WORLD BANK GROUP | KOREA GREEN GROWTH TRUST FUND | Ministry of Finance and Economy | SEJONG CITY

KGID 2026 SEJONG

Spatial Expansion Patterns of Cambodia's Secondary Cities: Implications for Sustainable and Inclusive Growth

So Young Lee, Saheum Hong, Seongwook Lee, Dabin Lee

Korea Research Institute for Human Settlements

01 Background

Rapid Urban Transformation in Cambodia

- Rapid socioeconomic and spatial transformation driven by sustained economic growth and improved regional connectivity.
- Urbanization rate remains low (26% in 2024), but urban growth exceeds 3% annually
- One of the fastest urbanizing countries in East Asia

Growing Role of Secondary Cities

- Phnom Penh dominates the national urban system
- Secondary cities (Sihanoukville, Poipet, Bavet, Battambang, Kampong Cham) gaining strategic importance
- Key nodes for trade, logistics, and service delivery along national and regional corridors

Policy Imperatives and Emerging Challenges

- Sustainable City Strategic Plan 2020–2030: competitiveness, environmental sustainability, and livability of secondary cities
- Accelerating urbanization intensifying:
  - Spatial inequality and uneven service access
  - Land-use and environmental pressures
  - Climate-related risks (floods, droughts)

Need for Spatially Grounded Analytics

- Cambodia Livable Cities Program (ASA): smart, green, and inclusive urbanization
- Need for evidence-based, spatial diagnostics of secondary cities
- This assignment applies satellite imagery and geospatial analysis to assess
  - Urban expansion and land-use change
  - Spatial typologies to inform national and municipal decision-making

02 Objectives

Generate spatially grounded insights to support evidence-based planning for **Cambodia's secondary cities**

Research Strategy

Analyze Urban Growth Dynamics

- Examine urban expansion and spatial growth patterns in representative secondary cities
- Apply multi-temporal remote sensing and geospatial datasets

Assess Land-Use and Spatial Transformation

- Identify major land-use and land-cover (LULC) transitions
- Analyze growth of built-up areas and peri-urban transformation
- Capture key spatial change typologies linked to urbanization pressures

Support Policy Dialogue and Knowledge Sharing

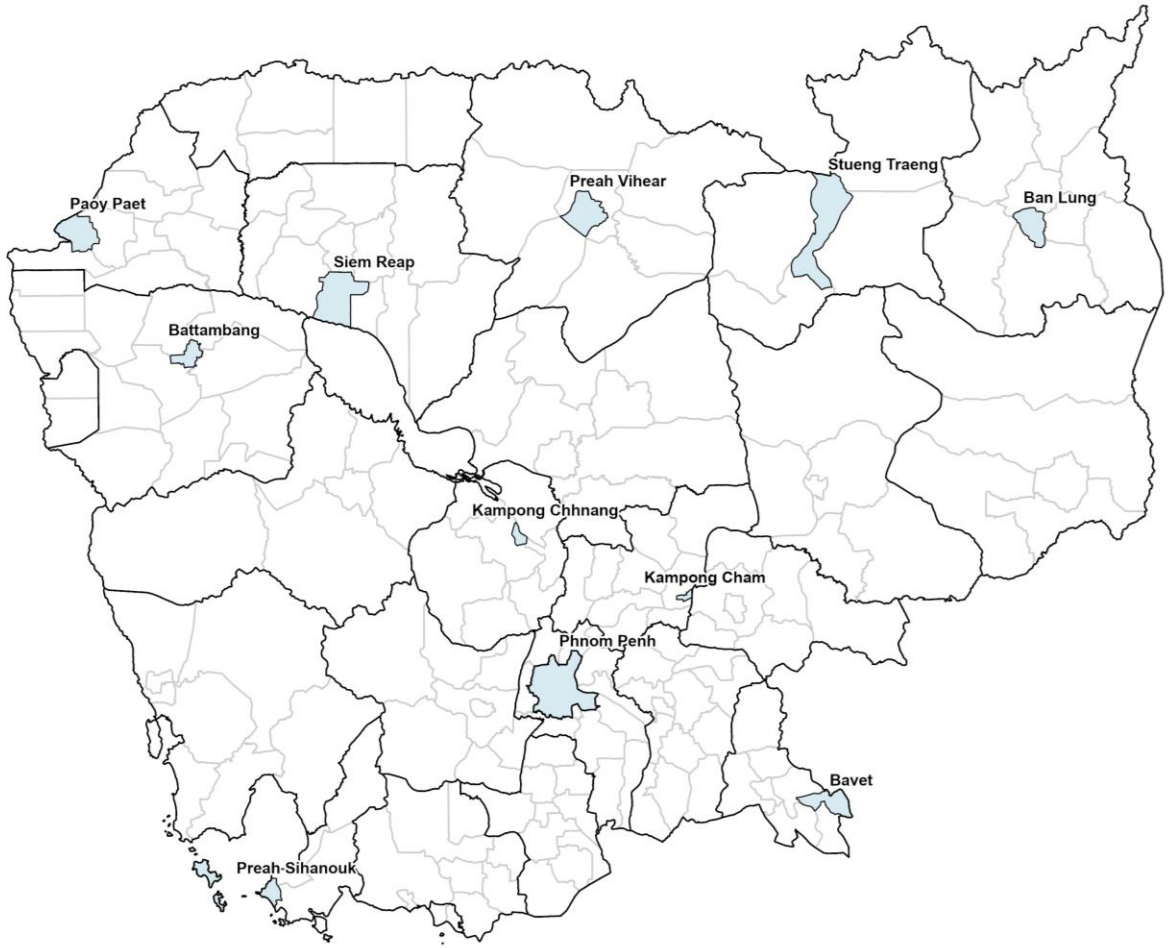
- Develop concise spatial profiles for selected secondary cities
- Integrate spatial analysis with demographic and administrative data
- Inform policy discussions with MLMUPC

03 Scope of Work

01 Spatial Coverage

- 10 Secondary Cities in Cambodia

Battambang (Krong Bat Dambang)	Bavet (Krong Bavet)
Boung Long (Krong Ban Lung)	Kampong Cham (Krong Kampong Cham)
Kampong Chhnang (Krong Kampong Chhnang)	Poipet (Krong Paoy Paet)
Preah Vihear (Krong Preah Vihear)	Siem Reap (Krong Siem Reab)
Sihanoukville (Krong Preah Sihanouk)	Stung Treng (Krong Stueng Traeng)



02 Temporal Coverage

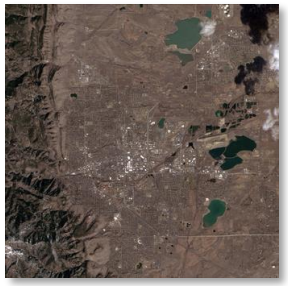
- 1995-2025

04 Built-up Expansion Analysis

1 LULC Classification Methodology

ROI

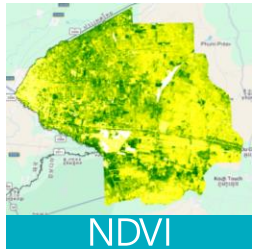
Landsat 8/9

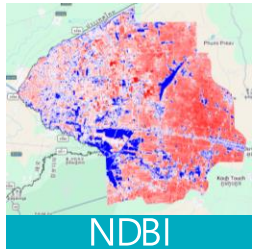


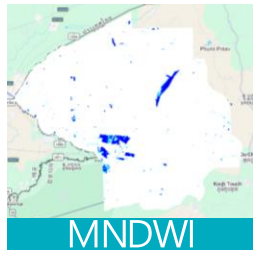
Dry Season
(Jan - Mar)

