



Overview of Urban Growth Simulation

(with examples of results from three SA cities)



Outline

- Introduction
 - Objectives of the work
 - Overview of technology with emphasis on STATSSA data used as input to the model and for validation
 - Typical process followed in each of the cities
 - Examples of results obtained
 - From first application of the Growth Simulation Platform in the cities of eThekweni, Johannesburg and Nelson Mandela Bay. Funded by the Department of Science and Technology, completed in 2012. See stepSA.org
 - How STATSSA data supports the work
-

Objectives

Simulate spatial growth patterns 30 years into the future, to better understand:

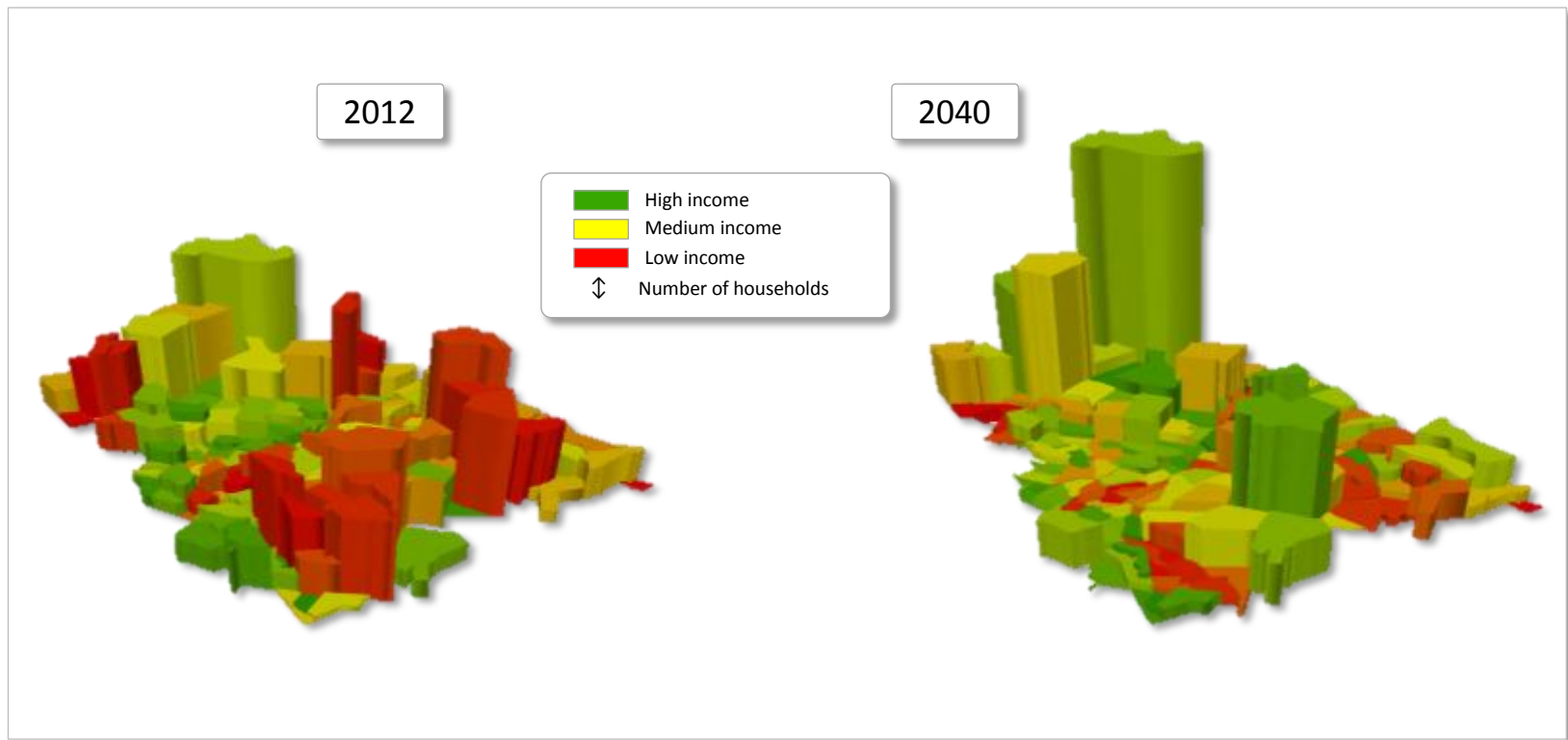
- How future **urban form** may impact on the **sustainability of our cities**
- Future **demand for infrastructure, facilities and services** such as water, electricity, sanitation, schools, clinics and hospitals.

Risk free means of assessing the likely outcome of major policy decisions:

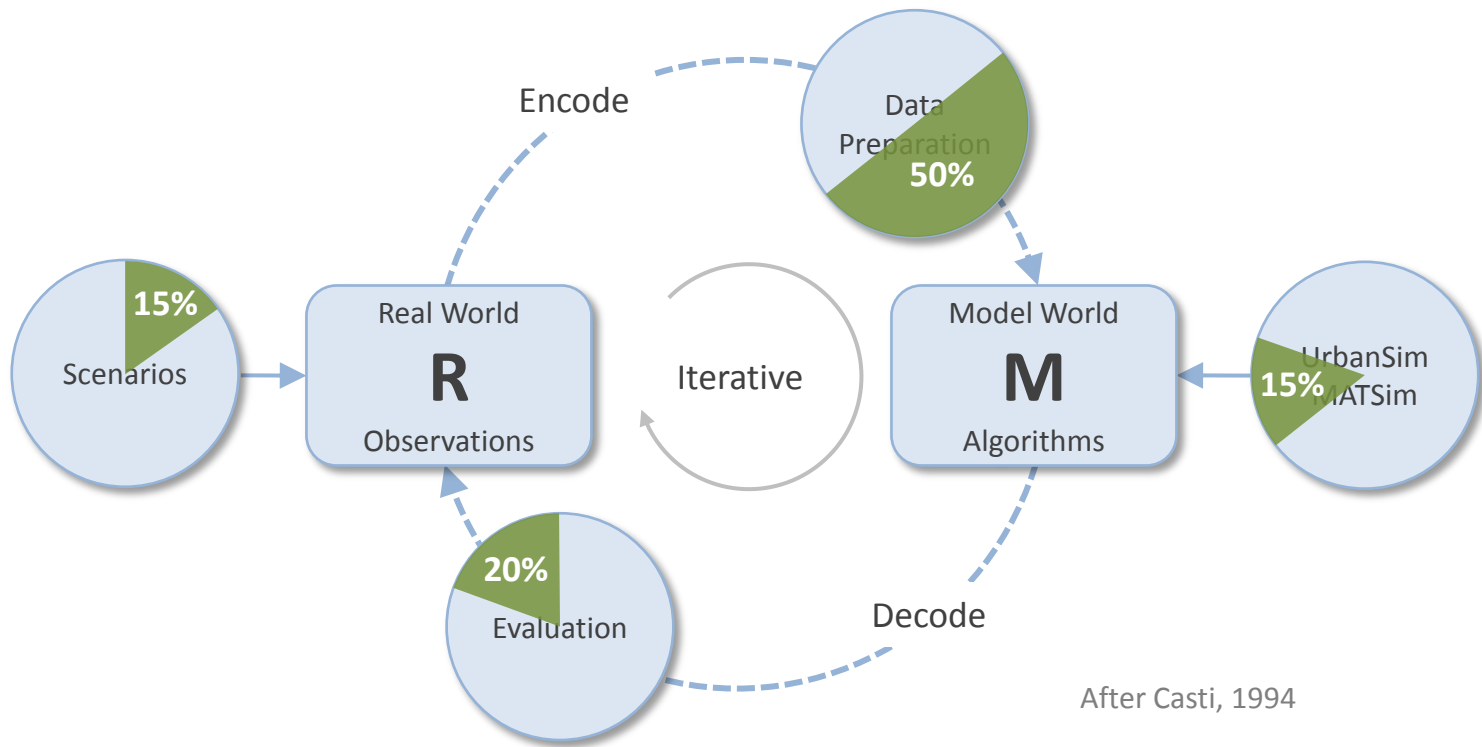
- Significant scope for developing and validating Capital Investment and Spatial Development Frameworks
- Standardising population growth projections and other assumptions across sectors.

