Transport Infrastructure for Sustainable Development

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IIT PALAKKAD

Global Lessons in Integrated Multimodal Transport: Insights from Case Studies

Integrated multimodal transport combines diverse systems into a cohesive network. Analyzing case studies reveals how institutional coordination and policy levers drive sustainable modal shifts and improve connectivity.

Urban Integration and Performance

Physical and digital integration

67%

Public Transport Modal Share

Singapore increased its public transit share from 59% in 2008 through physical and network integration.

The 300m Accessibility Standard

90% of Singapore's population lives within 300 meters of a bus stop, enabling MRT access.

Madrid's Sustainable Rewards

A gamification system rewards citizens with points for choosing walking, cycling, or public transit.

Policy Impacts and System Reform

12%

Reduction in Car Dependency

Modeling shows car usage dropping from 60% to 48% when combining tolls with subsidies.

	Before		After
Private Car	60%	to	48%
Public Transit	20%	to	32%
Walking/Biking	20%	to	20%

Integrating Informal Paratransit

Lagos improved transit efficiency by involving informal "Danfo" operators in the formal BRT introduction.

Laissez-Faire vs. Interventionist

The Netherlands applies flexible designs for shared mobility while maintaining structured public transit.

Smart Urban Freight: A Sustainable Roadmap for Modern Cities

THE PROBLEM: CONGESTED URBAN LOGISTICS

TRADITIONAL URBAN LOGISTICS

Struggling with a projected 140% INCREASE IN DEMAND by 2030, leading to SEVERE CONGESTION and HIGH COSTS.

Transitioning to a DYNAMIC FREIGHT MANAGEMENT (DFM) SYSTEM is essential for economic and environmental health.

THE SOLUTION: SMART, SUSTAINABLE FREIGHT

MODERN INFRASTRUCTURE: THE URBAN BACKBONE

URBAN CONSOLIDATION CENTRE (UCC)

UCCs: Strategically located warehouses that combine small shipments to maximize vehicle load factors.

MICRO-HUB & PARCEL TERMINAL

50% REDUCTION

50% REDUCTION IN LAST-MILE COSTS: Addressing the most expensive leg of the supply chain.

DYNAMIC SPATIAL MANAGEMENT

Using flexible buffer zones and real-time space allocation to prevent readside parking congestion.

MODERN MODES: THE GREENER LAST MILE

NON-MOTORIZED TRANSPORT (NMT) & CARGO BIKES

NMT & CARGO BIKES: The most energy-efficient mode for dense urban areas with zero tailpipe emissions.

DECARBONIZING THE CITY FLEET: Shifting to EVs mitigates the 25% of city CO_2 caused by height.

SHARED PASSENGER-CARGO SYSTEMS: Utilizing existing rapid-transit networks to move goods during off-peak passenger hours.

MODERN DELIVERY MODES: ENERGY & INTERCONNECTIVITY

DELIVERY MODE	ENERGY EFFICIENCY	SMART INTERCONNECTIVITY
Cargo Bikes/E-Bikes		
Autonomous Robots		
Electric Vans		

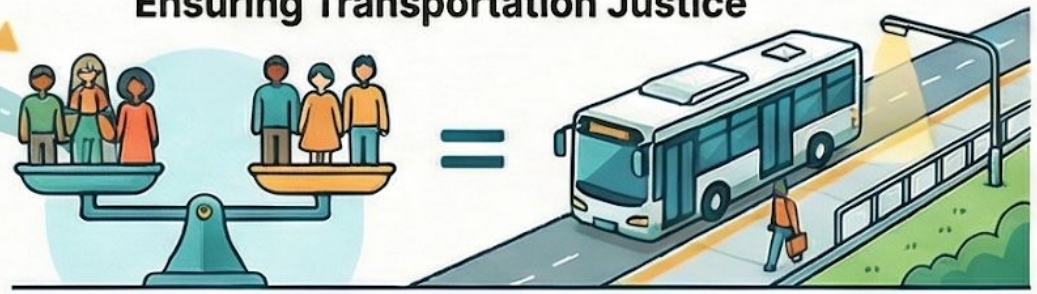
Shaping Quality of Life

Planning links infrastructure to air quality, social equity, and long-term economic development.

The "3-C" Planning Principles

Successful planning must be **Comprehensive, Cooperative, and Continuous** to ensure credible decision-making.

