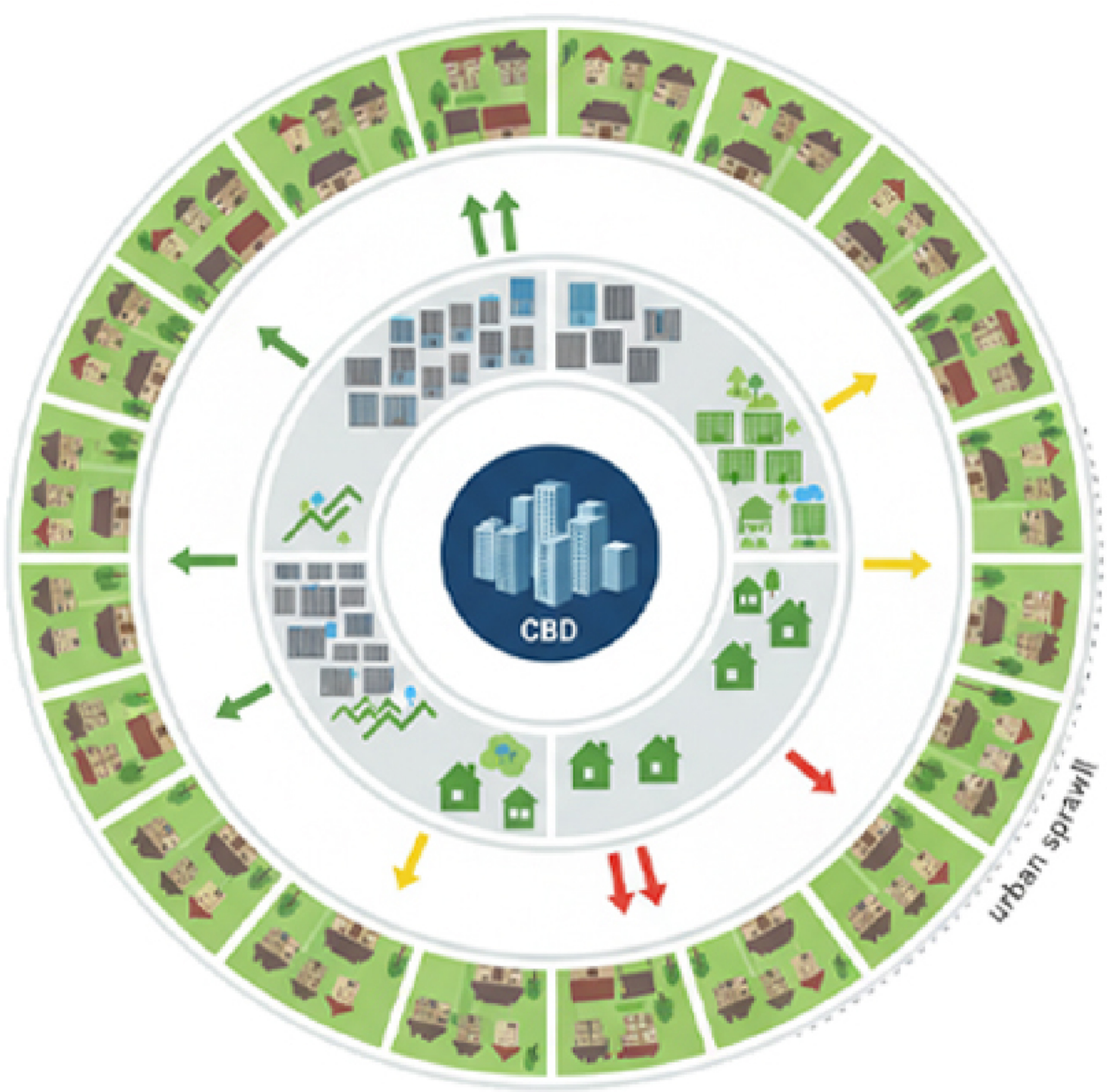
World-Changing Equations in Urban Planning & Design

