Overview of Urban Growth Simulation

(with examples from different cities)

SAPI Seminar

28 August 2013

Outline

- Why Urban Growth Simulation?

- Essence of Modelling and Simulation

- Examples of outputs obtained

- Examples of scenarios from 3 cities

Why Urban Growth Simulation?

Unabated urbanisation

Quest for sustainable development

"Making cities sustainable is one of the most important missions of current generations. The planet requires that we move with haste towards sustainability and <u>because of the population concentrated in cities and the opportunities to gain efficiencies, cities are the most important arena for intervention</u> Maurice Strong

What makes a city sustainable?

Smart and compact cities
- Information and communication technology, curtailing sprawl through mixed-use and higher-density zoning
- Mass transit, bicycle and pedestrian oriented

Reduced carbon footprint
- Reduced resource consumption, recycling, renewable energy

Densification in SA cities

High Income

Mixed Middle High to High Income

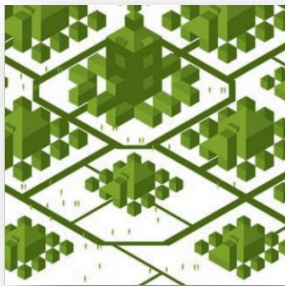
Middle High Income

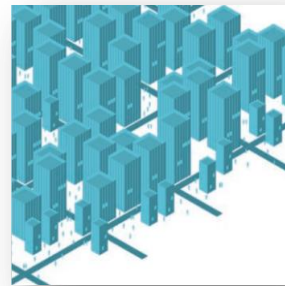Low Middle Income

Mixed Low to Middle Low Income

Low Income

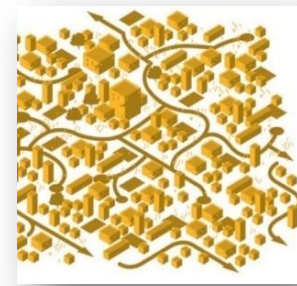# Different Approaches to Spatial Planning in SA

Metros use common instruments but with differences in emphasis and in different combinations: Highly dependent on context.

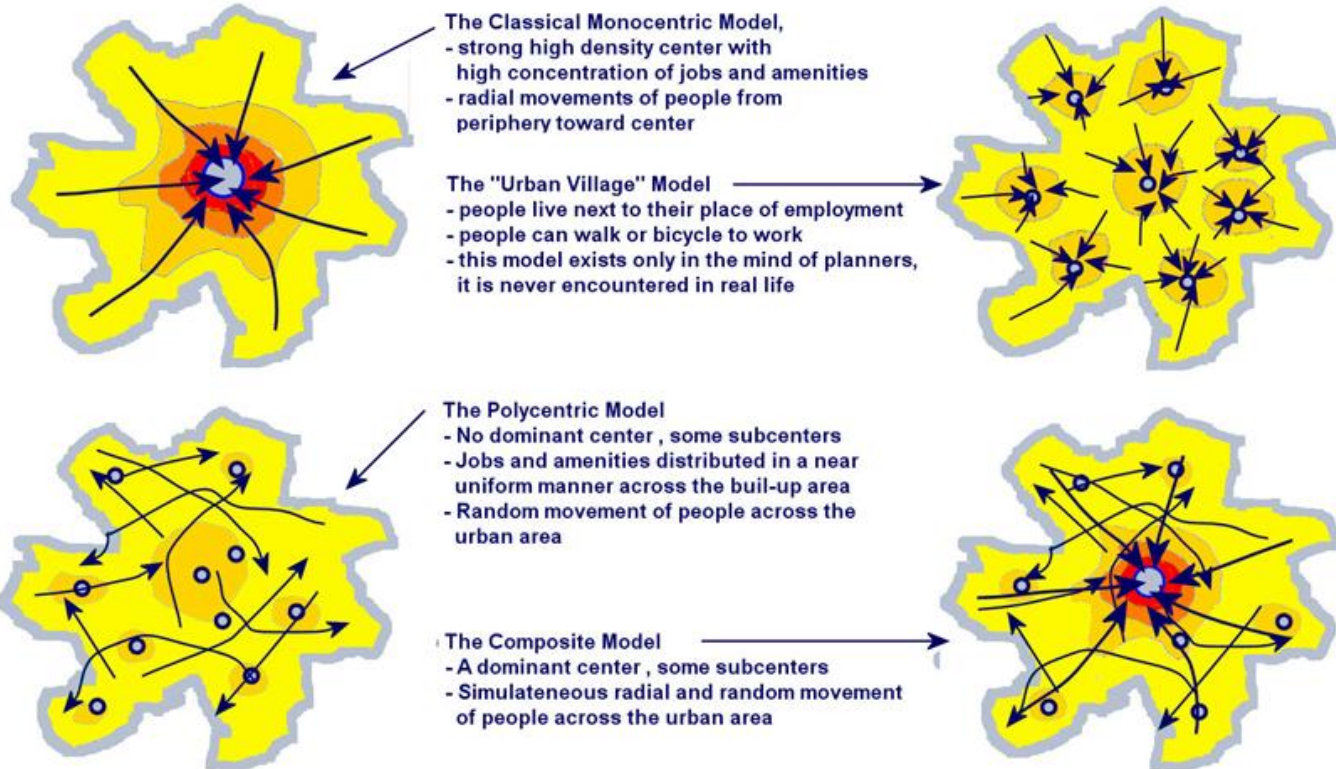**Transit orientated approach**

Urban management approach

Sustainable community unit approach

Different Approaches to Spatial Planning in SA

THE MOST COMMON URBAN SPATIAL STRUCTURES

The Classical Monocentric Model,
- strong high density center with high concentration of jobs and amenities
- radial movements of people from periphery toward center

The "Urban Village" Model
- people live next to their place of employment
- people can walk or bicycle to work
- this model exists only in the mind of planners, it is never encountered in real life

The Polycentric Model
- No dominant center , some subcenters
- Jobs and amenities distributed in a near uniform manner across the buil-up area
- Random movement of people across the urban area

