Building-Level Consumption-Based Carbon Accounts in Hong Kong

From City-Scale Building MRIO to Residential Consumption

Part I (completed): all buildings | Part II (in progress): residential consumption emissions

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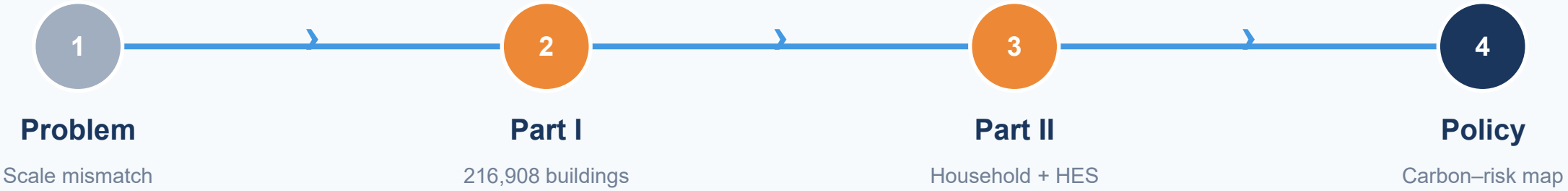
Talk Roadmap



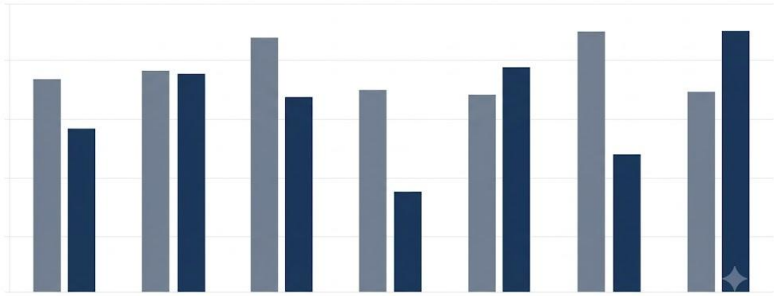
- Problem — city-scale carbon accounts vs building-scale policy
- Part I — MRIO downscaling + four case-area contribution–vulnerability
- Part II — residential two-segment model + HES expenditure profiles
- Policy implications and next steps

Climate Policy Acts on Buildings — Accounts Do Not

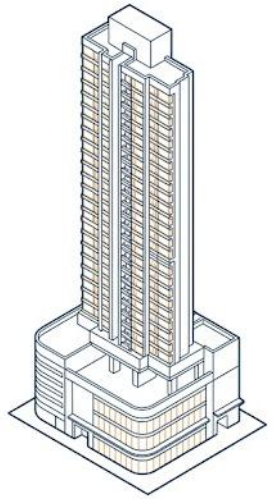
- City/sector inventories ≠ units for disclosure, retrofits, green finance
- Consumption-based (MRIO) vs production-based (on-site energy)
- Hong Kong: high density, vertical mixing, dual housing system

?

City inventory



Single building



Research Questions

RQ — Part I

Can city IO totals be conserved at building scale and reveal a contribution–SLR exposure mismatch?

→

residential refinement

RQ — Part II

How do public/private segments and expenditure heterogeneity reshape residential CB versus the Part I floor-area allocation?

Part I

Building-Level MRIO for Hong Kong (2022)

216,908 buildings · ADB 2022 · RCP8.5 exposure

Study Area & Data (2022)

- Hong Kong SAR, single inventory year (2022)
- Buildings: Lands Department open data
- City IO: ADB 2022 symmetric table (35 sectors)
- Sectoral GHG intensities: EPD 2022 inventory
- Merchant activity: AMap POI → sector shares σ
- SLR: Government RCP8.5 flooded structures (2050 / 2100)