How mathematical models reshaped cities, policies, and the way we live

1. Land Rent & Urban Location – Alonso-Muth-Mills Model

$$R(x) = R_0 - t \cdot x$$

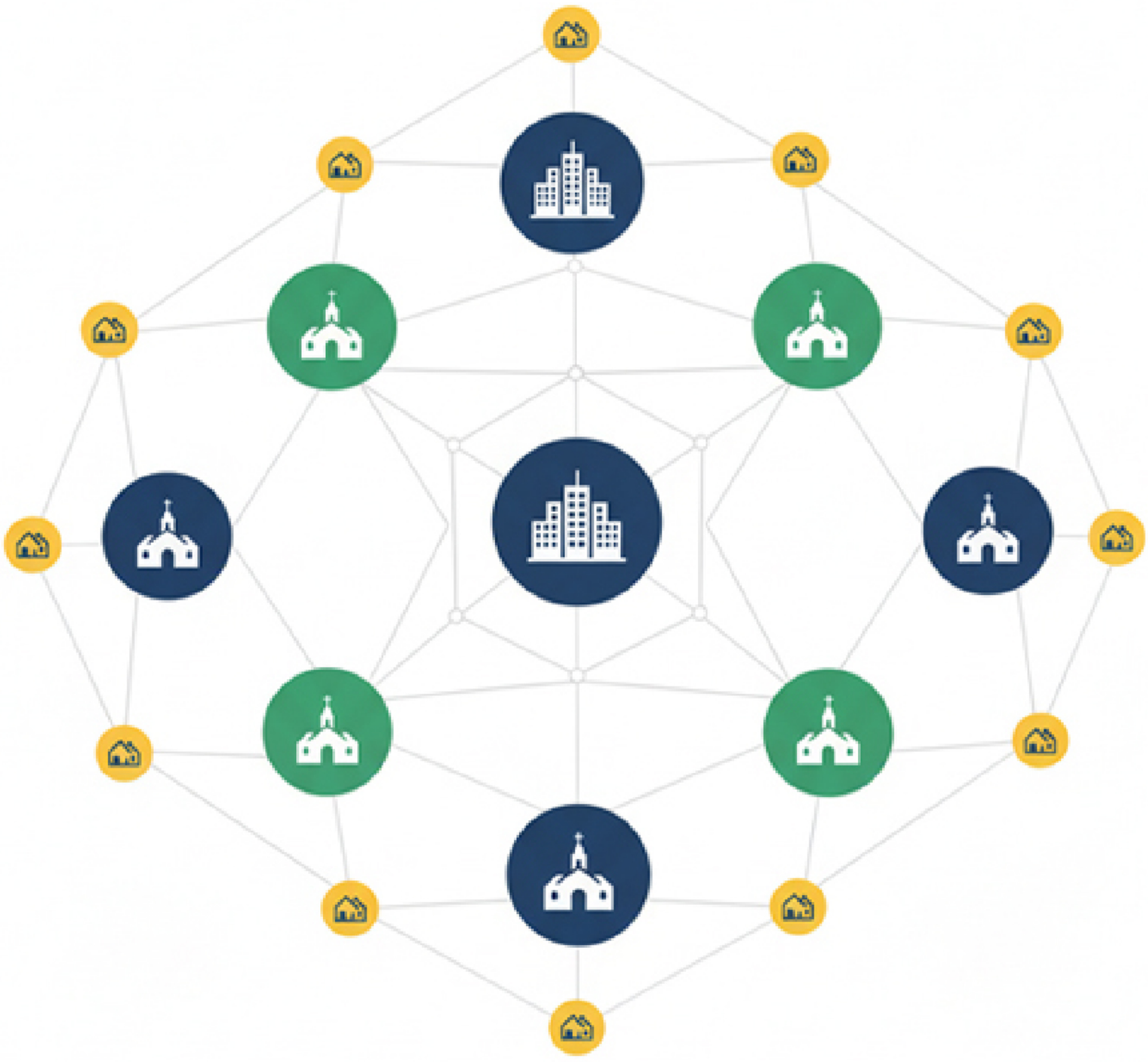


Where: R(x)rent at distance x from city center; t = transport cost per unit distance; R_0 rent at center.

Impact: Founded modern land-use theory & urban economics. Determines urban sprawl, CBD location, real estate pricing gradient.

2. Central Place Theory – Christaller's Distance Threshold

$$T = \frac{K \cdot A}{\pi r^2}$$

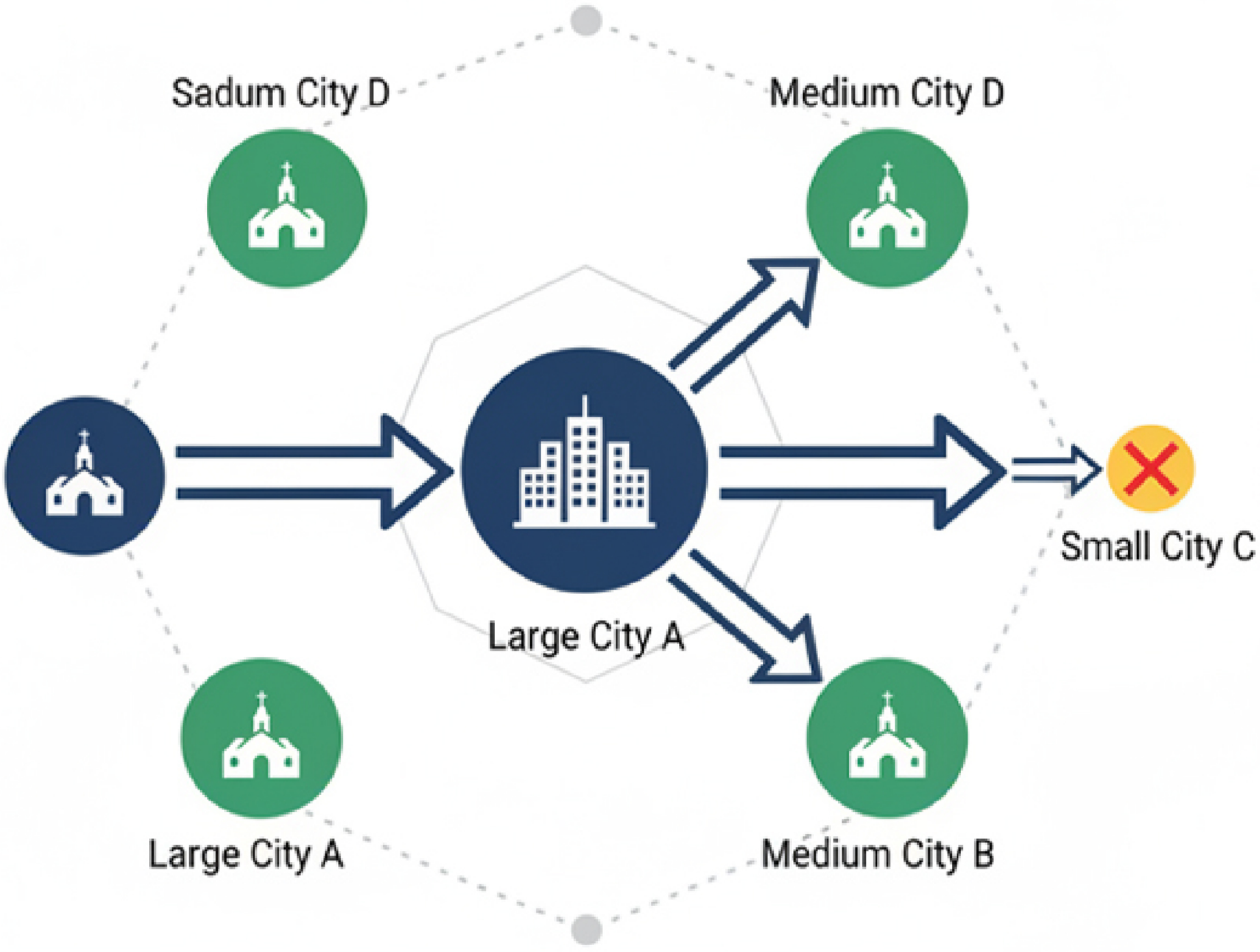


Where: T = number of central places; r = market radius; K = hierarchy constant.