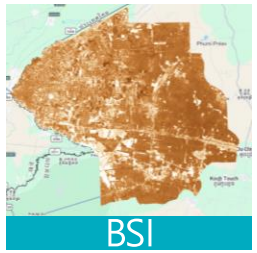
Texture | NDBI | NIR

Spectral Indices

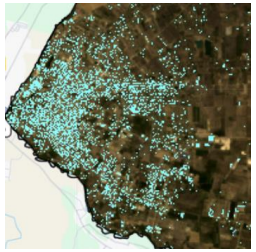




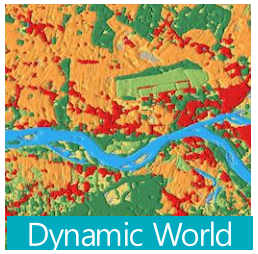




Google Open Buildings



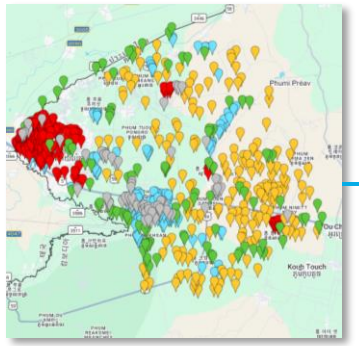
Reference Data



5 Classes

Spectral Thresholding

Stratified Sample



Training 70%

Predictors

Bands
- RGB
- NIR
- SWIR 1
- SWIR 2

+ Indices, Texture, Reference Data, Open Buildings

RF Classification 300 Trees

Validation 30%

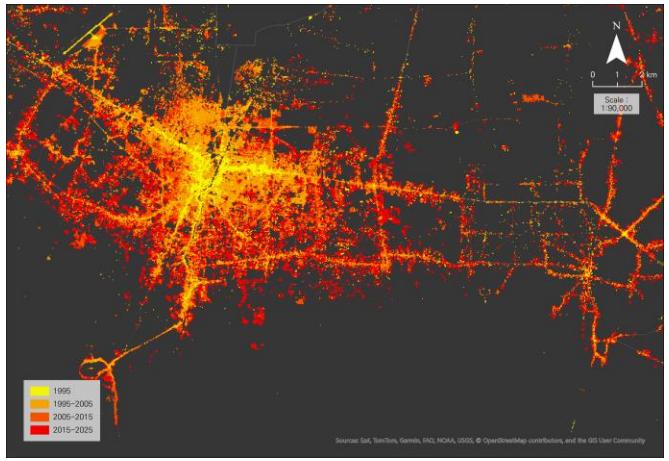
Accuracy Assessment

- Overall accuracy (OA)
- Kappa

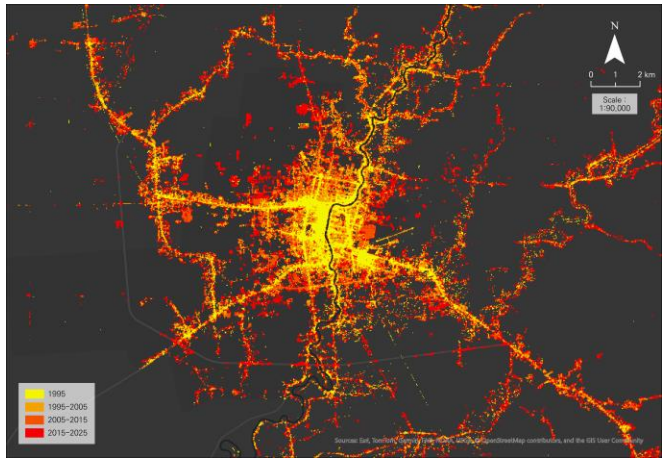
04 Built-up Expansion Analysis

2 Built-up Area Expansion

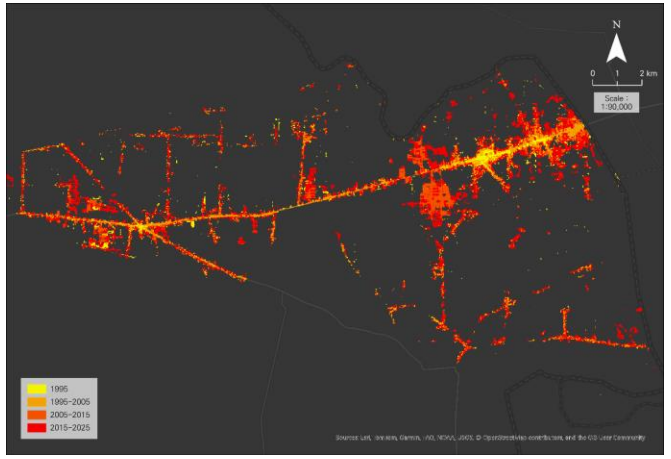
Siem Reap (1995-2025)



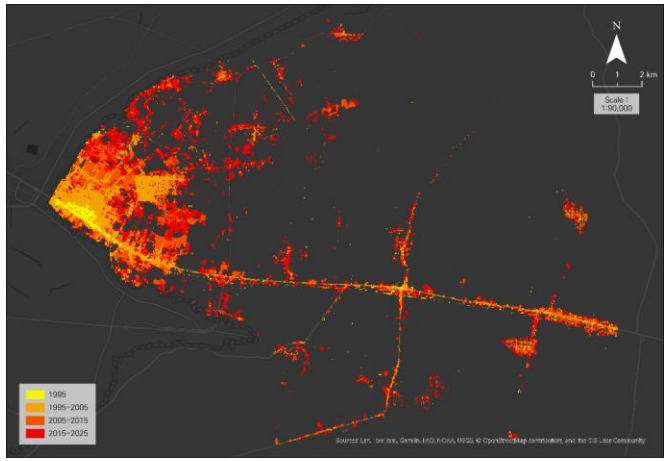
Battambang (1995-2025)



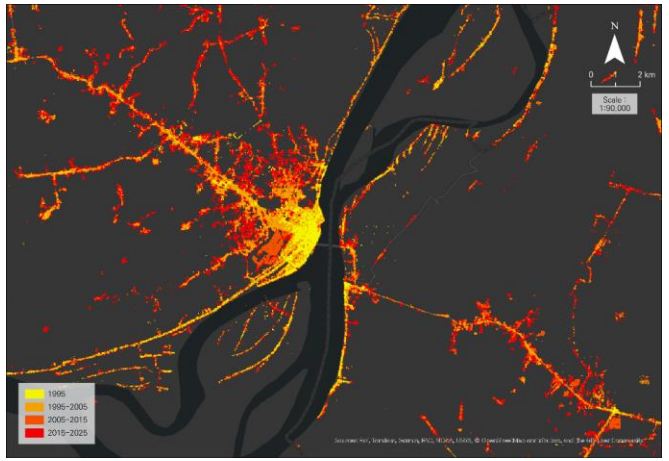
Bavet (1995-2025)



Poipet (1995-2025)



Kampong Cham (1995-2025)

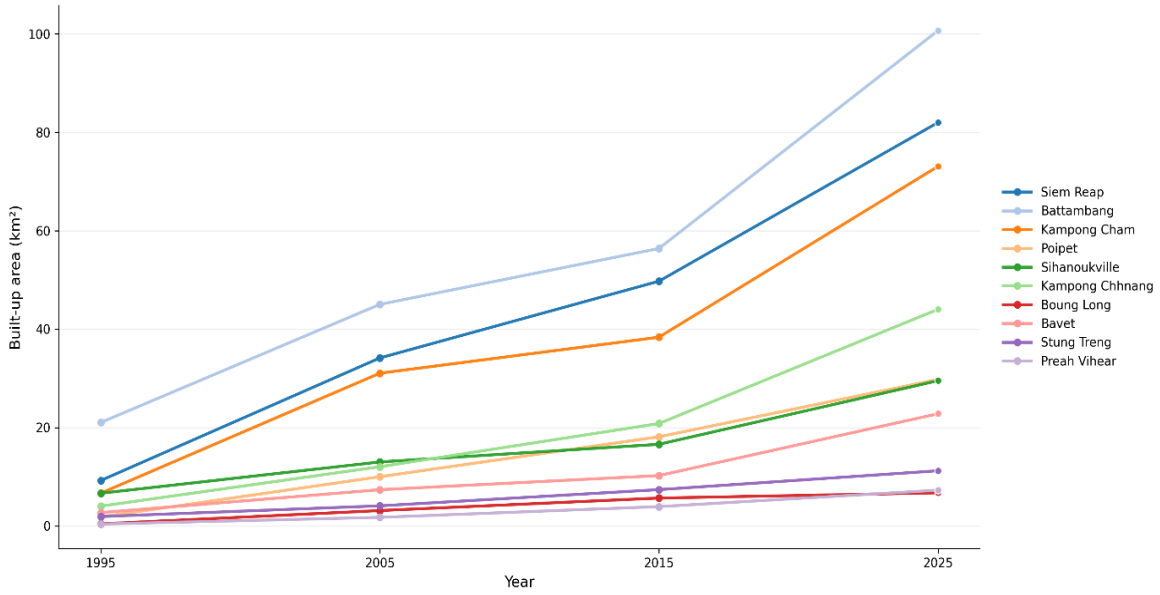


04 Built-up Expansion Analysis

2 Built-up Area Expansion

- Built-up areas expanded steadily across all ten cities between 1995 and 2025.
- Total Built-up areas increased more than sevenfold, with the largest increases in Siem Reap and Battambang.