Buildings
Lands Dept

IO table
ADB 2022

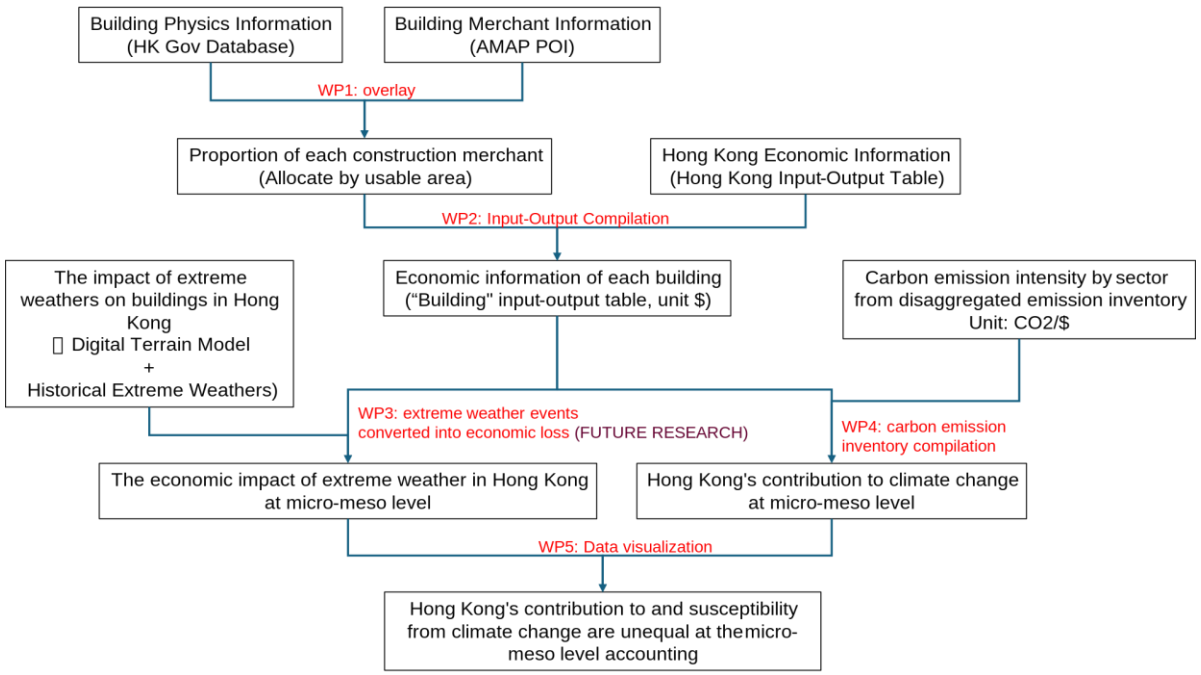
GHG intensity
EPD 2022

POI activity
AMap 2022

SLR 2050
RCP8.5

SLR 2100
RCP8.5

Conceptual Framework & Two-Region MRIO



- Building register + POI + IO + intensities → building-level CB
- Each building = Bldg; remainder = RoHK → 2n-sector partition
- Residual closure + RAS → city totals conserved
- CB_b = e′ L y_b + RCP8.5 inundation overlay

Floor-Area Downscaling & Intermediate Transactions (Bldg ↔ RoHK)

Production layer

$w_{prod} = (Area_{prod} \times \sigma_{POI}) / \Sigma_b Area_{prod}$
$X_{Bldg} = w_{prod} \times X_{HK}$
Commercial / mixed-use · POI maps activity to 35 IO sectors

Final-demand layer

$w_{res} = Area_{res} / \Sigma_r Area_{res}$
$Y_{Bldg} = w_{res} \times Y_{HK}$
Residential floor area only · city FD columns aggregated

Four intermediate blocks (Bldg ↔ RoHK)

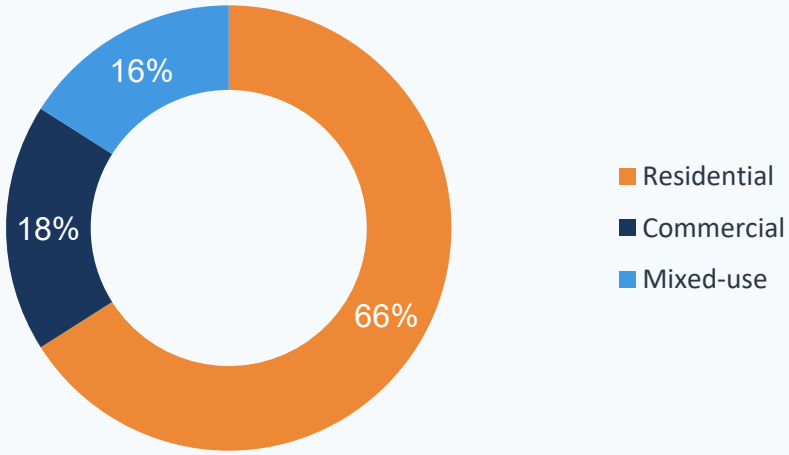
Z_BB	Z_BR	Z_RB	Z_RR
Bldg→Bldg	Bldg→RoHK	RoHK→Bldg	RoHK→RoHK

