; 419/496 post-1999 sites converted	AFAD designation; no binding land-use instrument	*Designation only; no statutory protection against rezoning*
Kathmandu Valley, Nepal (IOM, 2020)	~3.5 million	≈0.25 m^2 per person; Lalitpur 0.06 m^2; ~50% of 888 designated sites now unusable	Municipal open space registry; post-2015 emergency guidelines	*No statutory protection; designated sites occupied by govt buildings*
Tehran, Iran (Kamranzad et al., 2020; Parizi et al., 2024)	~9.5 million	Severe shortage; open space ranked among highest seismic risks in historical districts	Municipal parks network; no formal assembly area system	*Article 5 Commission approves densification; open space not protected*

Lima, Peru (PREDES, 2009; INDECI, 2017)	~10 million	≤80% of housing built without regulatory input; near-total absence of assembly areas in informal settlements	INDECI civil defence network; 2011 law requires DRR plans	*No protection for open space; informal areas lack assembly sites entirely*

This matters because the seismic hazard - energy release along the North Anatolian Fault - is fixed and essentially uncontrollable. The risk that hazard generates: who is exposed, who can reach safety, who has somewhere to gather - is entirely a product of decisions made at planning desks and in municipal councils. Istanbul's assembly area record is, in this sense, a legible index of how a city has chosen to distribute risk across its population (Wisner et al., 2004).

Who bears the risk

Quantity conceals geography. Averaged across Istanbul's population of approximately 16 million (TÜİK, 2024), our analysis yields a citywide per-capita assembly area of 2.98 m^2. This figure sits below the minimum humanitarian standard of 3.5 m^2 per person recommended by international humanitarian guidelines (Sphere Association, 2018). The citywide mean obscures a stark spatial inequality.

Districts with the highest per-capita provision (TÜİK, 2024) - Bakırköy (9.48 m^2), Şile (8.11 m^2), Başakşehir (6.81 m^2) (this analysis; AFAD, 2025; TÜİK, 2024) - tend to be those with lower population density and more recent, planned urban development. At the opposite extreme, Gaziosmanpaşa, Bahçelievler, Beyoğlu, Sancaktepe, and Bağcılar each fall below 1.5 m^2 per person. These are among Istanbul's most densely settled districts, characterised by older building stock and high proportions of pre-1980 construction - the very conditions that maximise casualty risk in a major earthquake and maximise the number of people who will need somewhere safe to go. The alignment is almost perfectly perverse: those most likely to be displaced are least likely to have adequate space to assemble.

This spatial inequality is not accidental. It reflects decades of concentrated urbanisation in areas that never received commensurate investment in public infrastructure - and a planning system that has consistently treated open space as residual rather than essential. The pattern aligns with what disaster risk scholars term the social production of vulnerability: the communities least resilient to hazard are those who have been systematically disadvantaged by the same processes of urban growth that generated their exposure in the first place (Cutter et al., 2008; Wisner et al., 2004). The Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015) calls explicitly for national and local disaster risk reduction strategies that address such structural inequalities - yet the spatial distribution of assembly areas in Istanbul demonstrates how thoroughly these ambitions can be undone by routine planning decisions made outside the disaster management apparatus.

At the neighbourhood scale, the picture sharpens further. Of 973 neighbourhoods analysed, 65 had no designated assembly area whatsoever (this analysis; IMM, 2025): The spatial distribution of these gaps is not random: the choropleth map (Figure 2) reveals a concentration in inner historic districts and dense inner-city areas - precisely where building vulnerability and daytime population pressures are highest. Accessibility analysis further complicates this picture. A network-based service area analysis using 250 m, 500 m and 750 m walking distance thresholds shows that 964 of Istanbul's 973 neighbourhoods intersect with at least one 250 m service area, although the proportion of accessible space varies considerably. In many neighbourhoods, only small fragments of the urban fabric fall within

walking distance, limiting the practical usability of these sites during an emergency. While coverage appears nearly universal at the 750 m threshold, this masks significant differences in proximity, walkability and effective access, particularly in dense inner-city districts characterised by fragmented street networks and limited open space. Proximity, in short, does not equal adequacy. Across approximately 75% of the city's neighbourhoods, per-capita provision falls below the Sphere standard of 3.5 m^2. Figure 2 makes the compounding risk visible at neighbourhood scale.