Built-up Area Expansion Across Ten Secondary Cities (1995-2025)

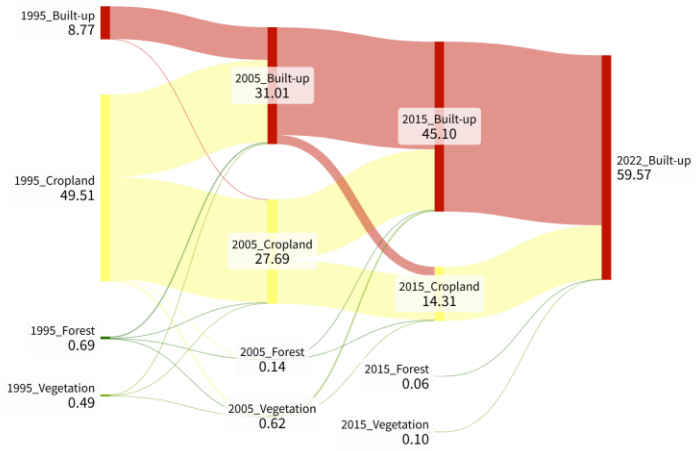
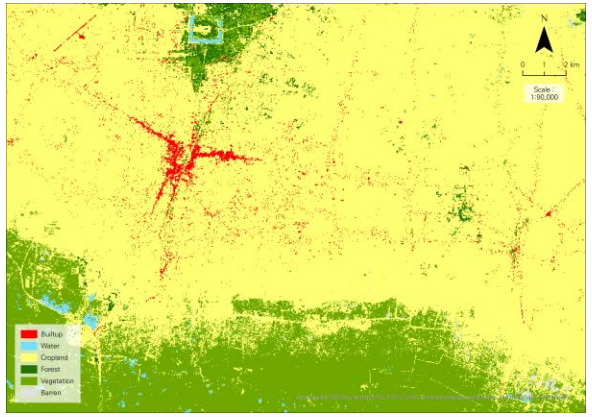
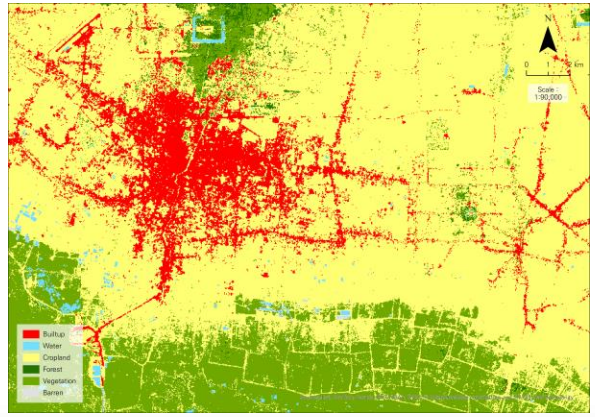
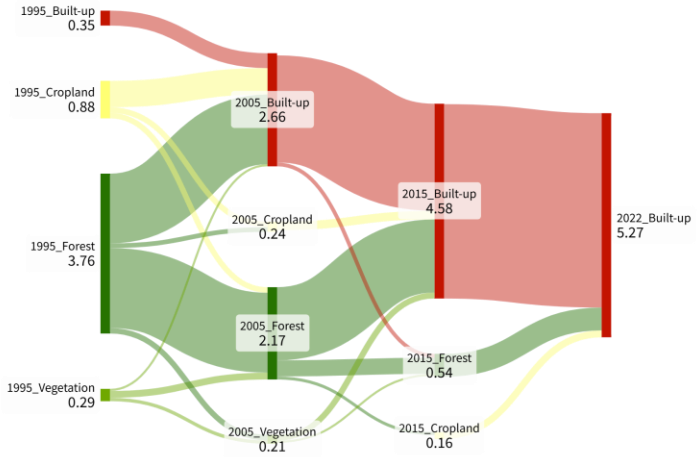
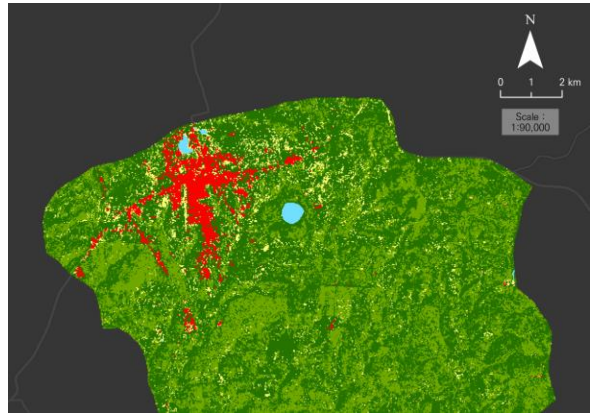


Built-up Area of Ten Secondary Cities (1995-2025, Unit: ㎢)

Year	1995	2005	2015	2025
Siem Reap	9.24	34.15	49.75	82
Battambang	21.03	45.04	56.4	100.69
Kampong Cham	6.67	31.05	38.37	73.09
Poipet	1.83	10.01	18.12	29.78
Sihanoukville	6.65	13.01	16.6	29.53
Kampong Chhnang	4.03	12.04	20.82	44.03
Boung Long	0.42	3.13	5.67	6.73
Bavet	2.71	7.37	10.24	22.81
Stung Treng	1.91	4.09	7.38	11.22
Preah Vihear	0.39	1.75	3.93	7.27

04 Built-up Expansion Analysis

3 LULC Transitions

	Sankey Diagram 1995-2022	LULC	
		1995	2022
Siem Reap			
Boung Long			

05 Urban Growth Typology

1 Metrics for Assessing Urban Growth Pattern

UEP Urban Expansion Pace

$$\mathrm{UEP} = \frac{\ln(\mathrm{A}_{t_2}) - \ln(\mathrm{A}_{t_1})}{t_2 - t_1} \times 100$$

A_t: total urban footprint area at time t

Average annual logarithmic growth of urbanized area

LEI Landscape Expansion Index

$$LEI = 100 \times \frac{A_o}{A_o + A_v}$$

A_0: overlap between buffer and pre-existing urban land,
A_v: overlap between buffer and vacant/non-urban land

Growth mode: internal filling,
contiguous edge growth, or leapfrog expansion

DG Density Gradient Slope

$$BD_x = BD_0 e^{-\lambda x}$$

BD_x: built-up density in ring x, λ: density gradient slope

Center–periphery concentration of built-up density

DI Dispersion Index

$$DI = \frac{NP_n + (100 - LP_n)}{2}$$

NPn: normalized number of patches, LPn: normalized largest patch

Fragmentation and spatial dispersion
of the urban pattern

LSI Landscape Shape Index

$$LSI = \frac{E}{\min E}$$

E: total edge length, min E: minimum edge length for a given area

Overall shape complexity and irregularity
of the urban footprint

DBI Directional Bias Index

$$DBI = \frac{\sigma_A}{\mu_A}$$

σ_A: standard deviation of directional urban expansion,
μ_A: mean of directional urban expansion