1 Allocate X, Y via floor area → 2 Residual Z closure (mask M_i) → 3 RAS balance

Building scale: RAS conserves city totals | 2,800 m case disks: RAS unstable → stable no-RAS indicator in Fig. 2

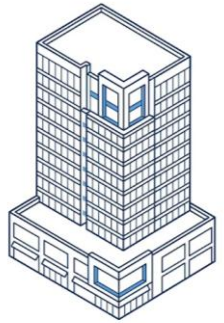
Functional Classes, Allocation & Building Stock

- Residential / commercial / mixed-use — POI → 35 IO sectors
- Residential FD via **floor area** (Part I baseline; Part II improves)
- 216,908 buildings · 66% res · 18% com · 16% mixed



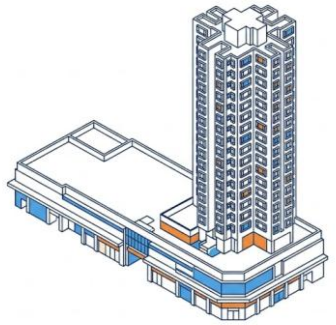
66%

Residential



18%

Commercial

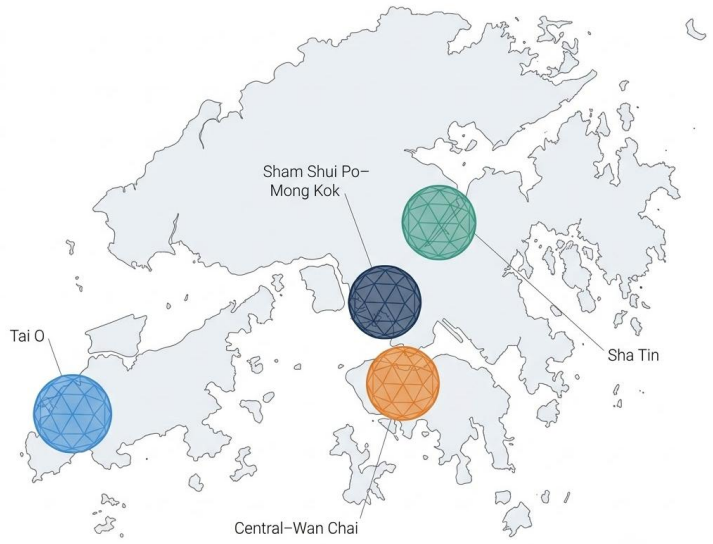


16%

Mixed-use

Four Case Areas — Morphology & Statistics

2,800 m geodesic disks · Central–Wan Chai · Sham Shui Po–Mong Kok · Tai O · Sha Tin



Case area	Bldgs	Floor (M m²)	Contrib. (kt)	2050 fl.%	2100 fl.%	Inund. 2100
Central–Wan Chai	8,410	50.4	3,892.7	36.6%	40.5%	2,032
Sham Shui Po–Mong Kok	11,367	45.7	3,636.7	4.8%	7.1%	561
Tai O	1,141	0.17	10.4	60.5%	62.8%	635
Sha Tin	7,757	19.5	1,456.2	7.6%	29.0%	524