The Composite Model
- A dominant center , some subcenters
- Simulateneous radial and random movement of people across the urban area
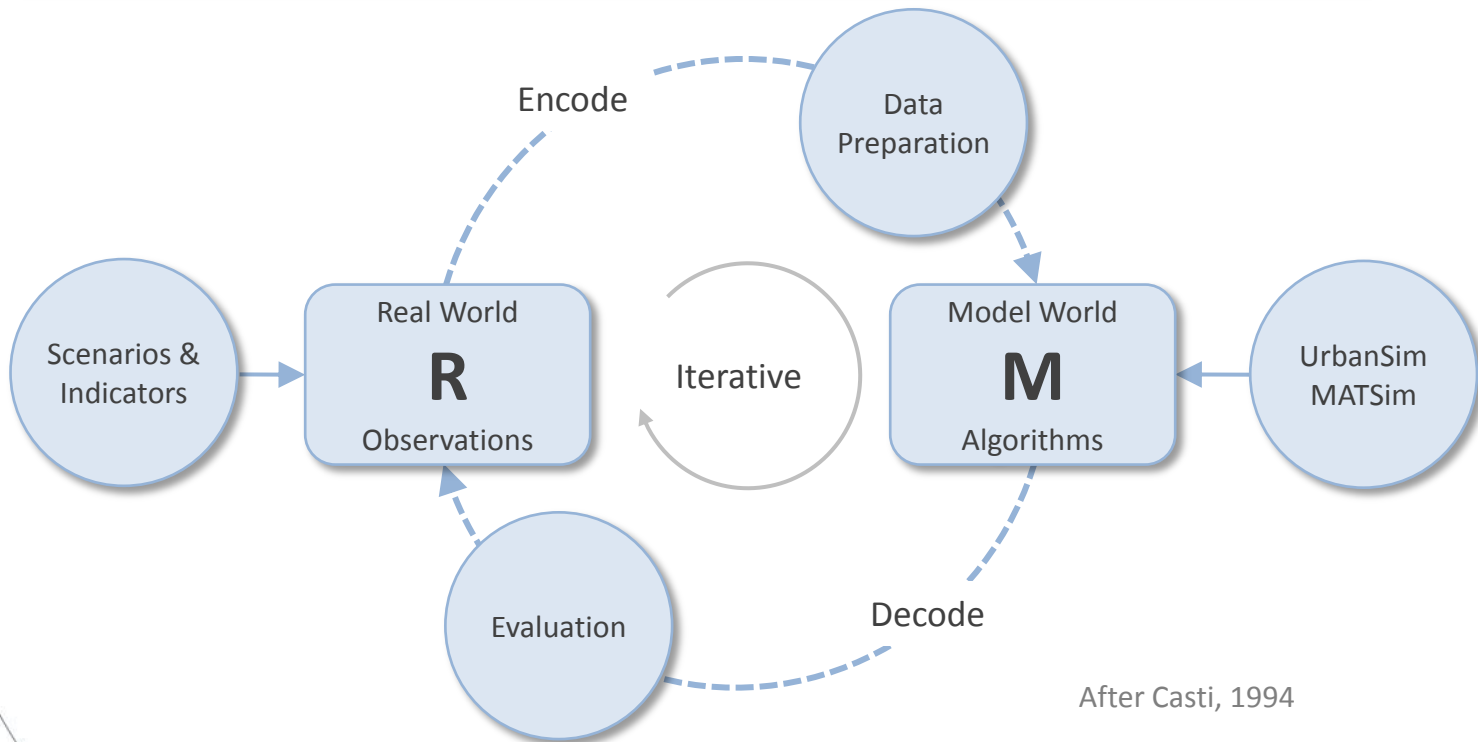
"Order Whithout Design" Bertaud 2006 (unpublished)
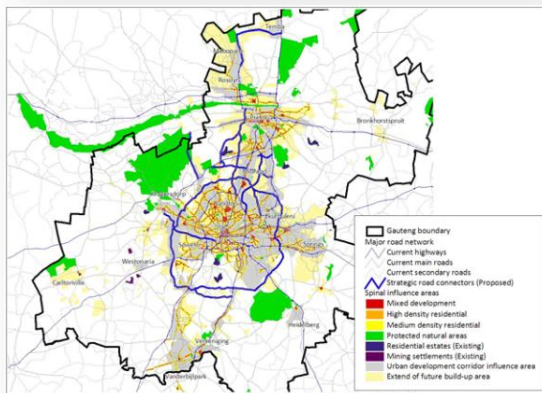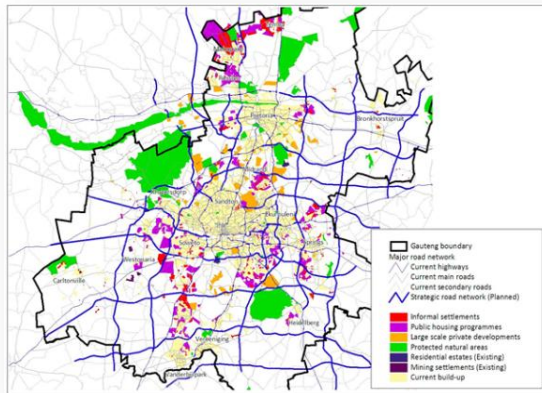
Modelling and Simulation

Process Overview

Why Urban Growth Simulation ?
It provides a risk free means of assessing the likely future outcome of major policy and investment decisions that affect everybody in city

Encode

Data Preparation

Scenarios & Indicators

Real World

R

Observations

Iterative

Model World

M

Algorithms

UrbanSim MATSim

Evaluation

Decode

After Casti, 1994

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
- Government low-cost housing in accessible areas.

Living Laboratory Process

- Living Laboratory Processes followed in three metropolitan areas
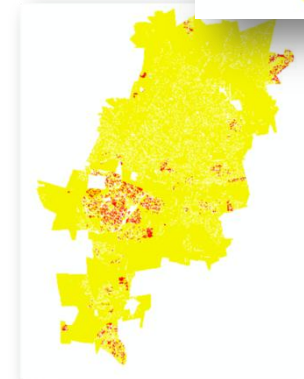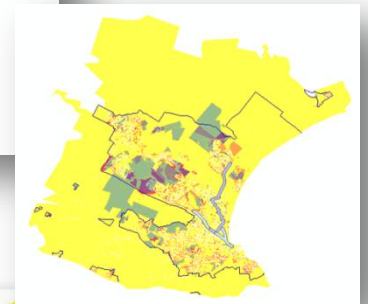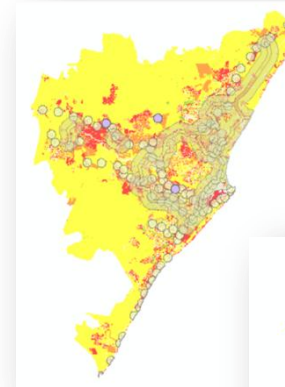
- A Living Laboratory comprises a series of interactive work sessions with **end users** in **real life contexts** to ensure:

  - the participation and collaboration of relevant municipal stakeholders; in the

  - process of developing, testing and applying the urban simulation platform.

Data Preparation

From a variety of data sources:

Control Totals
Households by income, age, children, cars …
Employment by Standard Industry Classification

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

Land and buildings
Property boundaries (~2 300 000)
Classify by typology of ~50 classes
Type of building and market value

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

Study area
In the case of Gauteng whole province must be modelled due to mobility of people between cities

# 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 encoded into **M**?
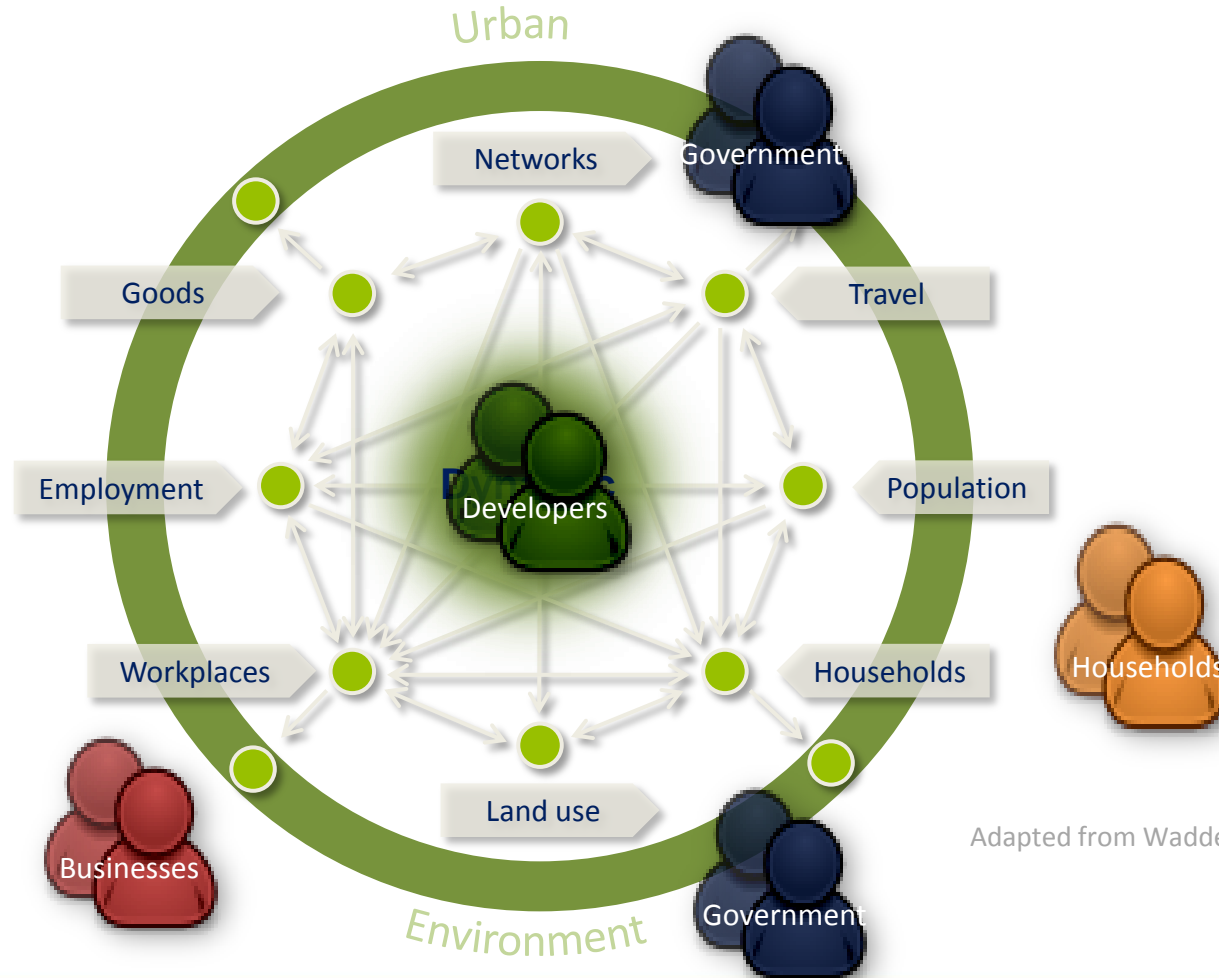
Adapted from Waddell, 2005

