



Centre for Earth Systems
Engineering Research



The 'Tyndall Cities' Integrated Assessment Framework

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Transforming Urban System Futures

- **Cities focal points of consumption and emissions:**
 - Concentrations of vulnerability
- **Climate change coincidence with urban change**
 - Demographics
 - Ageing
 - Infrastructure development
 - Land-use change
- **Policy-makers and planners must**
 - Adapt to climate hazards
 - Mitigate against their severity
 - Strive for economic growth
 - Aim for sustainability
- **We require analytical tools that allow improved urban design today and into the future.**

Understanding the system and pressures

- **Recognising the time scales of future change + legacy of past decisions** (planning, infrastructure, buildings)
- **Collective understanding of urban function**
- **Collaborative platforms for exploration**
 - transition strategies
- **Consideration of the city as a whole**
- **Modelling complex interactions**

Dubai



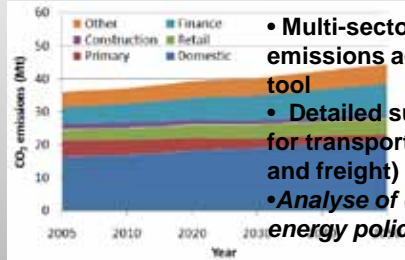
1991



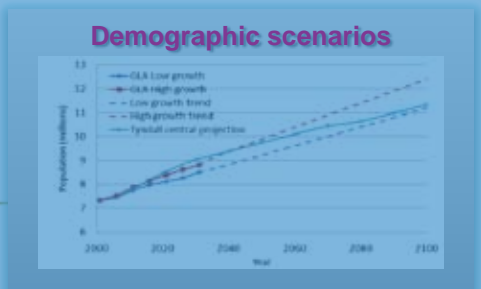
2005

The Urban Integrated Assessment Facility

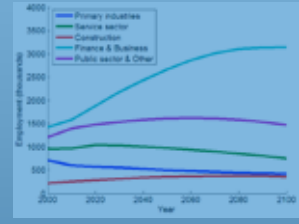
Greenhouse gas emissions assessment module



- Multi-sectoral emissions accounting tool
- Detailed sub-modules for transport (personal and freight)
- Analyse of city-scale energy policies



MDM-E3 Multi-sector city-scale economics module



- Dynamic resource interactions between sectors
- Specialist energy sector module

Vulnerability/Exposure



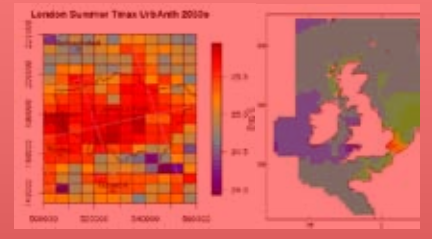
- Employment
- Multi-modal transport
- Developed land cover
- Population
- Land use planning constraints and attractors

Interface for testing of policy options

Working with key London stakeholders

Environment Agency
MAYOR OF LONDON
Thames Water
Transport for London

City-scale climate scenarios

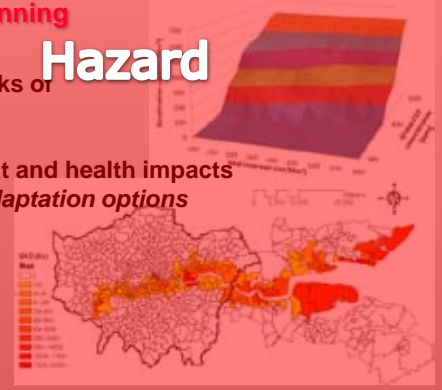


- Temperature
- Precipitation
- Sea level rise
- Storm surge

Climate impacts assessment and adaptation planning

Hazard

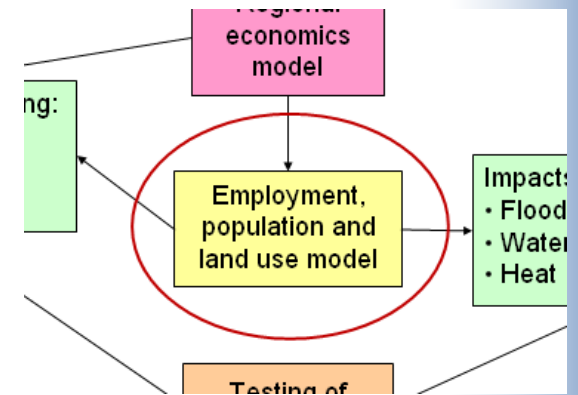
- Analyse risks of
- Flooding
 - Drought
 - Urban heat and health impacts
- Test adaptation options



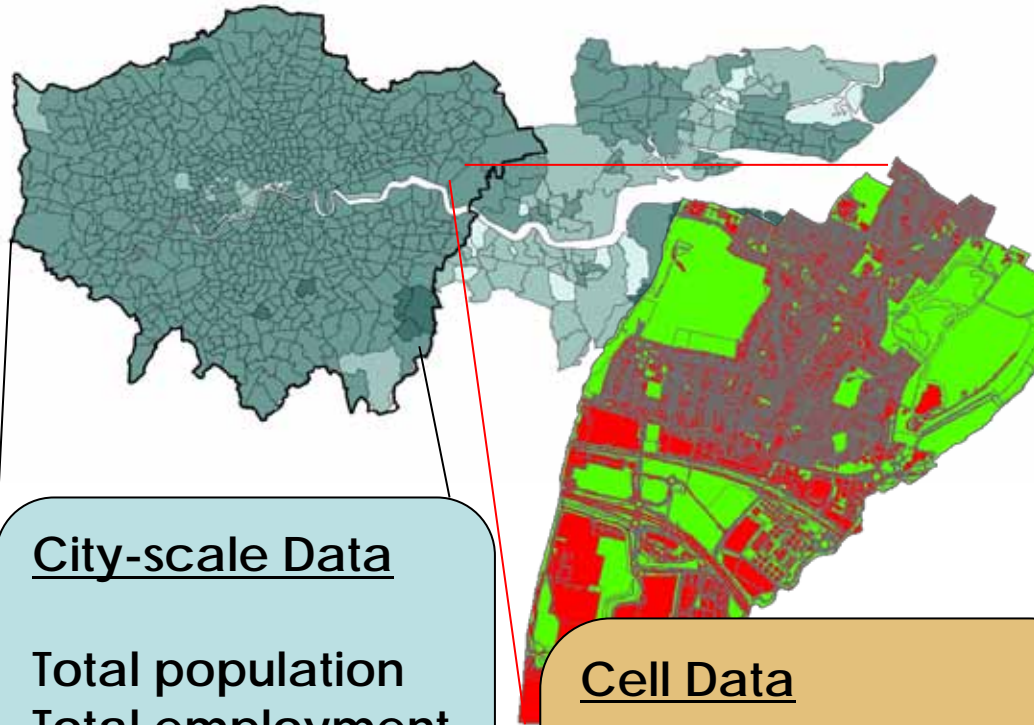
RISK

Land-use Transport Model (LUTM)