Objectives ...

Illustrative results for high economic growth scenario show potential impact of different scenarios on future provision of infrastructure and services



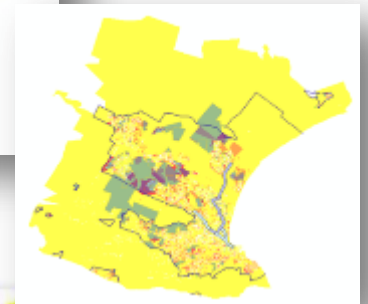
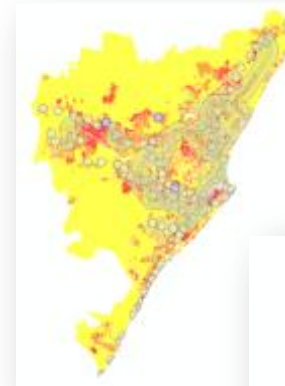
Typical Process



Percentage of total effort

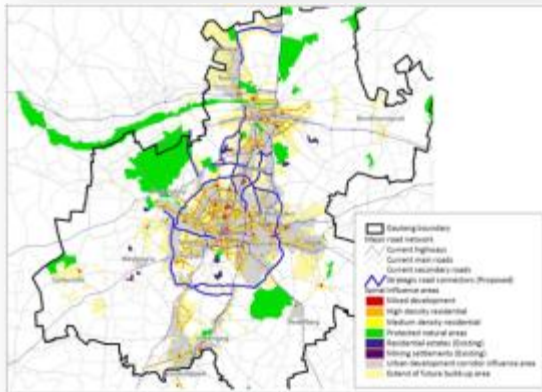
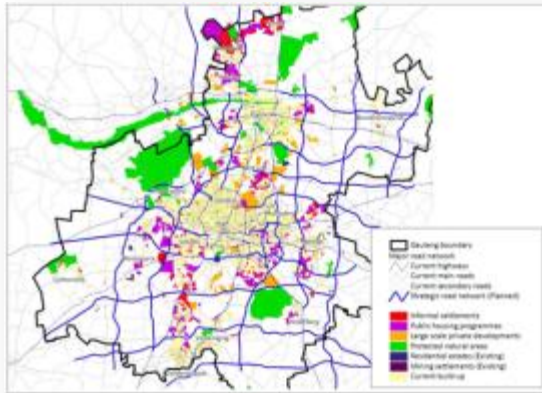
Living Laboratories

- Living Laboratory Processes followed in three metropolitan areas



- A Living Laboratory comprises a series of interactive work sessions with **end users** in **real life contexts** to ensure:
 - the participation and collaboration of relevant municipal stakeholders in the process of developing, testing and applying the urban simulation platform.

Policy Scenarios



Scenarios describe distinctly different development trajectories that the city could plan for.

Examples:

- Densification of priority areas and transport corridors
- Protecting nature areas
- Limit urban sprawl
- Developing low-cost housing in well-located areas.

Data Preparation



From a variety of data sources:

Control Totals

Households by income, age, children, cars ...
Employment by Standard Industry Classification

STATSSA

Synthetic population

From 10% sample of enumerator forms from census and control totals for sub places and main places

STATSSA

Land and buildings

Property boundaries (~2 300 000)
Classify by typology of ~50 classes derived from Knowledge Factory (more examples follow on next slide)
Type of building and market value

Other

Account level water & electricity consumption
Environmentally sensitive, undermined, dolomitic areas ...
Developments in the pipeline ...

Study area

Previously: Metro boundaries. Currently: Whole Gauteng.

Settlement typology



A 1M: Upper Crust

They are the elite of South African society – anointed through wealth and achievement. The Upper Crust live lives of distinction in pampered luxury, with little concern about cost – for them, quality is not negotiable. They know and can afford the best the world has to offer. Properties



A 2M: Pearl Strings

Closely related to the Upper Crust, the Pearl Strings are crowning lifetimes of achievement with refined, slightly understated style – in fact, they may well frown on flash. While their incomes are only outstripped by those of the Upper Crust, properties



A 3M: Cheese and Wine

They insist on the American Dream in South African suburbia, on being the captains of their own ships and on recognition of their status as self-made. A decade or two ago, the Cheese and Wine led the trek from the older suburbs to the new suburban Meccas



A 4M: Fashion Café Society

They are hip and happening – the trend-setters that push themselves hardest to live according to the dictates of lifestyle magazines. They work hard, earn big and, sometimes, spend even bigger. Fashion Café Society represents the new wave of residents of



I 25M: Chakalaka

Chakalaka clusters (named after a spicy vegetable relish/dish developed in the townships of Gauteng) were meant to be orderly locations – much like the eKasi clusters, however, all open spaces in this cluster have been crammed full with a wide assortment of shacks and structures. The result is a lively community that is,



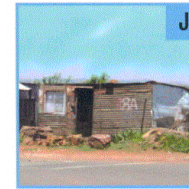
I 26M: Poor Neighbours

The residents of the Poor Neighbours cluster, too, have outgrown the old 'matchbox' houses originally built in the area. As a result, the cluster is typified by numerous shack dwellings erected amongst the permanent structures or nearby. Dwellings are basically standard four-room or three-room