Settlement typology

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

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

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

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

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,

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
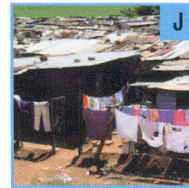
27M: Tin Town

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
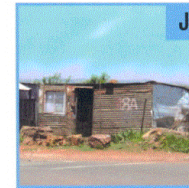
28M: eKaya

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

6T: Rusty Blues Town

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

7T: Young Blues Town

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

8T: Basic Town

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

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

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
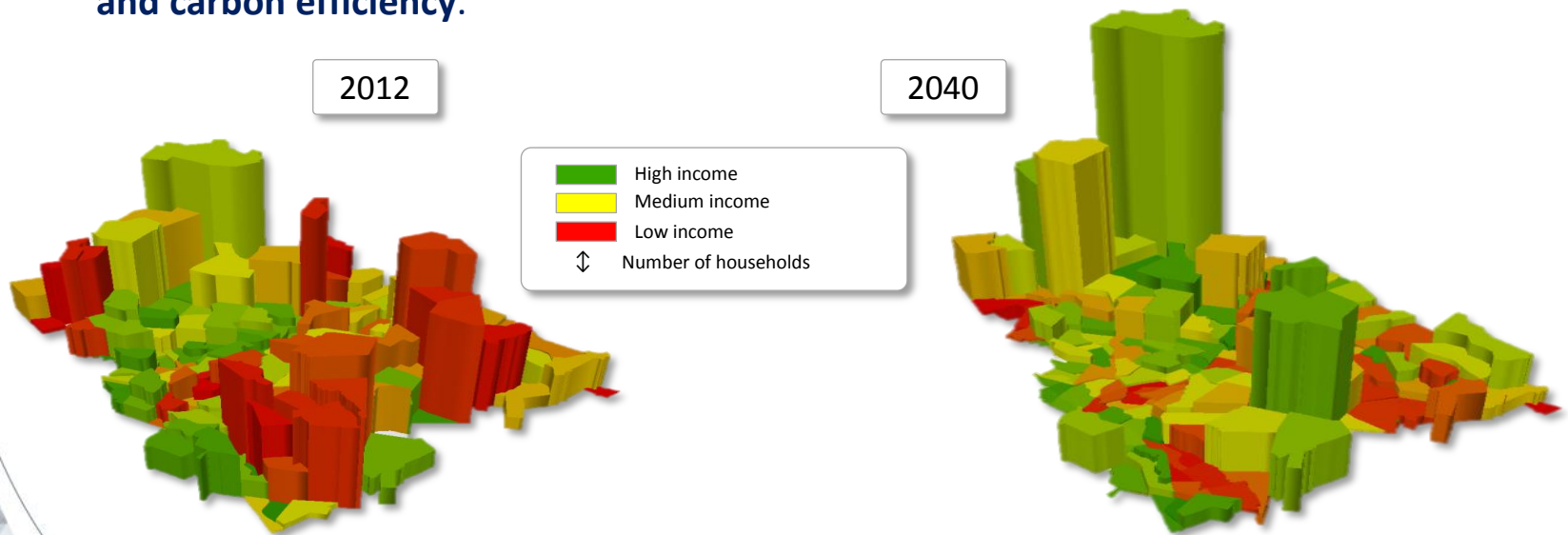
Currently based on Knowledge Factory Cluster+

Objective

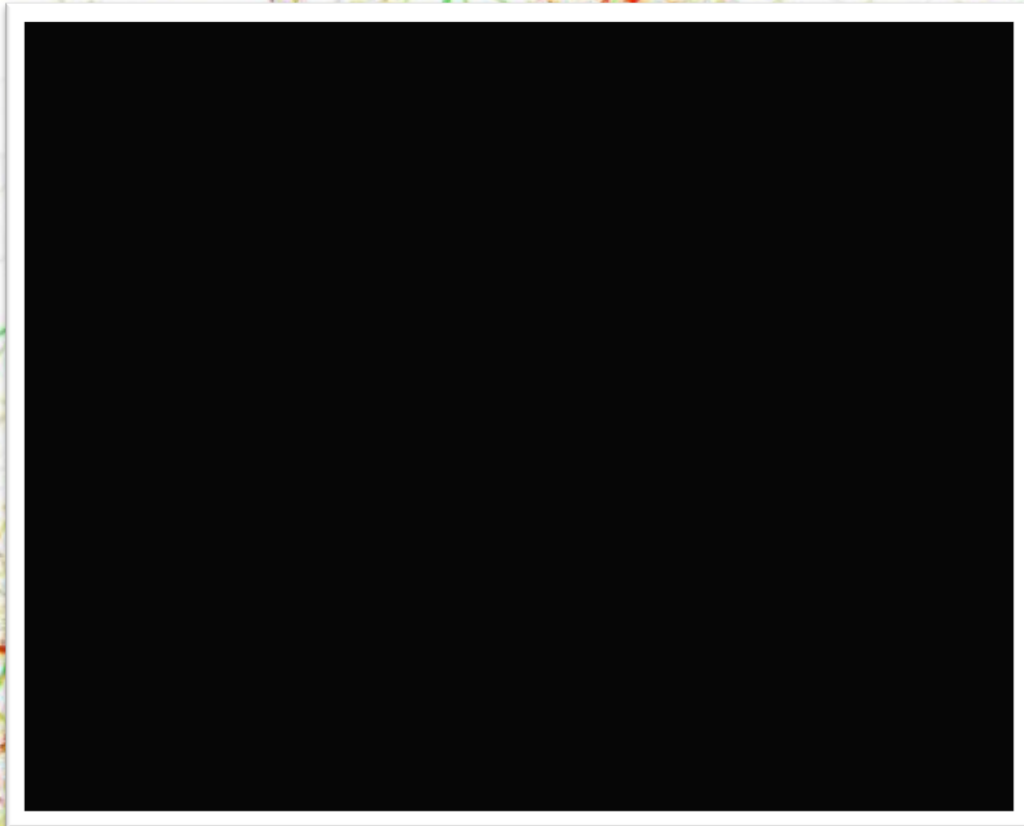Simulate spatial expansion on an annualised basis for a 30 year period to better understand:

– Future patterns of **demand for infrastructure, facilities and services** such as water, electricity, sanitation, schools, clinics and hospitals.