- Land-use co-evolves with infrastructure / economy
- Central to modelling framework
- Simulating possible future scenarios of growth
- Spatial patterns of vulnerability
- Disaggregating city-scale totals to local scale
- Simple parameterisation
- Low processing requirements



Nested spatial representations



Zonal Data

Total population
Total employment
Travel costs
Available land
Attractors
Constraints

City-scale Data

Total population
Total employment
Planning policies

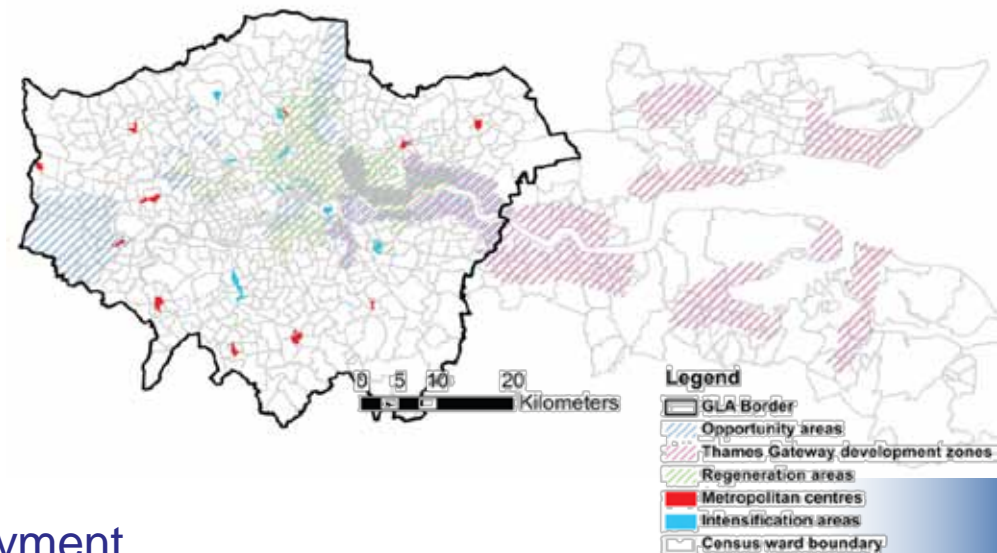
Cell Data

Population density
Development status
Attractiveness
Planning restrictions



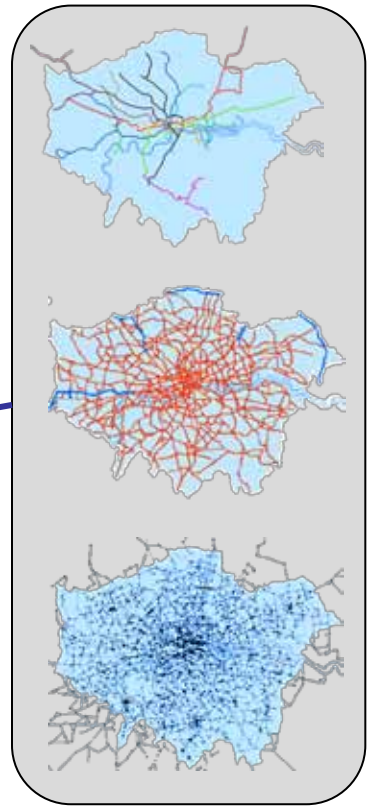
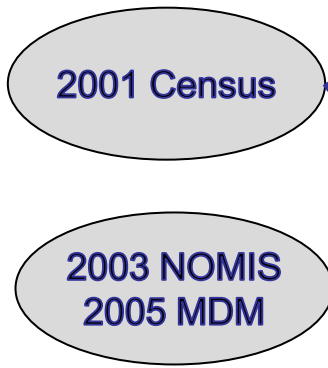
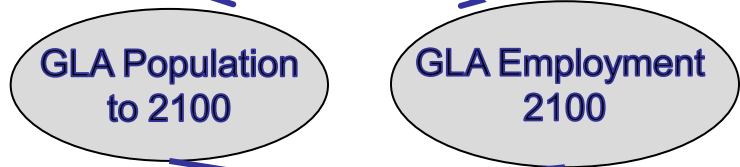
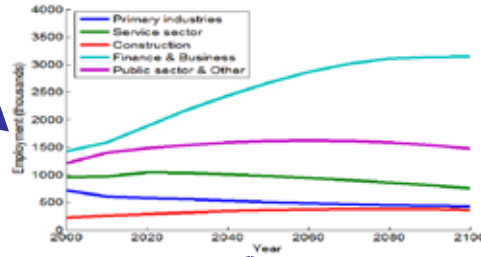
Zonal Spatial Interaction Model

- Simple Lowry-type model
- 633 zones in London
 - Observed population and employment
- Forecasts future population
- Employment disaggregated
 - Attractors
 - Constraints
 - Future scenarios
- Emp't drives population
- Attractors / constraints
 - Available land
 - Accessibility to employment
 - Planning policies



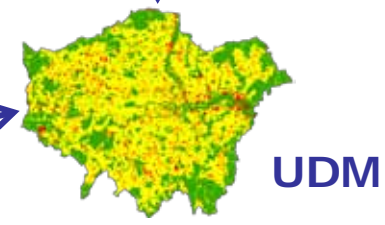
Urban Integrated Assessment: Spatial Land-Use Components

