

Enabling Dynamic Interoperability between Indicators - the key to Evidence-based Policy Making



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eResearch Lab

The University of Queensland



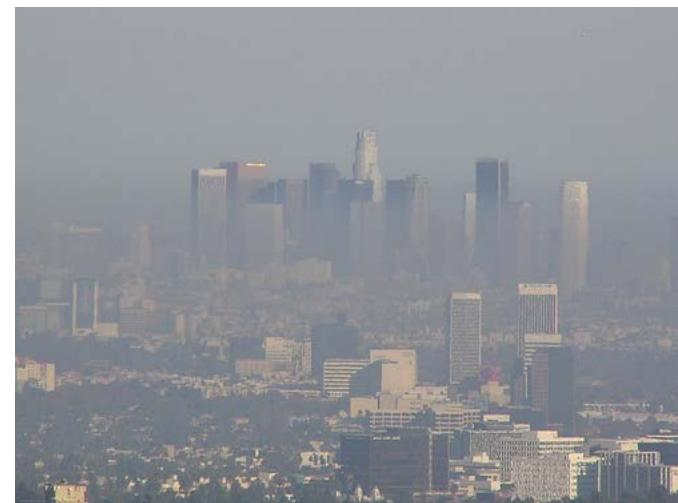
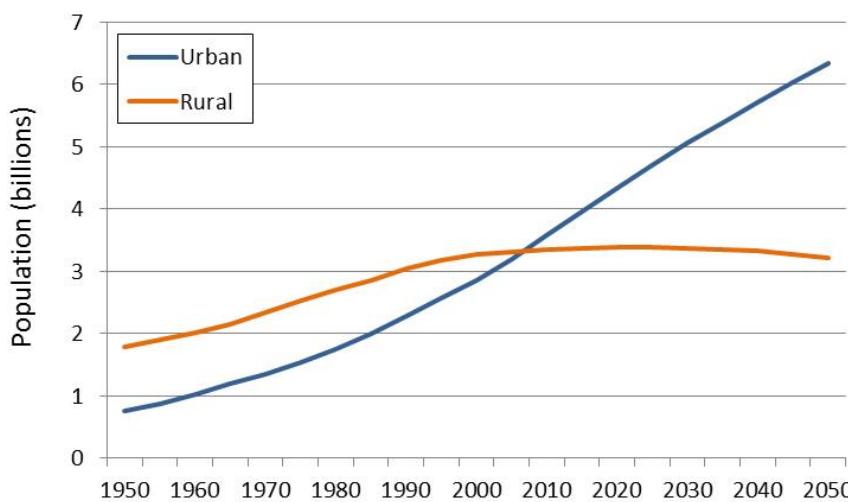
THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

Overview

- Indicators - Discovery, Re-use & Interoperability
- Related work
- Indicator Ontology
- Integrated Architecture – Datasets, Analyses, Visualization
- 3 Example Applications
 - UADI - Reducing Urban Carbon Emissions
 - Indigenous Housing
 - Environmental Resource Management
- Extensions
 - Evidence-Based Policy Making Ontology
 - R Statistical Analysis tools -> Correlations/Dependencies
 - Hypothesis testing

Indicators

- Measure attributes/monitor trends in areas of concern – focussing on a specific region and point in time/period
- Focus of this work – City Indicators
- > 50% population live in cities -> 66% by 2050 *
- Cities generate ~70% of green house gas emissions (UN Habitat)



* <https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf>

Indicators - measure, monitor, manage *Urban Development*

Economic

- Gross Domestic Product
- Wealth Distribution/Poverty
- Employment rate

Environmental

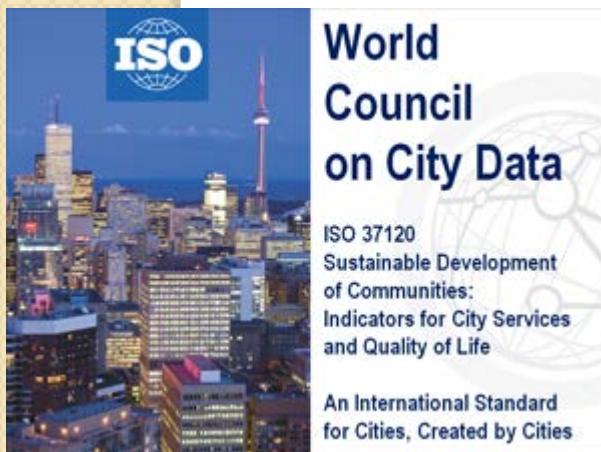
- Water Quality:
- Turbidity , Salinity, Temperature, Dissolved Oxygen, pH, Secchi depth, Nitrogen, Phosphorus and Chlorophyll
- Air Quality