Territory stock

216,908 buildings

RCP8.5 inundation

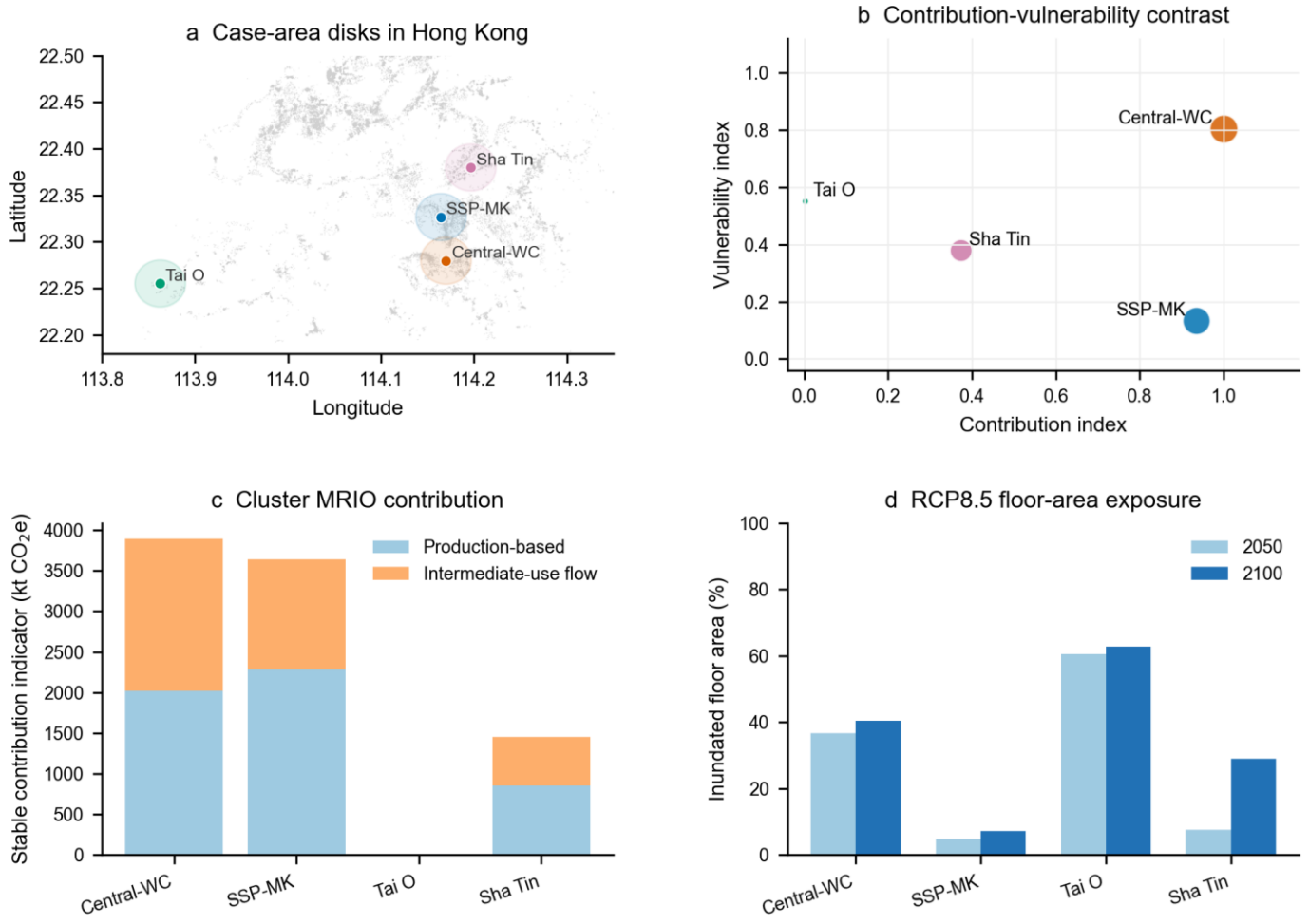
18,046 (2050) · 25,057 (2100)

Contribution spread

374× (3,893 / 10.4 kt)

Contribution and Coastal Vulnerability Decouple

Contribution = PB GO carbon + intermediate embodied | Vulnerability = RCP8.5 2100 inundated floor share | High contribution ≠ high exposure



93%

SSP-MK / Central contrib.

3,637 / 3,893 kt

18%

SSP-MK / Central exposure

7.1% / 40.5%

0.3%

Tai O / Central contrib.

10.4 / 3,893 kt

155%

Tai O / Central exposure

62.8% / 40.5%

Building-Scale CB & Inundation — Four Case Disks

Fill = CB CO_2 (kt) · Light blue = 2050 inundation · Dark blue = 2100 inundation

Part I Takeaways & Motivation for Part II

✓ Part I — findings

- 216,908 buildings; IO conserved at building scale
- 66% residential — contribution–SLR mismatch quantified
- Four disks: 374× contribution spread; exposure decouples (93% vs 18%)

✗ Limits

- Dividing commercial activities by floor area only
- Ignores tenure & expenditure heterogeneity

→ Part II: residential type split 44.7% / 54.6% · HES mean exp. HK$16,181 (public) vs HK$41,174 (private)