Impact: Defined hierarchy of settlements and spatial distribution of cities across the globe.

3. Gravity Model of Spatial Interaction

$$T_{ij} = k\frac{P_i P_j}{d_{ij}^b}$$

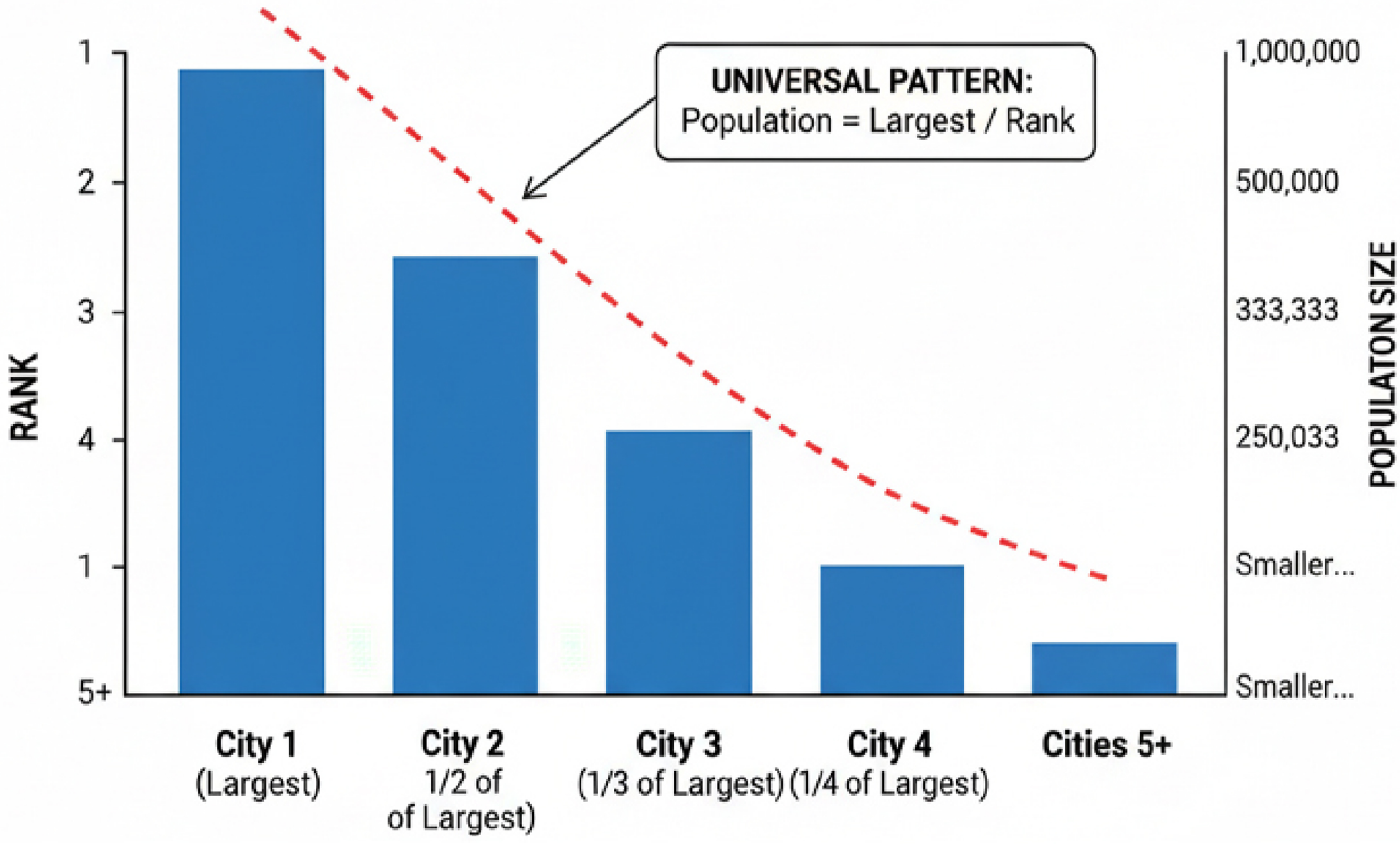


Where: movement between locations i and j; P = population; d = distance; b = distance decay exponent.

Impact: Used in transportation planning, migration modelling, trade between cities. Basis for transport assignment models.

