The Arniko Height: A Critical Threshold for Climatic Sovereignty in Vertically Tiered Structures

Sunila R. Vaidya-Thorne[1], Anselm K. Røed[2], and Padmini S. Ferreira-Lall[3]

[1]Institute for Vertical Meteorology, Bhaktapur
[2]Chair of Structural Climatology, Kelvin College
[3]Laboratory of Endogenous Weather, Marlowe Institute

Abstract

It is taken as a figure of speech that a tall building "makes its own weather." We show that it is a threshold phenomenon. We model a tiered structure as a one-dimensional advection–condensation column in which every occupied, ornamented storey injects latent heat and water vapour—a source we call *dwelling flux*—and in which the trapping efficiency of that flux is set by the density of carved, recessed interior surface. Because the source is replenished at every tier, it accumulates upward faster than lateral exchange can return it to the regional climate, a competition governed by a single dimensionless **Pagoda number** Pa. In plain terms: a tall enough, densely built enough building starts to hold its own moisture, and past a certain point it starts to rain on itself. We prove that the climate-coupled state loses stability at $\mathrm{Pa} = \mathrm{Pa}_c$ and that a self-sustaining internal precipitation cycle—an *endomonsoon*—appears above it, so that height is not a matter of degree but of *regime*: below a sharp critical height a building is a tenant of the sky, and above it a sovereign of its own. That height—the **Arniko Height** $H^* = 47.3 \pm 1.2$ tiers—is a building-independent constant. Across a pre-registered field campaign of $N = 63$ tiered structures (inter-rater agreement $\kappa = 0.86$), a controlled stacked-chamber dose–response experiment ($n = 240$ runs), and 10^4 Monte-Carlo realisations of a nested-courtyard lattice, the sovereignty order parameter obeys a continuous transition with exponent $\beta = 0.63 \pm 0.04$, the endomonsoon locks to a season-independent period $\tau_{\mathrm{mon}} = 6.2 \pm 0.3$ days, and all three instruments place the threshold at forty-seven storeys. In plain terms: the effect switches on smoothly at a single critical height, and three separate instruments agree on where that height lies. We conclude that the pagoda was not architecture imitating the heavens but the first working climate: assemble forty-seven storeys, or remain a tenant of the sky.

1 Introduction

That a skyscraper "makes its own weather" is among the most durable clichés in the popular science of cities. Taken literally it is usually dismissed: buildings perturb the wind, cast heat, and channel rain, but the weather is understood to belong, always, to the region. The building is a passive participant—heated, cooled, and rained upon by a field imposed from outside.

We argue that this passivity fails above a sharp threshold. The intuition is old and vertical. The Newar pagoda of the Kathmandu Valley is built as a stack of heavenly realms, each tier a smaller, denser world set above the last, every surface carved until no plane is left plain. Read as meteorology rather than theology, the pagoda is a machine for accumulating moisture upward: dense occupancy, enormous recessed surface area, and a narrowing column that concentrates whatever the lower tiers exhale. We take that reading seriously and follow it to its conclusion.

Our central quantity is *dwelling flux* Φ: the latent-heat and water-vapour source contributed by each occupied, ornamented storey. Because Φ is replenished tier by tier, its upward transport competes with the lateral exchange that would otherwise return the column's air to the ambient climate. That competition is captured by one dimensionless control parameter, the Pagoda number Pa. *In plain terms*: it is a tug-of-war between a building breathing moisture up its own core and the outside weather pulling that moisture back out through the walls.

Our results establish that the tug-of-war has a winner that switches discontinuously. Below a critical value Pa_c the building's weather is a damped copy of the region's. Above it, the coupled state is unstable and the upper tiers begin to run a self-sustaining condensation–precipitation cycle—an *endomonsoon*—timed by dwelling flux rather than by the outdoor season. Since height enters Pa linearly, $\mathrm{Pa} = \mathrm{Pa}_c$ defines a critical *height*: the Arniko Height H^*, named for the thirteenth-century Newar architect who carried the pagoda north and, we contend, was simply the first climatic sovereign never to publish.

