



The 23rd International Asset Facility and Maintenance Management Conference

INTEGRATING DIGITAL TWIN AND STRATEGIC TRANSPORT MODELS

lessons from london



ABOUKIR HIGH INSTITUTES

12-14 January 2026

Riyadh, KSA

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Research Outlines

- **Introduction**
- **Applications of Urban Digital Twins**
- **Digital Twin and Strategic Transport Concept**
- **London's Strategic Transport Model**
- **Digital Twin and Urban Development in Arab Cities**
- **Discussion and Conclusion**

Introduction

المقدمة

Urban challenge

Urban mobility has emerged as one of the most critical challenges facing 21st-century cities, particularly in environments grappling with rapid population growth, complex infrastructure demands, and the urgent need for sustainable development.

Research Problem

The escalating pressures of congestion, environmental degradation, and rising operations and maintenance (O&M) costs necessitate a shift from traditional planning to data-driven strategies.

Research Significance

By leveraging such simulation and Digital Twin (DT) technologies, decision-makers in London can significantly reduce planning uncertainty, optimize infrastructure investments, and enhance the longterm effectiveness of transport policies

Approach

In this context, London represents a mature global benchmark, where advanced strategic transport models—specifically MoTiON, LoHAM, Railplan, and Cynemon—have been institutionalized to govern the city's complex movement network

Methodology

These integrated frameworks go beyond simple traffic counting; they synthesize demographic, economic, and behavioral variables to predict multimodal travel demand and simulate highway congestion dynamics

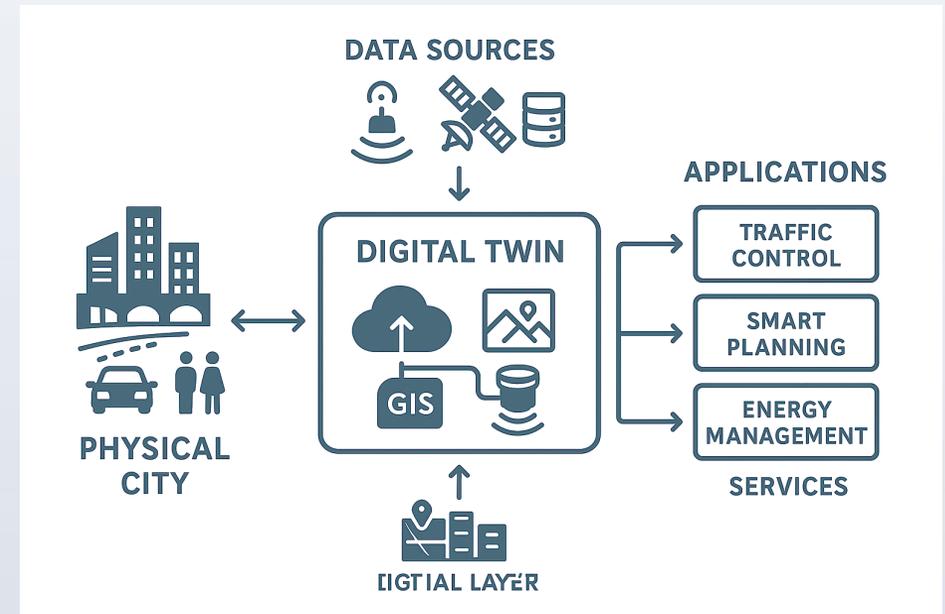
This study presents a comparative analytical snapshot of three distinct urban contexts to illustrate this spectrum

Applications of Urban Digital Twins

تطبيقات التوائم
الرقمية الحضرية

Digital Twin

Figure 1 shows the city Digital Twin framework and its interaction with data, platforms, and smart applications. The study uses literature review, Arab cities policy analysis, and benchmarking against London’s strategic models



Digital Twin and strategies Transport Concept

التوأأم الرقمي
واستراتيجيات مفهوم
النقل

Active safeguards represent an economic and environmental approach to building management and a pre-assessment of the impact of its phase across the building life cycle to participate in the impact of harmful effects.

Overview of Study

- Explore the role of Digital Twin and strategic transport models in enhancing urban mobility.
- Compare London's advanced experience with diverse Arab cities (Jeddah, Irbid, Abu Dhabi).
- Identify ways to adapt modern technologies to each city's local conditions

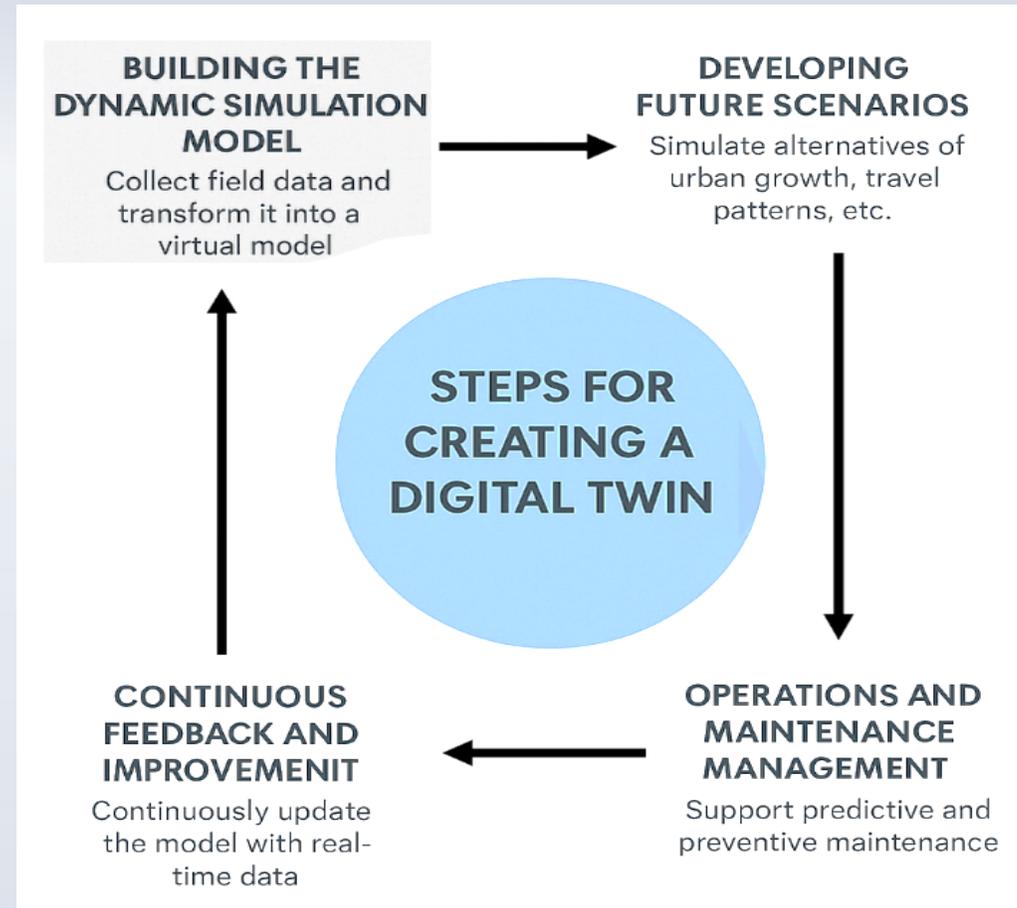


Figure 2 : a visual representation of the main steps for creating a Digital Twin (by Author, 2025).