J 27M: Tin Town

When the people of the Tin Town cluster go to bed at night, a good dream would be to wake up somewhere else for it is difficult to find redeeming factors about this most oppressive cluster, other than the tenacity of its inhabitants. Tin Town clusters consist of very dense, relatively small shack settlements. What distinguishes this cluster



J 28M: eKaya

Informal settlements are nothing new in South Africa – eKaya clusters are proof of this. They are, however, different from newer informal settlements, being older, with the majority older than a decade and, often quite far from the city centres. Properties are slightly larger and more established – you might well find a clearly



E 6T: Rusty Blues Town

They have served their time providing skilled labour to the dominating industries of the small town – now they



F 7T: Young Blues Town

They are the agile young fingers supplying skilled labour and technical services to the town's industries. Many



G 8T: Basic Town

Their parents were most likely not allowed to own property. They were most likely condemned to second-class



I 9T: The Other Town

The social engineering that saw forced removals and gave rise to the townships of the cities was applied with equal force



J 10T: Forgotten People

Wherever you may be in South Africa, spare a thought for the Forgotten People, for they are truly the poorest of the

Currently based on Knowledge Factory Cluster+

The model system

UrbanSim (Open Source)

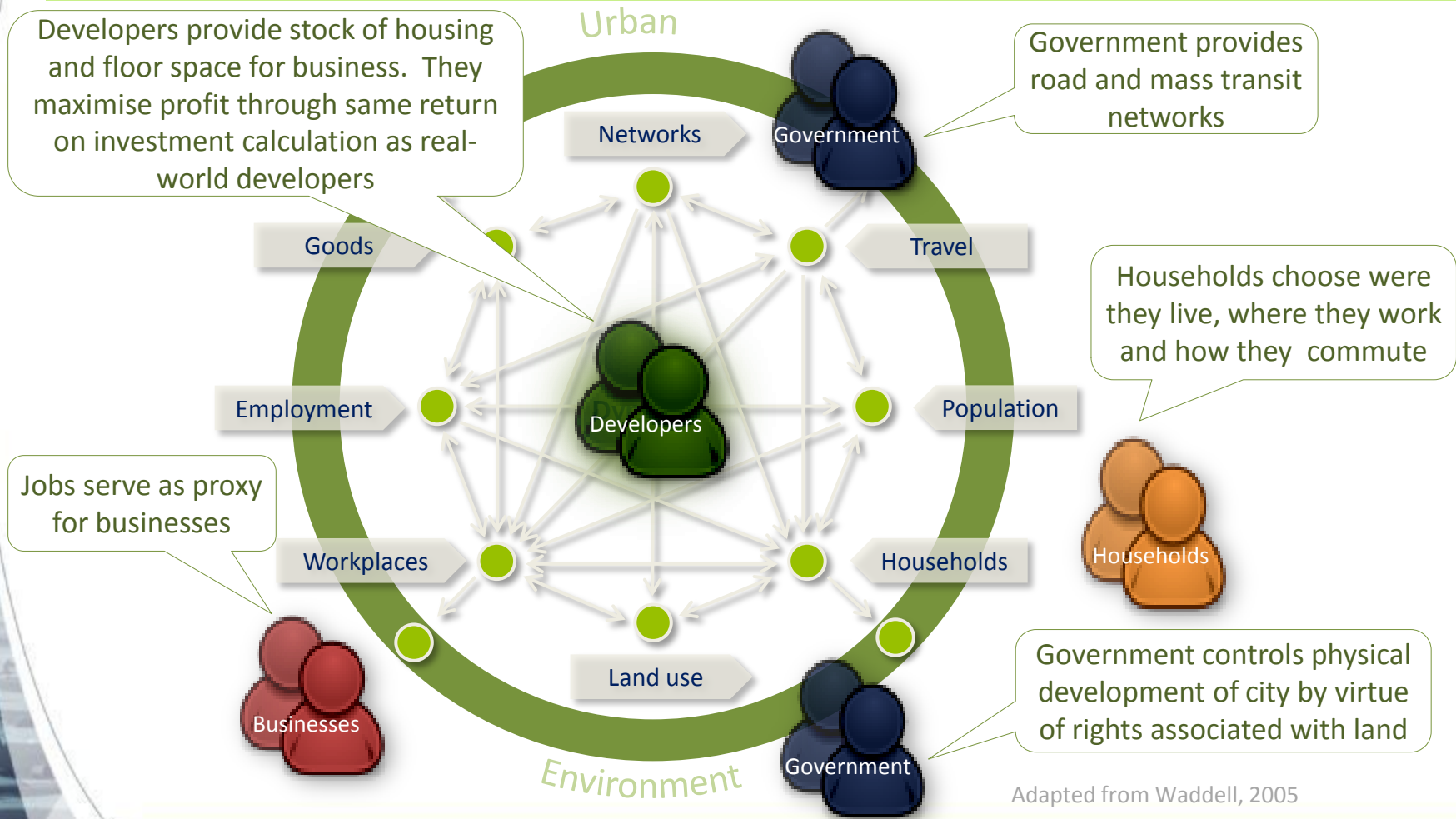
Based on discrete choice theory: Simulates the choices made by various agents

- For example the probability of a household agent characterised by attributes such as age, income, size, children and cars choosing a particular house characterised by price, location, etc.
- Sub-models allow for different behaviour of different income groups

MATSim (Open Source)

Based on queue theory: Simulates autonomous agents executing and optimising their daily trip plans

What part of R is represented in M?