Directional imbalance of urban expansion

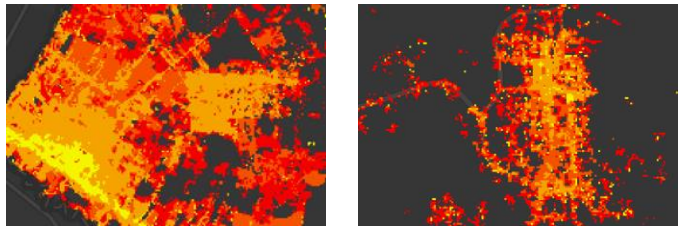
05 Urban Growth Typology

1 Metrics for Assessing Urban Growth Pattern

1995 2005 2015 2025

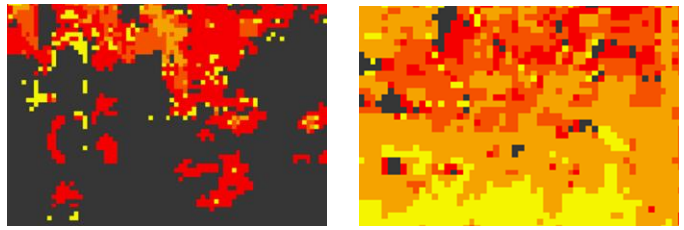
UEP Urban Expansion Pace

High Low



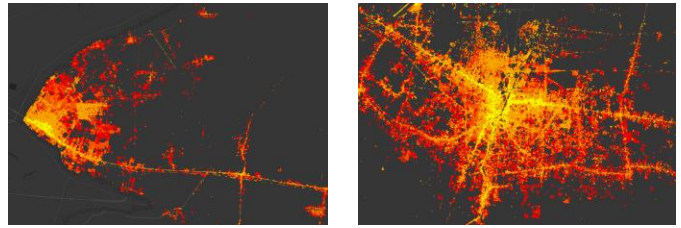
LEI Landscape Expansion Index

High Low



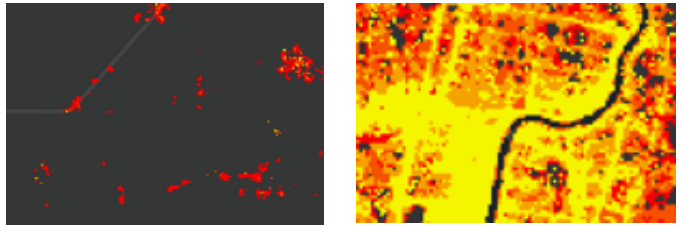
DG Density Gradient Slope

High Low



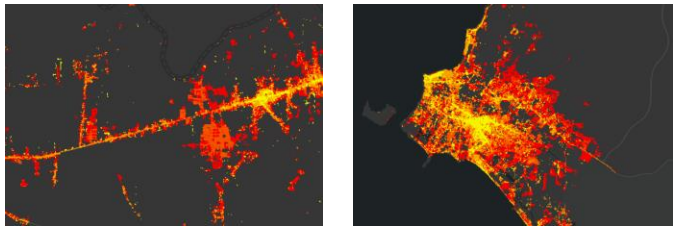
DI Dispersion Index

High Low



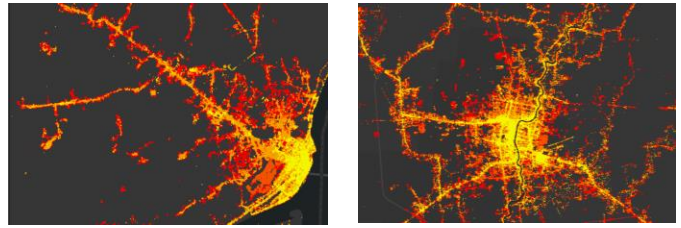
LSI Landscape Shape Index

High Low



DBI Directional Bias Index

High Low

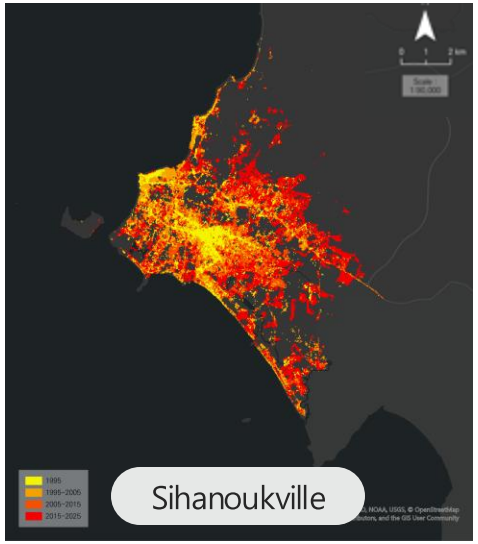


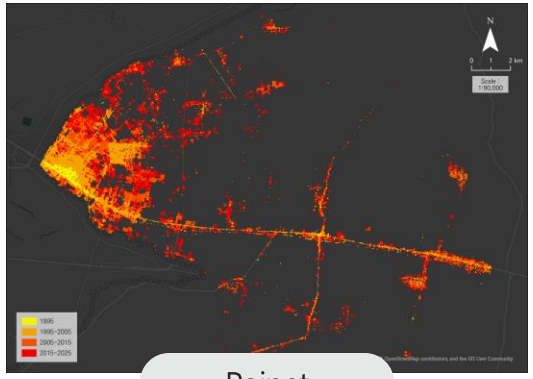
05 Urban Growth Typology

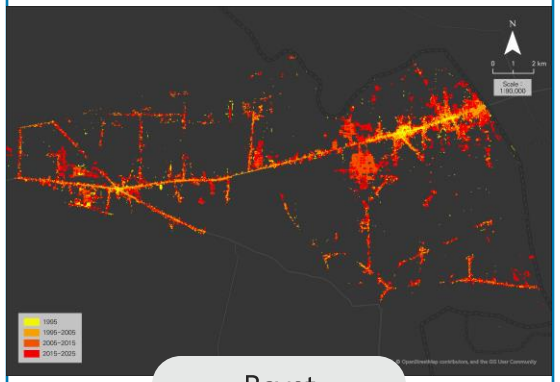
2 Four Types of Urban Growth Patterns

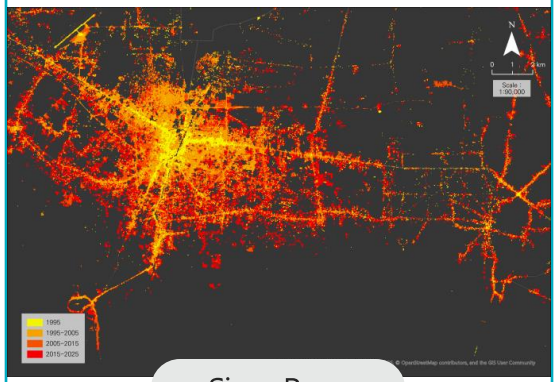
- Four urban growth types were identified by normalizing six spatial indicators and comparing expansion patterns across the ten secondary cities.

	Single-core intensification	Low-complexity expansion	Corridor-biased growth	Mature complex form
Cities	Sihanoukville	Boung Long, Poipet, Preah Vihear, Stung Treng	Bavet, Kampong Cham	Battambang, Siem Reap, Kampong Chhnang
Main indicator characteristics	Compact, concentrated around one core	Dispersed outward growth, simple shape	Linear growth along transport corridors	Established, fragmented, multi-directional