4. Zipf's Rank-Size Law of Cities

$$P_r = \frac{P_1}{r}$$

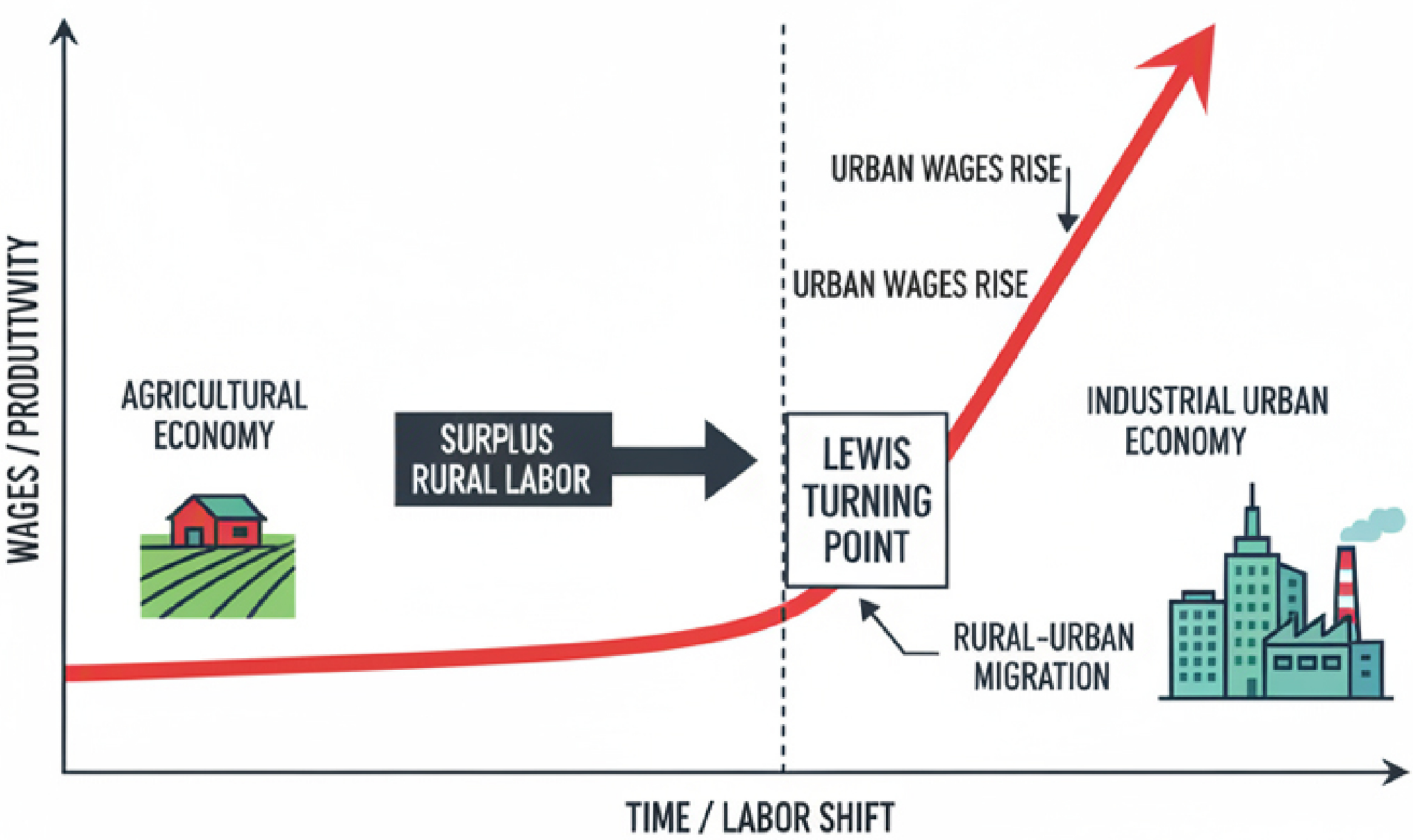


Where: P_r = population of city with rank r; P_1 = population of largest city.

Impact: Universal law showing self-organizing systems of cities. Explain mega-city dominance, globalization patterns.