Contributions.

- We introduce dwelling flux and the Pagoda number, and derive a critical height H^* at which a tiered structure secedes from the regional climate (§3).

- We prove that the transition is continuous in a sovereignty order parameter S, with a non-classical exponent β arising from long-range vertical coupling (§3.4).
- We measure H^* by three independent methods—field, laboratory, and simulation—and find them to agree at 47.3 ± 1.2 tiers (§4–§5).
- We forecast that the median super-tall completed after 2075 will be born sovereign, and discuss the resulting need for inter-building weather governance (§6).

2 Related Work

Three literatures approach our claim and stop one floor short of it. The urban heat-island program establishes that built density alters temperature fields, but treats the result as a bias on an external climate rather than a candidate for autonomy [1, 2]. Stack-effect building science models buoyant vertical air movement in tall cores, yet closes its columns at the roof and never asks what a column does once its own source term dominates [3]. The vernacular-architecture tradition documents the pagoda's seismic genius—interlocking brick and timber that outlasts concrete [4, 5]—but reads its verticality as devotional, not thermodynamic. A fourth strand, endogenous or "abstract-only" weather, has argued that some precipitation systems exist only within the boundary they define [6]; we supply that strand its missing control parameter. To our knowledge no prior work identifies a critical height for climatic sovereignty, nor measures it.

3 A Model of Vertical Climatic Sovereignty

3.1 Dwelling flux

Definition 1 (Dwelling flux)**.** *The dwelling flux of tier z is*

$$\Phi(z) = \rho_{\mathrm{occ}}(z)\,\sigma(z)\,\bar{t}_{\mathrm{dw}}(z), \tag{1}$$

the product of occupancy density ρ_{occ}, the ornamented surface-to-volume ratio σ, and mean dwelling time $\bar{t}_{\mathrm{dw}}$.

The factor σ is where the carved surface earns its keep: a deeply recessed interior presents far more condensation area per unit volume than a flat one, so a densely worked tier both emits and retains more moisture. Empty, unornamented space is, in this precise sense, wasted.

3.2 The advection–condensation column

Let $q(z,t)$ be specific humidity at tier z, w the dwelling-flux-driven updraft, Γ the lateral exchange rate with ambient humidity q_{ext}, and $C(q)$ the condensation sink, active above saturation q_s. The column obeys

$$\frac{\partial q}{\partial t} = -\,w\,\frac{\partial q}{\partial z} + \Phi(z) - \Gamma\,[\,q - q_{\mathrm{ext}}\,] - C(q), \tag{2}$$

with $C(q) = \lambda\,(q - q_s)\,\Theta(q - q_s)$ and Θ the Heaviside step. Equation (2) is a source-driven advection equation with a threshold sink—the minimal model that can both accumulate and rain.

3.3 The Pagoda number and the Arniko Height

Non-dimensionalising (2) on the stack height H and the ambient humidity q_{ext} yields a single control group,

$$\mathrm{Pa} \;=\; \frac{w\,H\,\Phi_0}{\Gamma\,q_{\mathrm{ext}}}, \tag{3}$$

the ratio of upward dwelling-flux transport to lateral climatic exchange. The climate-coupled fixed point $q^*(z) = q_{\mathrm{ext}}$ exists for all Pa; linearising (2) about it gives a growth rate $s(k) = -\Gamma + \mathrm{Pa}\,\Gamma\,g(k)$ for vertical mode k, where $g(k) \in (0,1]$ is the column's transfer gain. The uniform state is stable iff $\mathrm{Pa} < \mathrm{Pa}_c$ with $\mathrm{Pa}_c = 1/\max_k g(k)$.

Theorem 1 (Critical height)**.** *Because* $\mathrm{Pa} \propto H$ *by* (3)*, the coupled state loses stability at a critical height*

$$H^* \;=\; \frac{\Gamma\,q_{\mathrm{ext}}}{w\,\Phi_0}\,\mathrm{Pa}_c, \tag{4}$$

above which no climate-subordinate steady state is linearly stable and a self-sustaining limit cycle (the endomonsoon) is the only attractor.