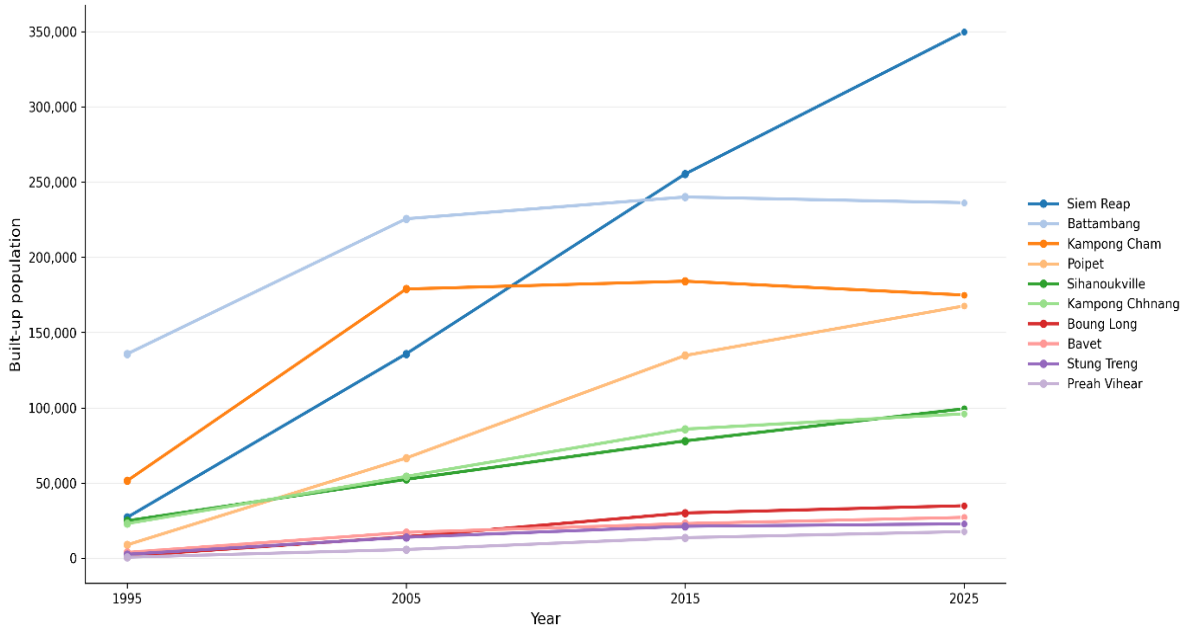


06 Population and Density Dynamics

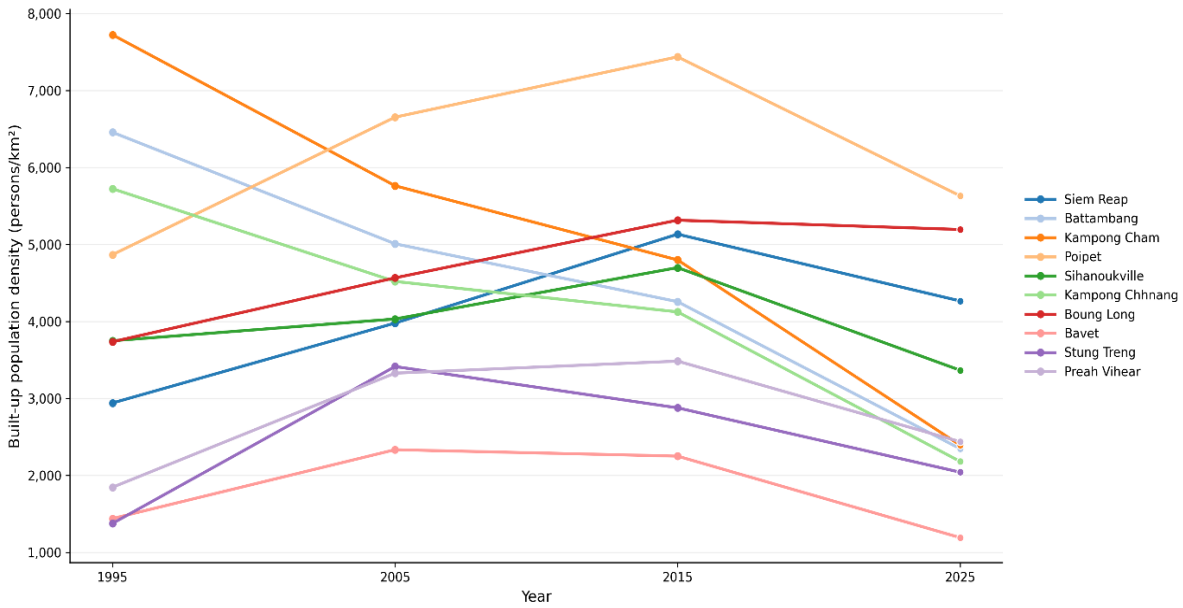
1 Population Growth in Built-up Areas

- Population within built-up areas increased across all ten secondary cities between 1995 and 2025.
- Population density within built-up areas declined in most cities, with the most pronounced decline in Kampong Cham, Battambang, and Kampong Chhnang.

Population Change in Built-up Areas of Ten Secondary Cities (1995-2025)

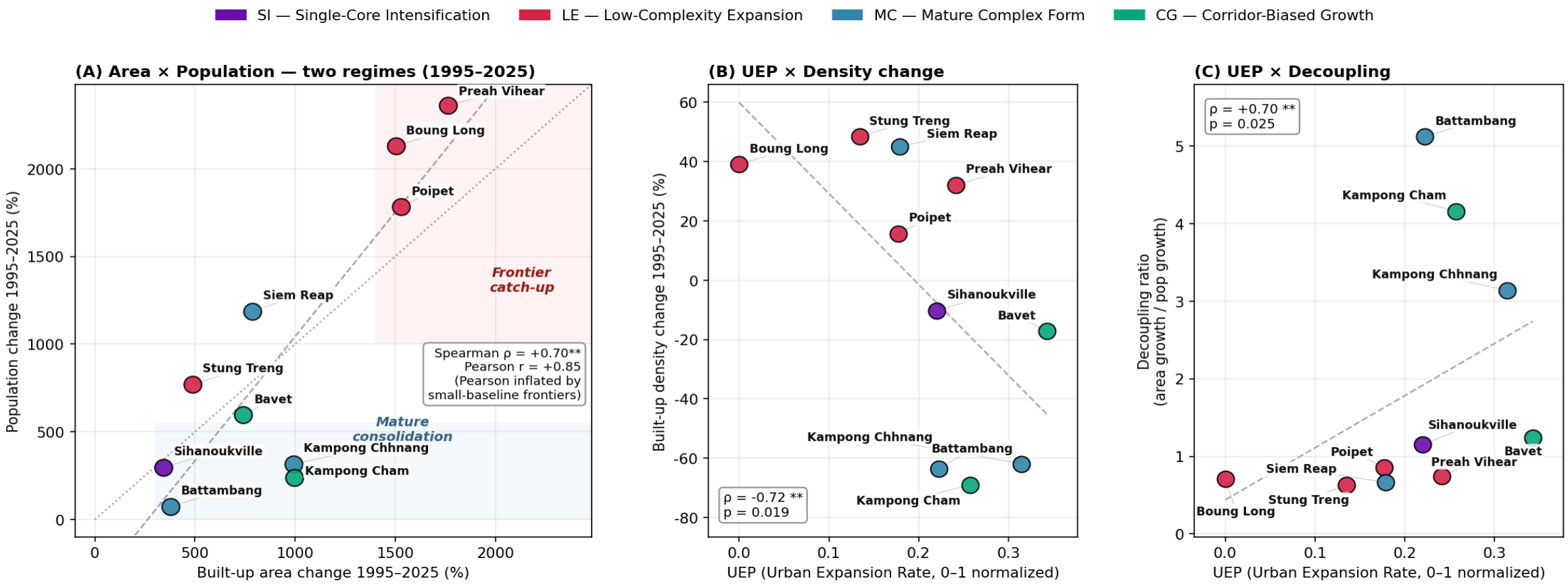


Population Density Change in Built-up Areas of Ten Secondary Cities (1995-2025)



2 Expansion-Population Decoupling

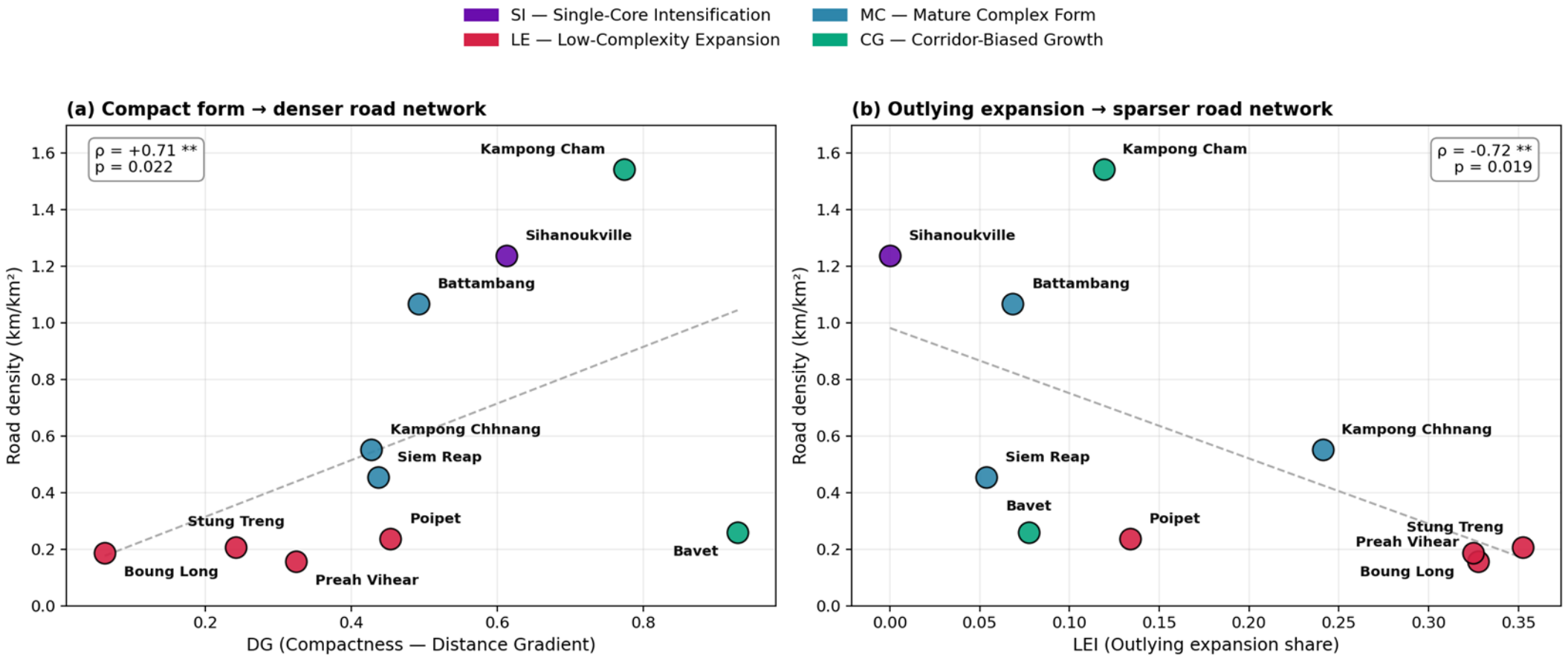
- Built-up and population changes reveal two broad urbanization patterns: frontier catch-up and mature consolidation.
- Cities with faster expansion show greater density decline, suggesting a growing mismatch between urban land consumption and population increase.