Ensuring Transportation Justice



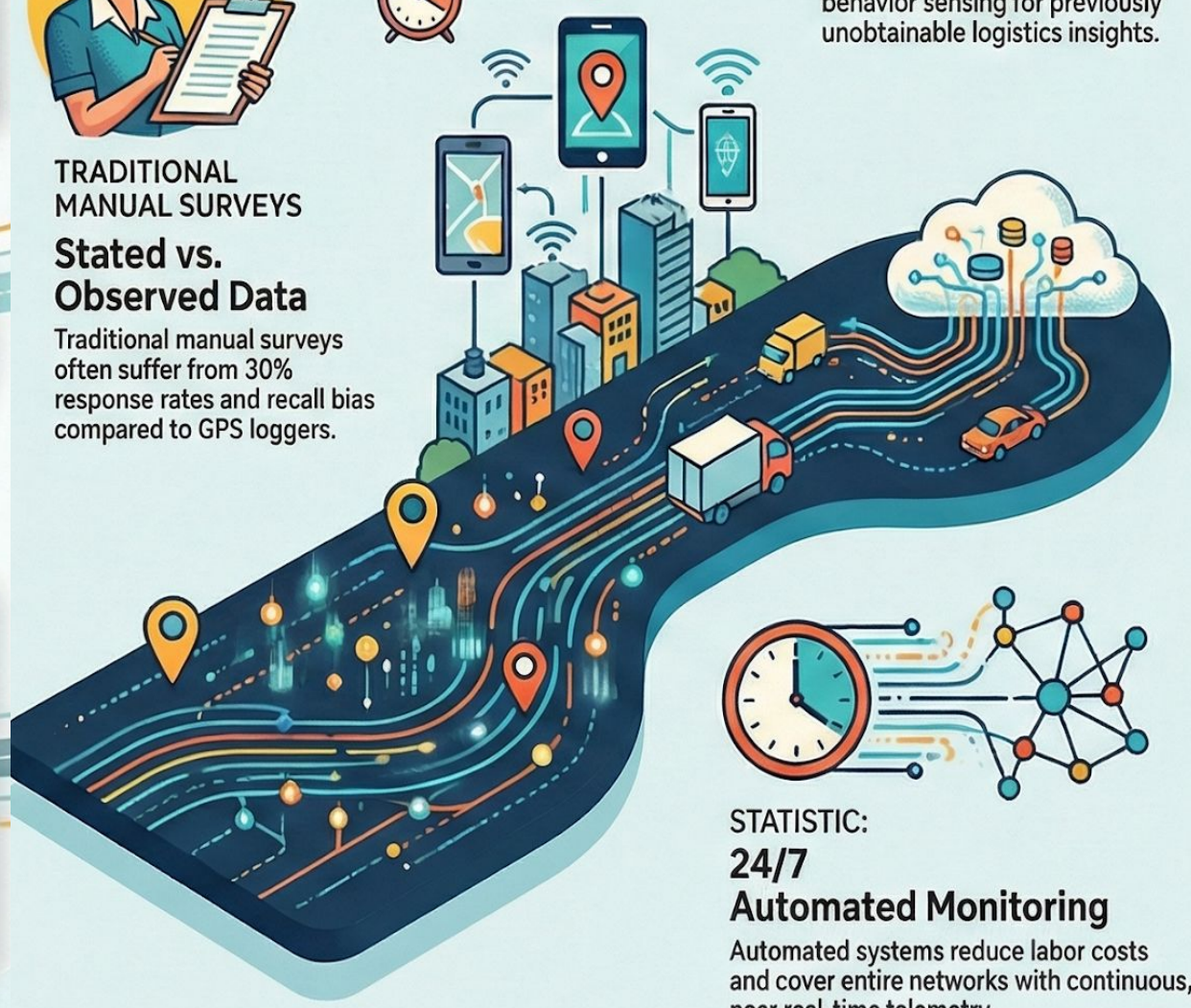
Planning identifies disadvantaged populations to ensure equitable access to transit and safe infrastructure.

THE EVOLUTION OF DATA COLLECTION

TRADITIONAL MANUAL SURVEYS

Stated vs. Observed Data

Traditional manual surveys often suffer from 30% response rates and recall bias compared to GPS loggers.



Commodity Chain Sensing (CCS)

Singapore's framework fuses shipment tracking and driver behavior sensing for previously unobtainable logistics insights.

STATISTIC:

24/7 Automated Monitoring

Automated systems reduce labor costs and cover entire networks with continuous, near real-time telemetry.

Beyond the City Limits:

Understanding the Rural-Urban Continuum

The Folk-Urban Spectrum

From Folk Society to Urban Society

Folk Society
(Rural Extremity)

Social Relations
Intimats, traditional, and group-centered

Education
Non-literate; oral traditions

Organization
Spontaneous; governed by custom

The Blurred Boundary

There is rarely a sharp physical or social division between rural and urban populations.