Adapted from Waddell, 2005



Examples of typical output



analysis

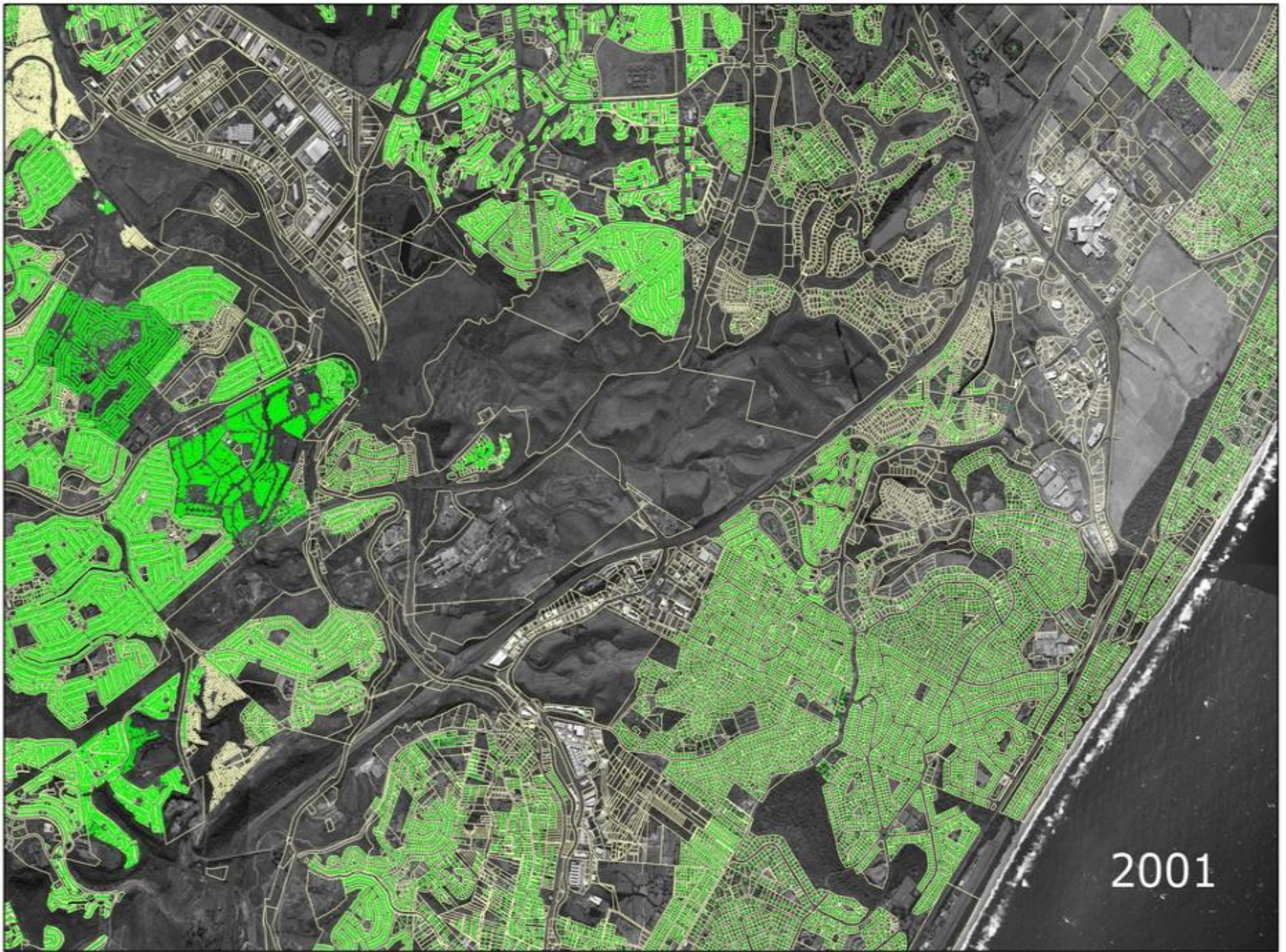
monitoring travel speed



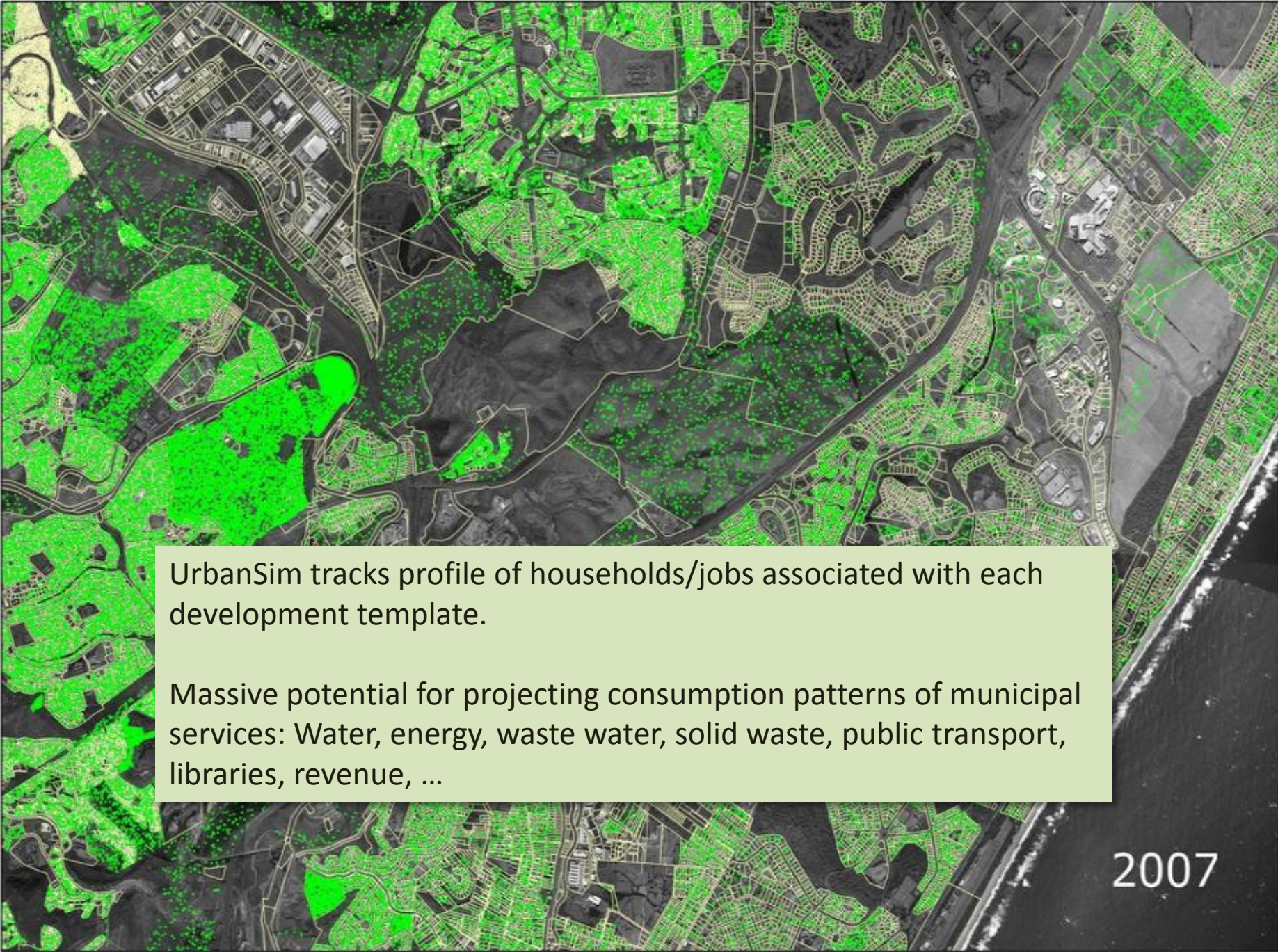
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Information Technology

MATSim
Multi-Agent Transport Simulation

senozon



2001

An aerial photograph of a city, likely Seattle, with a large portion of the urban area overlaid in bright green. The green areas represent different development templates tracked by UrbanSim. The city's layout, including streets, buildings, and a river, is visible in the background. The green overlays are concentrated in various urban areas, showing the spatial distribution of different development types.