– How future urban form may **impact on the sustainability our cities** by using indicators such as travel time and cost, access to social and economic opportunities and **energy and carbon efficiency**.
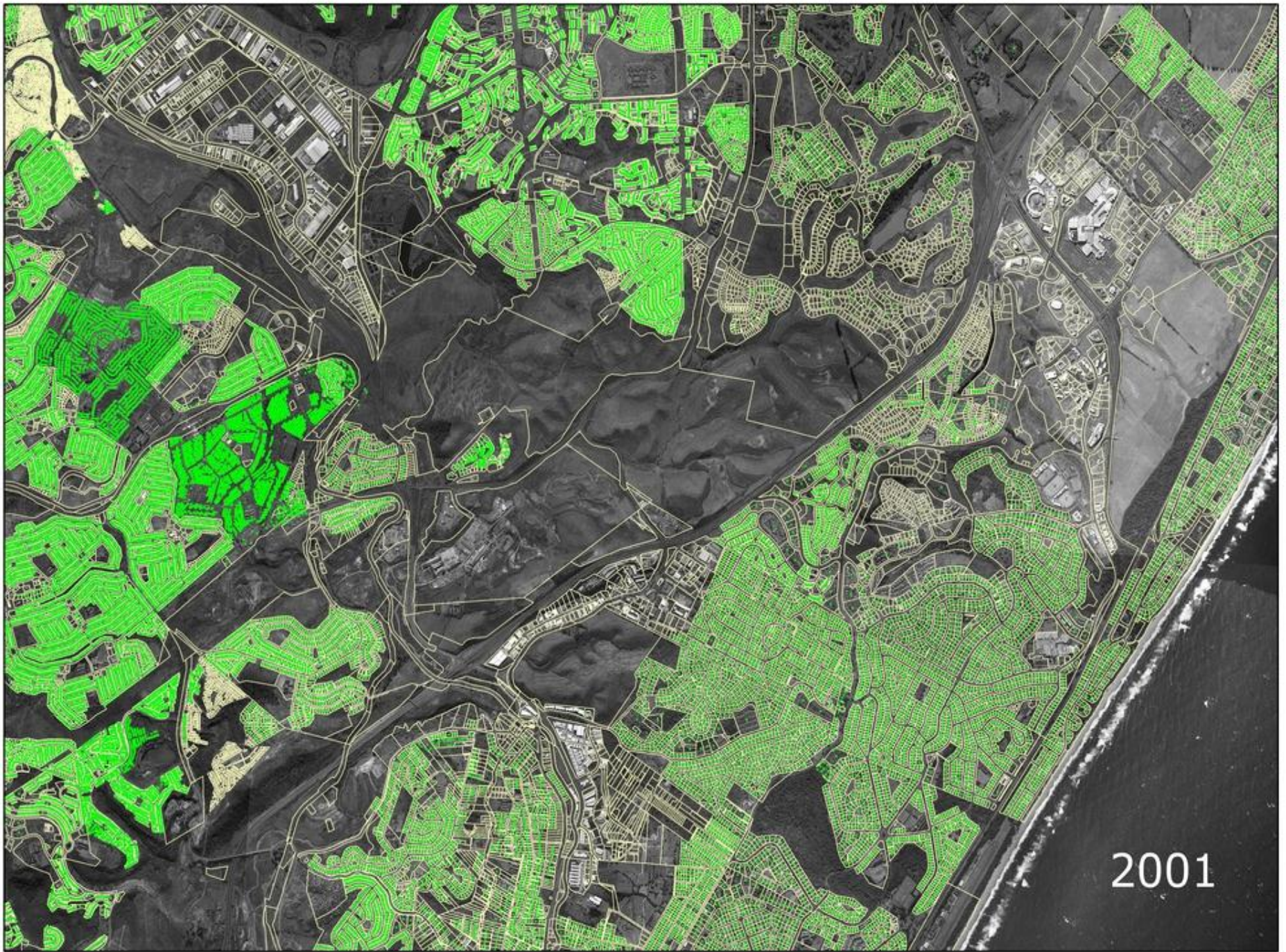
2012

2040

High income
Medium income
Low income
⇕ Number of households

Examples of typical output

analysis

monitoring travel speed
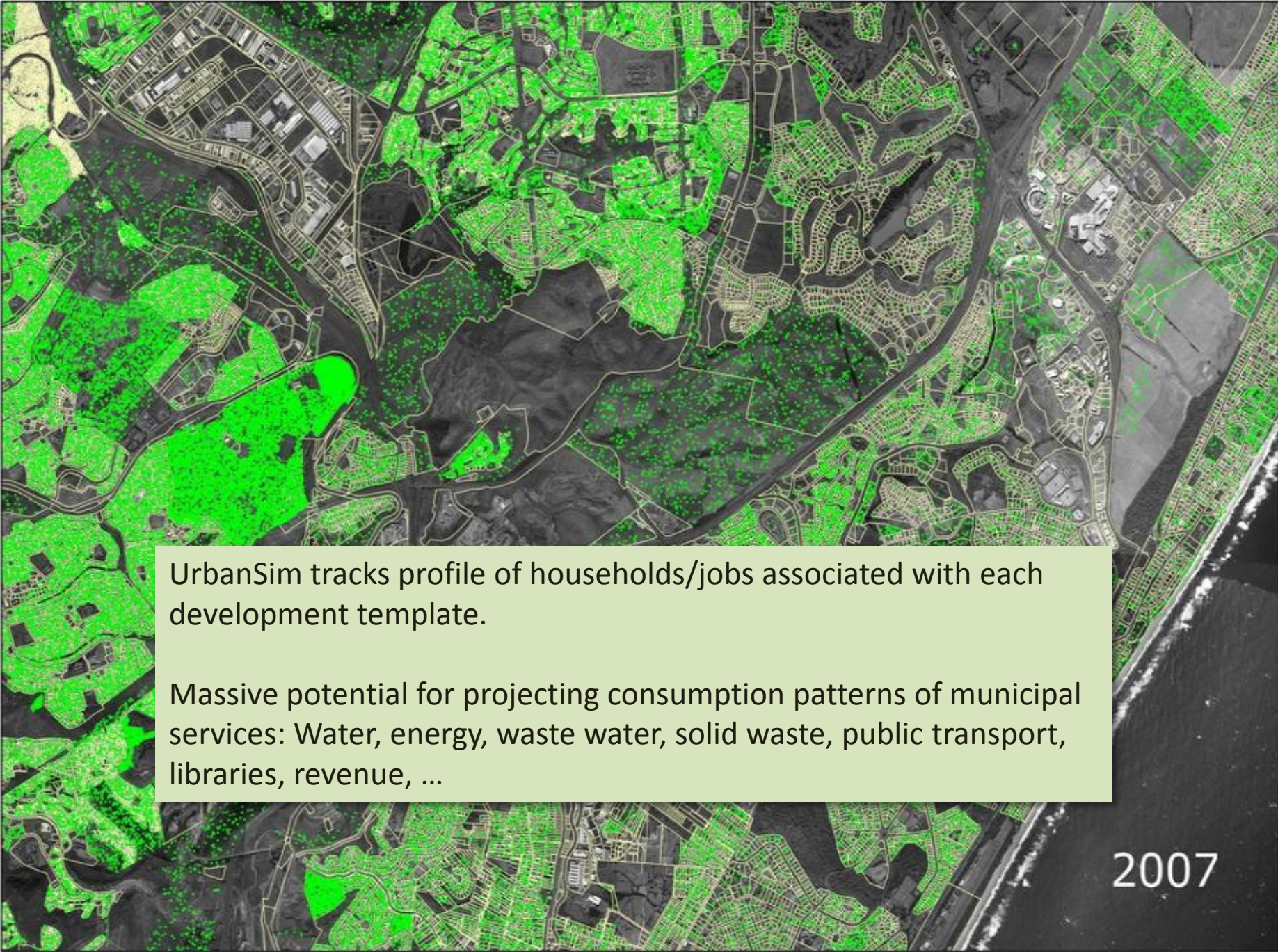
2001

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, ...
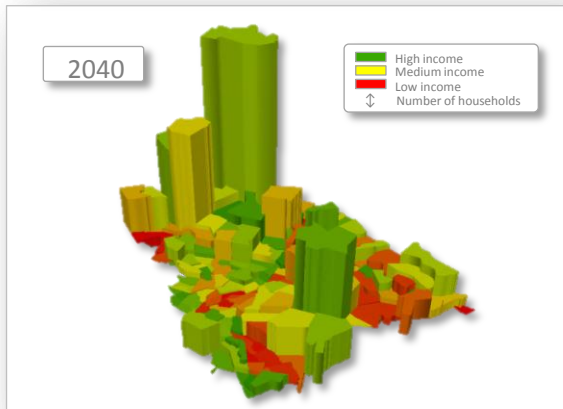
2007