07 Urban Form and Infrastructure Access

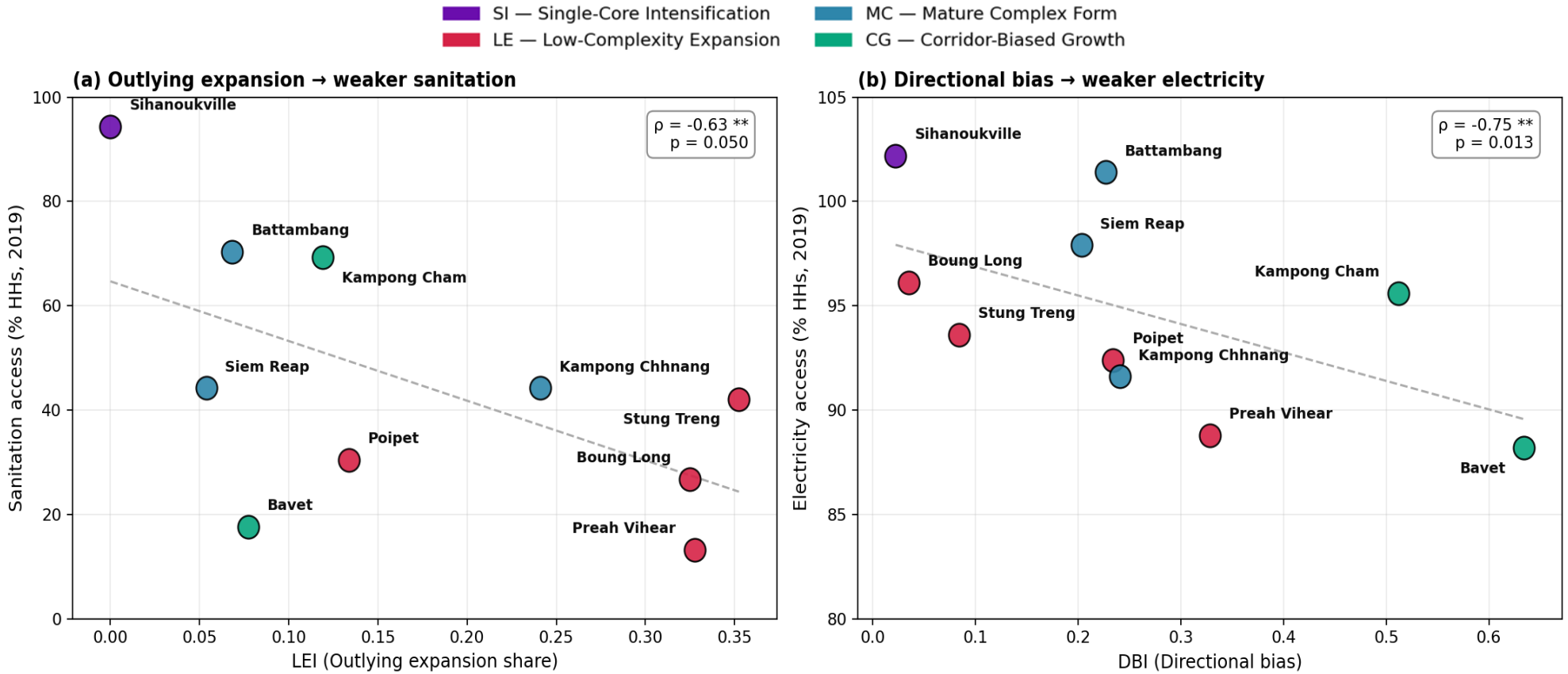
1 Road-Network Coverage

- More compact urban form (higher DG) is associated with higher road density, indicating denser road-network provision.
- Greater outlying expansion (higher LEI) is associated with lower road density, suggesting weaker road-network coverage.



2 Basic Infrastructure Access

- Greater outlying expansion (higher LEI) is associated with lower sanitation access, suggesting weaker sanitation coverage in more dispersed cities.
- Stronger directional bias (higher DBI) is associated with lower electricity access, suggesting potential service gaps in more directionally biased urban forms.

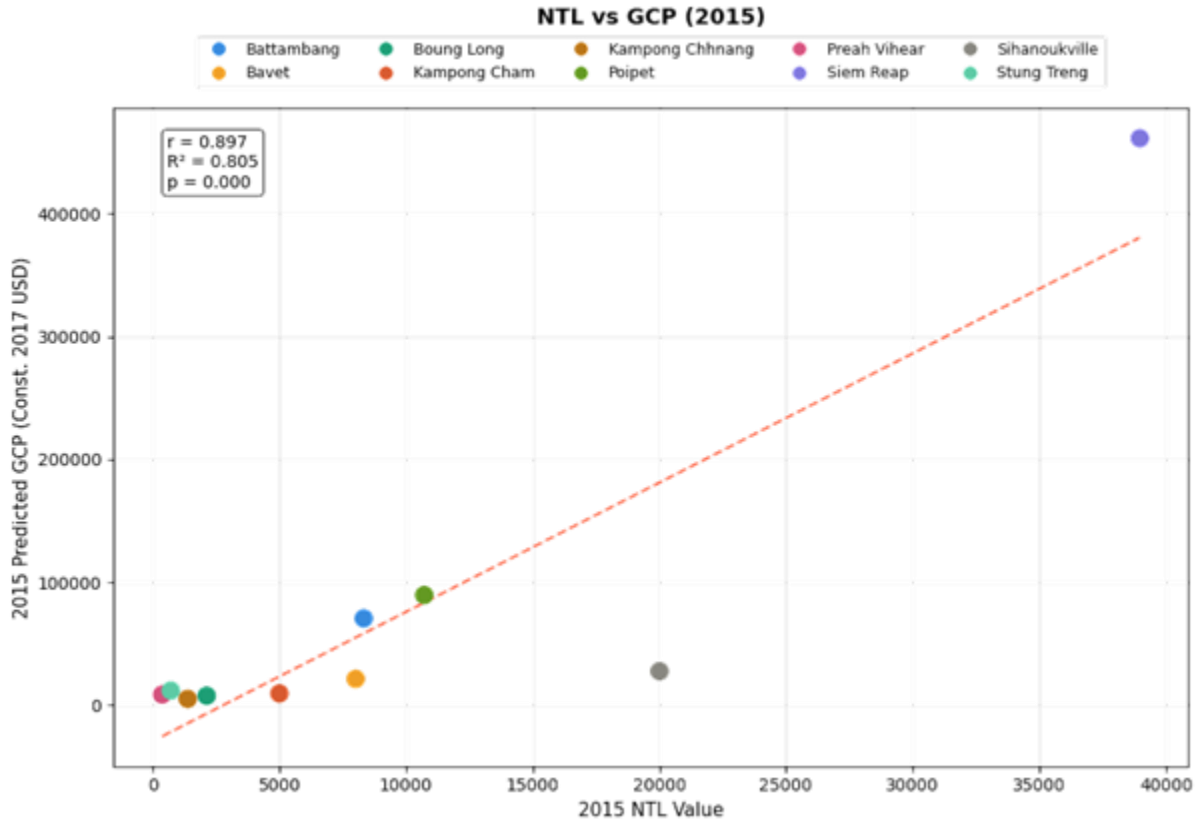


08 Urban Expansion and Economic Activity

1 NTL-Based Economic Activity

- Economic Proxy (NTL): Utilizes DMSP-OLS and VIIRS satellite imagery as a proxy for economic intensity.
  - Validation: High statistical correlation (R^2≈0.8–0.9, p<0.001) confirms that NTL is a robust and reliable indicator.