UrbanSim tracks profile of households/jobs associated with each development template.

Massive potential for projecting consumption patterns of municipal services: Water, energy, waste water, solid waste, public transport, libraries, revenue, ...

2007



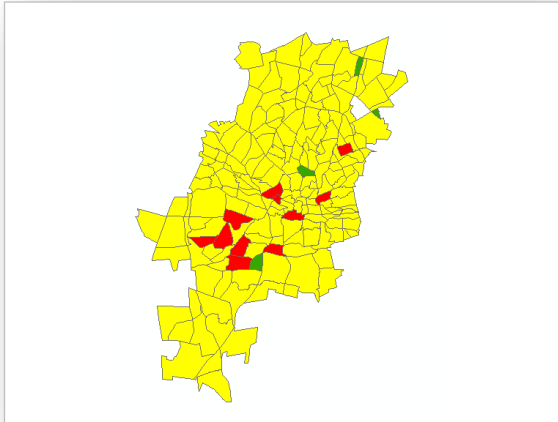
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SPATIAL TEMPORAL EVIDENCE FOR PLANNING **SOUTH AFRICA**

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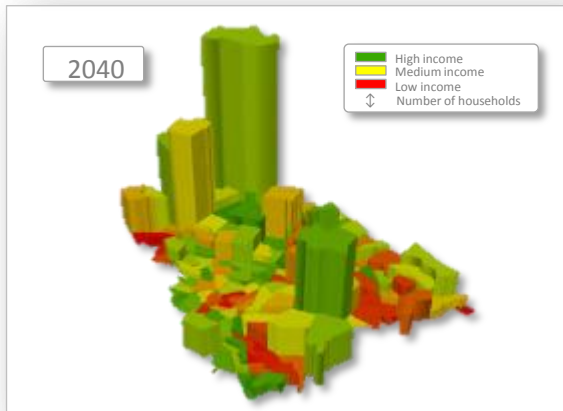
Evaluation

Evaluation of results



Validation

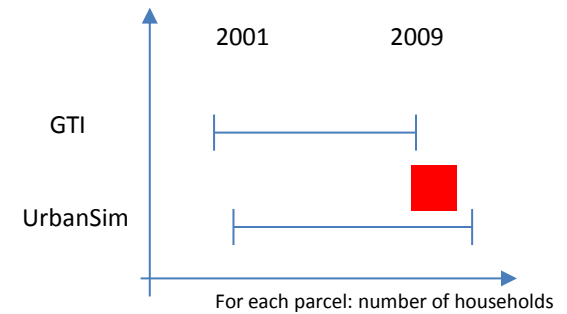
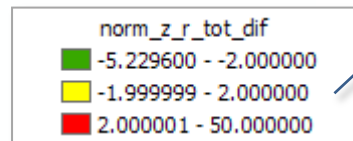
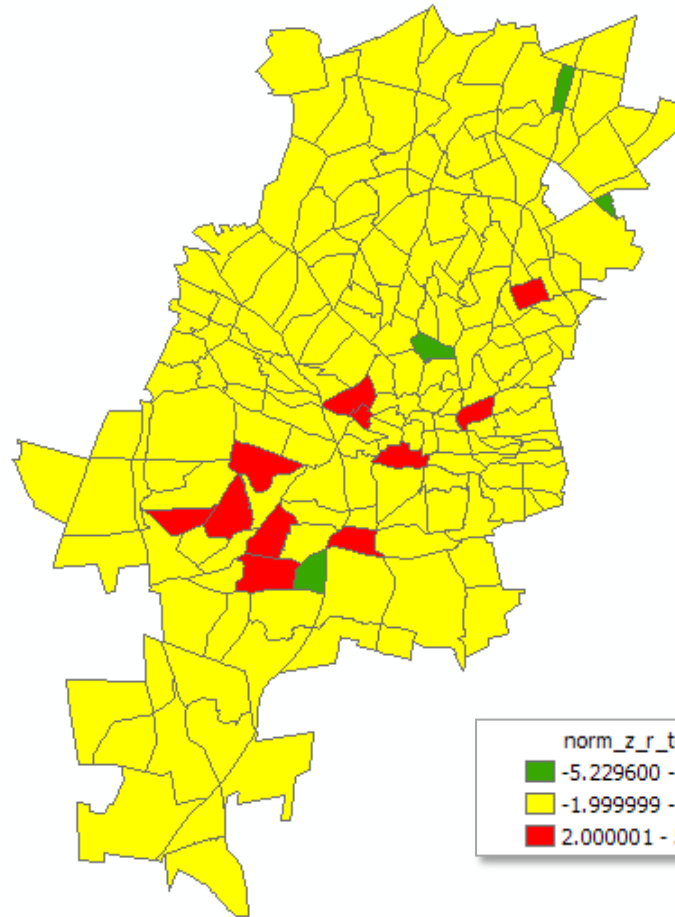
- Based on simulating a period in the past.
- Compare results with actual growth during the same period.
 - Previously: Based on GTI dwelling counts
 - Currently: Census 2001 to Census 2011.
- Onerous but the only way to build trust. **STATSSA**



Evaluation against expert opinion

- Simulating the future.
- Conducted in Living Laboratory setting.

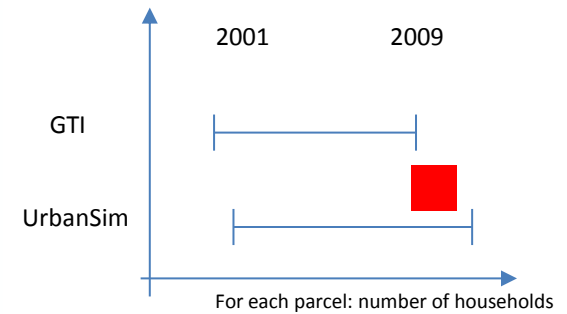
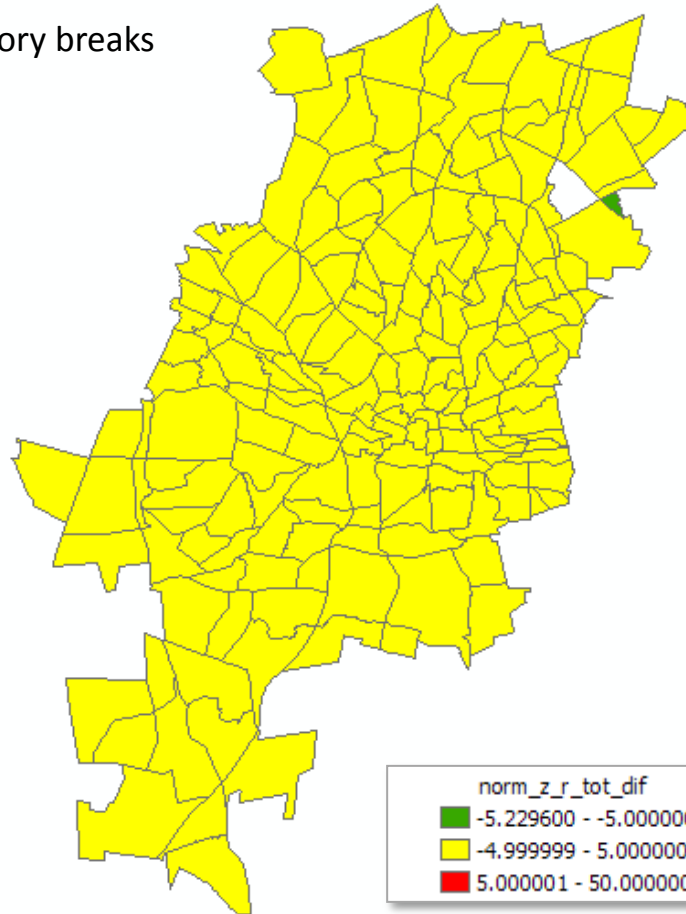
Normalised growth ($\Delta\text{Sim} - \Delta\text{GTI}$) aggregated to TAZ