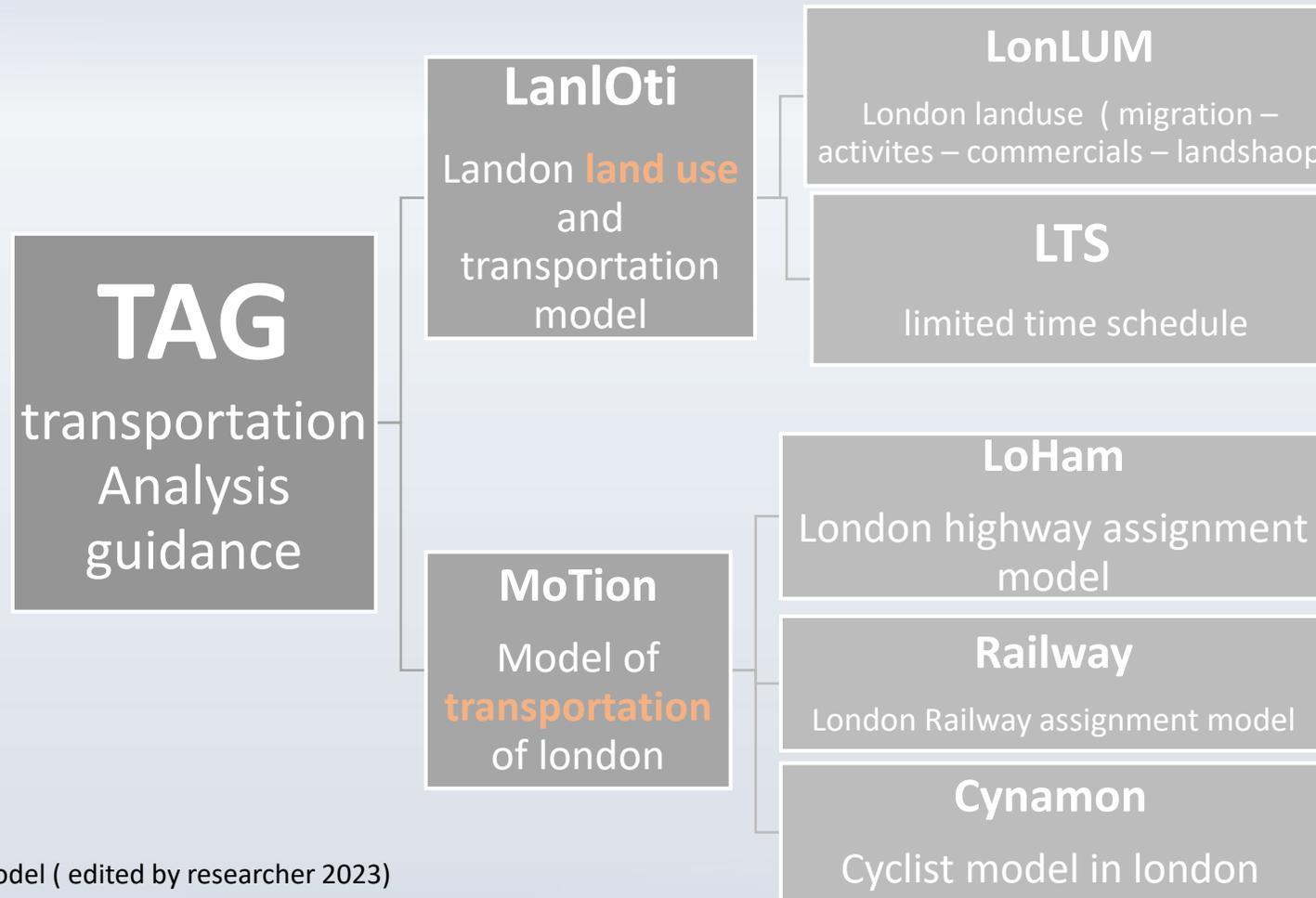
	Travel behavior and transport modes	Socio-economic data	Land use patterns	Transport infrastructure	Real-time traffic flow & congestion hotspots	Environmental data	Energy & utilities	3D spatial data	Climatic indicators	Safety and emergency systems
Population density &	●	●	●	●	●	●	●	●	●	●
	Travel behavior and transport modes	●	●	●	●	●	●	●	●	●
		Socio-economic data	●	●	●	●	●	●	●	●
			Land use patterns	●	●	●	●	●	●	●
				Transport infrastructure	●	●	●	●	●	●
					Real-time traffic flow & congestion hotspots	●	●	●	●	●
						Environmental data	●	●	●	●
							Energy & utilities	●	●	●
								3D spatial data	●	●
									Climatic indicators	●
										Safety and emergency systems
<p>● Strong Relationship: A direct and significant impact.</p> <p>● Medium Relationship: A moderate or indirect influence.</p> <p>● Weak Relationship: No or Weak influence.</p>										

- Digital Twin & Strategic Transport: Digital Twins use real-time and historical data to create virtual city/transport models, supporting scenario planning, predictive maintenance, and efficient operations
- Relationship Matrix: Shows connections between urban data sets, helping prioritize research and understand city-wide impacts for better planning