5. Lewis Turning Point – Urbanization Economic Equation

$$\text{Urban Real Wage} = MPL = \frac{dY}{dL}$$

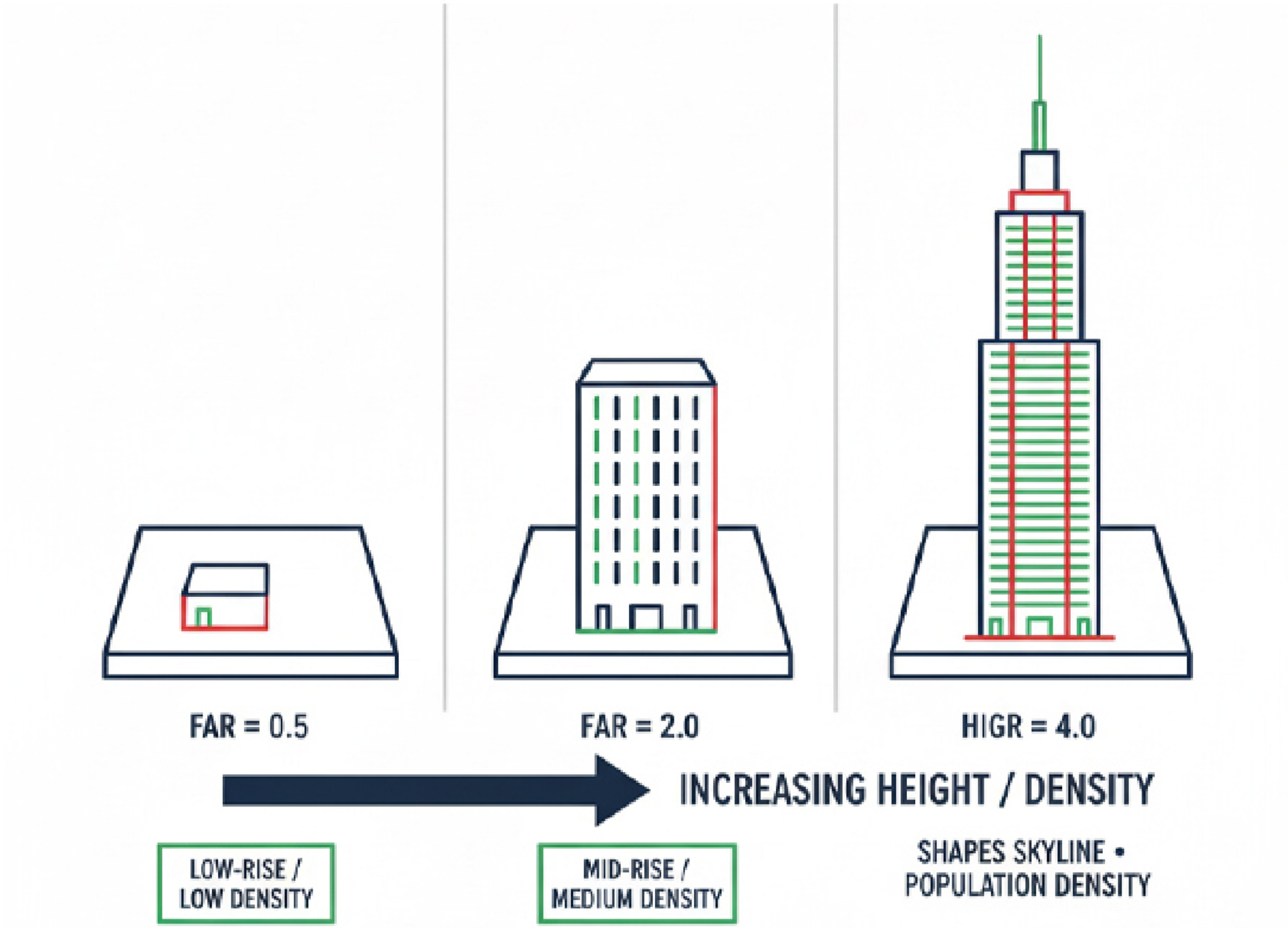


Defines: Industrialization point where surplus labor shifts from rural to urban.

Impact: Fundamental in understanding rapid urbanization in China, India, Brazil.

6. Floor Area Ratio (FAR) Regulation

$$\text{FAR} = \frac{\text{Total Built-up Area}}{\text{Plot Area}}$$



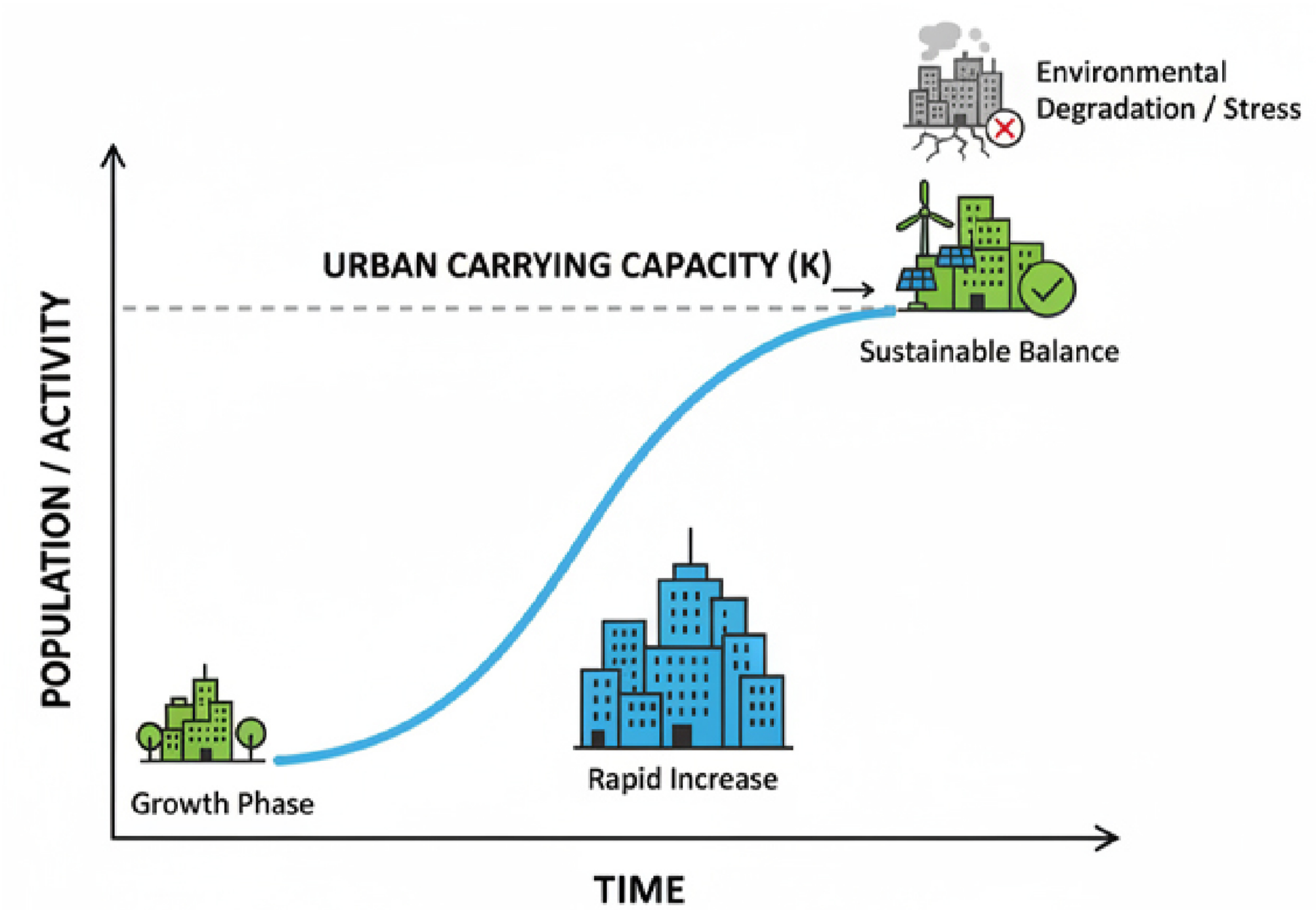
Impact: Probably the most influential urban design equation of the 20th century.

Determines: Density, skyline, land value, infrastructure pressure.

Used globally in zoning.