Part II

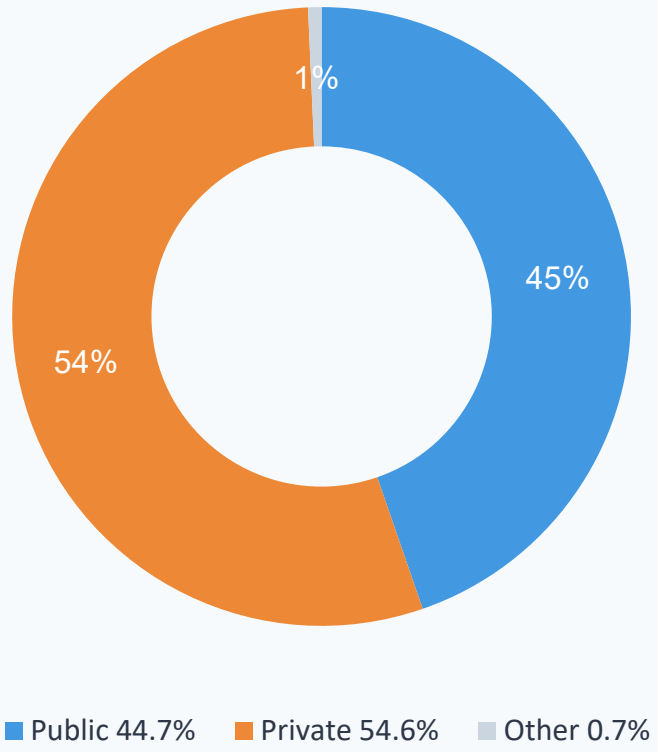
Residential Consumption-based Carbon (Public 44.7% · Private 54.6%)

Two-Segment Household Model

- **Public 44.7%** = rental 29.4% + subsidised sale 15.3%
- **Private 54.6%** = private housing only
- Subsidised sale → public segment (queue-based entitlement)

Source: Housing Bureau, Housing in Figures 2025

Public = rental 29.4% + subsidised 15.3%

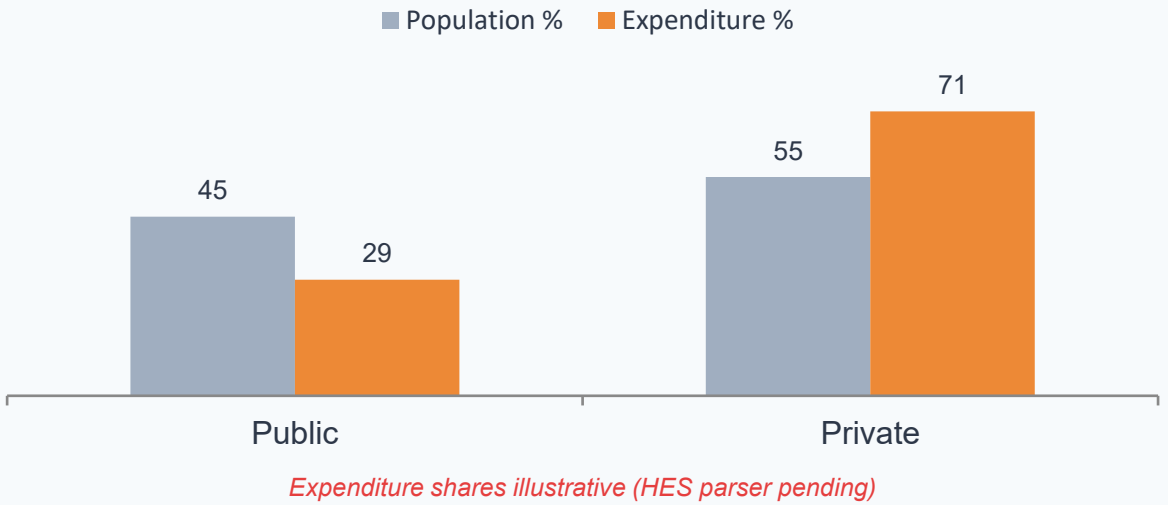


Part II Pipeline Overview

BClass 3 residential · ~143,759 buildings

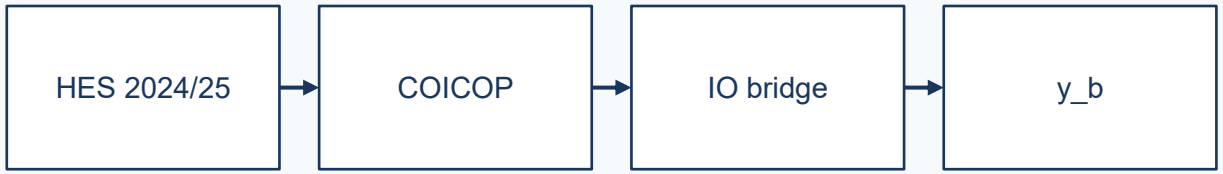
Final-Demand Split & HES Expenditure Profiles