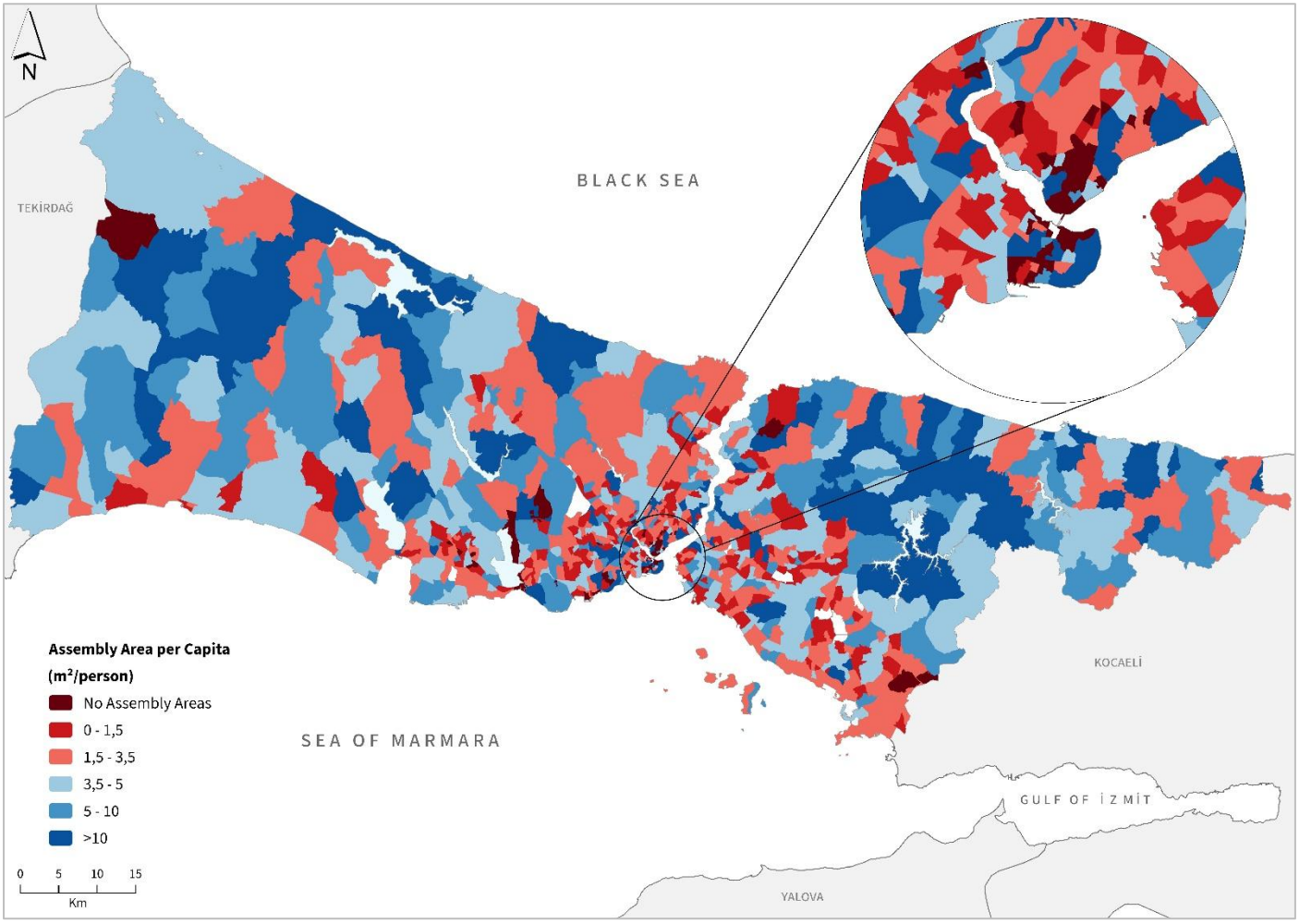

Figure 2. Spatial distribution of per capita assembly areas across Istanbul (m^2/person). Areas below 3.5 m^2 per person are shown in red, indicating insufficient provision, while higher values are represented in blue tones. The inset map provides a detailed view of central districts.