Relationship between NightTime Light Intensity (NTL) and Predicted Gross City Product (GCP) of Ten Secondary Cities (2015)

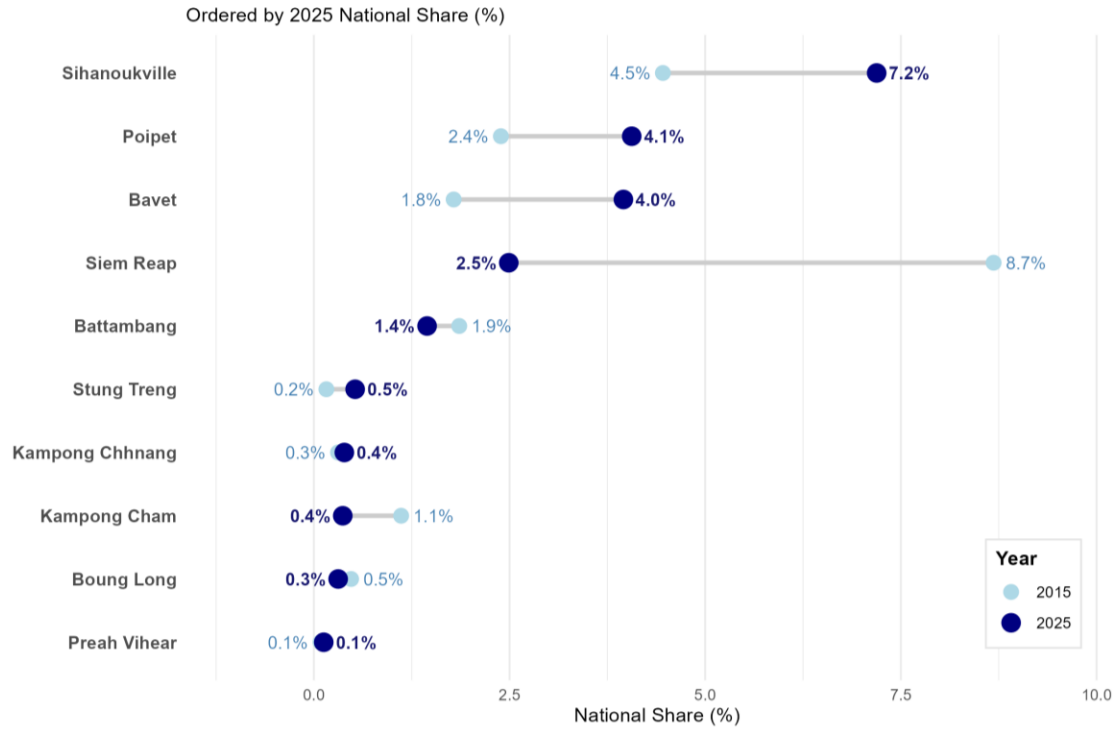


Source:
NTL (Earth Observation Group);
Predicted GCP (Rossi-Hansberg & Zhang, 2025)

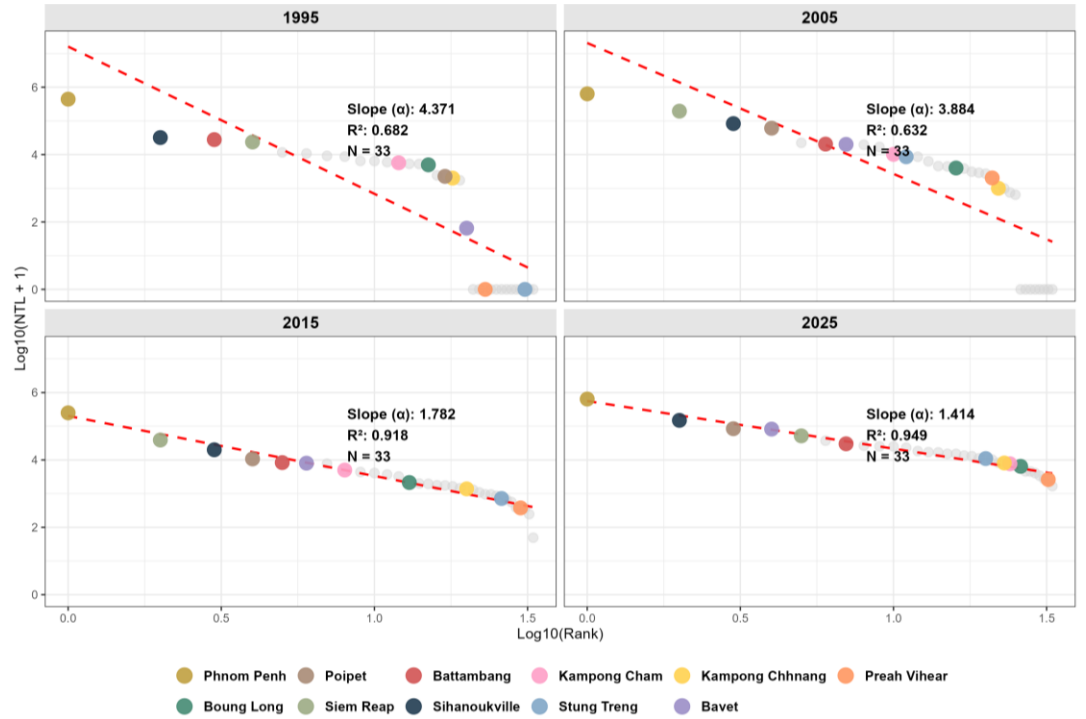
2 Changing Economic Hierarchy

- Sihanoukville, Poipet, and Bavet increased their shares of national NTL, while Siem Reap, Battambang, and Kampong Cham declined in relative importance.
- The rank-size slope declined from 4.37 to 1.41, suggesting that economic activity became more spatially dispersed across secondary cities.

NTL Share Change among Ten Secondary Cities (2015–2025)



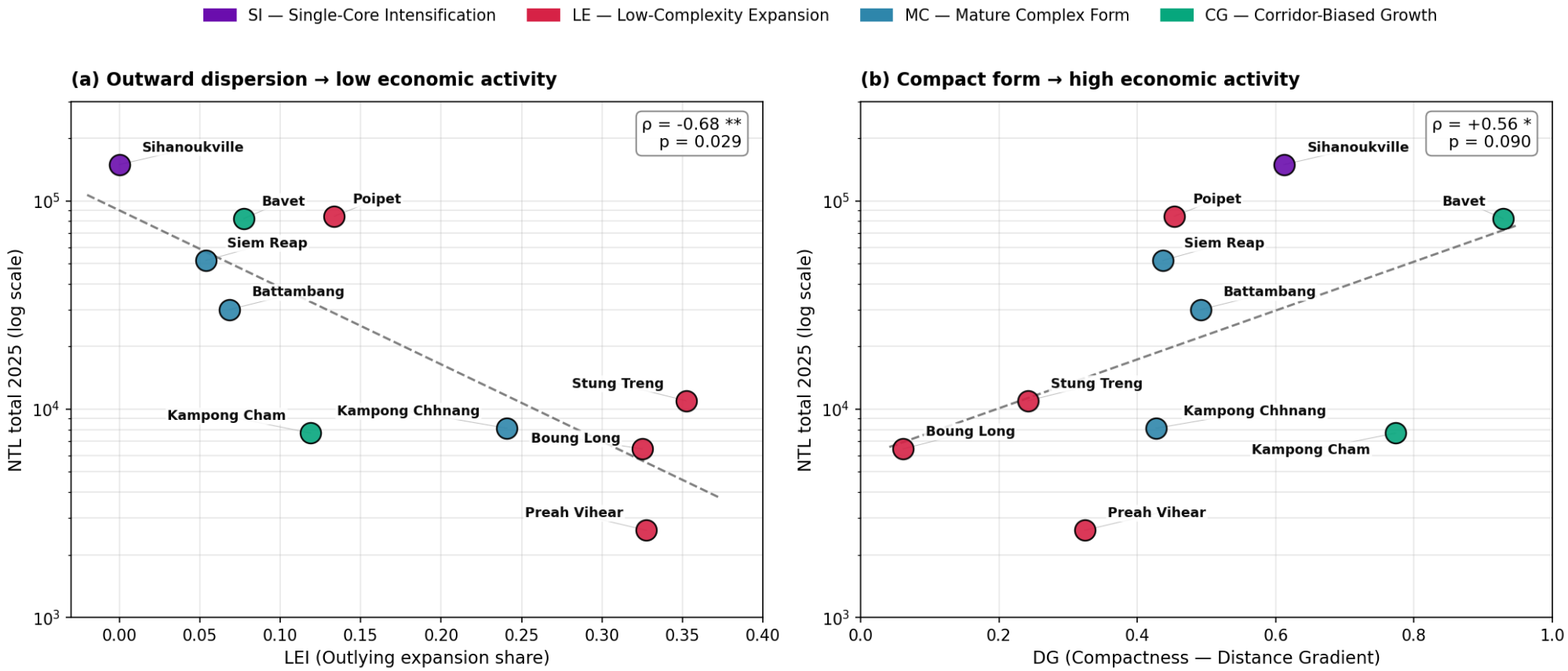
Rank-Size Plot Evolution for NTL (1995-2025)