- Y_{seg} from **expenditure mass**, not population share
- E_seg = N_seg × HES monthly spend
- Public: Table 3.3 public + subsidised × Table 4.2 region
- Private: Table 3.3 + Table 4.1 quartile anchors × Table 4.2



Expenditure shares illustrative (HES parser pending)

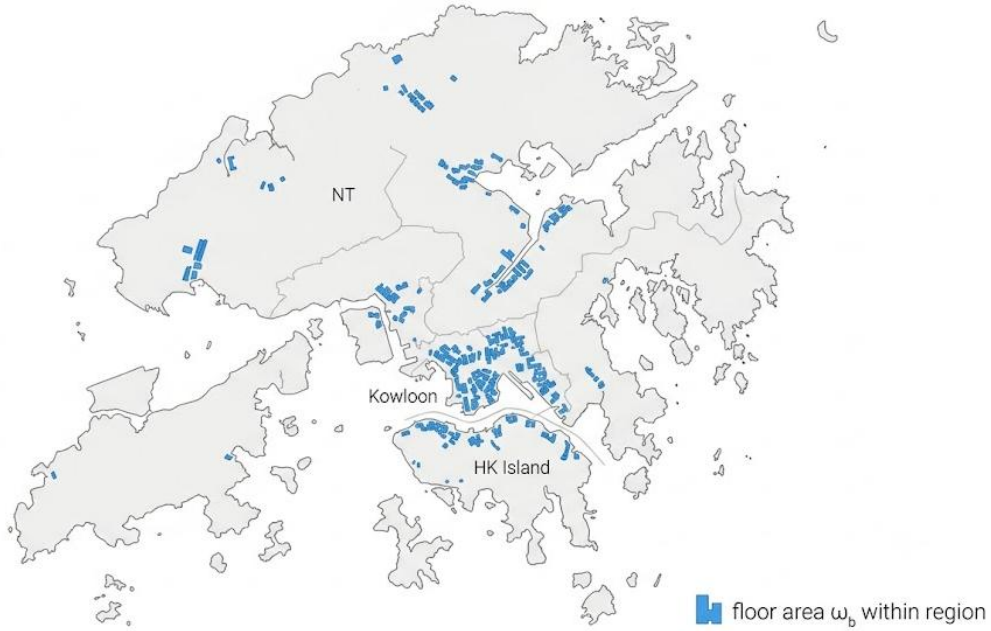
E_seg = N_seg × HES monthly expenditure



Two Attribution Branches

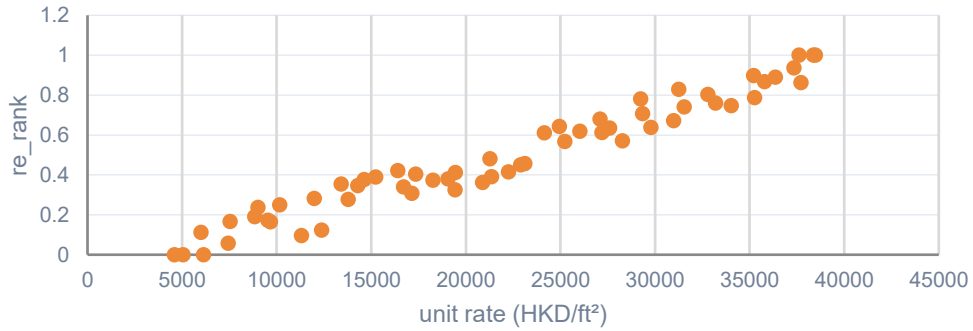
Public branch

- ω_b = floor area share within region
- y_b = ω_b × Y_public × f_public,r



Private branch

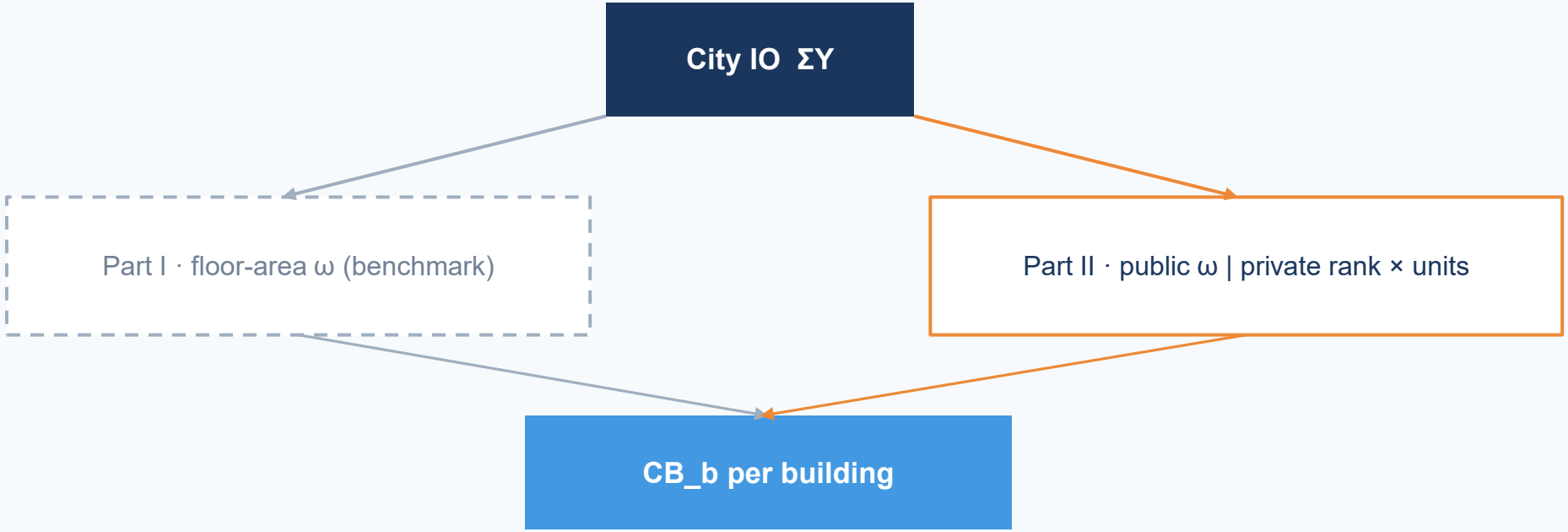
- unit_rate → re_rank; n_units ≈ floor area / unit area