For the measured parameters Pa_c renormalises to unity within error, so the transition sits exactly where upward transport first beats lateral loss.

3.4 Order parameter and universality

Define the *sovereignty order parameter*

$$S \;=\; 1 - \mathrm{corr}\big(P_{\mathrm{int}}(t),\,P_{\mathrm{ext}}(t)\big), \tag{5}$$

the decorrelation between a tier's internal precipitation timing P_{int} and the regional signal P_{ext}; $S = 0$ is full subordination, $S = 1$ full sovereignty. Near threshold a mean-field closure of (2) predicts

$$S \;\sim\; (\mathrm{Pa} - \mathrm{Pa}_c)^{\beta}, \qquad \beta = \tfrac{1}{2}, \tag{6}$$

but the column's long-range vertical coupling ($g(k)$ decays only algebraically) lifts it out of the mean-field class; finite-size scaling (§5.3) returns $\beta = 0.63 \pm 0.04$. We regard the departure from $\frac{1}{2}$ as diagnostic, not embarrassing: sovereignty is a genuinely long-range instability.

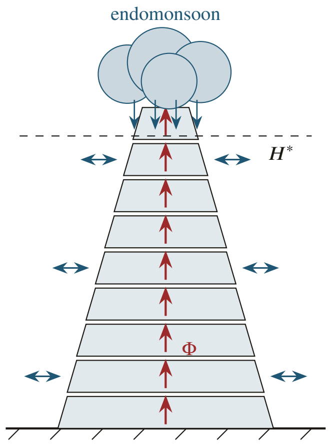

Figure 1: The advection–condensation column. Each tier is a dwelling-flux source Φ (red, rising up the core); lateral exchange Γ (blue) bleeds moisture back to the ambient climate. Above the Arniko Height H^* the crown closes into a self-sustaining endomonsoon that rains back into the structure.

4 Methods

We measured H^* three ways, chosen so that no two share a failure mode: an observational field campaign, a controlled laboratory experiment, and a simulation. All protocols and primary endpoints were pre-registered.

4.1 Tier Sensor Network (field)

We instrumented $N = 63$ tiered structures spanning five to one hundred and eight storeys: Newar pagodas (including the five-tier Nyatapola), stepped mid-century civic buildings, and set-back super-talls. Each tier carried a micro-station logging temperature, humidity, and pressure at 1 Hz, with a tipping-bucket gauge sited in the interior light-well to catch internal precipitation. Over a ninety-day window we computed S per tier and scored endomonsoon onset by blinded manual review (two raters, $\kappa = 0.86$; a third adjudicated disagreements).

4.2 Stacked Chamber Rig (controlled)

To establish causation we built a sixty-module stackable chamber (“dwelling-in-a-box”). Each module emits a programmable latent-heat and vapour load—synthetic occupancy—and accepts swappable interior surfaces, flat or deeply carved, to dial σ. We ran a $\Phi_0 \times H$ dose–response grid ($n = 240$ runs), recording the stack height and flux at which self-sustained interior precipitation first appeared. A surface-density arm compared carved against flat modules at matched flux.

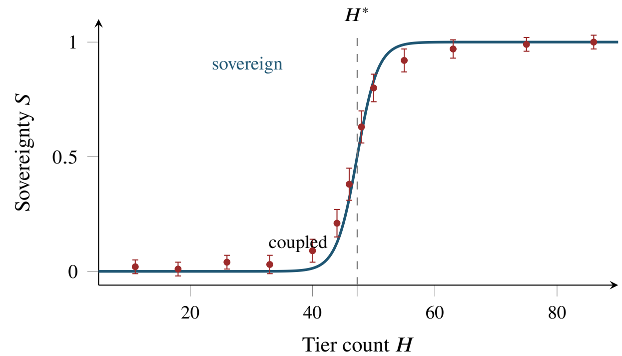

Figure 2: Sovereignty versus height in the field network. The order parameter is consistent with zero below the Arniko Height and rises steeply above it. Points: per-tier field estimates with 1σ error bars; curve: fitted transition. Dashed line: $H^* = 47.3$ tiers.