The *Desakota* Geography (Village-City Hybrid)

Desakota: The "Village-City"

Coined from indonesian desa (village) and kota (city) to describe intermingled land use.

Urban Society
(Urban Extremity)

Social Relations: Impersonal, individualistic

Education: High literacy

Organization: Formalized

Transitional Societies:
Many communities are "middle ground" entities, exhibiting characteristics of both village and city life.

Characteristics of the Continuum

The Administrative Challenge

Rapid settlement changes and unregulated land use make uniform planning and zoning extremely difficult.

Bridging the Gap: Transport Planning Across the Rural-Urban Continuum

THE INTEGRATED PLANNING FRAMEWORK

THE RURAL-URBAN CONTINUUM

A web of interrelationships where improved transport and ICT blur traditional administrative boundaries into "functional regions."

TRANSIT-ORIENTED DEVELOPMENT (TOD)

The Integrated Urban Development Framework (IUOF) advocates for higher-density development along mass transit corridors to strengthen rural-urban linkages.

SPATIAL TRANSFORMATION

Integrated transport serves as a critical lever to align people, jobs, and services, maximizing what is known as the "urban dividend."

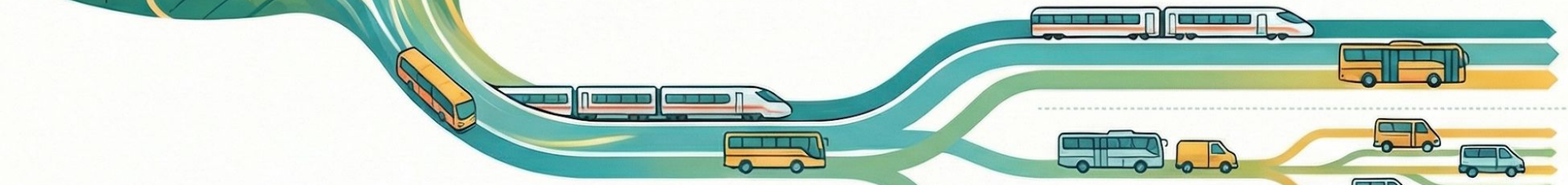
CASE STUDIES & LAST-MILE SOLUTIONS

AMHI SARATHI (VILLAGE SANGURDI, INDIA)

A community-driven vehicle cooperative providing feeder transit that links isolated villages to major transportation hubs and markets.

KUDUMBASHREE INITIATIVE (KERALA, INDIA)

A successful model where community development societies manage public transport in areas where state services are unavailable.



HIERARCHICAL NETWORK DESIGN

Effective systems use core train/bus networks for urban-rural links, feeder networks between settlements, and tailor-made on-demand services for the last mile.

BETWEEN URBAN & RURAL: CORE TRAIN AND BUS NETWORKS
STATE, REGION, OR PROVINCE

BETWEEN RURAL SETTLEMENTS: FEEDER AND BRANCH NETWORKS
REGIONAL

WITHIN MUNICIPALITIES: LOCAL/TAILOR-MADE LAST-MILE TRAVEL
MUNICIPALITIES

Proactive Road Safety: Why Conflict Heatmaps Outperform Traditional Crash Data

TRADITIONAL CRASH-RECORD ANALYSIS

The "Waiting for Fatalities" Dilemma

Supporting Detail: Analysis is reactive, often requiring years of data before a "blackspot" is officially identified.

Rare and Under-Reported Events

Supporting Detail: Crashes are statistically rare; many go unreported or contain subjective, inaccurate reasoning.

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Limited Behavioral Context

Supporting Detail: Historical records rarely capture the specific driver behaviors that lead to a collision.

SSM-BASED CONFLICT HEATMAPS

Proactive Conflict Identification

Identifies danger: danger by measuring near-misses like Time-to-Collision (TTC) before crashes occur.

Massive Data in Short Cycles

Supporting Detail: Obtains large sample sizes in hours or days rather than waiting years.

Precision Spatial Heatmapping

Supporting Detail: Heatmaps pinpoint exact conflict-prone spots, such as high-risk right-turning lanes or merging zones.