The citywide mean building age of approximately 30 years - corresponding to a mean construction date of around 1995 - masks sharp internal variation. The three vertical reference lines mark key regulatory thresholds: buildings predating 1980 (pre-seismic code era), those built around 1995 (the citywide mean), and those built around 2000 (post-1999 reform era). At the neighbourhood level, 31.7 per cent of all Istanbul neighbourhoods simultaneously carry mean building ages above 30 years and per-capita assembly provision below the Sphere minimum - the double jeopardy condition. Districts with the most acute combined shortfall - Kağıthane (79 per cent of neighbourhoods in double jeopardy), Gaziosmanpaşa (75 per cent), Bayrampaşa (73 per cent) - are among Istanbul's most densely settled inner areas (Figure 3). The most acute shortfalls concentrate in neighbourhoods with dense commercial activity and narrow street patterns - Tomtom and Asmalı Mescit in Beyoğlu, Halaskargazi

in Şişli - where high daytime populations and minimal open space create conditions in which orderly post-earthquake assembly is effectively impossible. Neighbourhoods in Fatih, Beykoz, and Esenyurt also lack coverage entirely. A further complication is that per-capita figures are calculated on resident populations, systematically understating vulnerability in districts with large daytime populations. The historic peninsula (Fatih), Beyoğlu, and the Halaskargazi corridor in Şişli each attract far greater daytime concentrations of workers, tourists, and commuters than their resident registers suggest. An earthquake at midday on a weekday would generate assembly demands in these areas far exceeding what per-capita metrics imply - and the designated sites are already inadequate for the resident population alone. Fatih district illustrates the distortion most starkly. Its district-level mean assembly provision of 30.9 m^2 per resident appears to place it comfortably above the Sphere threshold, but this figure is an artefact of large historic open spaces - the Hippodrome square, Gülhane park, the mosque forecourts of Sultan Ahmet and Süleymaniye - being attributed to neighbourhoods with very small registered populations. The JICA (2002) disaster prevention study for Istanbul distinguished explicitly between resident and daytime population in its casualty scenarios, recognising that the historic peninsula attracts far greater concentrations of workers, tourists, and visitors during the day than its resident register implies. Under a conservative ×3 daytime multiplier, Fatih's effective per-capita provision falls to approximately 10 m^2; under ×5, to just over 6 m^2; and under ×10 - readily plausible on a summer Friday at Sultan Ahmet - it crosses below the Sphere minimum entirely, to approximately 3.1 m^2 (JICA, 2002).

Structural vulnerability as compounding factor

The inadequacy of assembly provision cannot be understood in isolation from the building stock it is meant to serve. Of Istanbul's approximately 1.3 million buildings, 14.78% predate 1980 and a further 32.04% were constructed between 1980 and 2000 (DEZİM, 2022; IMM, 2024) - a combined 47% built under regulatory conditions that fall short of current seismic standards. In 2025, Turkey's Minister of Environment, Urbanisation and Climate Change publicly identified approximately 600,000 high-risk housing units in Istanbul requiring urgent transformation (Haber Global, 2025). Only 15.81% of the building stock postdates the 2007 earthquake regulations, which introduced the most substantive improvements to seismic design requirements.

This matters for assembly area planning because it determines the scale of displacement a major earthquake would generate. Rapid earthquake loss assessment for Istanbul produces casualty and displacement estimates that vary dramatically by district, driven precisely by the combination of building stock vulnerability and population density - and the districts most likely to generate mass displacement are, by the same token, those least equipped to absorb it (Erdik et al., 2011). In districts where both building vulnerability and assembly inadequacy are highest, the mismatch between post-disaster need and available capacity is not a planning inconvenience; it is a predictable humanitarian failure waiting to occur.

The distinction between hazard and risk is fundamental, and easily obscured. Seismic hazard in Istanbul is a geophysical constant; risk is constructed, incrementally, through thousands of planning decisions about where buildings are built and to what standard, where open space is protected or released, and who gets to live near adequate public infrastructure. The data presented here make that construction visible: in the districts where assembly space is most inadequate, buildings are oldest, populations are densest, and the political economy of urban development has consistently prioritised

short-term economic returns over long-term public safety. A repeat of 1999 would not affect all Istanbulites equally. It would, with high predictability, fall hardest on those who already have least.