Economic Scenarios



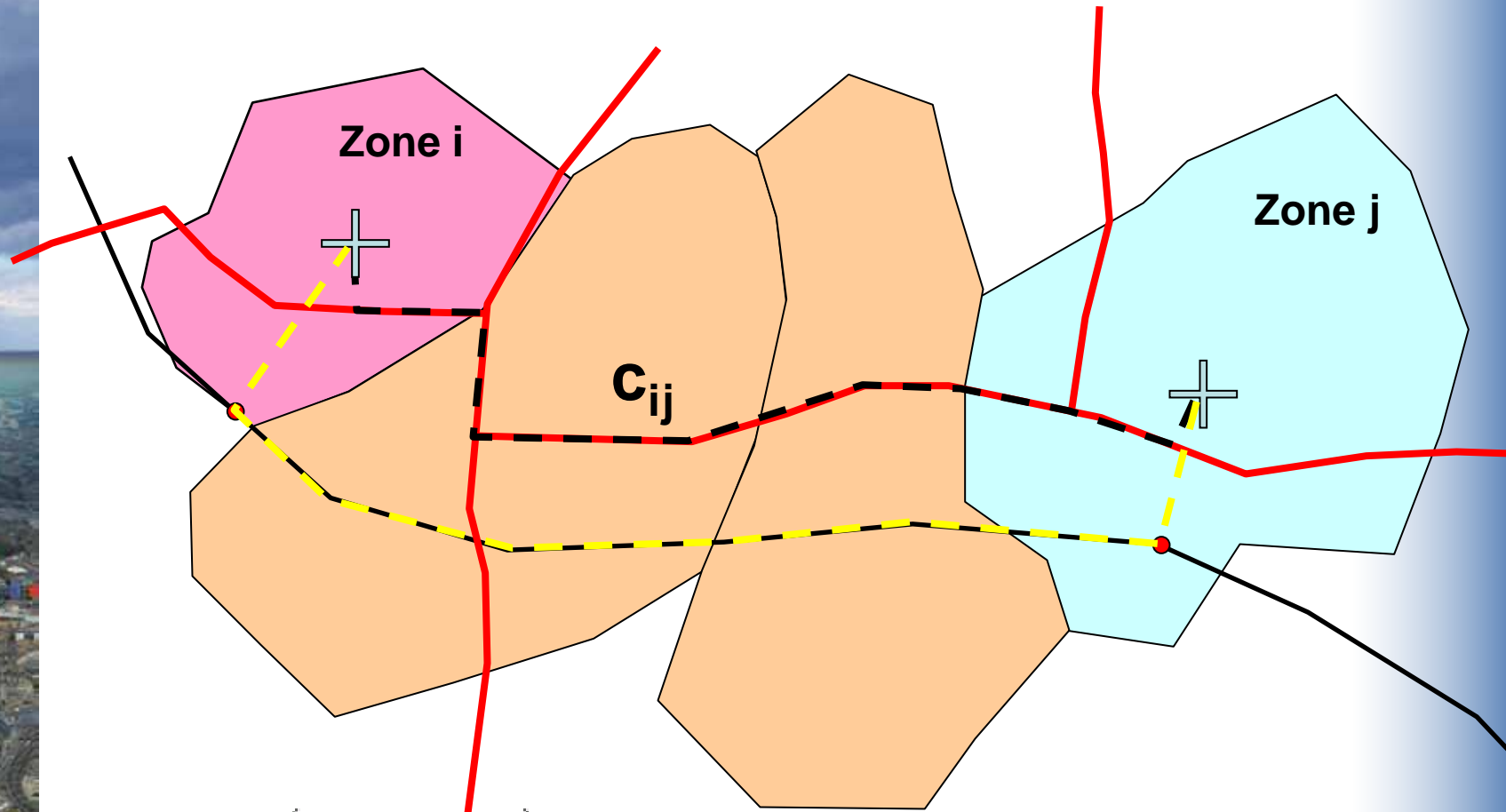
Transport Scenarios

Planning Scenarios



UDM

Modelling transport costs

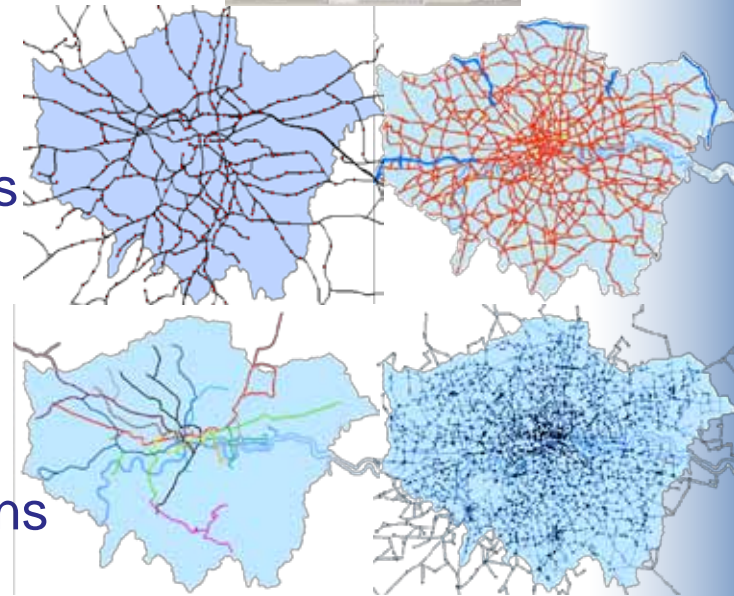
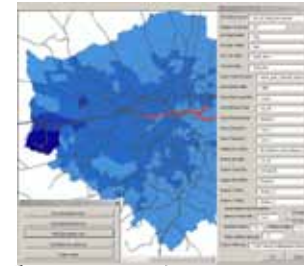


$$\rho_{ij} = f(A_j, c_{ij}, \mu)$$



Transport Model: Generalised Cost

- Computed from modal transport networks
 - Road (car)
 - Rail
 - Light Rail
 - Bus
- Takes into account multiple factors
 - Network distance
 - Average travel speed
 - Fuel or ticket costs
 - Service frequency
- Allows assessment of policy options
 - Infrastructure improvements
 - Road user charging



Year	Central area	Rest of inner area	All inner	Outer area
Morning peak period				
1977-1982	12.2	14.1	13.6	19.2
1983-1990	11.7	12.7	12.4	18.6
1990-1997	10.6	13.3	12.4	17.2
1997-2000	10.0	12.0	11.4	18.2
2000-2002	9.9	11.6	11.1	16.9
2003-2006	10.6	11.7	11.4	16.3