7. Carrying Capacity (Ecological & Tourism Planning)

$$CC = \frac{A \cdot R_f}{S_f}$$

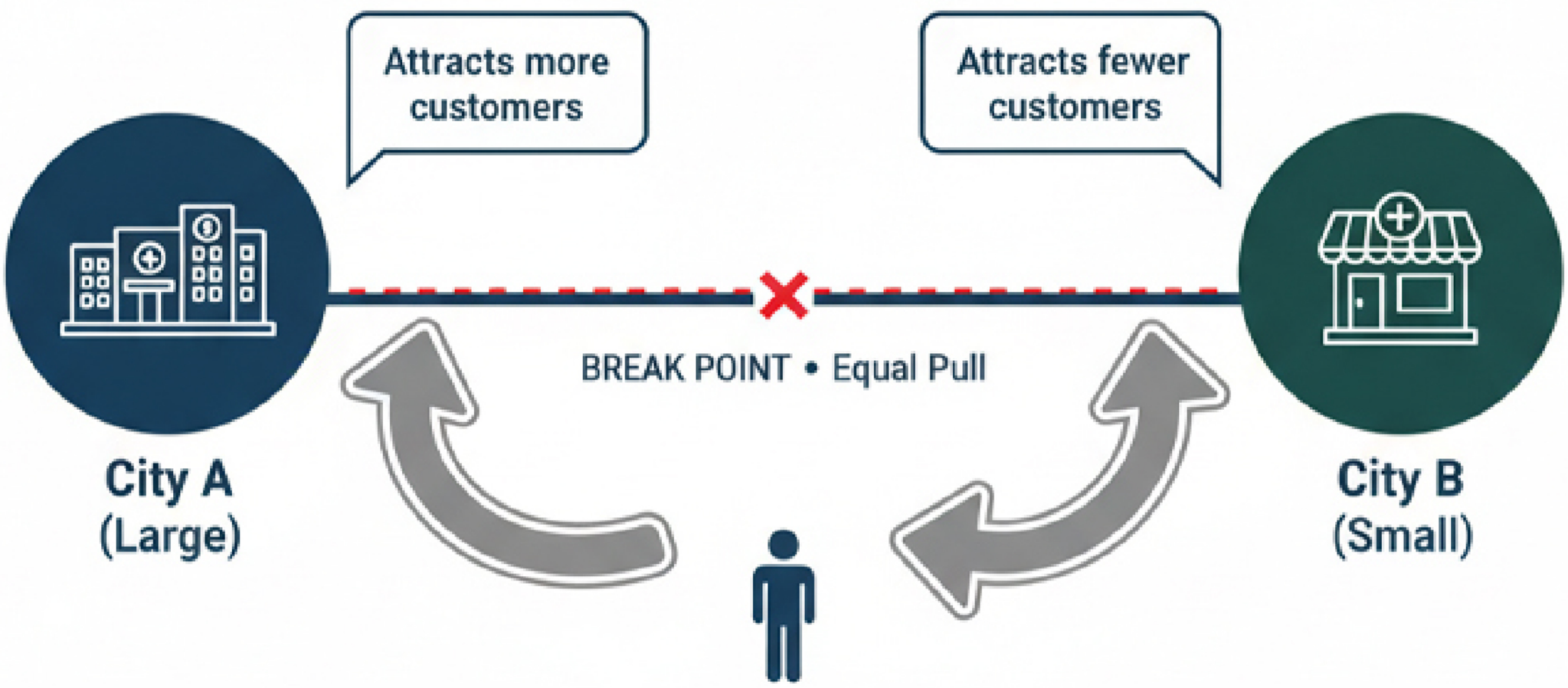


Where: available land/resource; R_f = regeneration factor; S_f = stress factor.

Impact: Driving concept behind sustainable cities, protected areas, overtourism mitigation.

8. Reilly's Law of Retail Gravitation

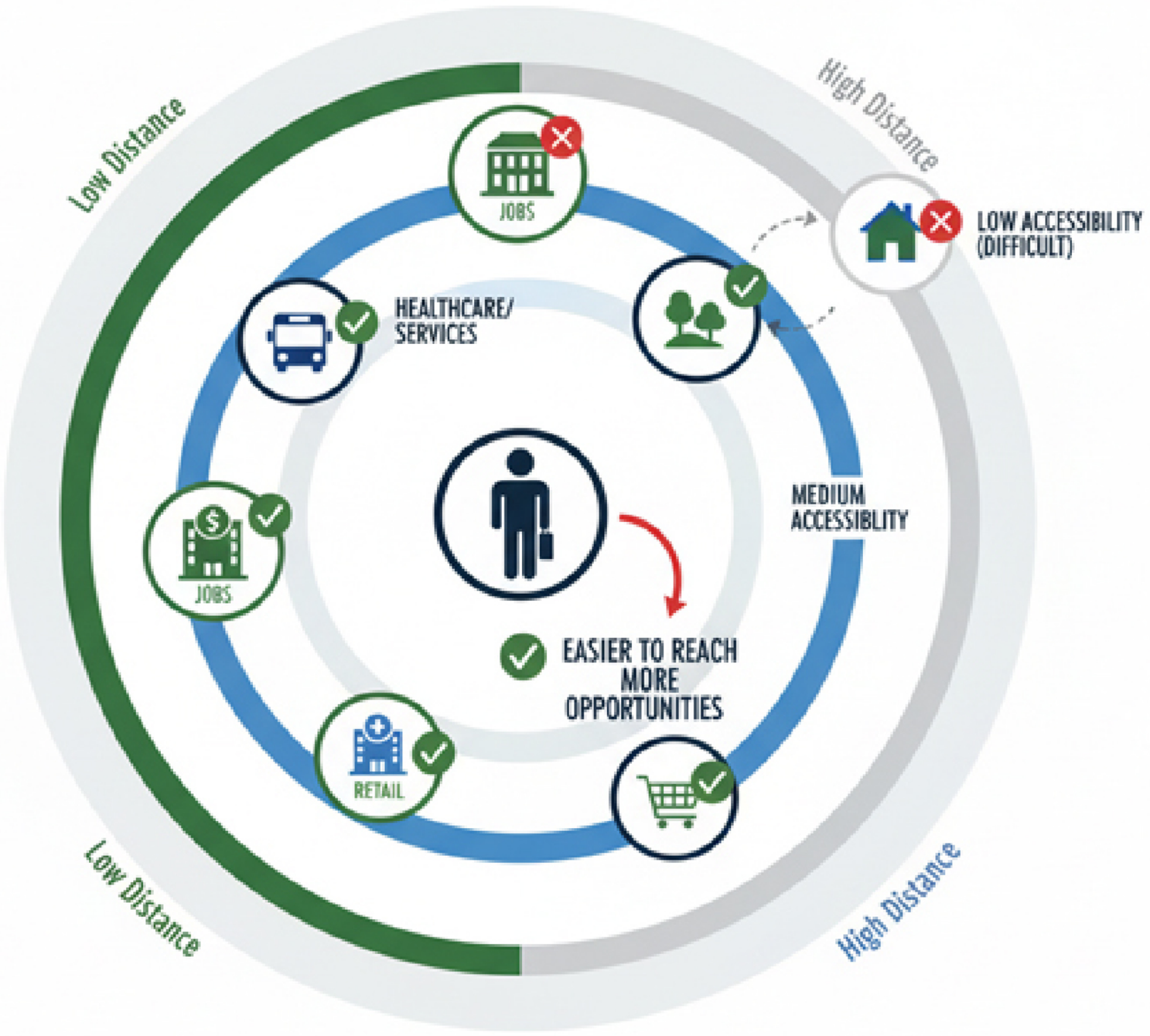
$$BP = \frac{D}{1 + \sqrt{\frac{P_B}{P_A}}}$$