London's Strategic Transport Model

نموذج النقل
الاستراتيجي في لندن

TFL transportation of london

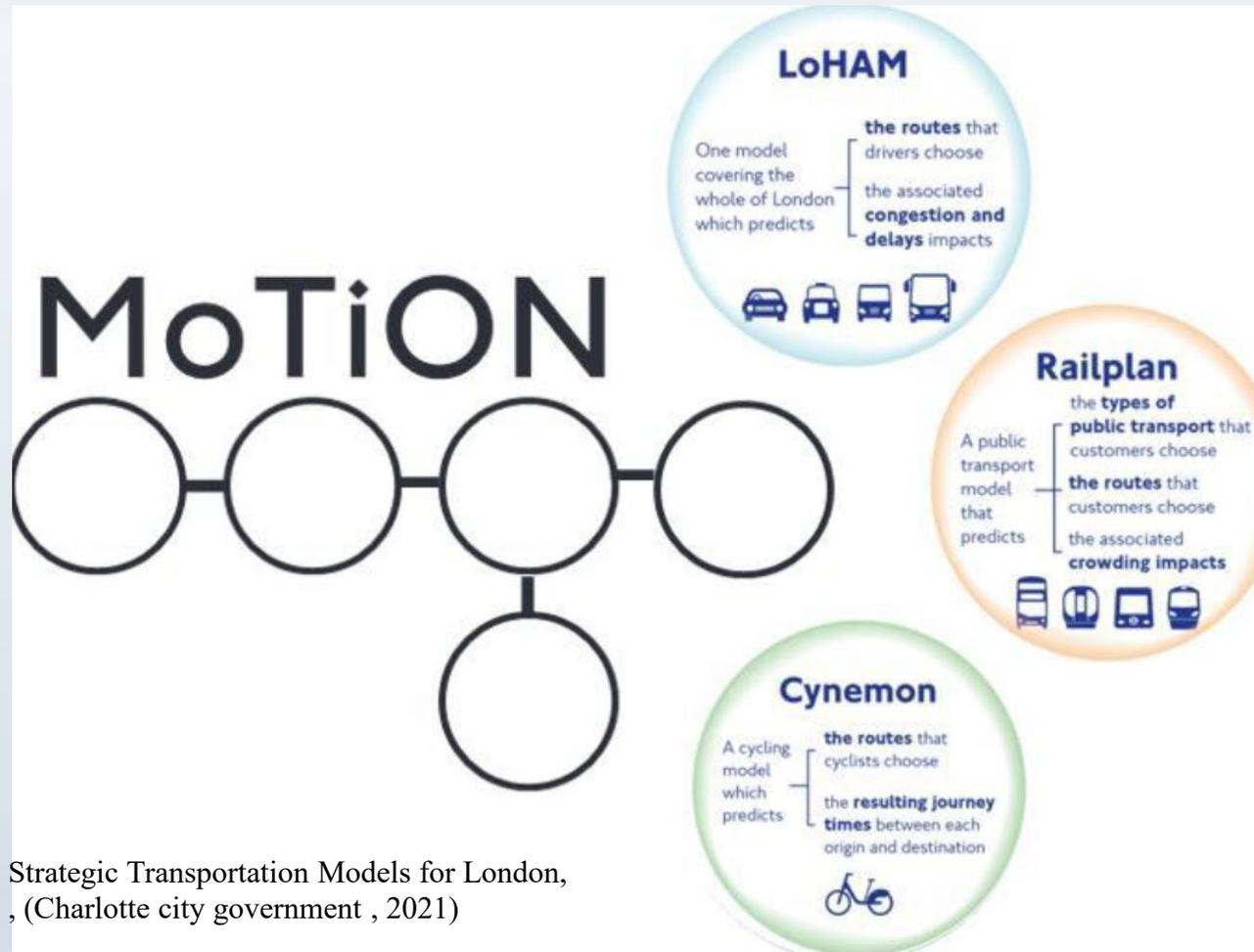


Transportation of London model (edited by researcher 2023)

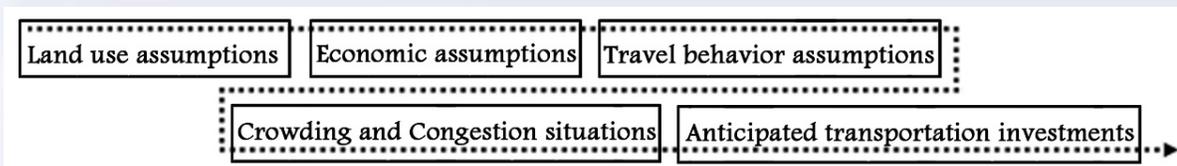
London uses several transport models—MoTiON (travel demand), LoHAM (highway congestion), Railplan (public transport flows), and Cynemon (cycling demand)—to forecast, plan, and optimize multimodal transport. These models help TfL make informed policy decisions, anticipate demographic changes, and guide investments, making London a global benchmark

Figure 2: Strategic Transportation Models for London (Ebrahim,2023)v

LONDON'S STRATEGIC TRANSPORT MODELS,



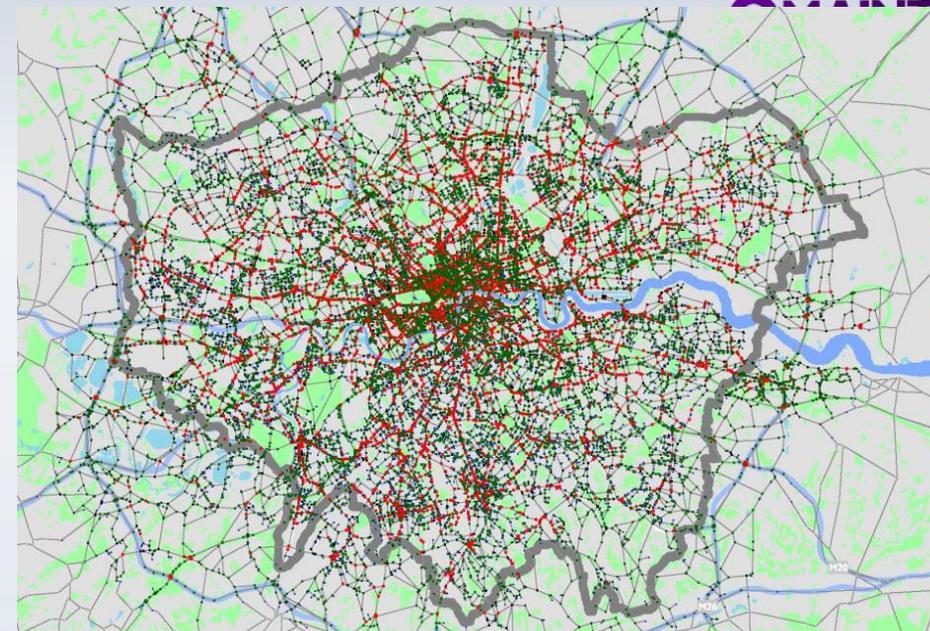
Strategic Transportation Models for London,
 (Charlotte city government , 2021)



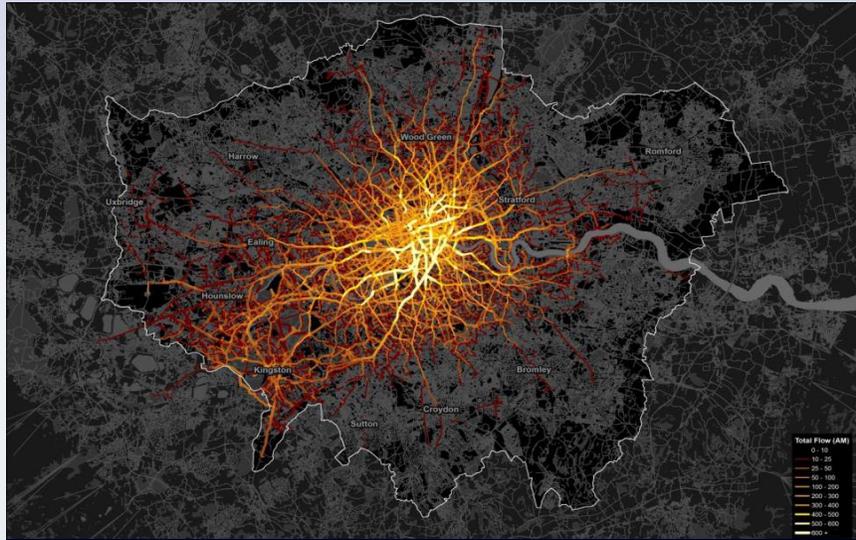
The MoTiON model covers five demand modules and various transport modes, including cars, public transport, cycling, and walking.