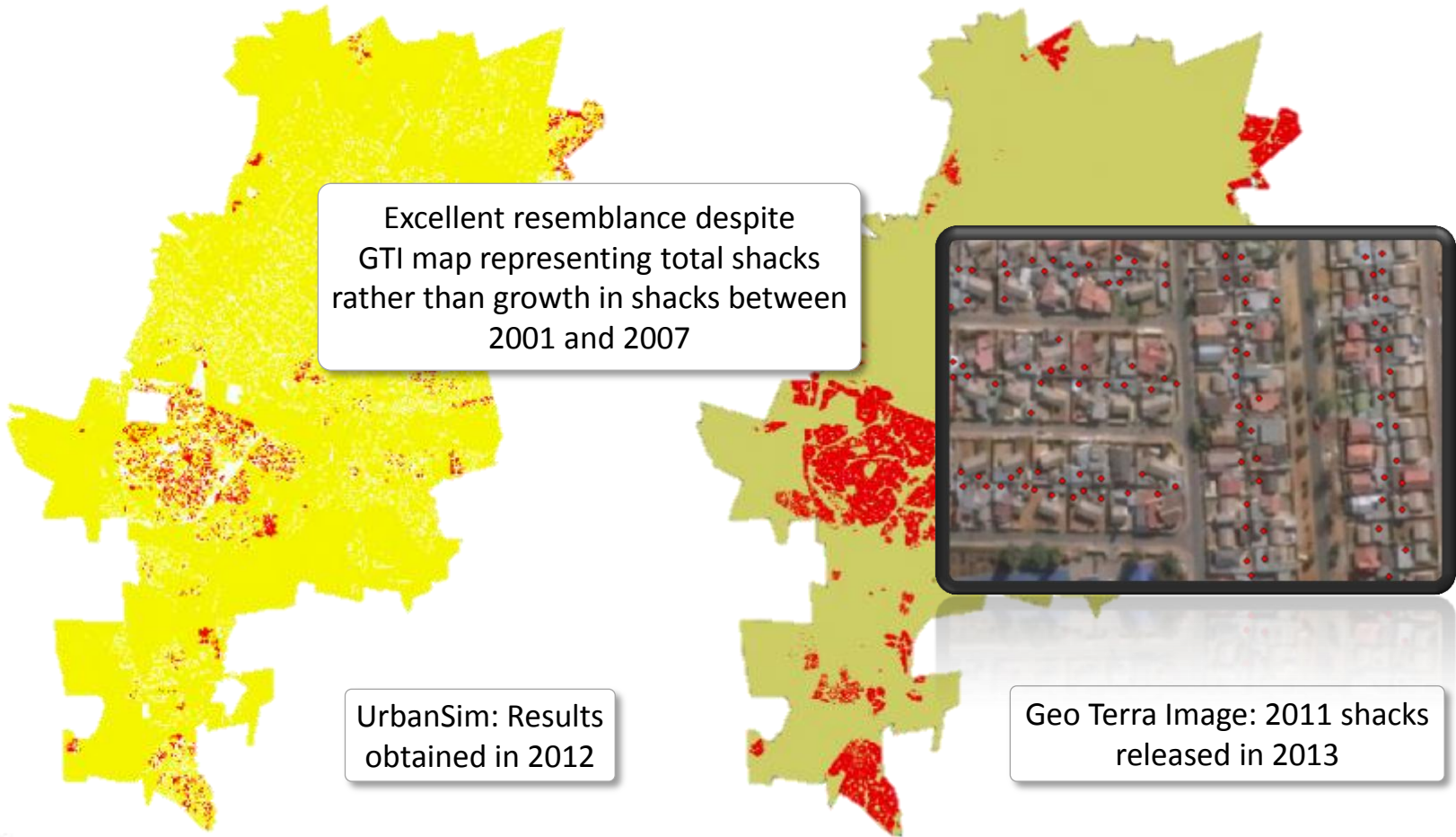
Units / ha

Normalised growth ($\Delta\text{Sim} - \Delta\text{GTI}$) aggregated TAZ

Different category breaks



CoJ: Backyard shacks 2001-2007



NMBM: Backyard shacks



Excellent results also obtained in
Nelson Mandela Bay



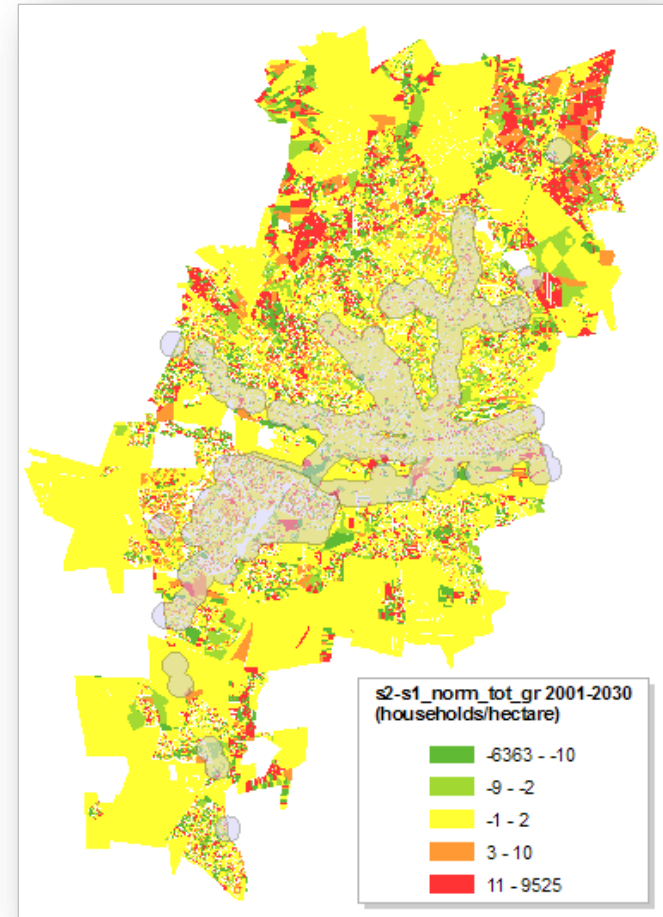
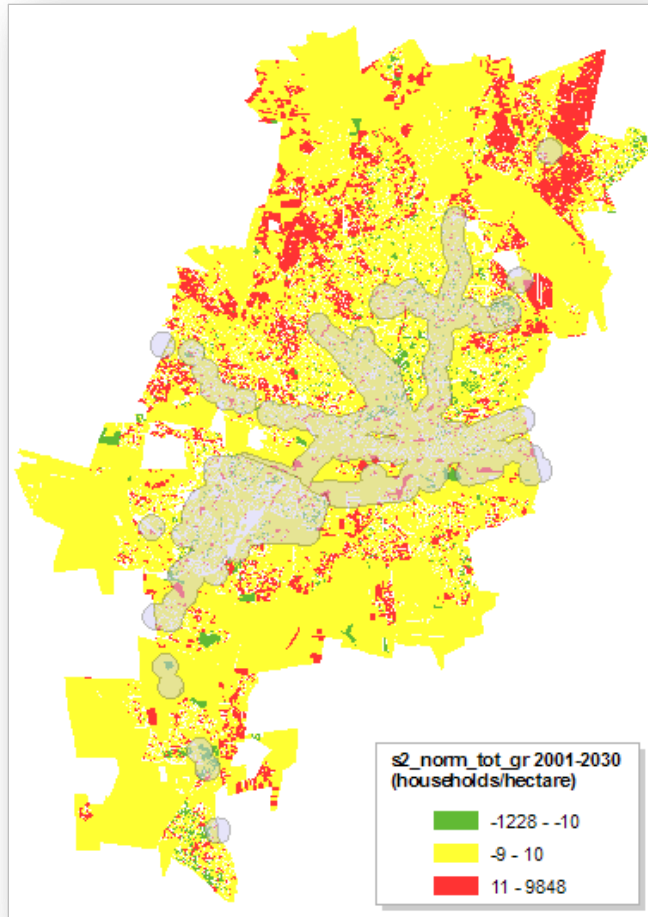
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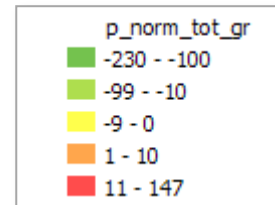
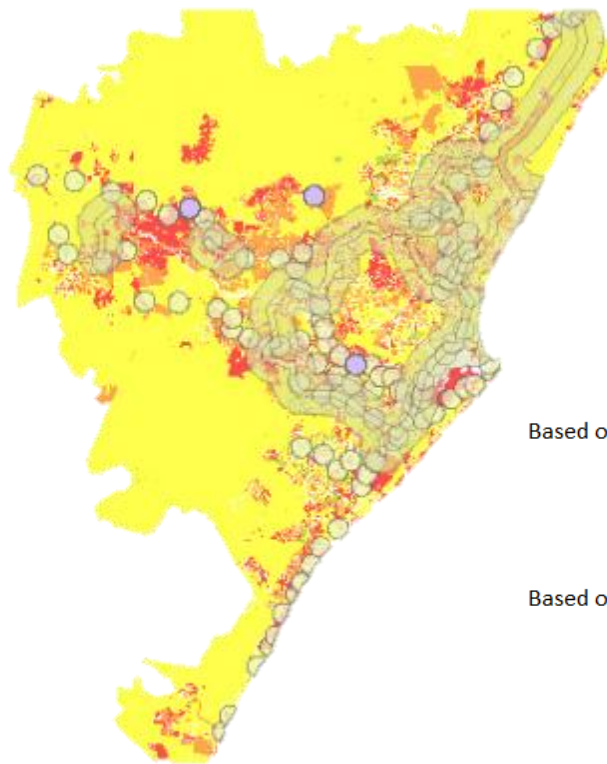
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Examples of scenarios simulated in different cities

CoJ: Alignment of growth with proposed policy interventions 2001 - 2030



eThekweni mass transit scenario 2001 - 2030



Based on total HPPTN area

	Households	Area (ha)	Gross density (hu/ha)
Base Scenario	555 779	73 618	7.5
Blue Sky Scenario	595 238	73 618	8.1

Based on area of residential land uses in HPPTN

	Households	Area (ha)	Gross density (hu/ha)
Base Scenario 2030	555 779	63 192	8.8
Blue Sky Scenario 2030	595 238	63 192	9.4

	Households	Area (ha)	Gross density (hu/ha)
All development 2008 - 2030 inside HPPTN	742 778	63 192	11.8

Conclusions

- Significant densification within corridors unlikely to happen due to market forces
 - An independent study in Ekurhuleni concluded that initial target densities also not achievable
- More work required on the factors that influence household location choices in SA. Some evidence that:
 - South Africans are prepared to (and do) commute over long distances
 - Exacerbated by scarcity of employment
 - 75% of the Gauteng population already lives within 10 minute walk from taxi, bus or train (GCRO Quality of Life Survey 2011)

Synthetic population

- As agent-based models UrbanSim and MATSim require:
 - Synthetic population of households, persons and jobs
 - Households by income, age, size, children, population group
 - Persons by income, age, population group
 - Jobs by Standard Industry Classification
- Procedure based on iterative proportional updating:
 - Developed at Arizona State University
 - Straightforward in the USA based on US Census Bureau Public-Use Microdata Samples (PUMS) and SF3 files
 - STATSA equivalents: 10% sample and SUPERCROSS but significant pre-processing required (done with R scripts)
 - STATSA sub places (SP) closest match to Public Use Microdata Areas. Median of 822 households per SP in Gauteng

Synthetic population ...