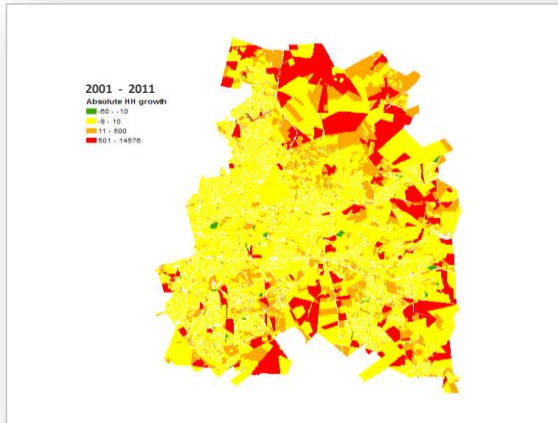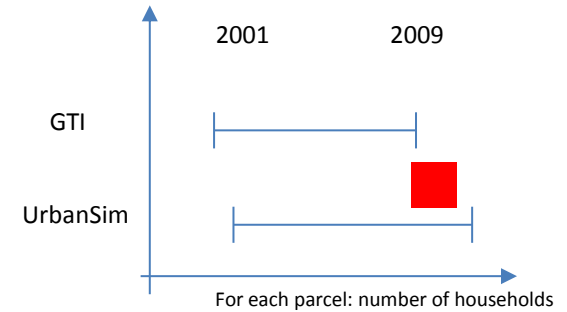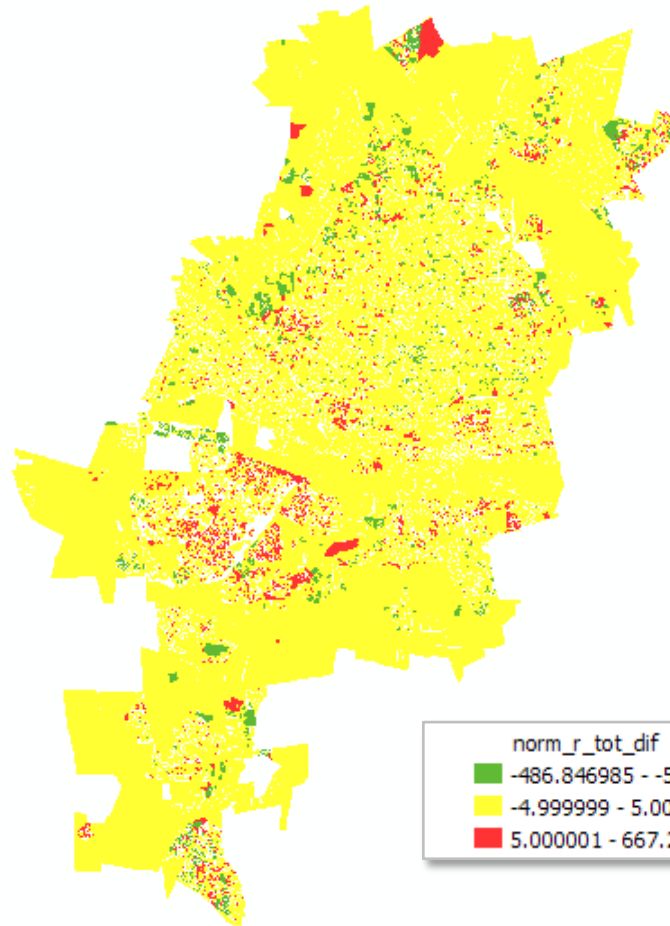# Evaluation

Evaluation of results

Validation
- Based on simulating a period in the past.
- Compare results with actual growth during the same period.
- Unique opportunity: Census 2001 to Census 2011.
- Requires synthetic population to be generated for Gauteng from 10% sample of Census 2001.
- Onerous but the best way to build trust.

Evaluation against expert opinion
- Simulating the future.
- Requires synthetic population to be generated from 10% sample of Census 2011 (Expected Sept).
- Conducted in Living Laboratory setting.

Relative growth (ΔSim − ΔGTI) normalised by parcel area

2001   2009

GTI

UrbanSim

For each parcel: number of households

Units / ha

norm_r_tot_dif
- -486.846985 - -5.000000
- -4.999999 - 5.000000
- 5.000001 - 667.260010

Detail view

Normalised growth (ΔSim − ΔGTI) aggregated to TAZ

For each parcel: number of households

Units / ha

norm_z_r_tot_dif
- -5.229600 - -2.000000
- -1.999999 - 2.000000
- 2.000001 - 50.000000
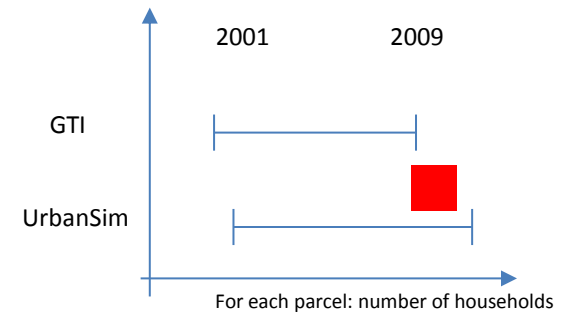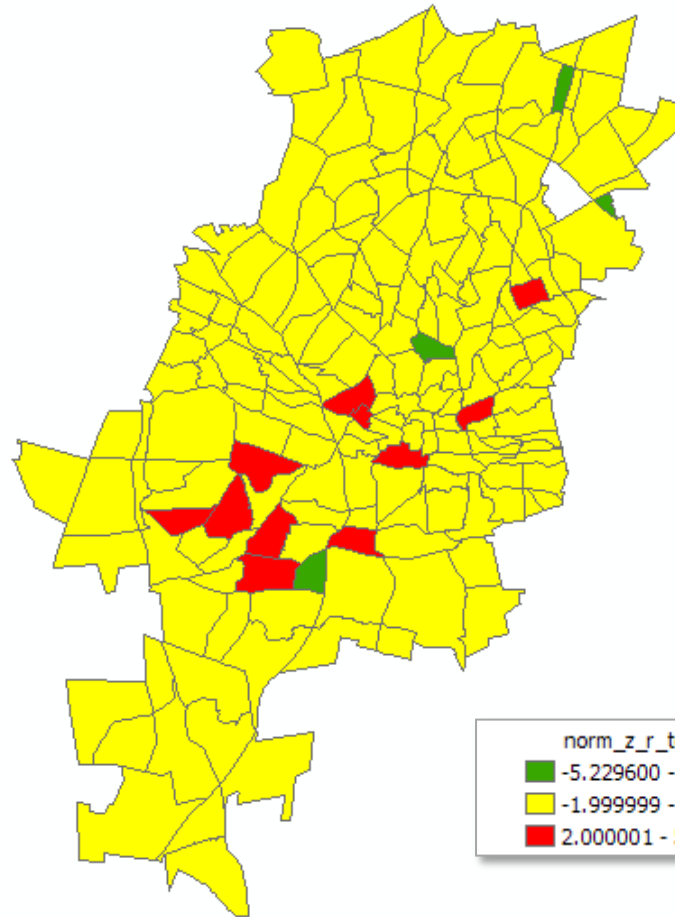
Normalised growth (ΔSim − ΔGTI) aggregated TAZ