- spend = n_units × HES exp(re_rank, region)
- Centaline = rank signal only



⚠ *incomplete coverage*

CB Identity & the Part I Benchmark

$$CB_b = e^T L y_b$$



ADB 2022 + EPD intensities

Outputs: CB_public · CB_private

Benchmark: Part I floor-area allocation

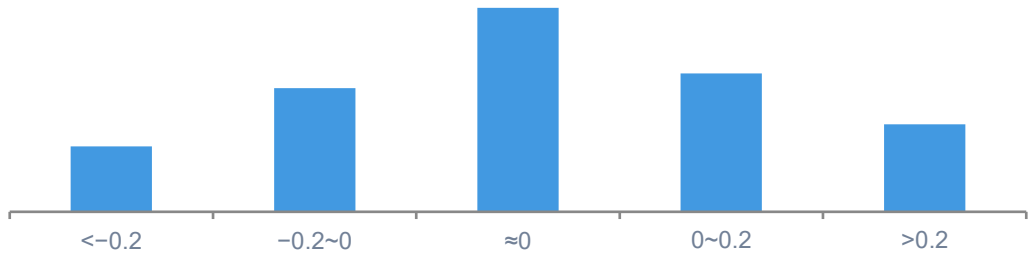
PRELIMINARY

Part II Results — Expenditure Split vs Part I & Segment × SLR

Pipeline check	FD expenditure split	HES monthly mean
FD closure error 0.0 (n=10 smoke test)	Public ~29% · Private ~71%	Public HK$16,181 · Private HK$41,174
ω sum = 1.0	Pop. 44.7% / 54.6% ≠ expenditure split	Private ≈ 2.5× public mean

Part II − Part I CB map (pending full run)