Transport Model: Generalised Cost

$$G_{car} = (V_{wk} * A) + T + D * VOC / (occ * VOT) + PC / (occ * VOT)$$

Access time to road network (walk to car) weighted by perception of walking

Travel time in car (from distance along network and speed (TfL report))

Vehicle operation costs (fuel and non-fuel) over the distance travelled

Number of occupants and **Value of Time**

Parking costs and **Congestion Charge**

$$G_{PT} = (V_{wk} * A) + V_{wt} * W + T + F / VOT + I$$

Access time to public transport network (walk to stop/station) weighted by perception of walking

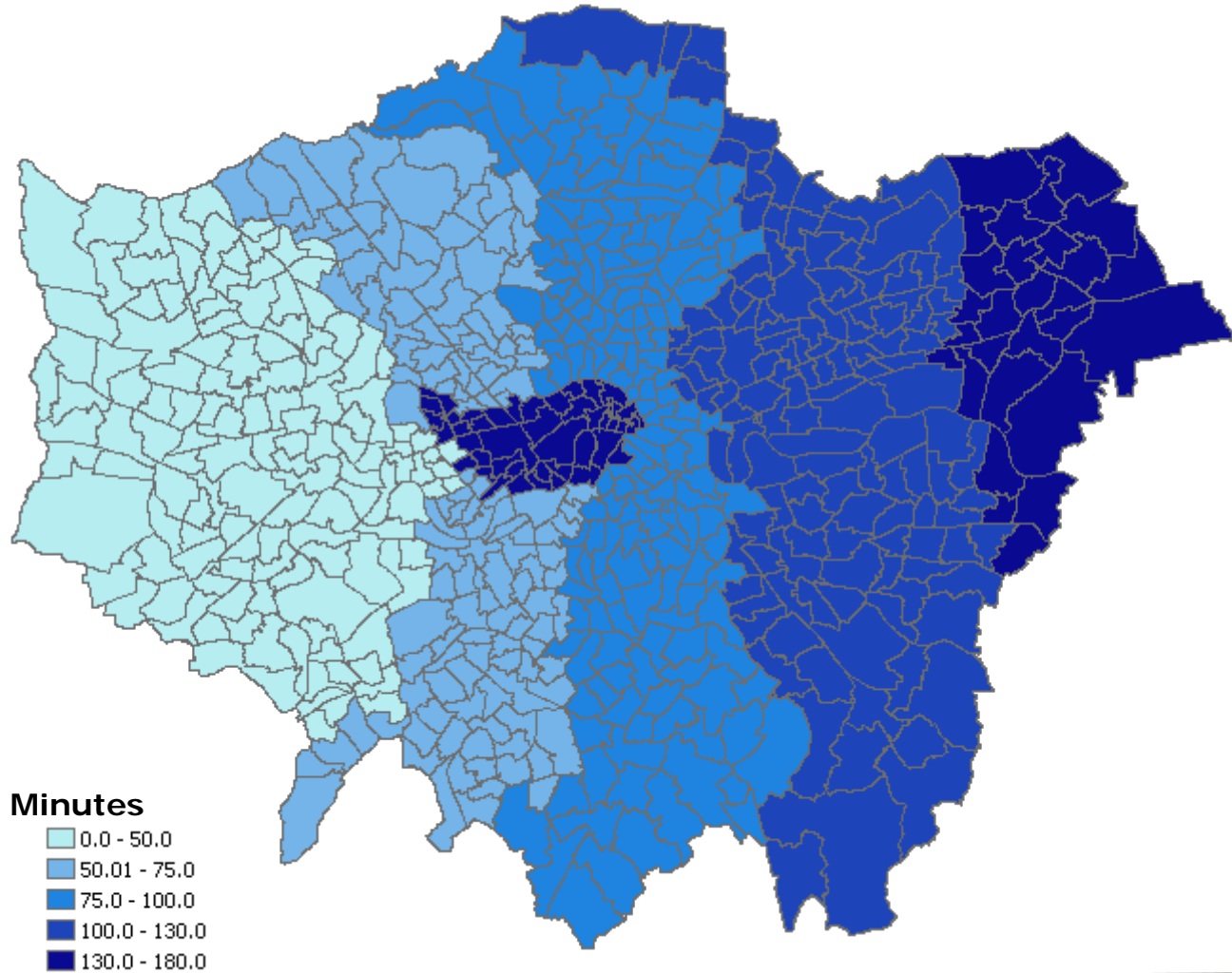
Waiting time for service weighted by perception of waiting