Different category breaks

2001   2009

GTI

UrbanSim

For each parcel: number of households

Units / ha

norm_z_r_tot_dif
- -5.229600 - -5.000000
- -4.999999 - 5.000000
- 5.000001 - 50.000000
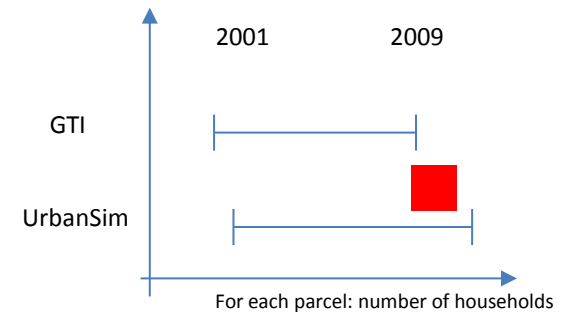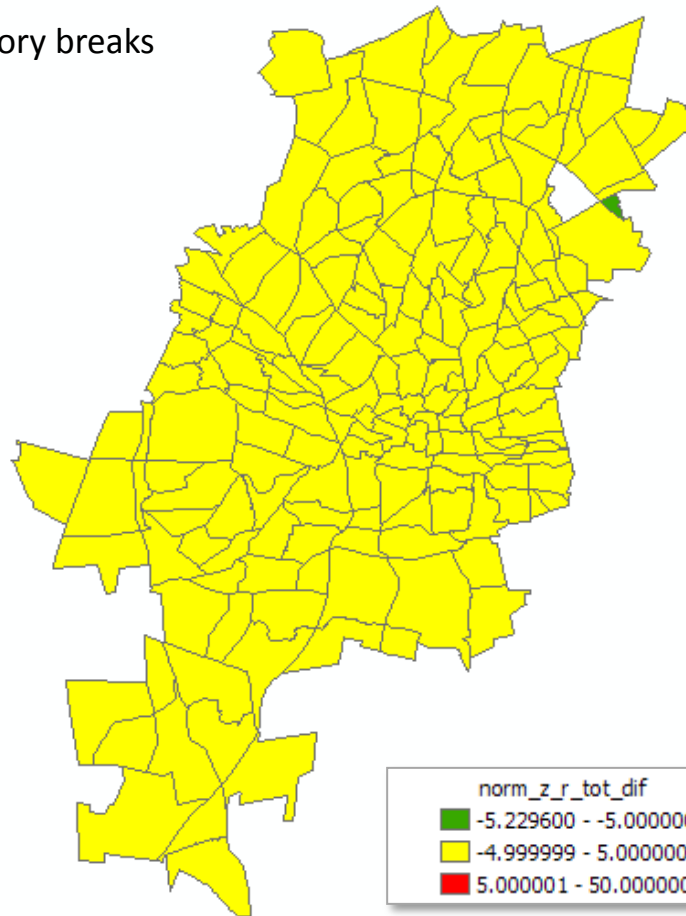
CoJ: Backyard shacks 2001-2007
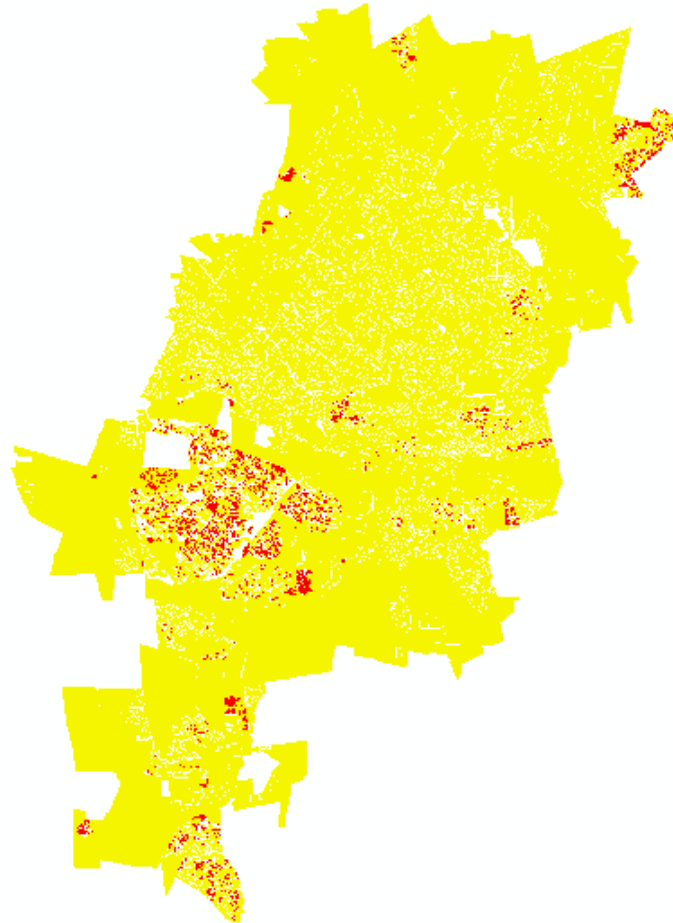
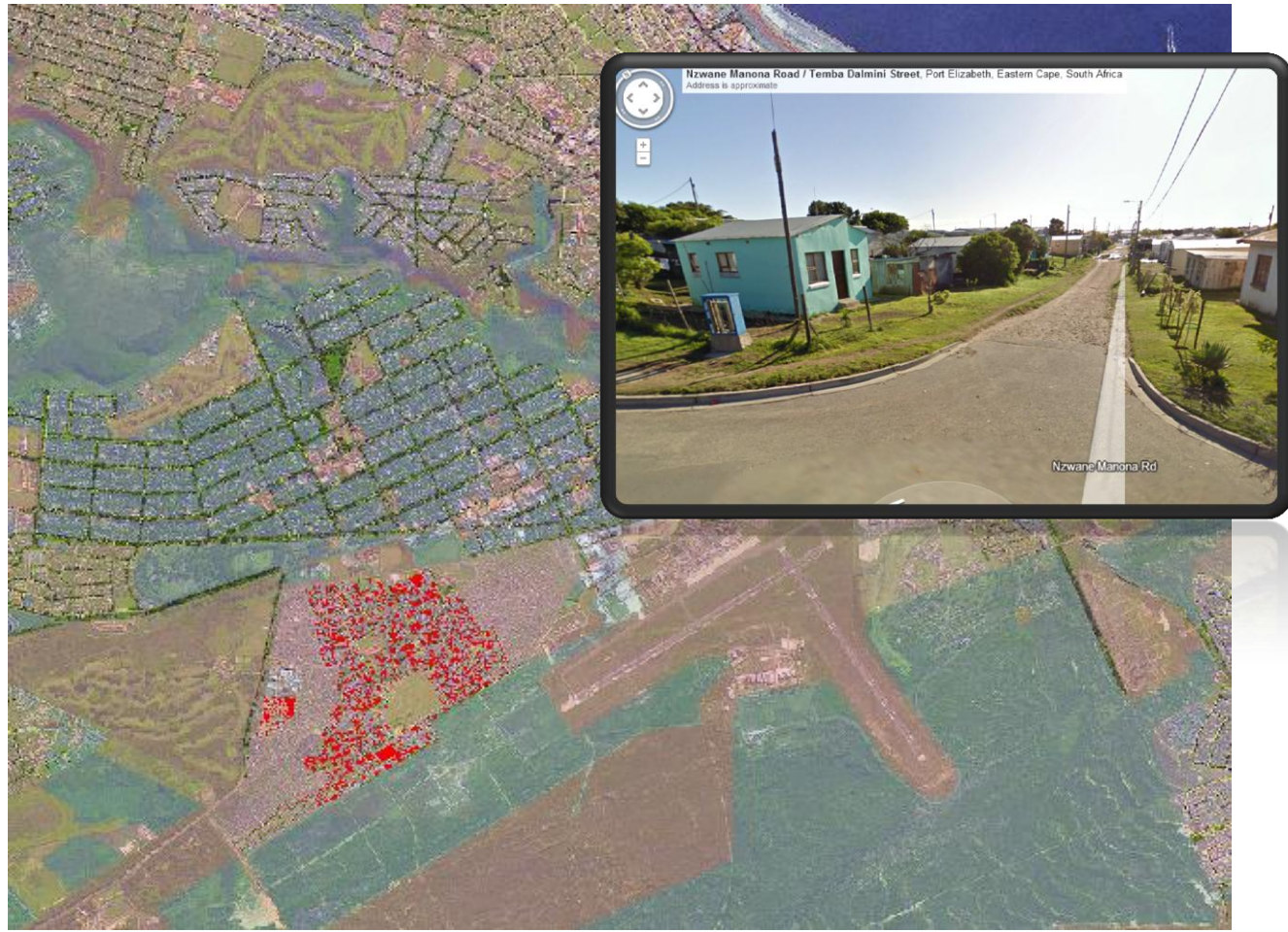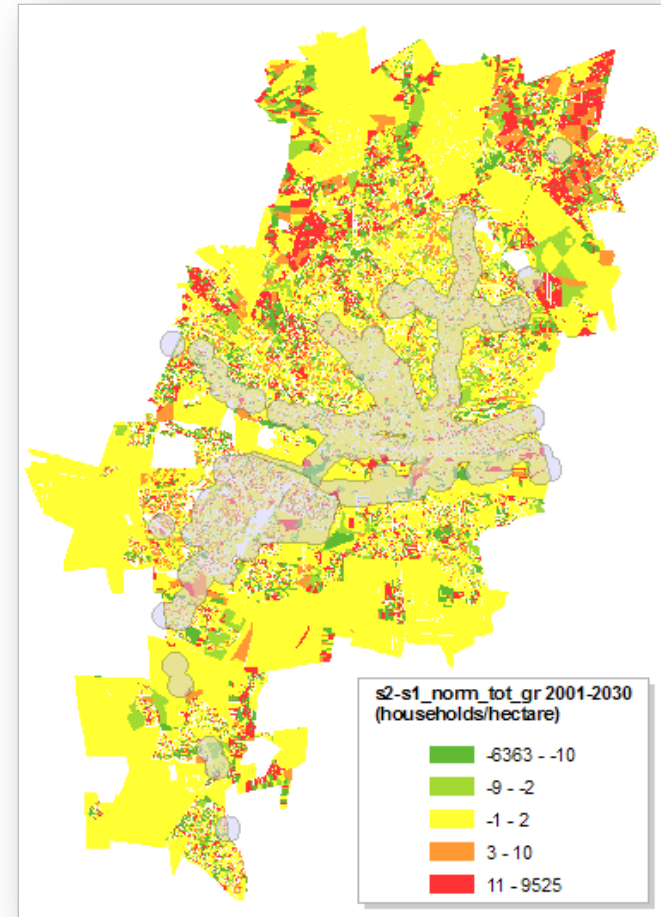# NMBM: Backyard shacks