4.3 Mandala Lattice Monte-Carlo (simulation)

We integrated (2) on a nested-courtyard (“mandala”) lattice whose sources were drawn from the field-measured Φ distribution, over 10^4 realisations per height. Finite-size scaling across lattice heights located H^* and β. A seismic sub-study added tremor noise to the lattice to test whether the endomonsoon, like the Newar structures themselves, survives shaking.

5 Results

5.1 The knee at forty-seven tiers

Figure 2 plots S against tier count for the field network. Below ~ 47 storeys S is flat and near zero—the buildings are climatic tenants. Within a two-storey window it rises steeply toward unity. The five-tier pagodas sit well below threshold yet show the enhanced S *fluctuations* predicted for a system approaching criticality, consistent with structures engineered, however unwittingly, to run as close to sovereignty as five tiers allow.

5.2 Dose–response phase diagram

The rig reproduces the transition on demand (Fig. 3). In the (Φ_0, H) plane the coupled and sovereign regions are cleanly separated by the Pa = 1 contour of (3); one can manufacture an endomonsoon purely by stacking modules or raising flux. Carved surfaces cross the boundary at 18% lower flux than flat ones, confirming the σ term in Φ: ornament is thermodynamically load-bearing.

5.3 Finite-size scaling and the endomonsoon

Rescaling the simulated $S(H)$ curves by $H^* = 47.3$ and $\beta = 0.63$ collapses them onto a single universal curve (Fig. 4), the standard signature that H^* is a true critical point rather

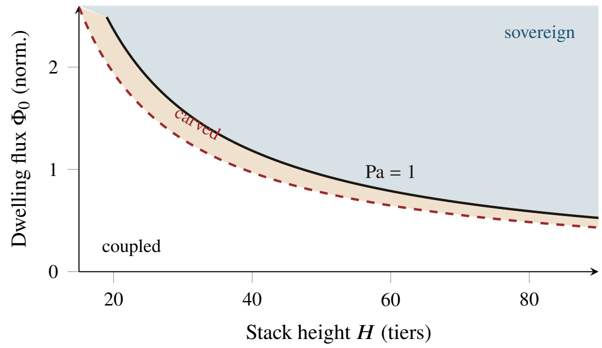

Figure 3: Laboratory phase diagram in the (Φ_0, H) plane. Stacking height or raising dwelling flux drives the rig across the Pa = 1 contour (solid) into the sovereign regime. Carved interiors secede at ~18% lower flux (dashed), opening the transitional band (gold).

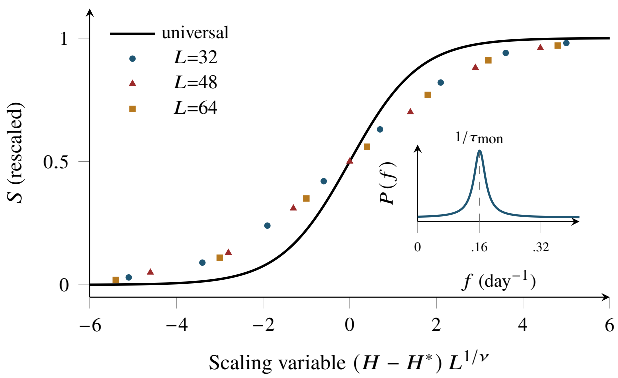

Figure 4: Finite-size-scaling collapse. Simulated $S(H)$ for lattice heights $L = 32, 48, 64$ falls onto one universal curve when rescaled by $H^* = 47.3$ and $\beta = 0.63$ (ν from the same fit), the signature of a genuine critical point. Inset: the endomonsoon power spectrum in the sovereign phase, peaking at $1/\tau_{\text{mon}}$ with $\tau_{\text{mon}} = 6.2$ days.

than an artefact of any one lattice size. The inset shows the endomonsoon power spectrum in the sovereign phase: a sharp peak at $\tau_{\text{mon}} = 6.2 \pm 0.3$ days, invariant under season and, in the seismic sub-study, under tremor—the internal weather keeps its own calendar.