MoTiON analyzes travel behavior and evaluates scenarios for mode share and trip totals, while LoHAM simulates highway routing and congestion, identifying hotspots and average speeds to support planning and economic evaluation.



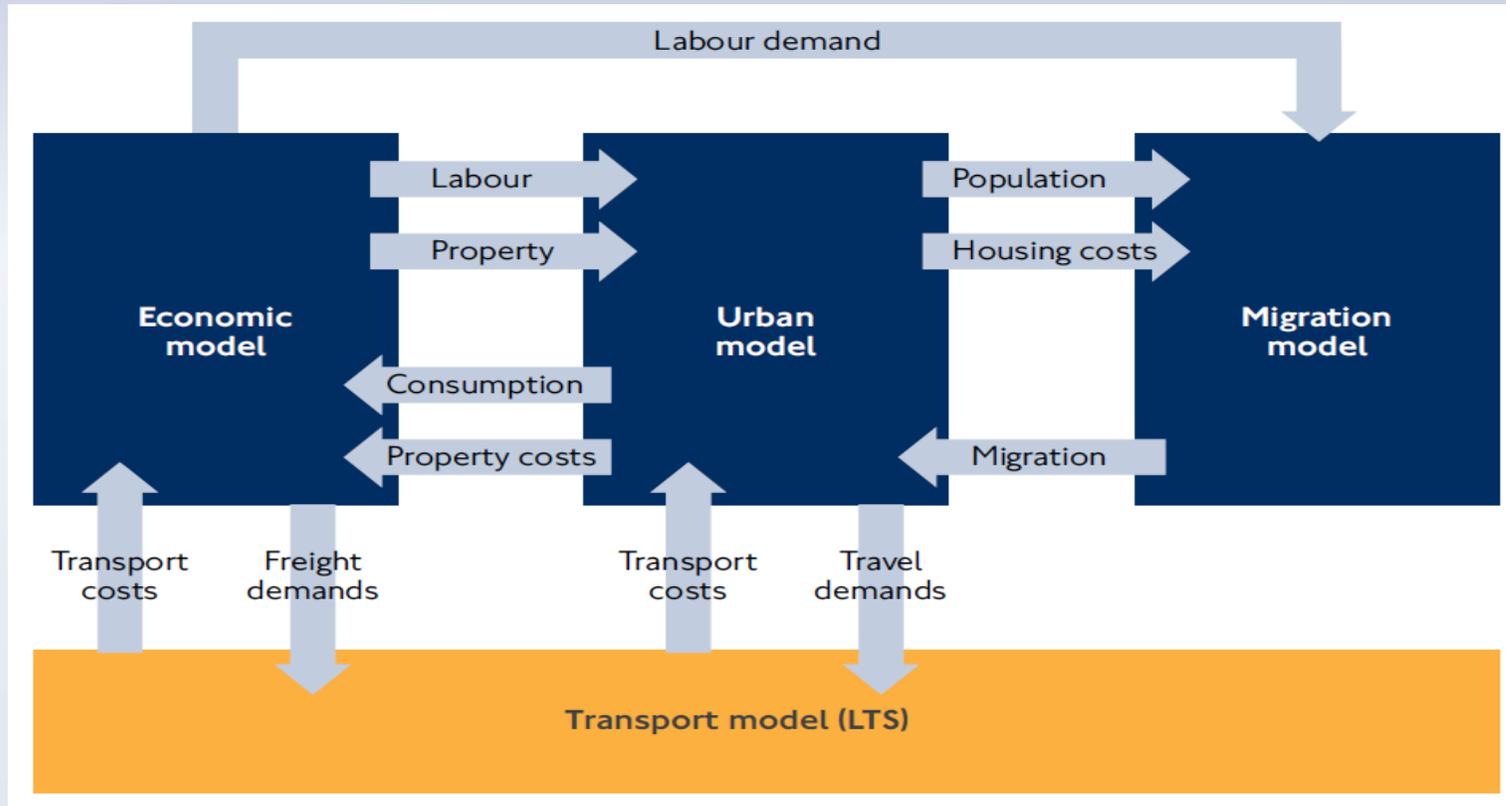
Railplan is a strategic public transport model in London that allocates trips from MoTiON to buses, trains, Underground, Overground, and trams, including pedestrian access. It predicts congestion and rerouting impacts from new services, changes in frequency, or vehicle speeds



Cynemon analyzes cyclists' route choices considering gradients, road types, bike lanes, and traffic, identifying key corridors, journey times, and future growth impacts to support cycling infrastructure investments. LonLUTI evaluates land-use impacts on demographics, economy, and transport, linking costs, accessibility, and congestion to provide detailed outputs for policy and economic planning.



Railplan compares different scenarios to assess transport plan impacts, providing data on passenger numbers, crowding, transfers, and travel times/distances. Cynemon is a strategic cycling model in London that estimates cyclist numbers, routes, and travel durations, supporting analysis of new cycling infrastructure initiatives