Determines: Breakpoint where customers switch between two cities.
Impact: Foundational for commercial planning, mall location, service area modelling.

9. Hansen's Accessibility Index

$$A_i = \sum_j \frac{O_j}{f(c_{ij})}$$

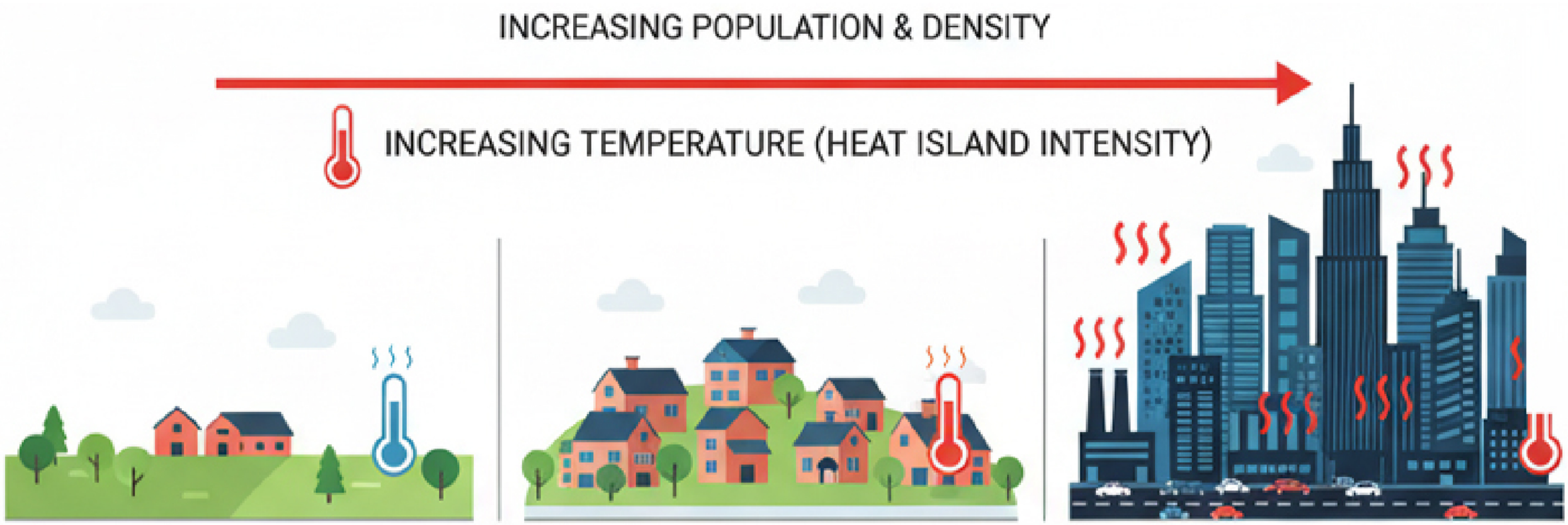


Where: accessibility at location i depends on opportunities O_j, and travel cost c_{ij}.

Impact: Fundamentally changed transit planning, helped design equitable mobility networks.