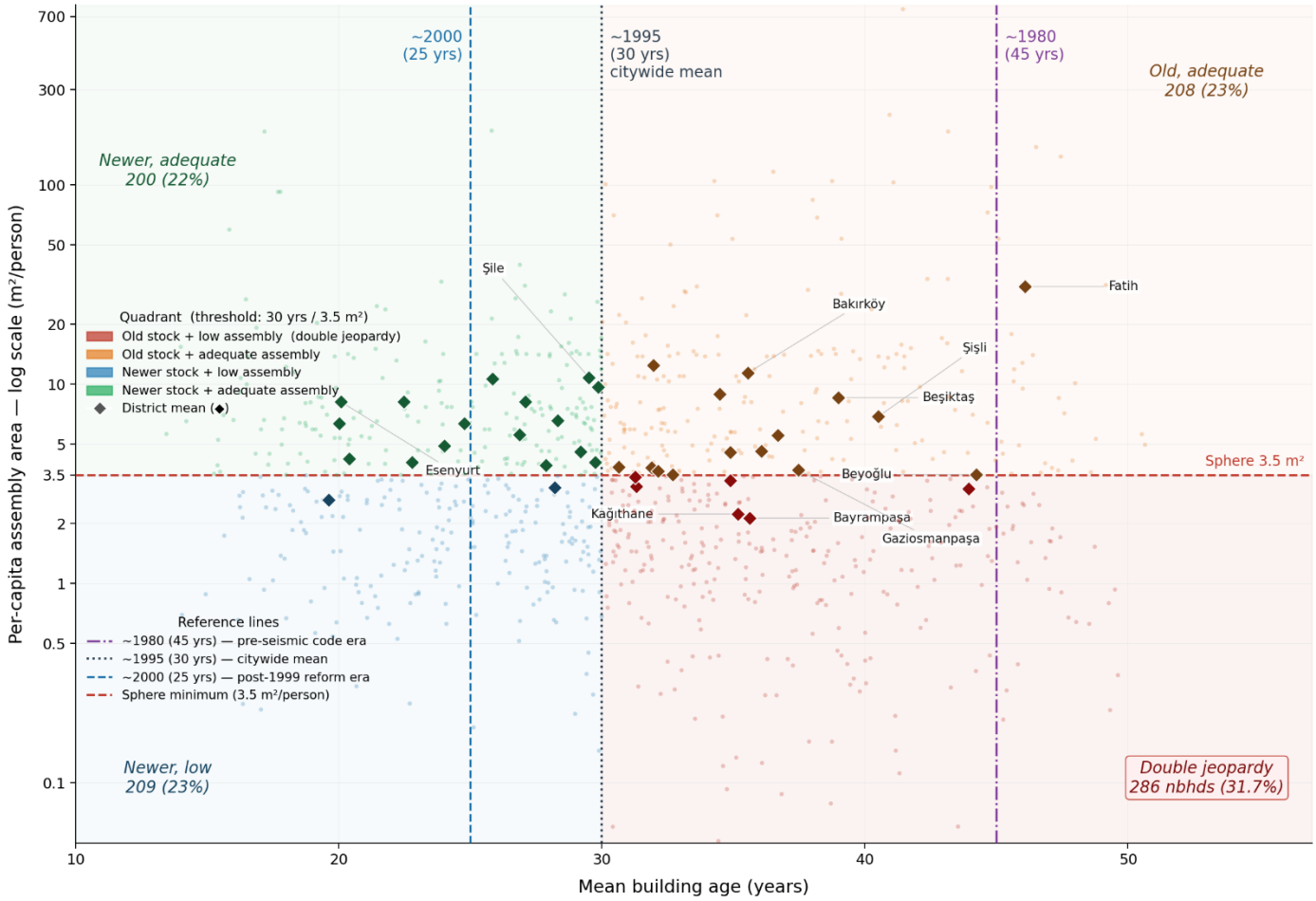

Figure 3. Per-capita assembly area against mean building age, plotted at neighbourhood scale (n = 973, log y-axis; 70 neighbourhoods with zero provision excluded). Neighbourhood points coloured by quadrant; district means shown as diamonds. Three vertical lines mark regulatory thresholds: ~1980 (pre-seismic code era), ~1995 (citywide mean), ~2000 (post-1999 reform era). Double jeopardy condition (age ≥30 years, provision <3.5 m^2): 286 neighbourhoods (31.7 per cent). Arrow on Fatih diamond shows daytime-adjusted provision under a ×5 multiplier (~6 m^2); dotted line shows ×10 scenario (3.1 m^2, below Sphere threshold). Sources: IMM (2025); TÜİK (2024); DEZİM (2022); JICA (2002).

What needs to change

Four shifts in policy and governance are urgent.

First, legal protection for assembly areas must be made unconditional. The pattern of post-1999 conversions demonstrates that designations alone, without binding land-use instruments, are insufficient. Assembly zones should be treated as infrastructure, not as reserve land available for development in periods of fiscal pressure or political opportunity.