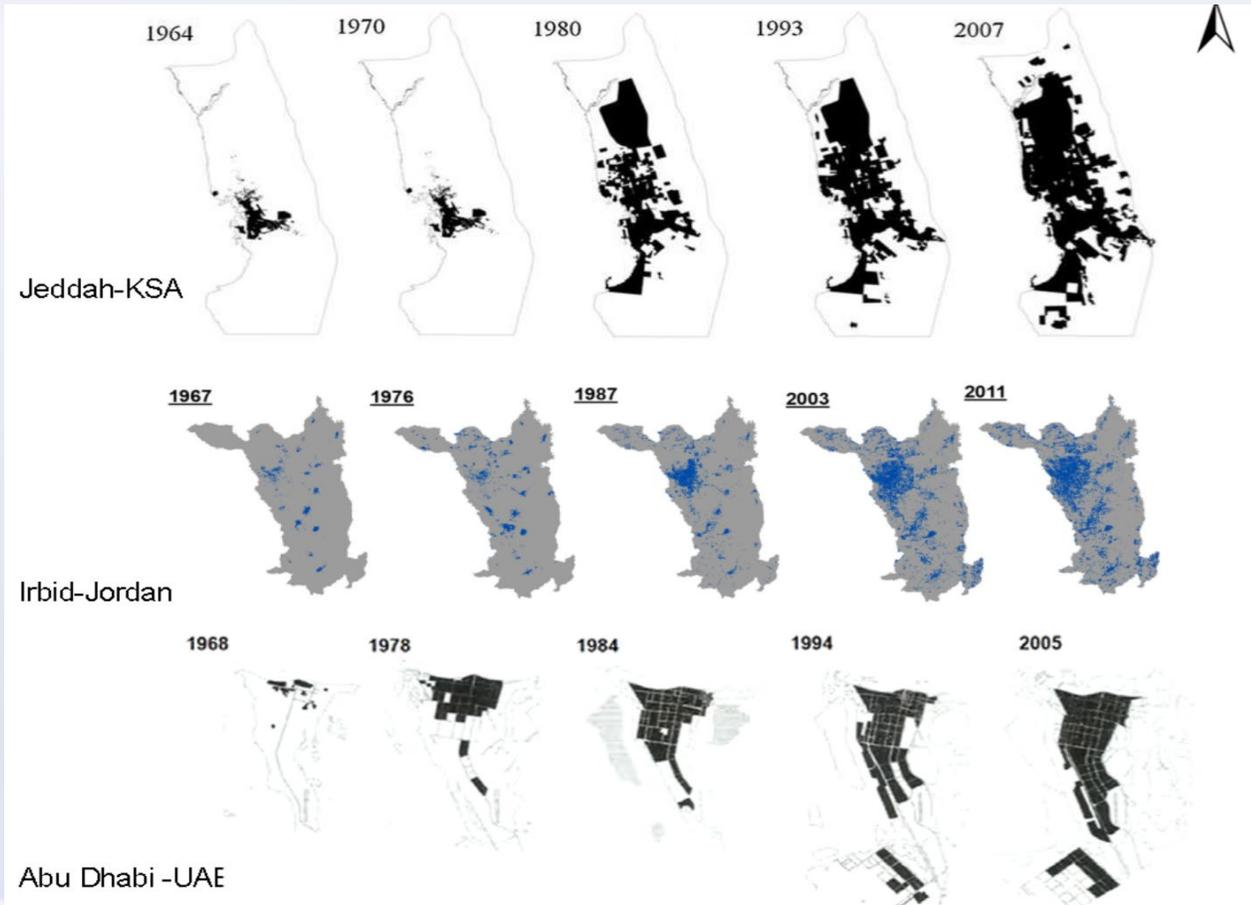
To use models effectively, their limits and ability to predict route choices and congestion in London must be understood. Models should be reviewed and improved for each project to ensure they meet objectives, with the table showing the most suitable model for each study type

Table 1: Applied Mobility Strategies in London

Assessing the impact of	Appropriate Model
An Opportunity Area Planning Framework	All
Forecast changes in population, employment or economic factors	All
A new residential or employment development	MoTiON, LoHAM, Railplan
A new policy such as 'car-lite' development	MoTiON
New strategic highway scheme	MoTiON, LoHAM
Introducing a toll on an existing highway	MoTiON, LoHAM
A new rail or Tube scheme	MoTiON, Railplan
Policies to encourage the use of public transport	MoTiON, Railplan
Applying new public transport fares	MoTiON, Railplan
Revised traffic arrangements in a town center	LoHAM, Cynemon
A new cycle superhighway	LoHAM, Cynemon
Land-use regulation policies	LonLUTI
A major transport scheme on land-use	LonLUTI

Digital Twin and Urban Development in Arab Cities

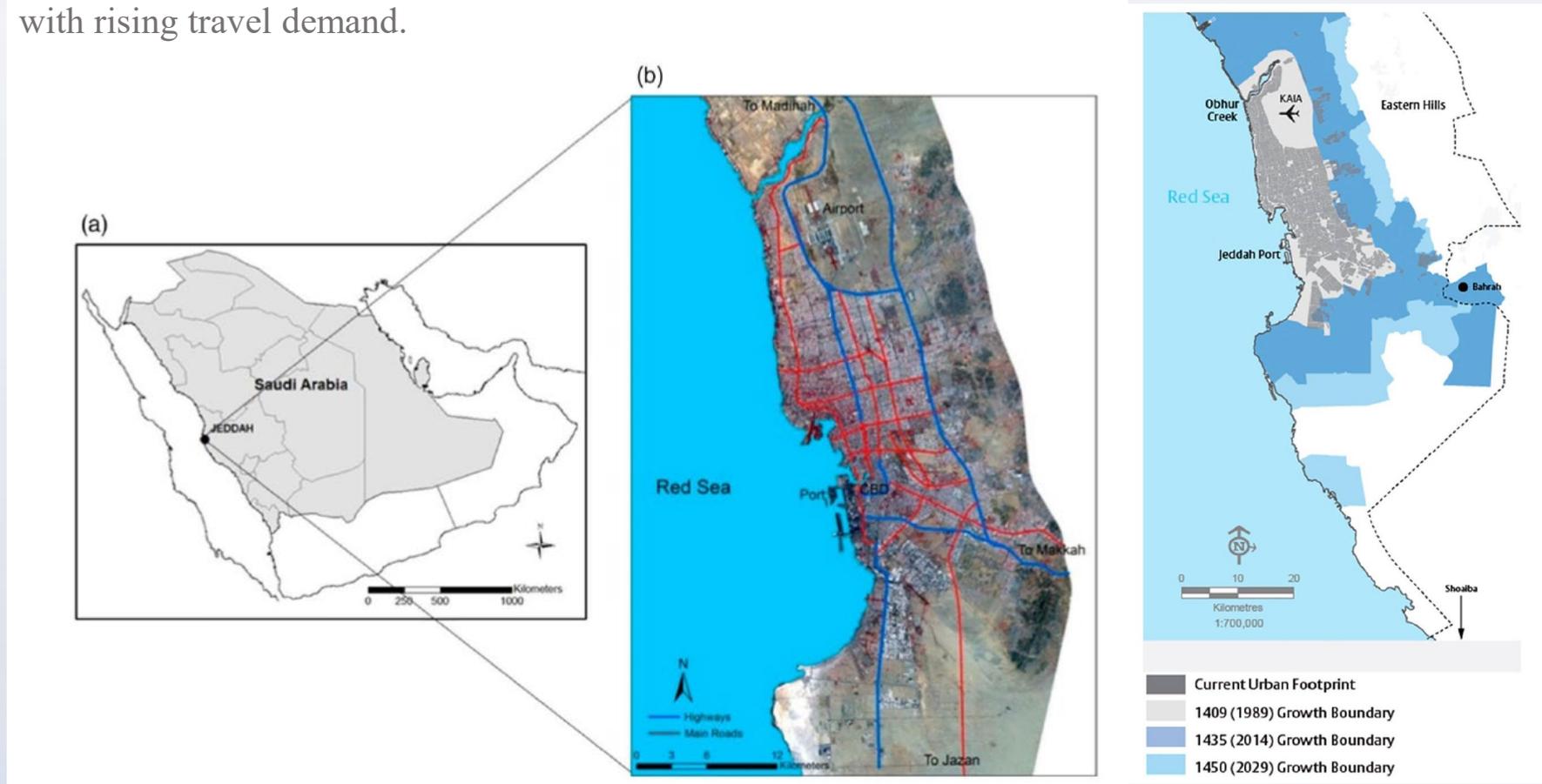
التوأأم الرقمي والتنمية
الحضرية في المدن
العربية



Arab cities have experienced rapid urban expansion with challenges such as congestion, resource management, and cultural preservation. The digital twin serves as a key tool for growth simulation, infrastructure assessment, and support sustainable planning. Examples of cities: Jeddah relies on cars with fragmented expansion, Irbid faces limited resources and population pressures, and Abu Dhabi invests heavily in smart mobility and sustainable urban planning

Jeddah City Location

Jeddah has experienced tremendous population growth and urban expansion over the past 40 years, putting immense strain on its transportation infrastructure and altering daily mobility patterns. The development of Jeddah's transport infrastructure has encouraged urban sprawl without keeping up with rising travel demand.