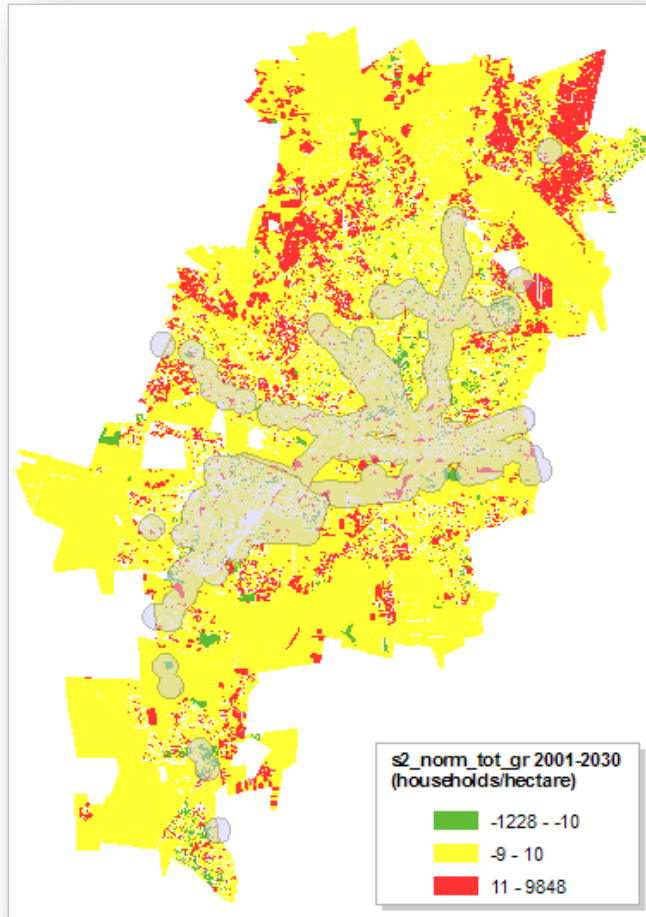# Examples of scenarios simulated from different cities

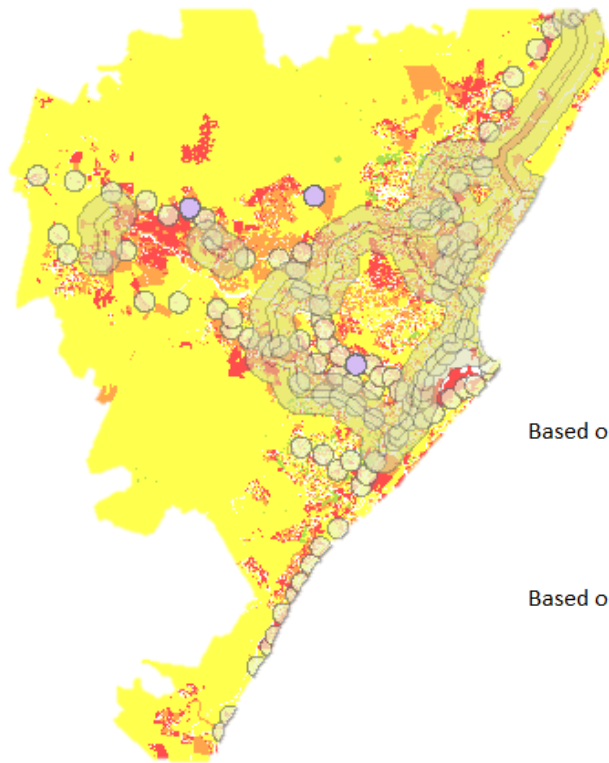# CoJ: Alignment of growth with proposed policy interventions 2001 - 2030

s2_norm_tot_gr 2001-2030
(households/hectare)

🟩	-1228 - -10
🟨	-9 - 10
🟥	11 - 9848

s2-s1_norm_tot_gr 2001-2030
(households/hectare)

🟩	-6363 - -10
🟩	-9 - -2
🟨	-1 - 2
🟧	3 - 10
🟥	11 - 9525

eThekwini mass transit scenario 2001 - 2030

p_norm_tot_gr
- -230 - -100
- -99 - -10
- -9 - 0
- 1 - 10
- 11 - 147
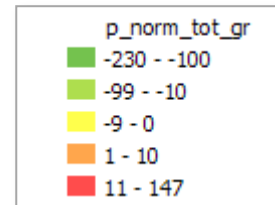
Based on total HPPTN area

	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

NMBM: Growth within priority projects

29% by number of households
(31 176 / 108 354)