Social

- Quality of Urban Life/Livability of a City
 - purchasing power, safety, health, commute time, pollution
 - index. = 65 + purchasingPowerInclRentIndex - (priceToIncomeRatio * 2) - cpiIndex / 5 + safetyIndex * 3 / 4 + healthIndex / 2 - trafficTimeIndex / 2 - pollutionIndex;

Sustainable City Indicators

- Global City Institute
- ISO 37120 Sustainable Development of Communities – Standardized Indicators for City Services and Quality of Life
- enable any sized city to measure its social, economic, and environmental performance in relation to other cities
- 20 themes



City Services

Education
Energy
Finance
Recreation
Fire & Emergency Response
Governance
Health
Safety
Solid Waste
Transportation
Urban Planning
Wastewater
Water

Quality of Life

Civic Engagement
Culture
Economy
Environment
Shelter
Social Equity
Technology And Innovation

→ Health

Number of in-patient hospital beds per 100,000 population
Number of physicians per 100,000 population
Average life expectancy
Under age five mortality per 1,000

ECONOMICS

Production & Resourcing
Exchange & Transfer
Accounting & Regulation
Consumption & Use
Labour & Welfare
Technology & Infrastructure
Wealth & Distribution

Organization & Governance
Law & Justice
Communication & Movement
Representation & Negotiation
Security & Accord
Dialogue & Reconciliation
Ethics & Accountability

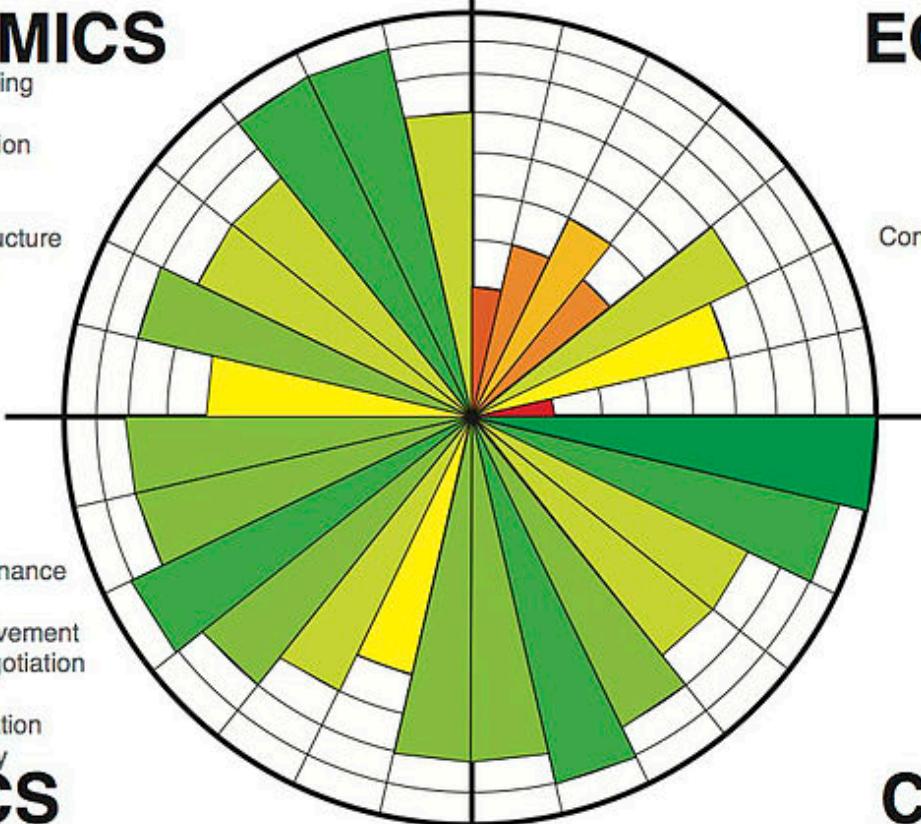
POLITICS

ECOLOGY

Materials & Energy
Water & Air
Flora & Fauna
Habitat & Food
Place & Space
Constructions & Settlements
Emission & Waste