(Mohammed Aljoufie, Mark Brussel, Mark Zuidgeest, Hedwig van Delden, Martin van Maarseveen, 2016).

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Jeddah City Policy Interventions and Future Scenarios

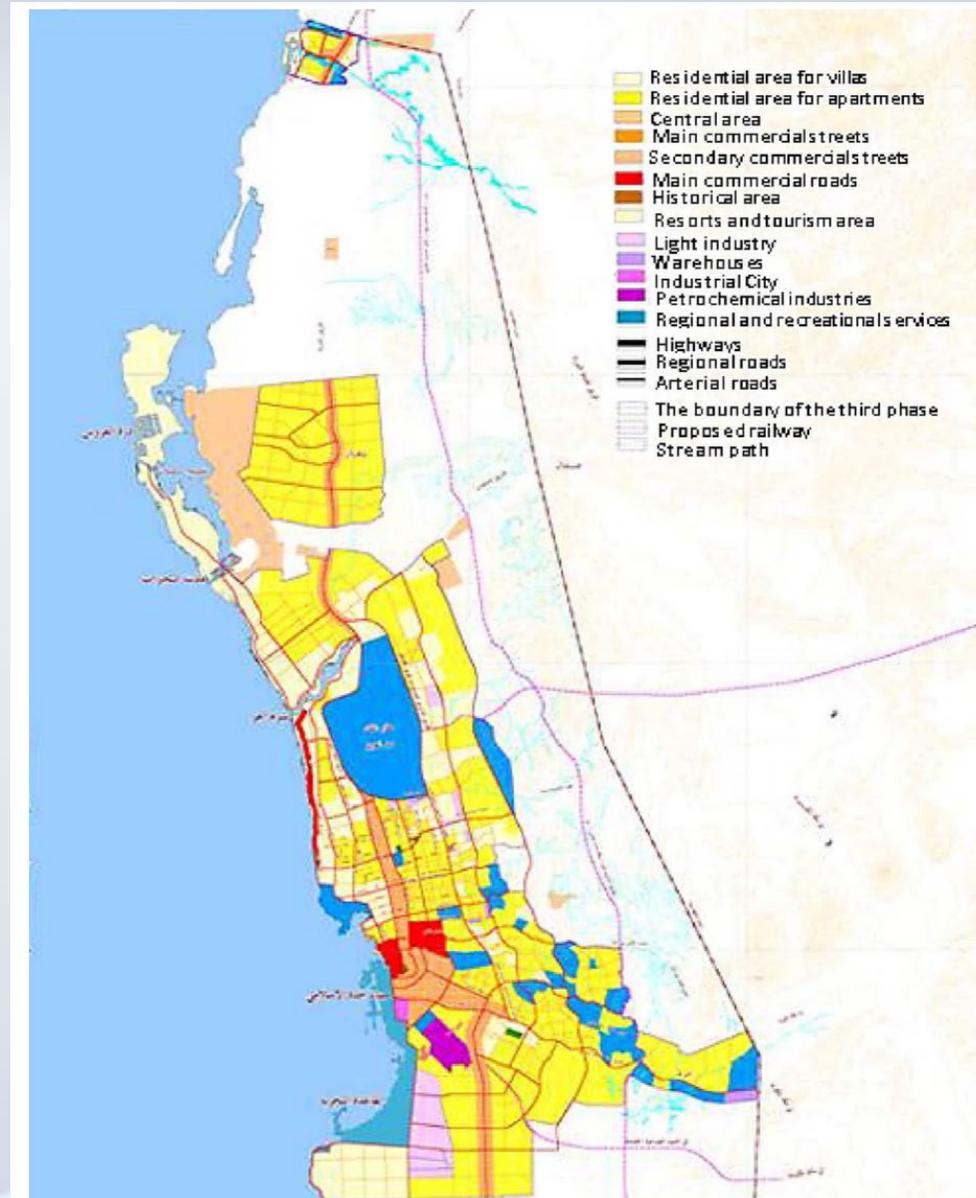
- BAU shows how land use and transport patterns changed over 30 years.
- TI aims to show how transport policies could impact urban expansion and the LUT system in Jeddah.
- CG reflects the 2009 Jeddah strategic plan recommendations on compact urban growth effects.
- Combined LUT integrates both CG and TI interventions.

These interventions aim to alleviate current traffic issues in Jeddah

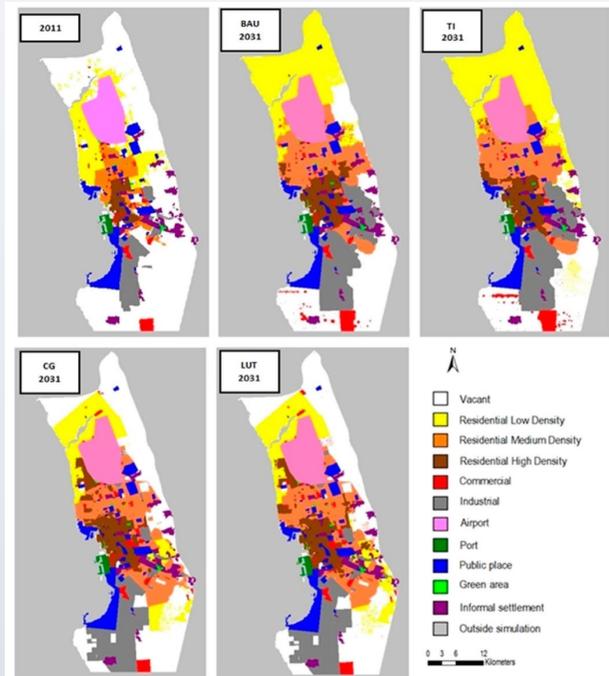
Jeddah City Structure Plan

Jeddah Structure Plan 2005

(IbrahimHegazy,Mansour Helmi, Emad Qurnfulah, AmmarNaji, Hossam Samir Ibrahim, 2021)