- Iterative Proportional Updating
 - Developed from more general iterative proportional fitting for improved synthetic person results
 - Provides a mechanism to derive joint distributions from marginal distributions and then to sample synthetic households from 10% sample

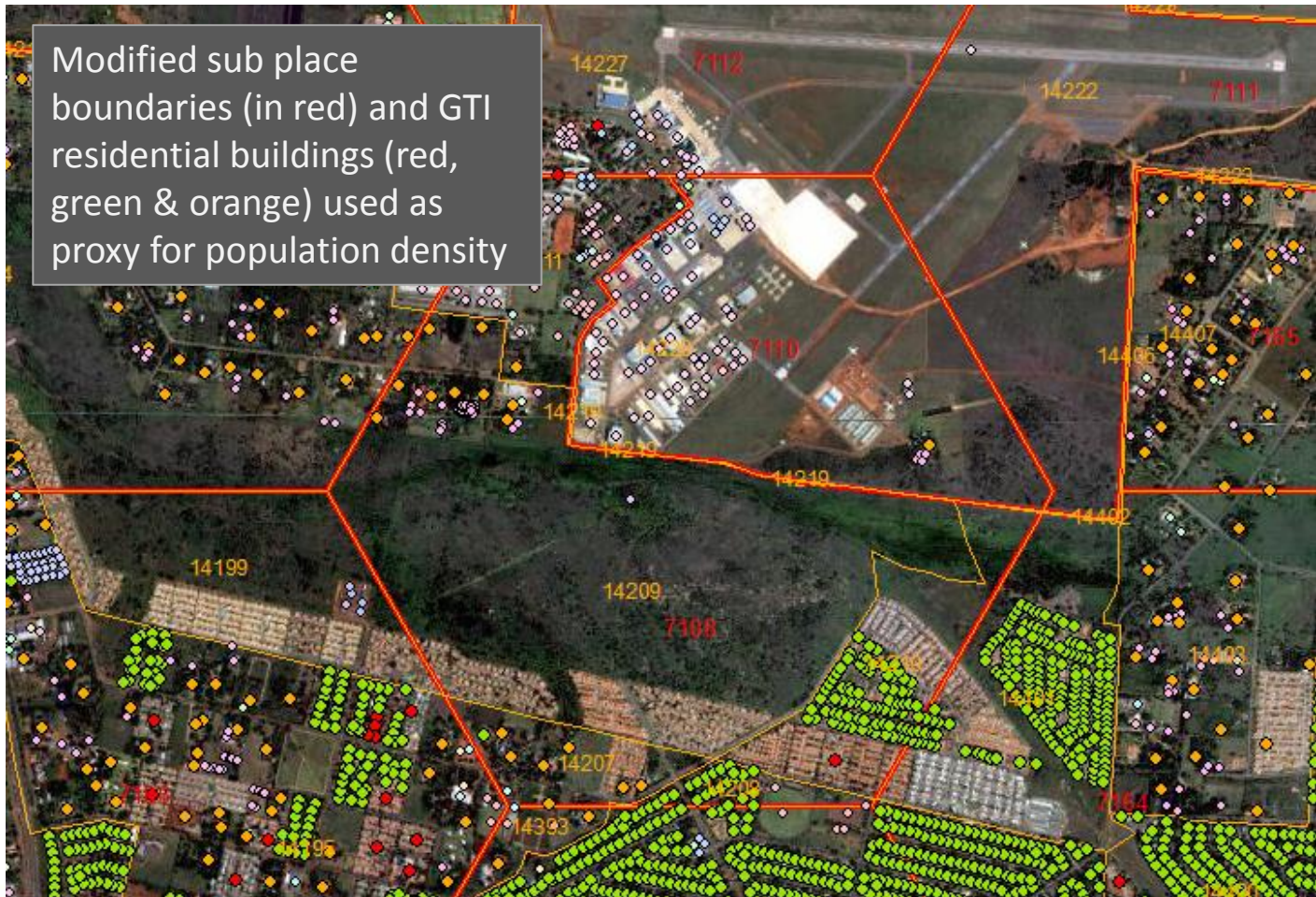
	A1	A2	Total
B1	?	?	46
B2	?	?	54
Total	80	20	100

- Lengthy procedure, runs for 7 days to complete Gauteng
- Urgently need 10% sample to progress with work

Validation

- Before Census 2011
 - Compared simulated growth between 2001 and 2009 with ‘actual’ growth in households derived from GTI Growth Indicators
 - Problem: Comparing households with dwelling counts
- After Census 2011
 - Busy comparing simulated growth between 2001 and 2011 with ‘actual’ growth in households from census at sub place geography
 - Problem: Sub place (SP) boundaries changed substantially
 - Problem: SPs in outlying areas too big for useful comparisons. Subdivide those greater than 75 percentile of SP areas ($\sim 3\text{km}^2$)
- Adjust using GTI household counts as proxy for population density

Validation ...



Validation ...

- Some peculiarities
 - SP 799045143 (2011)
 - Boundaries unchanged

	< R38k	>R38k	TOTAL	GTI
2001	70	124	194	94
2011	6	79	85	86

- 8 houses converted to businesses
- Resident domestic workers ?
- Parcels are intersected by SP2001, SP2011 and SA2011. This results in a large number of slivers
- Request: Please snap to previous boundaries were possible

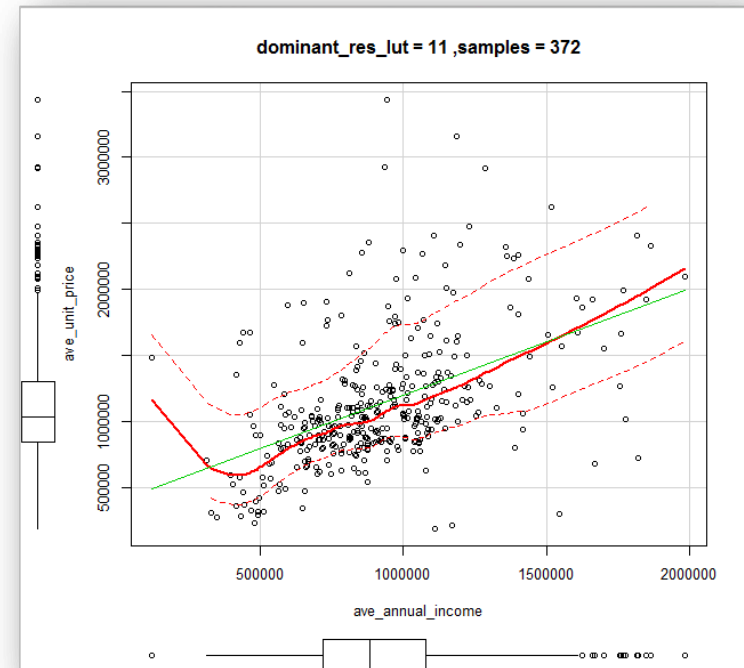


Affordability

- In the base year (2001 for validation and 2011 for simulation to 2040) households have to be associated with specific buildings



- Based on affordability
 - Average HH income per small area
 - Market value from valuation roll
- High unit price outliers map to security estates



Thank you



3D extensions due for release





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