10. Urban Heat Island Intensity

$$\Delta T = a + b\ln(P)$$

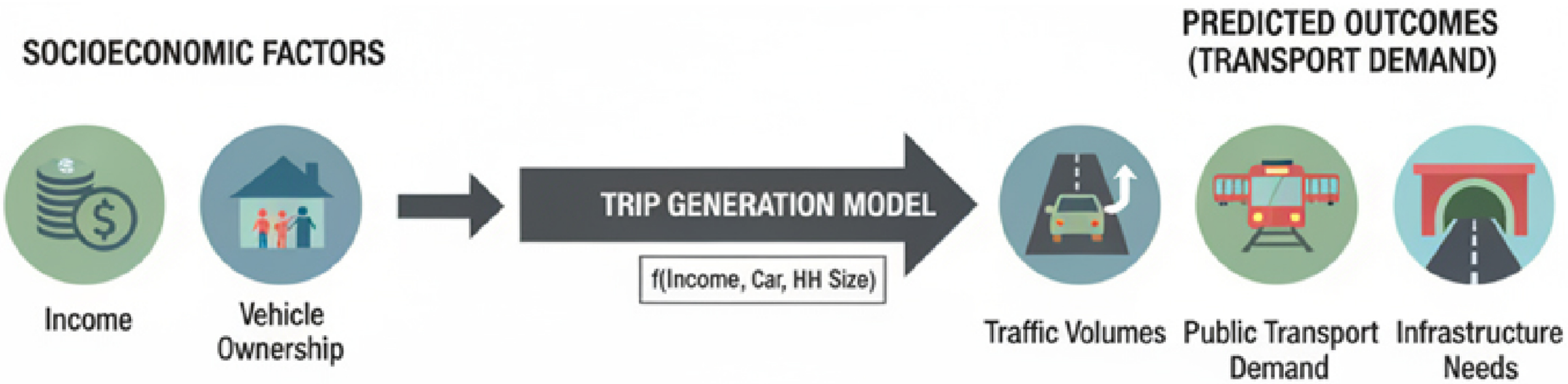


Where: P = population.

Impact: Established climate–urbanization relation. Led to green roofing, zoning for ventilation corridors, resilience planning.

11. Trip Generation Model (Transportation Planning)

$$T = a + bX$$

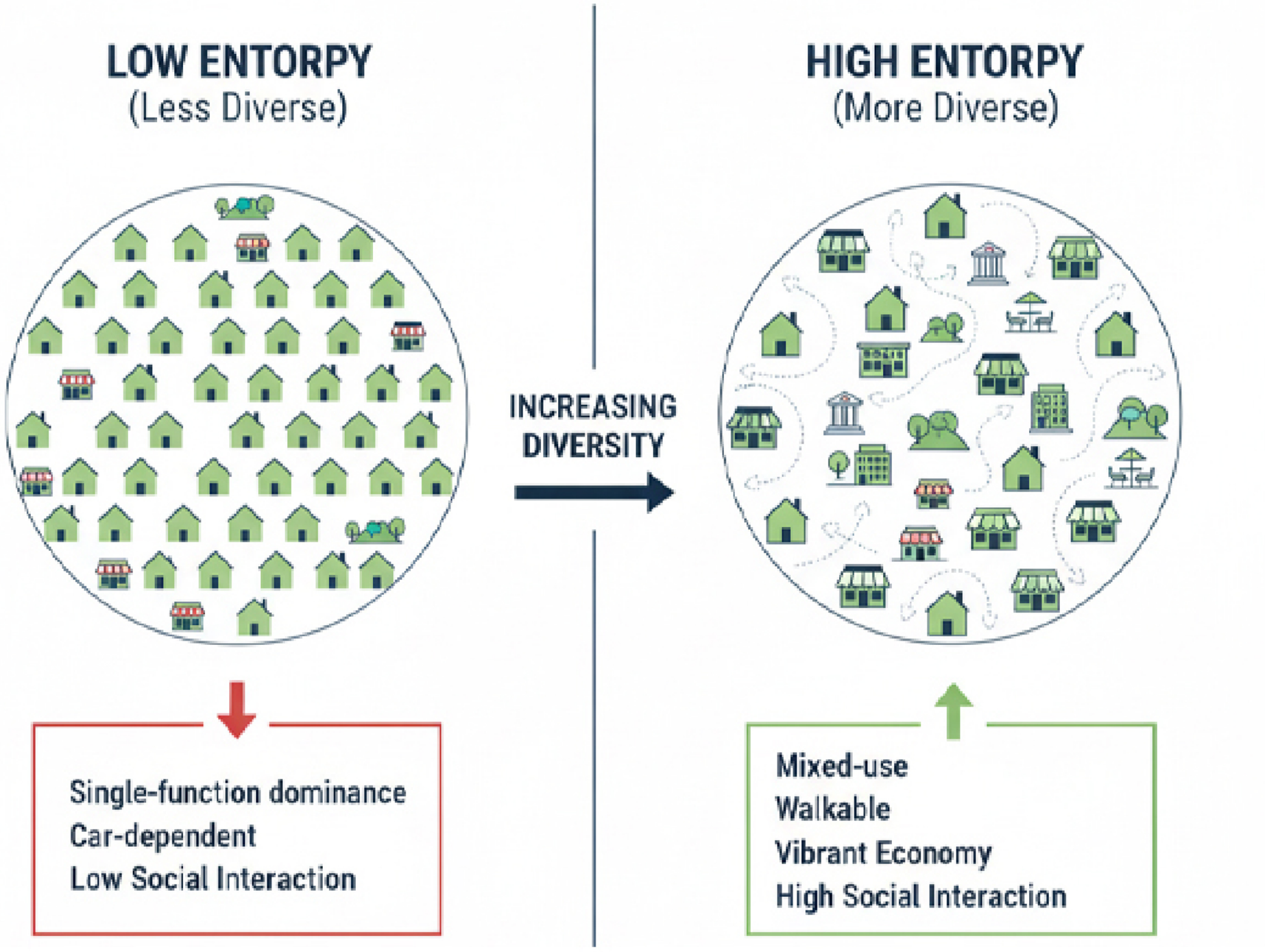


Where: T = trips; X = socio-economic variable like income, car ownership.

Impact: Forms the basis of 4-step transport model used in every major city globally.

12. Shannon's Entropy for Urban Land Use Mix

$$H = -\sum_{i=1}^{n} p_i \ln(p_i)$$



Where: p_i = proportion of land dedicated to land use i.

Impact: Used to measure diversity, essential for mixed-use planning & walkability studies.

Urban planning is no longer just about regulations it's a science built on mathematical logic, predictive models, and data intelligence.

If this changed the way you look at cities - **save, share, and tell us:** which equation surprised you the most?

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