COMPARISON: TRADITIONAL vs. SSM CONFLICT HEATMAPS

Feature	Traditional Crash Records	SSM Conflict Heatmaps
Approach	Reactive (after the event)	Proactive (predictive)
Data Source	Police/Insurance Reports	Video Trajectories (UAV/CCTV)
Collection Time	Years	Hours to Days

Evacuation Preparedness

TRIP DISTRIBUTION (WHO GOES WHERE)

STRATEGIC TRIP DISTRIBUTION

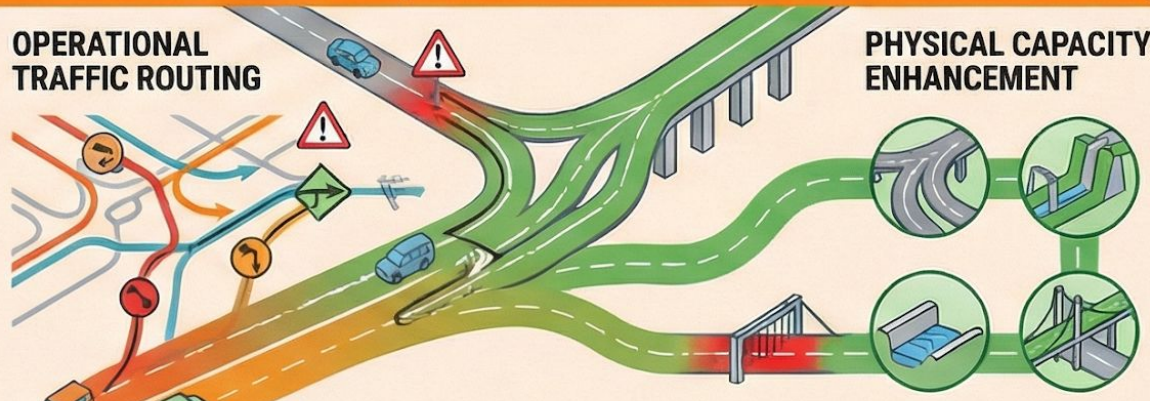
Optimally allocate sub-populations to minimize overall network risk.

RISK-AVERSE STRATEGY (RETDC) shows **28% to 27% RISK REDUCTION** in urban city networks compared to naive proximal methods.

INTEGRATED DESIGN (HOW PEOPLE MOVE & WHERE TO BUILD CAPACITY)

OPERATIONAL TRAFFIC ROUTING

PHYSICAL CAPACITY ENHANCEMENT



COMBINES operational routing with physical capacity enhancement for a holistic response.

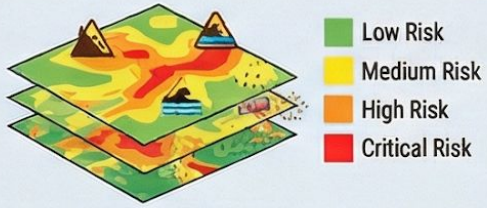
INTEGRATED STRATEGY (NPD) achieves **UP TO 29% REDUCTION IN OVERALL SYSTEM RISK** (Total Travel Time + Risk) compared to naive methods.

THE SHARED SCIENTIFIC FOUNDATION

RISK = PROBABILITY × CONSEQUENCE

Risk is quantified by multiplying link failure probability with the impact on traffic flow.

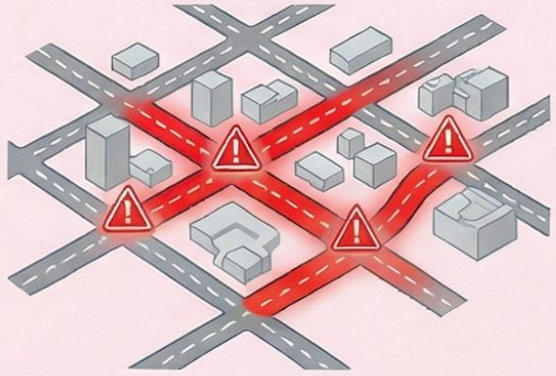
DATA-DRIVEN SUSCEPTIBILITY MAPPING



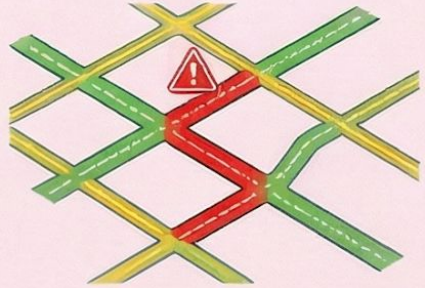
Leverage empirical disaster maps to predict road failures, moving beyond "Business-As-Usual" (BAU) patterns.

BEYOND "NEAREST ALLOCATION"

CRITICAL LINK IDENTIFICATION (WHAT LINKS TO PROTECT FIRST)



PRIORITIZES specific road segments for fortification based on topology and evacuation traffic exposure.



'The crucible'
Mural at IIT Palakkad

Thank you for your attention

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