Istanbul's experience points to a fundamental legislative gap that is far from unique to Türkiye. Designated assembly areas exist as planning designations - not as protected infrastructure. The distinction is consequential: roads, drainage systems, and utility networks enjoy statutory protections that make their removal for commercial development legally prohibitive in most jurisdictions. Emergency assembly space does not. Extending equivalent statutory protection to designated assembly zones - removing them from the domain of discretionary planning and treating them as infrastructure on a par with roads and drainage - is not a radical proposition. It is the logical

consequence of taking disaster preparedness seriously as a function of urban governance, and it is the reform that Istanbul's post-1999 record most clearly demands (Koren and Rus, 2019).

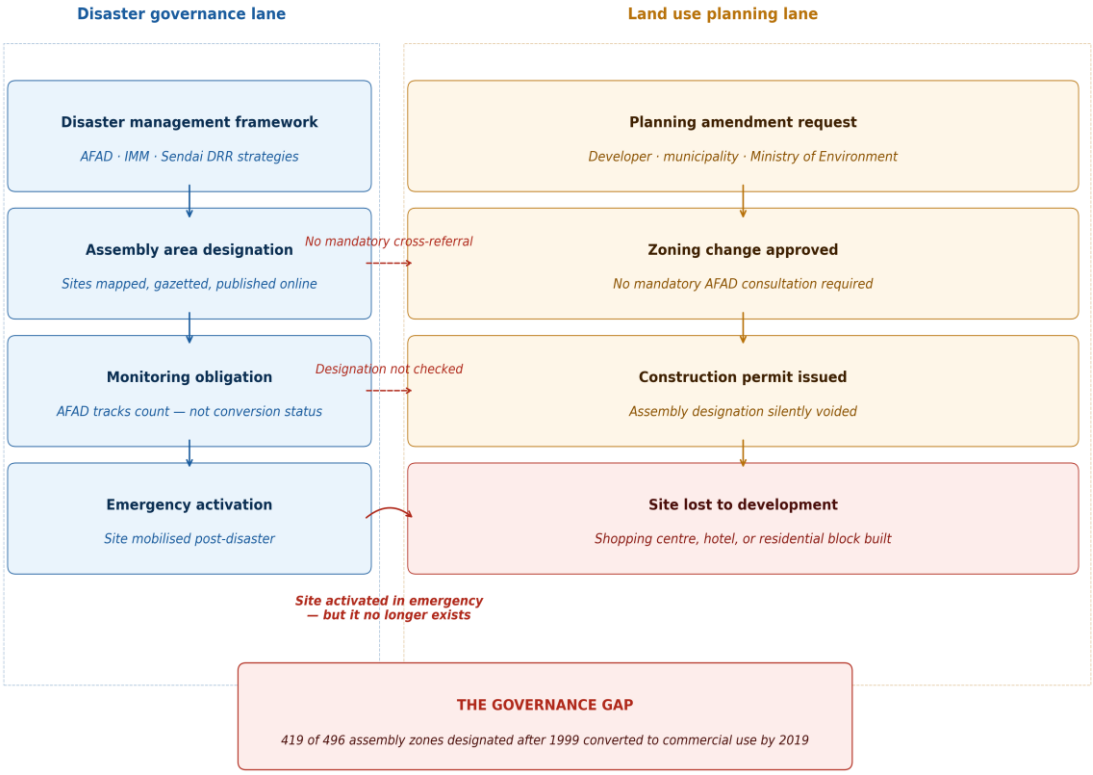

Figure 4. The governance gap: how routine planning amendments bypass the disaster management system. The two institutional lanes operate without mandatory cross-referral, enabling disaster governance commitments to be reversed by planning decisions made outside the disaster management apparatus - accounting for the conversion of 419 of 496 post-1999 designated sites in Istanbul.

Second, spatial justice must become an explicit criterion in assembly area planning. Current frameworks count area and calculate per-capita averages; they do not systematically require that provision track vulnerability. An allocation methodology that weights assembly area requirements by building age, structural risk, and population density would ensure that the districts most exposed to earthquake consequences are prioritised, rather than those with the most available open space.

Implementation requires institutional change as much as technical revision. Currently, assembly area planning in Turkey sits primarily within AFAD's mandate, while land-use decisions rest with municipalities and the Ministry of Environment, Urbanisation and Climate Change. These jurisdictions rarely converge in practice, and the result - illustrated by the conversion of 419 of 496 post-1999 designated zones - is that disaster governance commitments can be quietly reversed by routine planning decisions made in a different institutional lane (Figure 4). A vulnerability-weighted allocation framework would require joint operation across these institutions, with assembly area adequacy becoming a mandatory consideration in any planning decision affecting open space in high-risk districts. The Sendai Framework's Target E calls for substantially increased numbers of countries with national and local disaster risk reduction strategies by 2030 (UNDRR, 2015). Turkey has such strategies; Istanbul has AFAD and an elaborate designation system. The Istanbul record demonstrates that having the frameworks is insufficient: without institutional wiring that connects disaster management to land-use decisions, those strategies can be systematically dismantled by planning amendments that no disaster management body is formally empowered to challenge.