s2 2011 - 2030
p_tot_gr
- -2704 - -100
- -99 - -5
- -4 - 0
- 1 - 5
- 6 - 7595
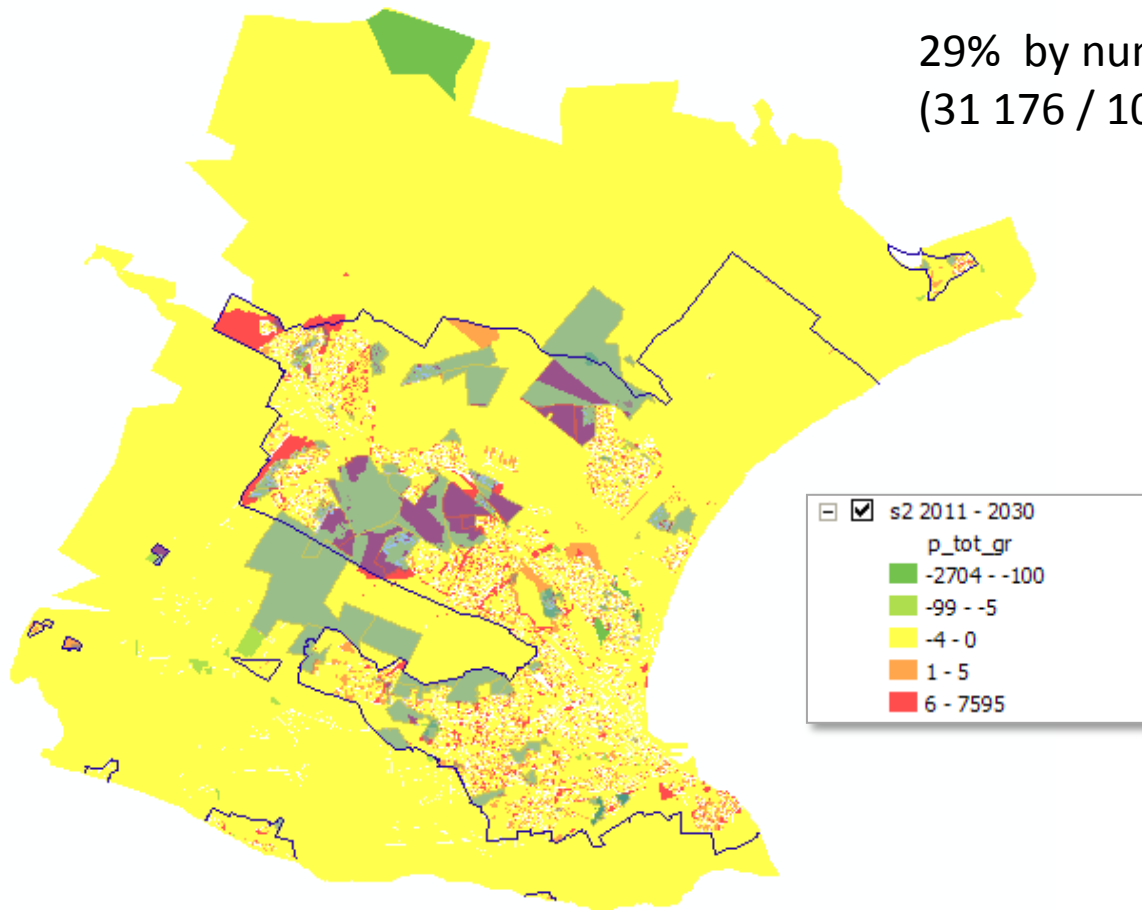
Detail view: Jachtvlakte
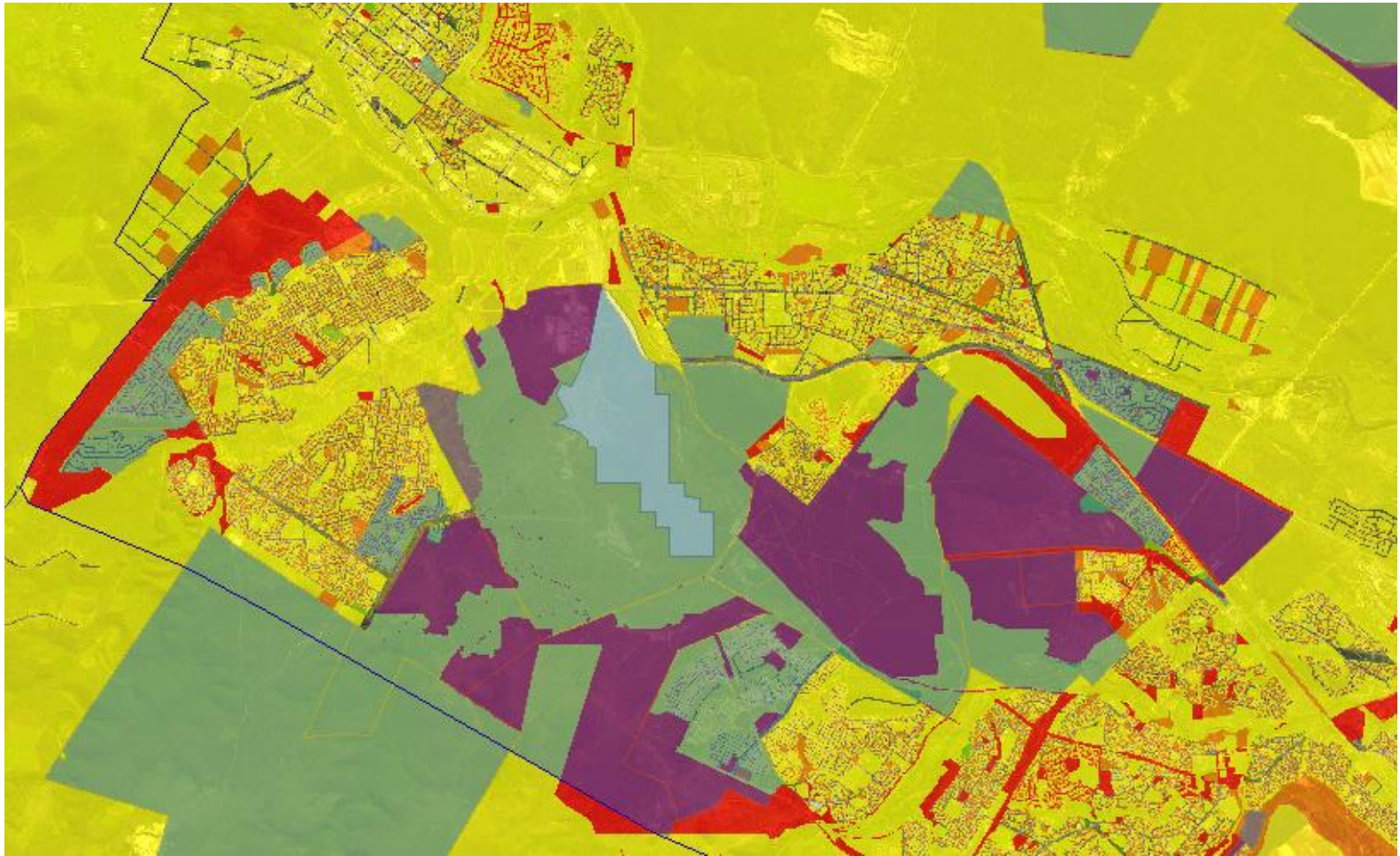
Effect of urban growth boundary

Growth 2011 - 2030

	Inside UGB	Outside UGB	Total	% Outside
S1	98 096	10 258	108 354	9.5
S2	112 887	-4 533	108 354	-4.2

s1 2011 - 2030
p_norm_tot_gr
-128 - -100
-99 - -10
-9 - 10
11 - 100
101 - 196
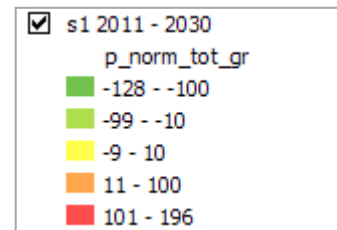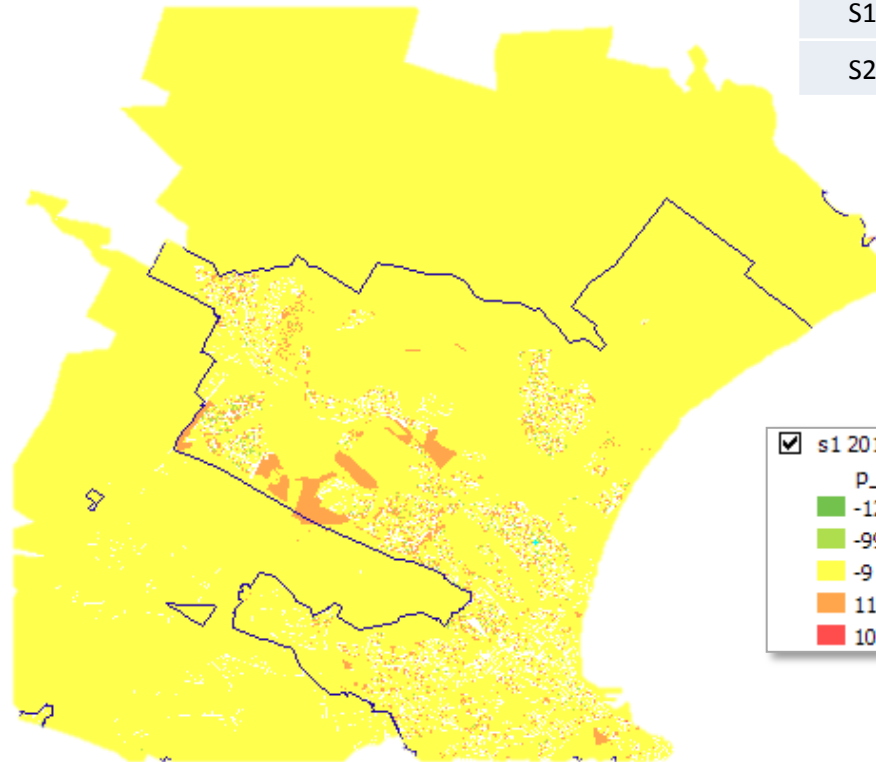
Examples of Indicators

Spatial inequality

Indicators	2007	Baseline Scenario	Policy Scenario
Wealth segregation	61% pop South 91% Low-income	60% pop South 90% Low-income	52% pop South 78% Low-income
Distribution and quantity of economic nodes and centres	82% com North 312 patches 127 HH/Ha 18% com South 143 patches 903 HH/HA	80% com North 325 patches 191 HH/Ha 20% com South 144 patches 1152 HH/Ha	67% com North 371 patches 221 HH/Ha 33% com South 221 patches 489 HH/Ha

Density patterns

Indicators	2007	Baseline Scenario	Policy Scenario
Amount and location of change (Urban Sprawl)	58% Built-up 15.8 hh/ha	86% Built-up 19 hh/ha	72% Built-up 22 hh/ha
Densification of transport management nodes	376460 hh Low-rise 42% Mixed 30% Small-holdings 15%	514420 hh Mixed 45% Low-rise 38%	673941 hh Government 61% Mixed 32%

Commuting distances

Indicators	2007	Baseline Scenario	Policy Scenario
Access to Gautrain	169939 hh	259635 hh 56% high income	417836 hh 59% low income
Access to BRT	508037 hh	669691 hh Majority low-income	879173 hh Majority low-income Additional 200000 low-income access
Access to Metrorail	487828 hh	740900 hh Low-income (mixed + informal)	825935 hh Low-income (mixed + government)

Thank you

3D extensions due for release