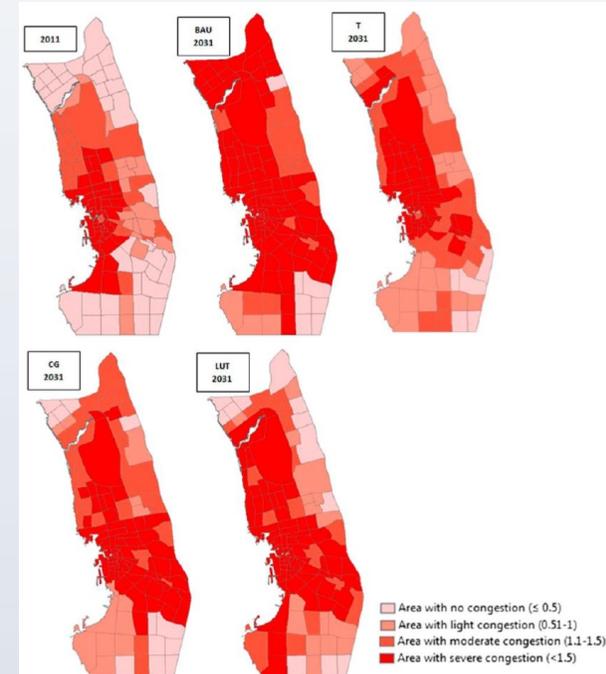
Spatial Expansion and Land-Use Dynamics through Excessive Growth Scenario



Urban growth and land-use changes of the four policy interventions under the excessive growth scenario.



Traffic flow (V/C) change at network level of the four policy interventions under excessive growth scenario.

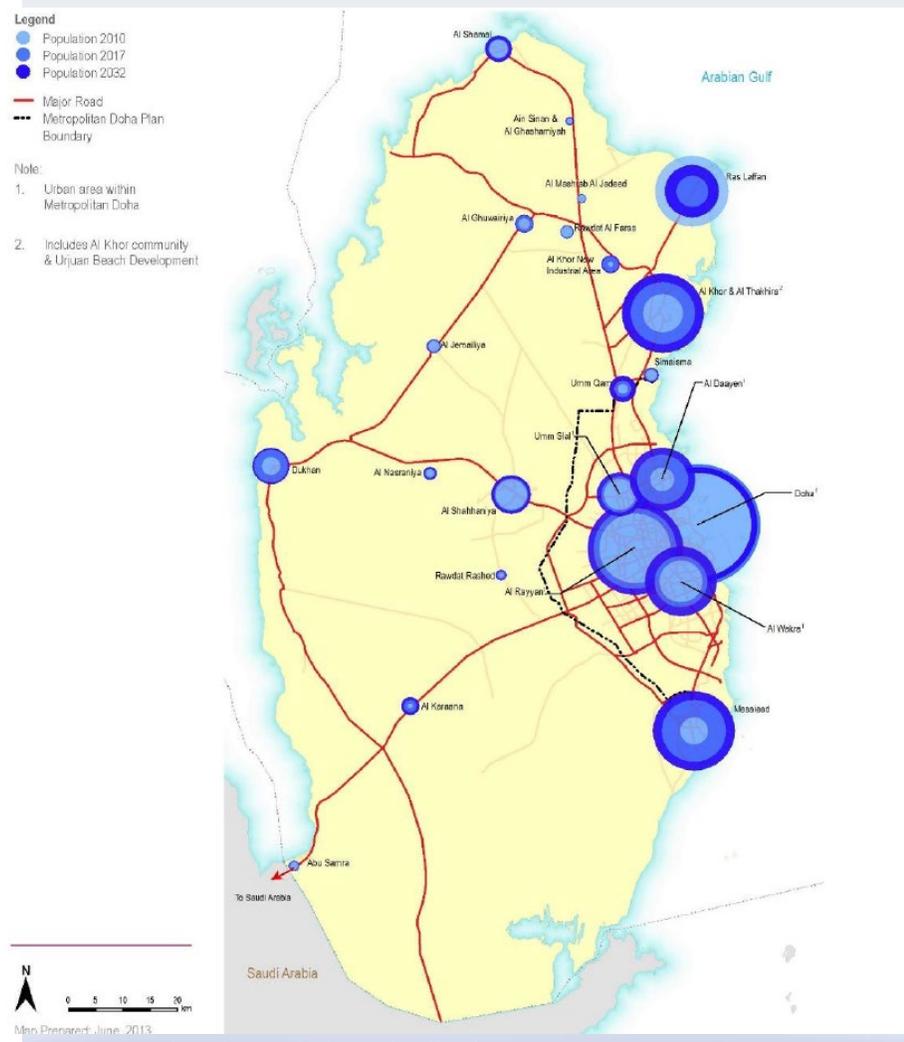


Flow change at district level of the four policy interventions under excessive growth scenario

DOHA-QATAR'S STRATEGIC TRANSPORT MODELS



Government, 2019)



Forecast National Population Distribution (2010 – 2032)