Actual travel time on service

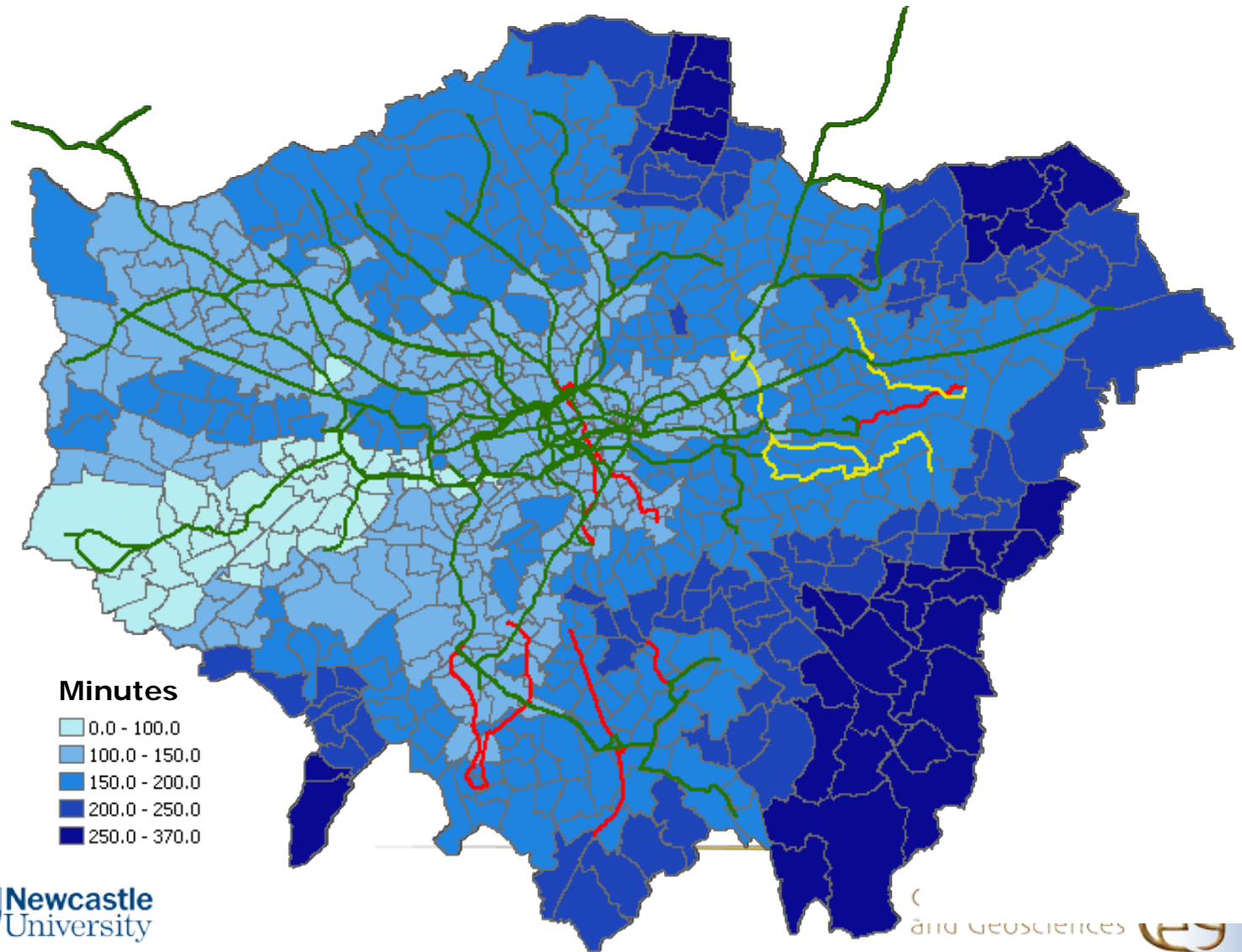
Fare paid, converted to time by Value of Time

Interchange time – Not modelled as mode changing not allowed.