Third, the quality and functionality of designated areas need systematic evaluation. Our analysis identified a proportion of areas that, on inspection of their designation logic, appear inadequate for mass gathering - narrow forecourts, constrained schoolyards, spaces that are accessible in daytime but not at night. Designating a space and verifying its fitness for purpose are not the same exercise.

This gap between designation and fitness has direct consequences for post-disaster capacity. A shopping mall forecourt designated as an assembly area may be gated, privately managed, or structurally compromised by the very earthquake that triggers its activation. A schoolyard adequate for a normal school population may be entirely insufficient for a surrounding neighbourhood of ten thousand. Fitness-for-purpose evaluation requires, at minimum, assessment of capacity against projected displaced population, accessibility under post-earthquake conditions (accounting for debris, structural collapse, and street obstruction), ownership and activation protocols, and the presence of basic services - water, sanitation, lighting - without which an open space cannot function as emergency shelter. The Sphere standards provide a baseline framework for these assessments; what is missing in Istanbul, as in most cities, is a systematic programme of verification against that baseline, and a mechanism for removing or replacing sites that fail it (Sphere Association, 2018).

Fourth, community awareness must be treated as a core component of assembly area policy, not an afterthought. Awareness of assembly area locations, routes, and activation procedures is as critical as the physical adequacy of the spaces themselves. Post-disaster behaviour research consistently shows that people default to familiar gathering places - school gates, park entrances, neighbourhood squares - regardless of official designations, particularly in the chaotic minutes immediately after a major event (Shaw and Goda, 2004). A designation that exists only in a GIS layer or a government portal offers little protection to communities who have never encountered it in practice. Effective policy therefore requires sustained community engagement: regular drills, multilingual signage, neighbourhood-level mapping, and active collaboration with the *mahalle muhtarlıkları* (neighbourhood councils) who hold the most granular knowledge of local conditions and the social trust necessary to communicate risk effectively. Turkey's *mahalle muhtarı* is a directly elected official with legal responsibility for resident registration, local coordination, and the delivery of official communications - the natural last-mile node in any disaster communication system. Yet the information chain between AFAD's designated assembly area data and the *muhtarlık* level is inconsistent and largely dependent on individual initiative. In commercial districts like Mecidiyeköy, the *muhtar* serves a small resident electorate but effectively presides over a daytime population of tens of thousands of workers who have no relationship with the local neighbourhood council and no awareness of designated sites. Formalising this connection - requiring *muhtar*s to confirm assembly area accessibility annually, maintain neighbourhood-level printed maps, and conduct basic awareness exercises - would cost little and yield substantial returns in effective evacuation capacity.

The April 2025 earthquake was, by Istanbul's standards, moderate. A repeat of 1999 - a scenario the scientific literature consistently identifies as a matter of when, not if - would test a system that has grown in numerical extent while shrinking in spatial justice. Istanbul's assembly areas reflect the city's wider tension between the imperatives of urban development and the obligations of disaster governance. Resolving that tension requires not more designations, but better-protected, more equitably distributed ones - and the political will to treat safe public space as a non-negotiable element of urban infrastructure. The empirical record presented here - a city that has converted 84% of its post-1999 assembly zones to commercial use, whose per-capita provision falls below international humanitarian standards in three-quarters of its neighbourhoods, and whose most vulnerable districts

simultaneously carry the oldest building stock and the least gathering space - is not a local administrative curiosity. It is a case study in how the accumulation of individually defensible planning decisions can produce, in aggregate, a city that is measurably and predictably less safe. The Istanbul record is best understood not as a local anomaly but as an instance of a global failure mode - one in which the infrastructure of urban disaster preparedness is systematically subordinated to the infrastructure of urban economic growth. Cities facing comparable seismic exposure and development pressure - Kathmandu, Tehran, Lima, and many others - are replicating versions of the same pattern, often without Istanbul's level of documentation and therefore without the evidence base needed to challenge it. The tools to reverse this are known: legislative protection, vulnerability-weighted allocation, community engagement, and cross-institutional coordination. What is required is the political decision to apply them - before, rather than after, the next major earthquake makes the cost of inaction undeniable.

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