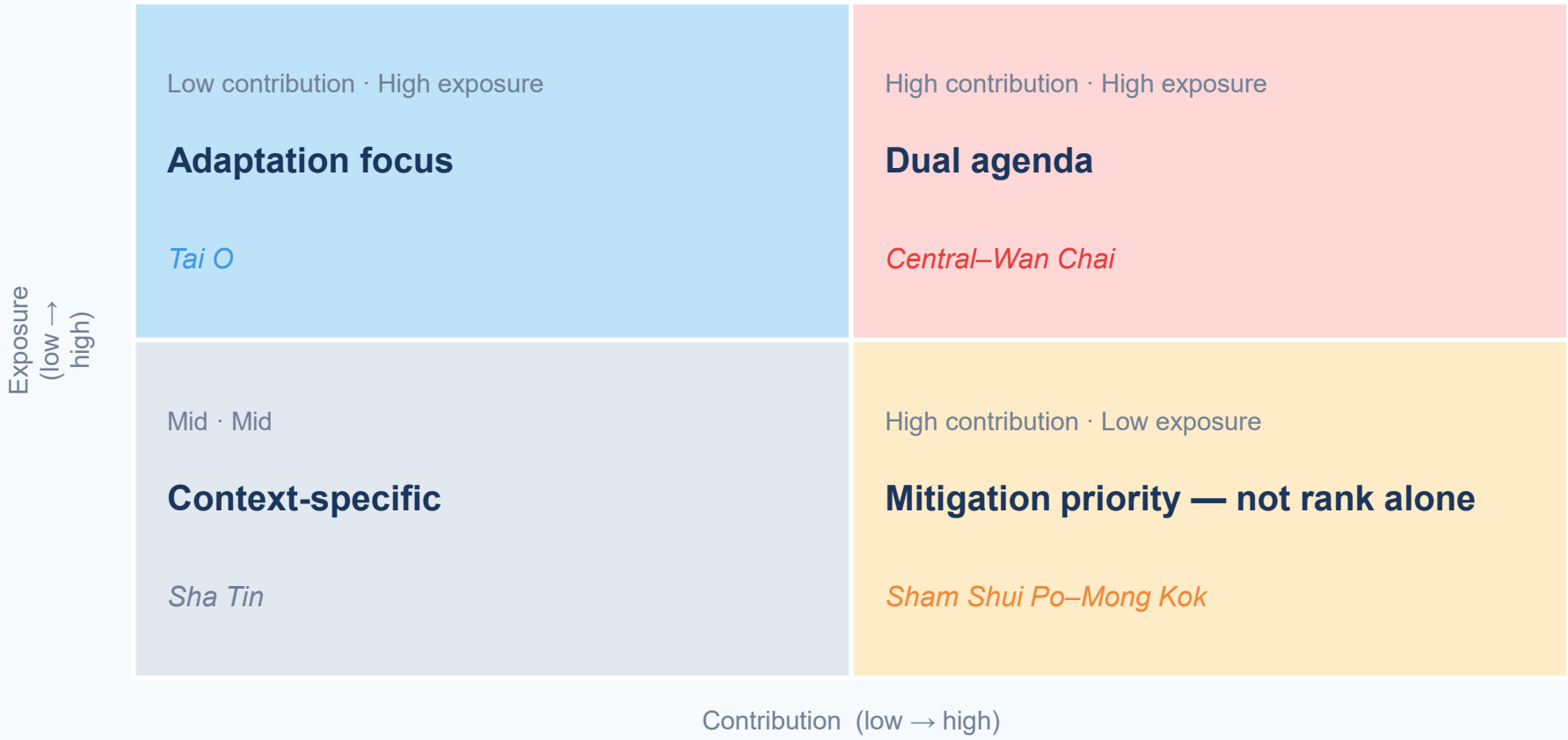
ΔCB distribution (median / p90 TBD)



Segment	CB share (est.)	2050 inund. floor %	2100 inund. floor %
Public (44.7% pop.)	*TBD*	*TBD*	*TBD*
Private (54.6% pop.)	*TBD*	*TBD*	*TBD*
Territory (Part I ref.)	100%	8.3% bldgs	11.6% bldgs

Confirmed: HES + smoke test. TBD: full-stock ΔCB and segment × SLR after final run.

Policy Implications & Limitations



Limitations: single-year · uniform intensities · Part II coverage & temporal mismatch

Conclusions

1. **Part I:** City IO conserved across 216,908 buildings; contribution & SLR exposure decouple

2. **Part II:** Two-segment model embeds household & HES expenditure in residential MRIO

3. **Together:** Building-scale CB accounts → operational carbon–risk map for policy

Thank You

Questions?

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