DOHA-QATAR'S STRATEGIC TRANSPORT MODELS

EXTENSION OF DOHA, QATAR



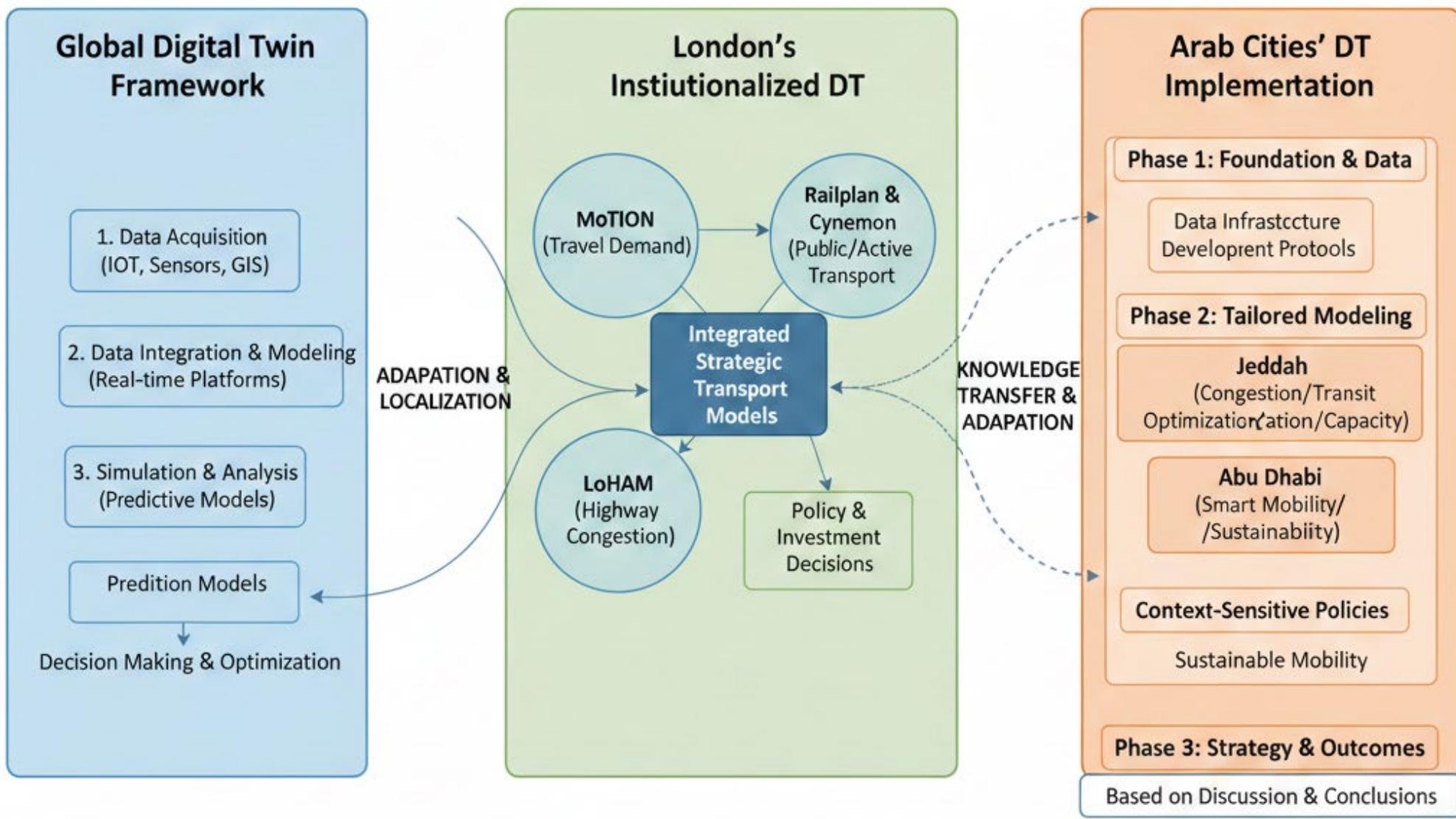
c. 1988

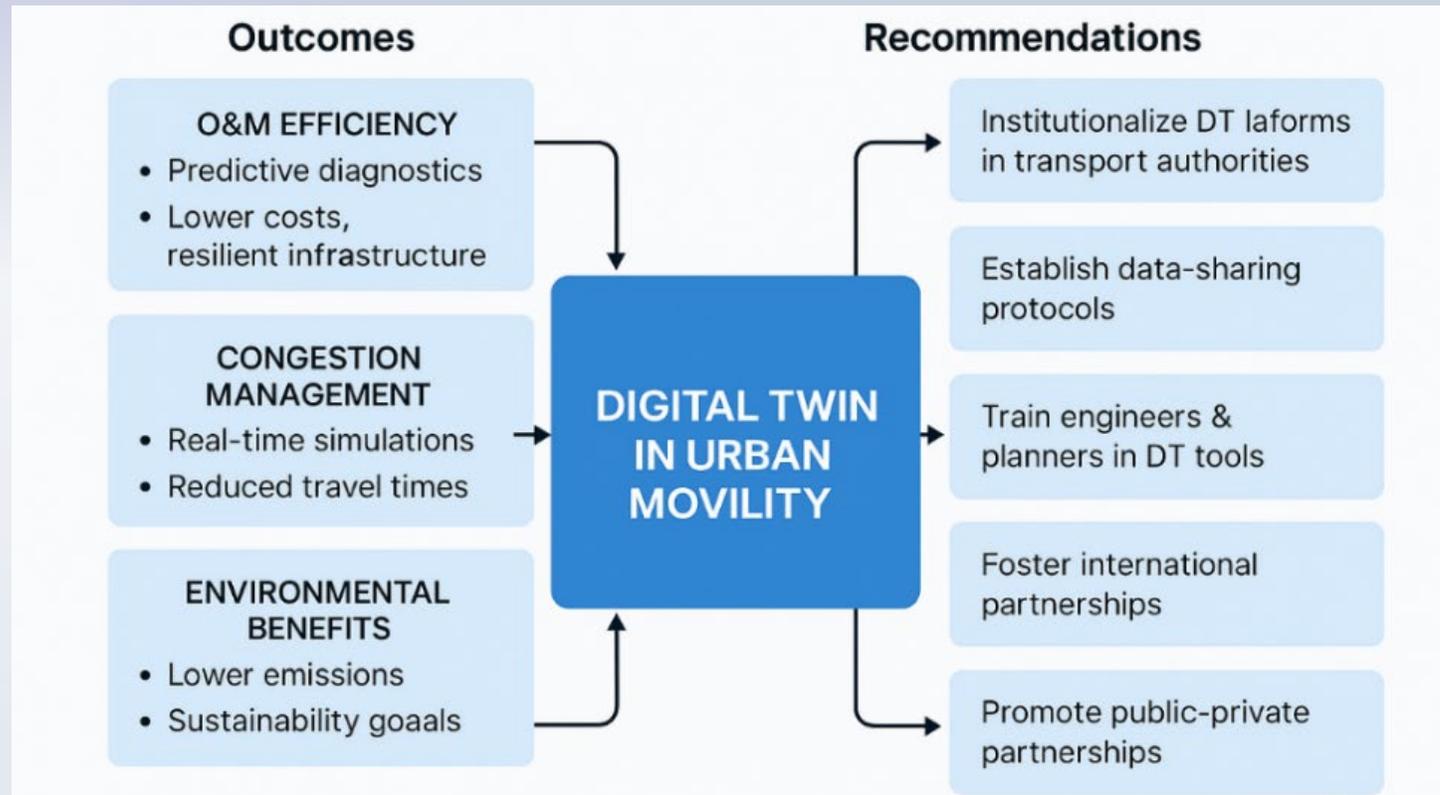


d. 2008



Doha builds new transportation hubs outside city due to space constraints and congestion. (Government, 2019)





The study highlights the role of Digital Twin integrated with strategic transport models in improving urban planning and congestion management. London’s experience with MoTiON, LoHAM, Railplan, and Cynemon shows effective modeling, while Arab cities (Jeddah, Irbid, Abu Dhabi) require context-specific adaptations. Recommendations include institutionalizing DT platforms, developing predictive models, enhancing data-sharing, training planners and engineers, and fostering international partnerships to achieve integrated, sustainable, and resilient urban mobility

Conclusion

الخاتمة

The study found that integrating Digital Twin with strategic transport models improves urban planning, congestion management, and sustainable mobility, while solutions must be adapted to the local context of Arab cities

Transformative Role

The findings of this research highlight the transformative role of Digital Twins (DT) when integrated with advanced transport models

Broader Implications

Importantly, DT supports Policy Integration by providing policymakers with accurate, realtime data, thereby improving decision-making processes, long-term planning, and the integration of land use with transport networks.



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