London Road Network Generalised Cost

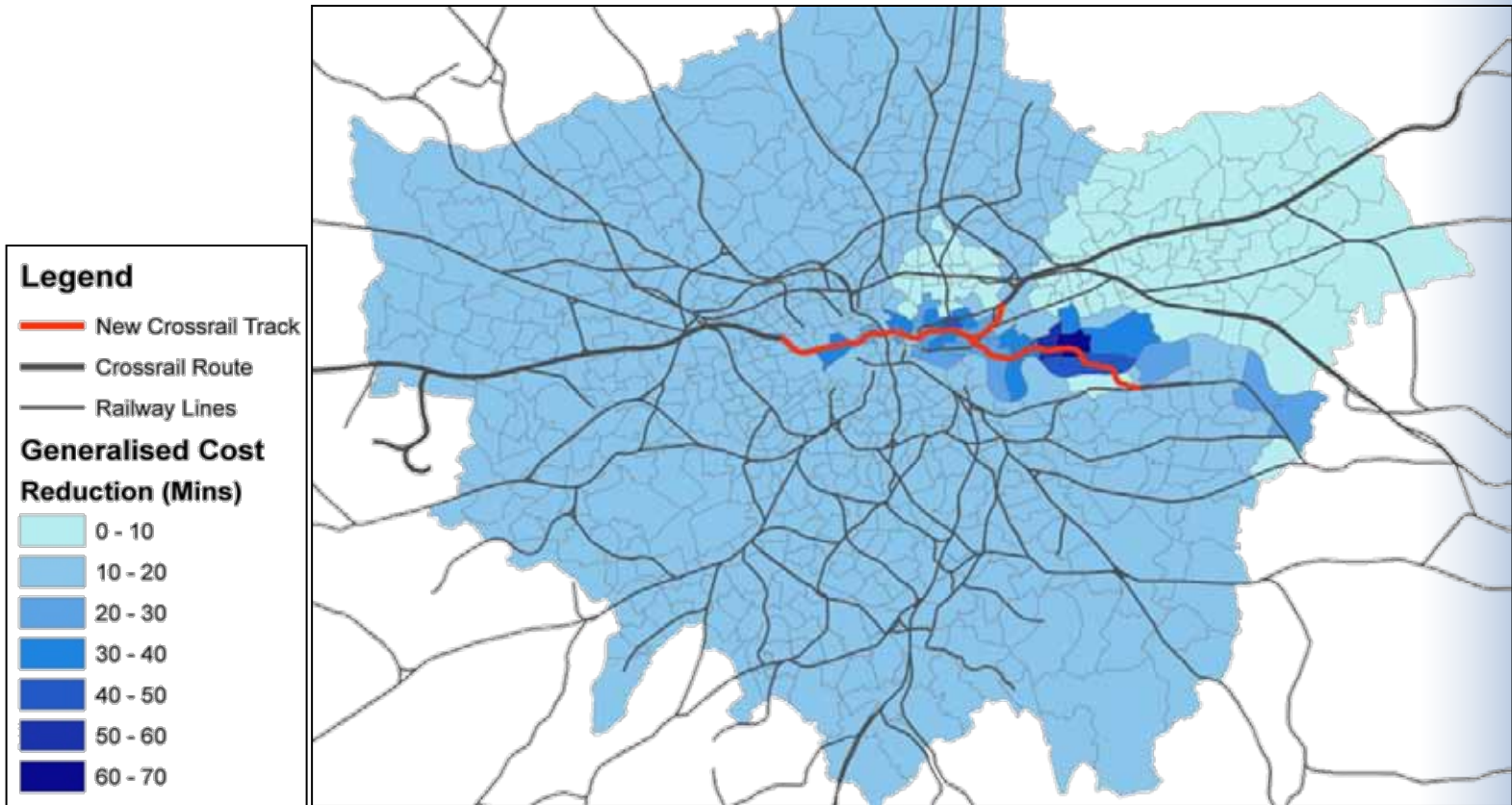


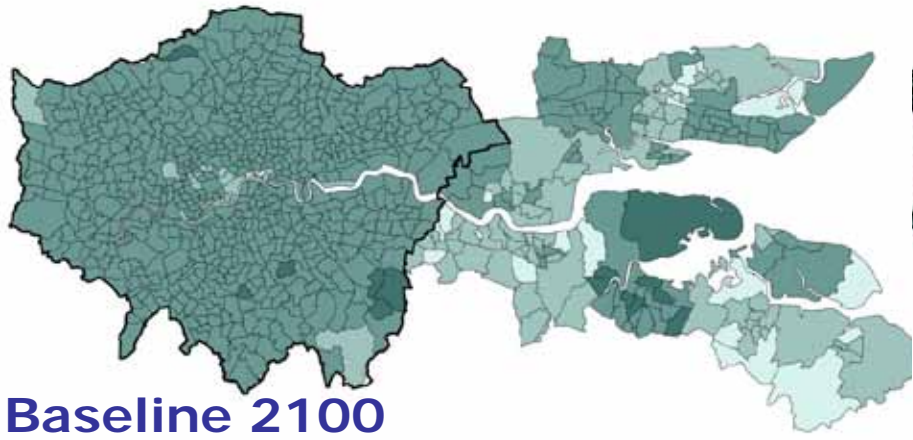
Light Rail Infrastructure Scenarios



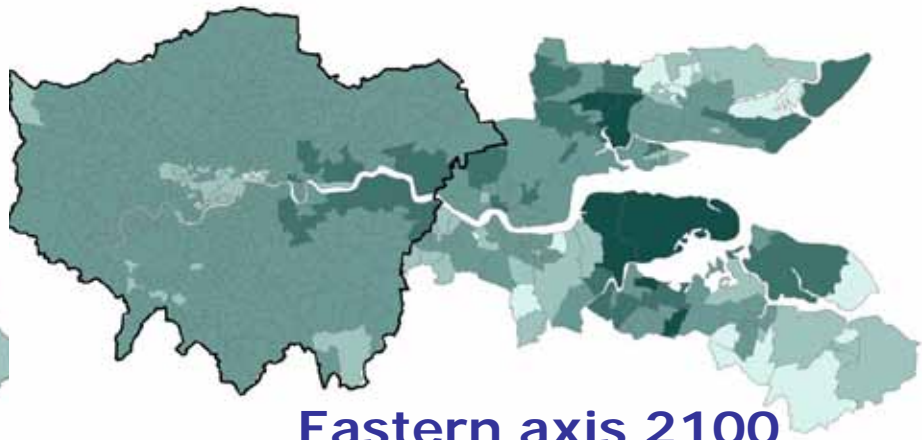
Transport Infrastructure Analysis

Transport Infrastructure Scenarios – accessibility improvements from Heathrow with the construction of Crossrail

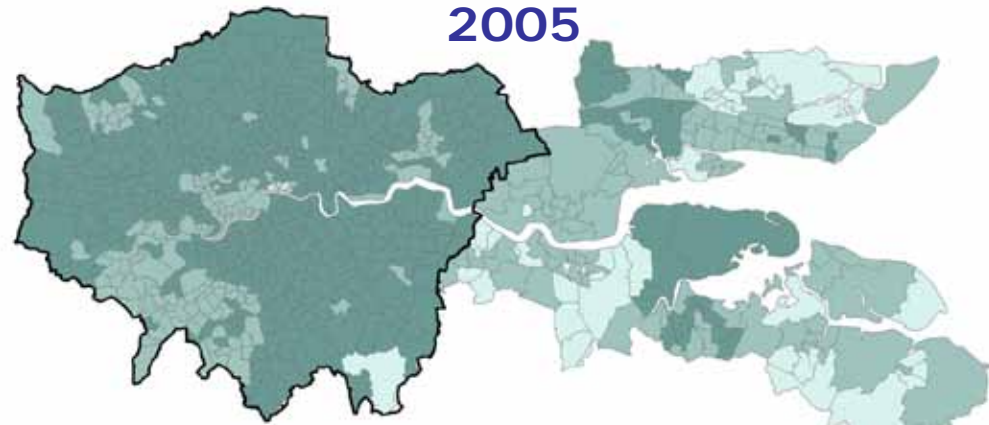




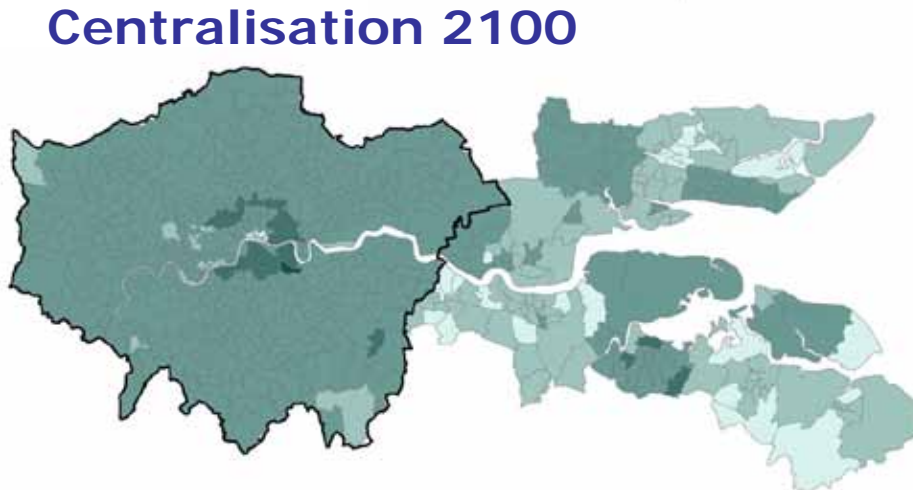
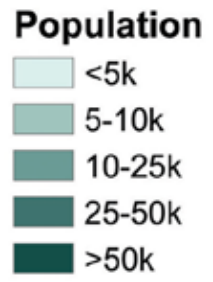
Baseline 2100