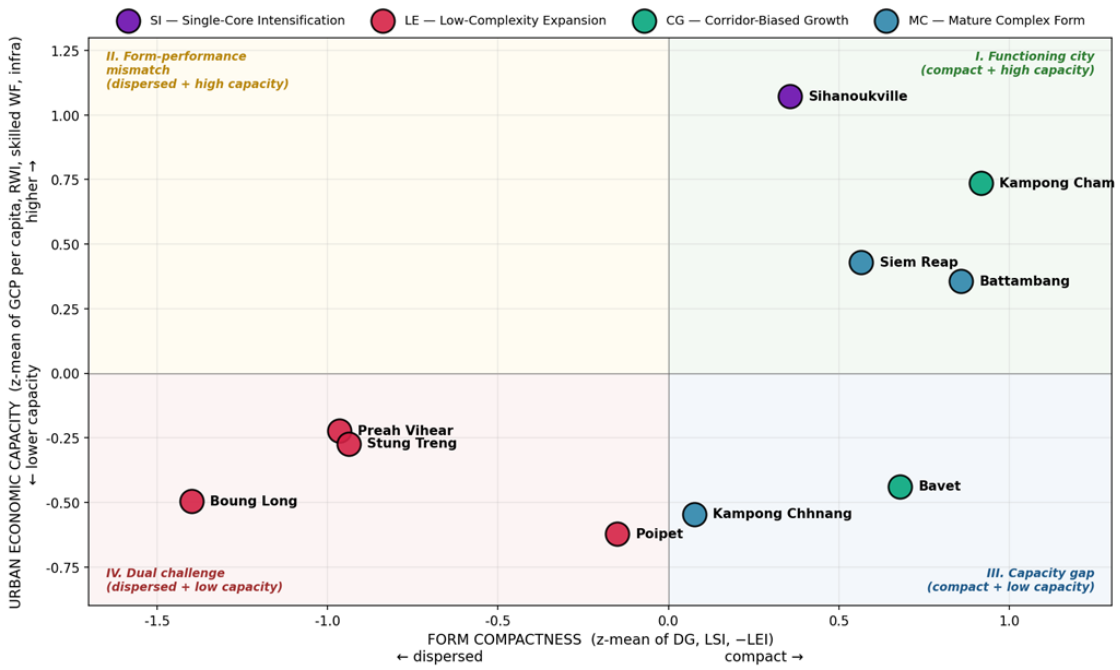
Source: VIIRS DNB (Elvidge et al., 2021)

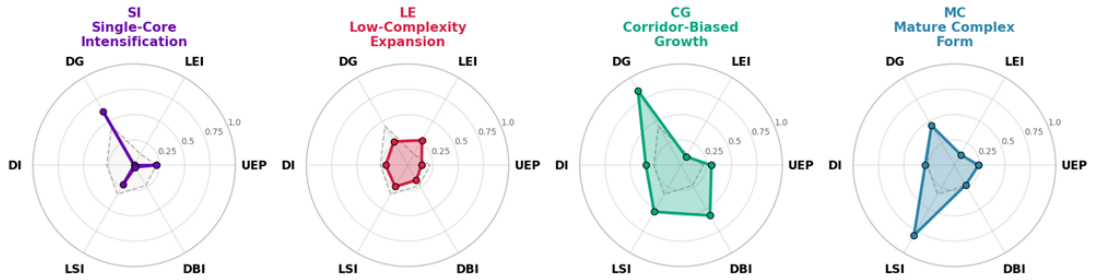
3 Urban Form and Economic Structure

- Cities with higher outlying expansion shares (higher LEI) tend to show weaker NTL signals, while more compact cities (higher DG) tend to show stronger NTL-based economic activity.
- Sihanoukville, Poipet, and Bavet show relatively high NTL levels, whereas Preah Vihear and Boung Long remain at the lower end of the NTL distribution.



09 Integrated Diagnostic: Urban Form x Socioeconomic Capacity





I Consolidated Growth Nodes

More compact form + higher economic capacity

Sihanoukville, Kampong Cham, Battambang, and Siem Reap

These cities show relatively strong alignment between spatial structure and socioeconomic capacity. Planning should focus on consolidating existing built-up areas, managing changes in density, and leveraging established service, infrastructure, and human capital bases for qualitative upgrading.

III Capacity Gap

More compact form + lower economic capacity

Bavet and Kampong Chhnang

These cities have relatively compact spatial forms, but this has not yet fully translated into strong socioeconomic capacity. While the specific gaps differ by city, priorities include infrastructure upgrading, human capital investment, industrial diversification, and service strengthening.

IV Dual Challenge

More dispersed form + lower economic capacity

Boung Long, Preah Vihear, Stung Treng and Poipet

Planning should prioritize basic service provision, node-based infrastructure, and hub-and-satellite development. Poipet should be treated separately as a potential strategic node, where rapid economic growth needs to be better connected with human capital, infrastructure, and local welfare.

10 Planning Priorities by Urban Typology

Type	Cities	Observed characteristics	Planning implications
Single-core intensification	Sihanoukville	Compact single core-form; recent built-up expansion accompanied by declining population density	• **Monitor whether new development remains connected to existing built-up and serviced areas.** • Planning could focus on managing the location and sequencing of growth to avoid a gradual shift toward lower-density expansion.
Low-complexity expansion	Poipet, Preah Vihear, Boung Long, Stung Treng	Dispersed, low-complexity expansion with weaker infrastructure and socioeconomic indicators; Poipet shows stronger economic activity.	• **Consider hub-and-satellite service provision, node-based infrastructure investment, and early sprawl monitoring.** • Preah Vihear, Boung Long, and Stung Treng may require basic infrastructure and service concentration around selected nodes, while Poipet could be managed as a strategic economic node.
Corridor-biased growth	Kampong Cham, Bavet	Compact, directionally biased corridor growth, with contrasting socioeconomic profiles.	• **Promote corridor-sensitive planning through targeted infill, linear infrastructure upgrading, and economic strengthening.** • Kampong Cham could focus on corridor infill and service-sector consolidation, while Bavet may need infrastructure improvement along the growth axis, industrial diversification, and human-capital upgrading.
Mature complex form	Battambang, Siem Reap, Kampong Chhnang	Mature and complex forms with stronger service and human capital bases; Battambang and Kampong Chhnang show long-term density decline, while Siem Reap shows recent population growth.	• **Prioritize infill, regeneration, and density recovery in established urban areas.** • Battambang and Kampong Chhnang may need stronger attention to re-densification, while Siem Reap could focus on accommodating recent growth in a compact manner.

WORLD BANK GROUP | KOREA GREEN GROWTH TRUST FUND | Ministry of Finance and Economy | SEJONG CITY

KGID 2026 SEJONG

Spatially grounded diagnostics can support city-differentiated planning.

Thank you for listening

For further questions,

Please contact So Young Lee (soylee@krihs.re.kr)