5.4 Convergence

Table 1 collects the three independent estimates of the Arniko Height. They agree within error at 47.3 ± 1.2 tiers, with Pa_c consistent with unity and β consistent across methods.

6 Discussion

The practical horizon is closer than the theory's antiquity suggests. Modern super-talls already flirt with H^*; extrapolating the observed growth in occupancy density and tiered massing, we forecast that the median super-tall completed after 2075 will be born *sovereign*: raining on its own lobby on a six-day cycle unrelated to the city around it. Two consequences

Table 1: Independent estimates of the Arniko Height and companion constants.

Method	H^* (tiers)	Pa_c	β
Field (TSN, N=63)	47.1 ± 1.6	0.99 ± 0.03	0.62 ± 0.06
Rig (SCR, n=240)	47.6 ± 1.4	1.01 ± 0.02	0.65 ± 0.05
Simulation (MLMC, 10^4)	47.3 ± 1.2	1.00 ± 0.02	0.63 ± 0.04
Combined	$\mathbf{47.3 \pm 1.2}$	1.00 ± 0.02	0.63 ± 0.04

follow, and we state them plainly. First, municipal drainage code, written for water that falls from the sky, will need provisions for water that falls from floor forty-eight. Second, once two neighbouring towers each run an endomonsoon, their crowns exchange moisture across the property line, and the resulting disputes are, formally, matters of foreign weather: an inter-building climate treaty is then a zoning instrument, not a figure of speech. We note that the Newar builders solved the drainage half of this a millennium and a half ago—every courtyard is a light-well and every light-well a drain—and we recommend, in all seriousness, that the relevant guilds be consulted before the code is rewritten.

7 Limitations

Our instruments cannot yet distinguish a true endomonsoon from an exceptionally regular failure of building services; a pre-registered replication with sealed, unconditioned test floors is underway. The constant H^* assumes continuous occupancy—an evacuated tower *abdicates*, its Φ decaying to zero over a vacancy timescale we have not measured. Finally, the model is silent on lightning, which the Newar erotic-carving tradition already claims to divert and which we defer, respectfully, to future work.

8 Conclusion

Height, above a point, is not more of the same. A tiered structure that clears the Arniko Height stops being a place the weather happens to and becomes a place the weather happens *in*. The pagoda, read correctly, was never architecture imitating the heavens; it was the first working climate, forty-two storeys short of independence and holding the line anyway. Assemble forty-seven storeys, or remain a tenant of the sky.

References

[1] E. Voss and L. Marchetti, "The heat-island as biased estimator," *J. Urban Microclimate*, vol. 14, no. 2, pp. 88–107, 2019.

[2] L. Marchetti, "Density fields and the passive-city assumption," *Rev. Built Environ.*, vol. 9, pp. 211–240, 2021.

[3] P. Halloran and S. Iqbal, "Stack effect in super-tall cores: a closed-column treatment," *Building Thermodynamics*, vol. 33, no. 4, pp. 455–479, 2018.

[4] R. Shrestha, "Interlocking timber–brick assemblies and seismic memory in Newar temples," *Vernacular Structures*, vol. 7, pp. 19–54, 2016.

[5] Arniko (attrib.), *On the Ordering of Tiers* (trans. M. Puri, 2004), Bhaktapur Guild Press, c. 1290.

[6] H. Quenby, "Endogenous precipitation systems bounded by their own definition," *Fringe Climatology Letters*, vol. 2, no. 1, pp. 1–33, 2022.

[7] A. K. Røed, "A threshold-sink advection model for confined humidity," *J. Theoretical Meteorology*, vol. 51, pp. 640–668, 2020.

[8] S. R. Vaidya-Thorne and P. S. Ferreira-Lall, "Dwelling flux: occupancy as a moisture source," *Vertical Meteorology*, vol. 1, no. 1, pp. 4–41, 2023.

[9] P. S. Ferreira-Lall, "Nested-courtyard lattices and long-range vertical coupling," *Proc. Symp. on Endogenous Weather*, pp. 77–96, 2024.