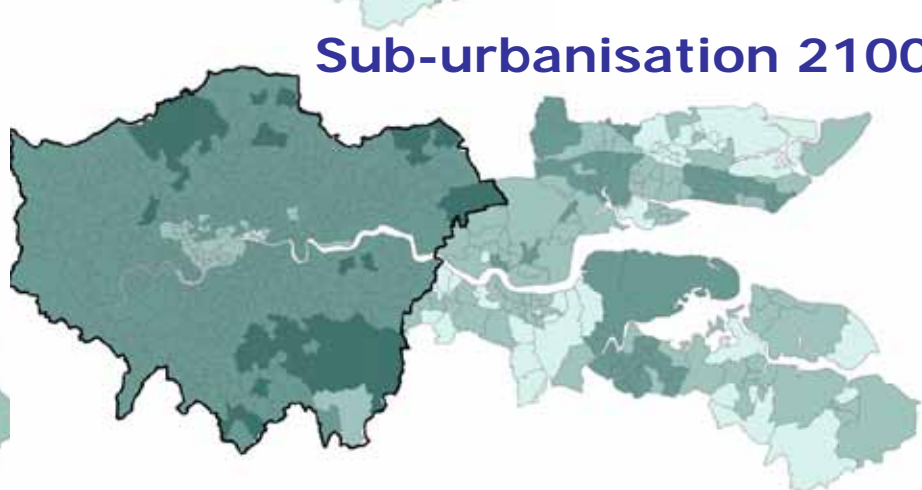
Eastern axis 2100



2005



Centralisation 2100



Sub-urbanisation 2100

Spatially Modelling Physical Development

Population



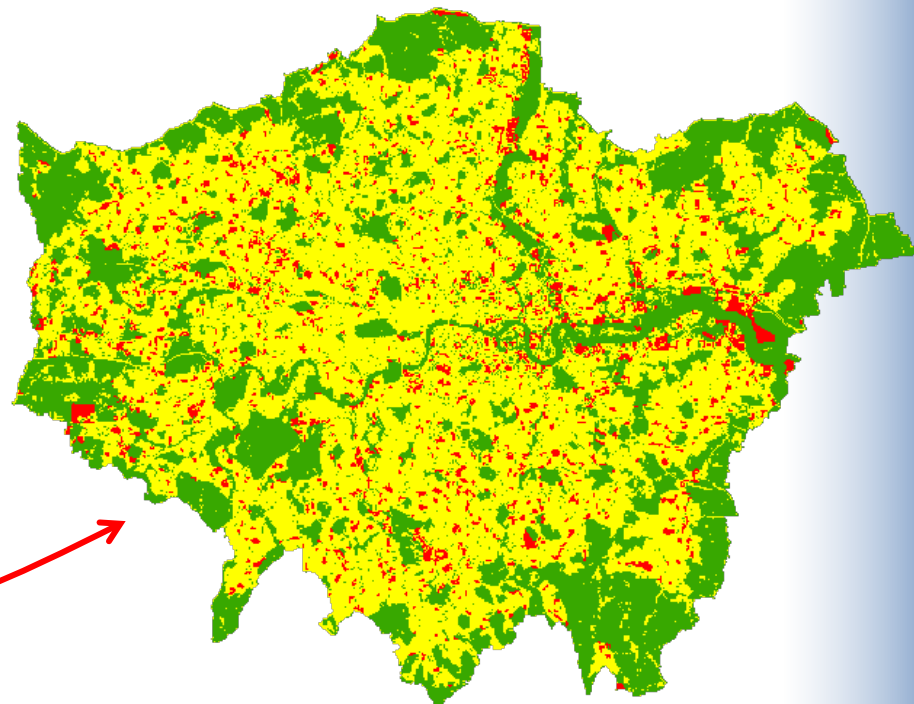
Legend

□ GLA Border

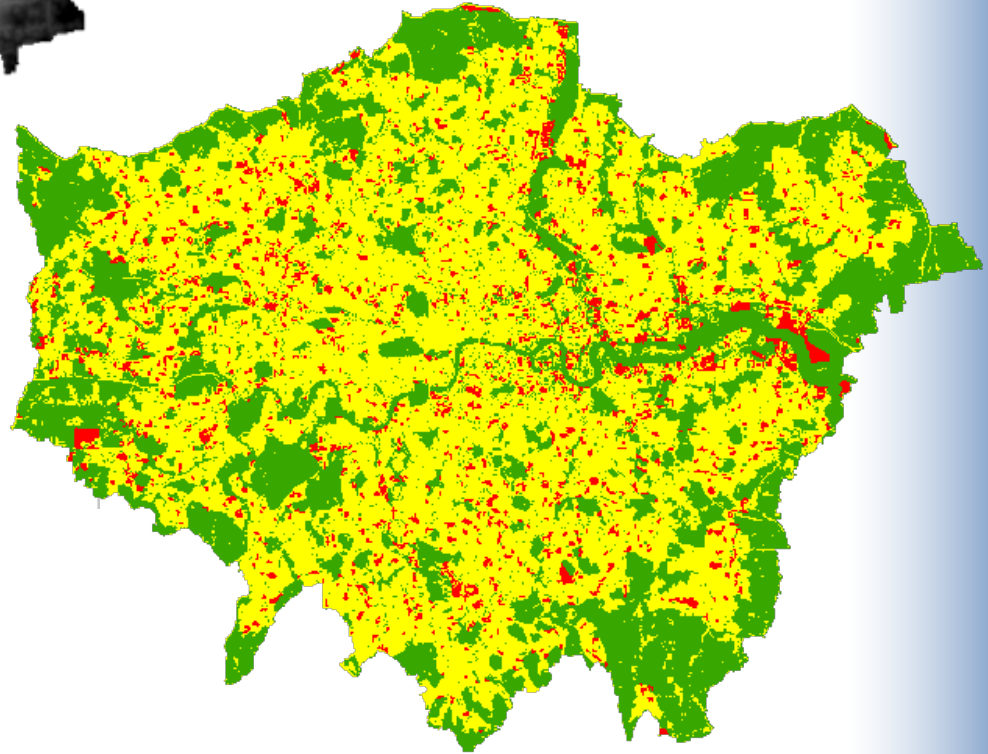
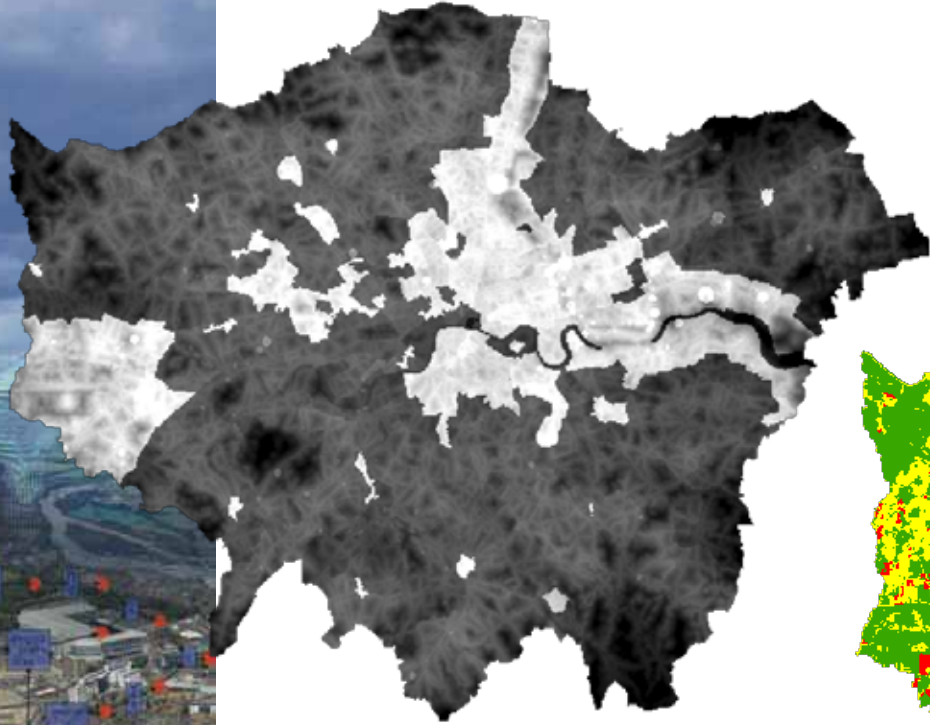
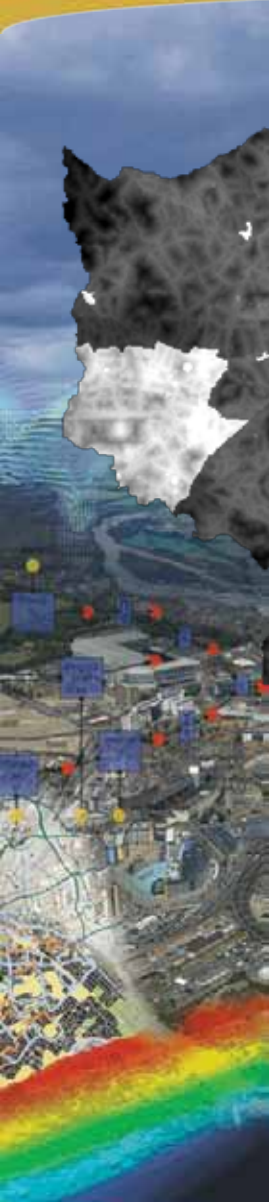
Population

- <5k
- 5-10k
- 10-25k
- 25-50k
- >50k

Urban Development

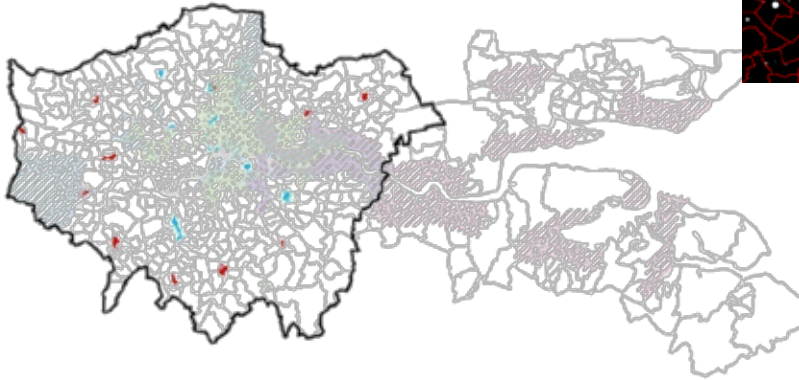


Tyndall Urban Development Model (UDM)

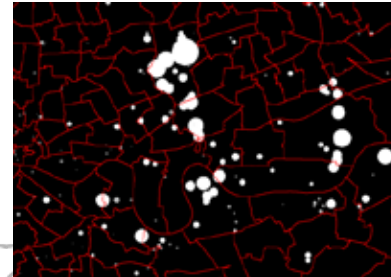


UDM Attractors

Planning Policy Drivers



Brownfield



Education



Proximity to Development



Proximity to road



Proximity Public Transport



Proximity Attractors



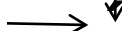
Attainment Attractors



Planning Attractors



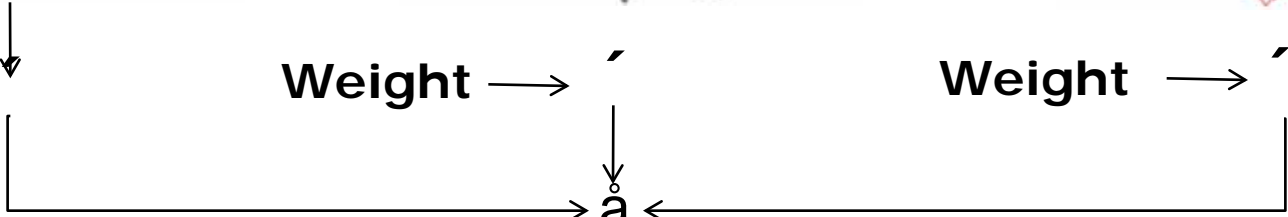
Weight



Weight

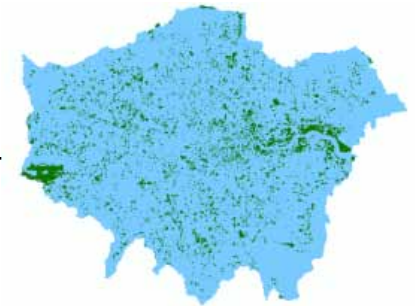


Weight



\hat{a}

Constraints



Planning Scenarios – Baseline Eastern