Engagement & Identity
Recreation & Creativity
Memory & Projection
Belief & Meaning
Gender & Generations
Enquiry & Learning
Health & Wellbeing

CULTURE



- Vibrant
- Good
- Highly Satisfactory
- Satisfactory+
- Satisfactory
- Satisfactory-
- Highly Unsatisfactory
- Bad
- Critical

Melbourne 2011

CIRCLES OF SUSTAINABILITY

World Bank Indicators



- Agriculture & Rural Development
- Aid Effectiveness
- Climate Change
- Economy & Growth
- Education
- Energy & Mining
- Environment
- External Debt
- Financial Sector
- Gender
- Health
- Infrastructure
- Poverty
- Private Sector
- Public Sector
- Science & Technology
- Social Development
- Social Protection & Labor
- Trade
- Urban Development

Green City Index

CO2

- CO2 emissions
- CO2 intensity
- CO2 reduction strategy

Energy

Buildings

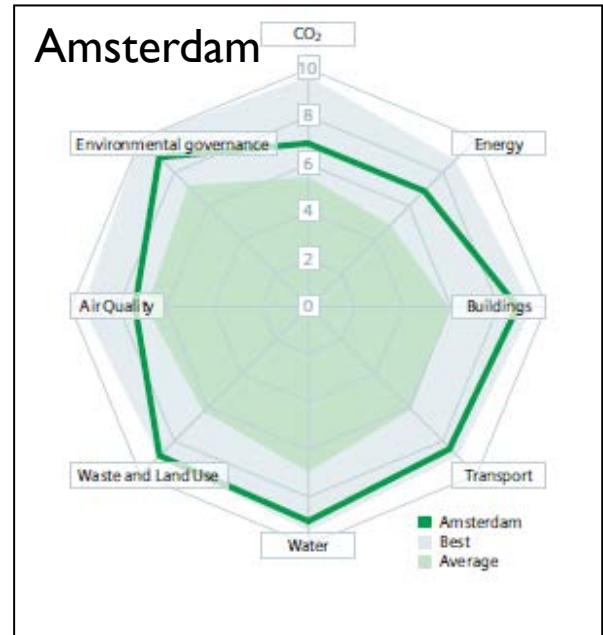
Transport

Water

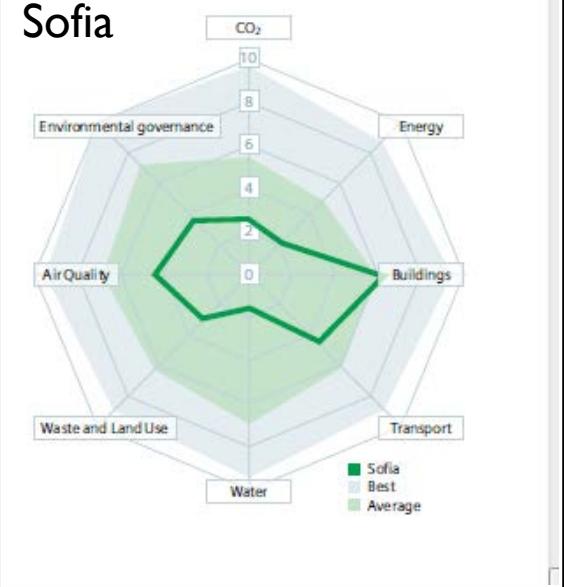
Waste & land use

Air quality

Environmental governance



Sofia



How to compare, re-use, map between Indicators?

- GCI Indicators - >146 indicators
- Circles of Sustainability Indicators
- UN Habitat Global Urban Indicators
- EuroStat Urban Audit >250 indicators
- Green City Index – weighted combination of 30 indicators

Interoperability Issues

- Same names – different formula
- Different names – same formula
 - At indicator level
 - At input variable level
- Different data/variable sources
- Missing data/ missing source/provenance
- Different units (people per km², people per sq mile)
- Different geographic regions
- Geographic boundaries change over time
- Different weightings (compound indicators)

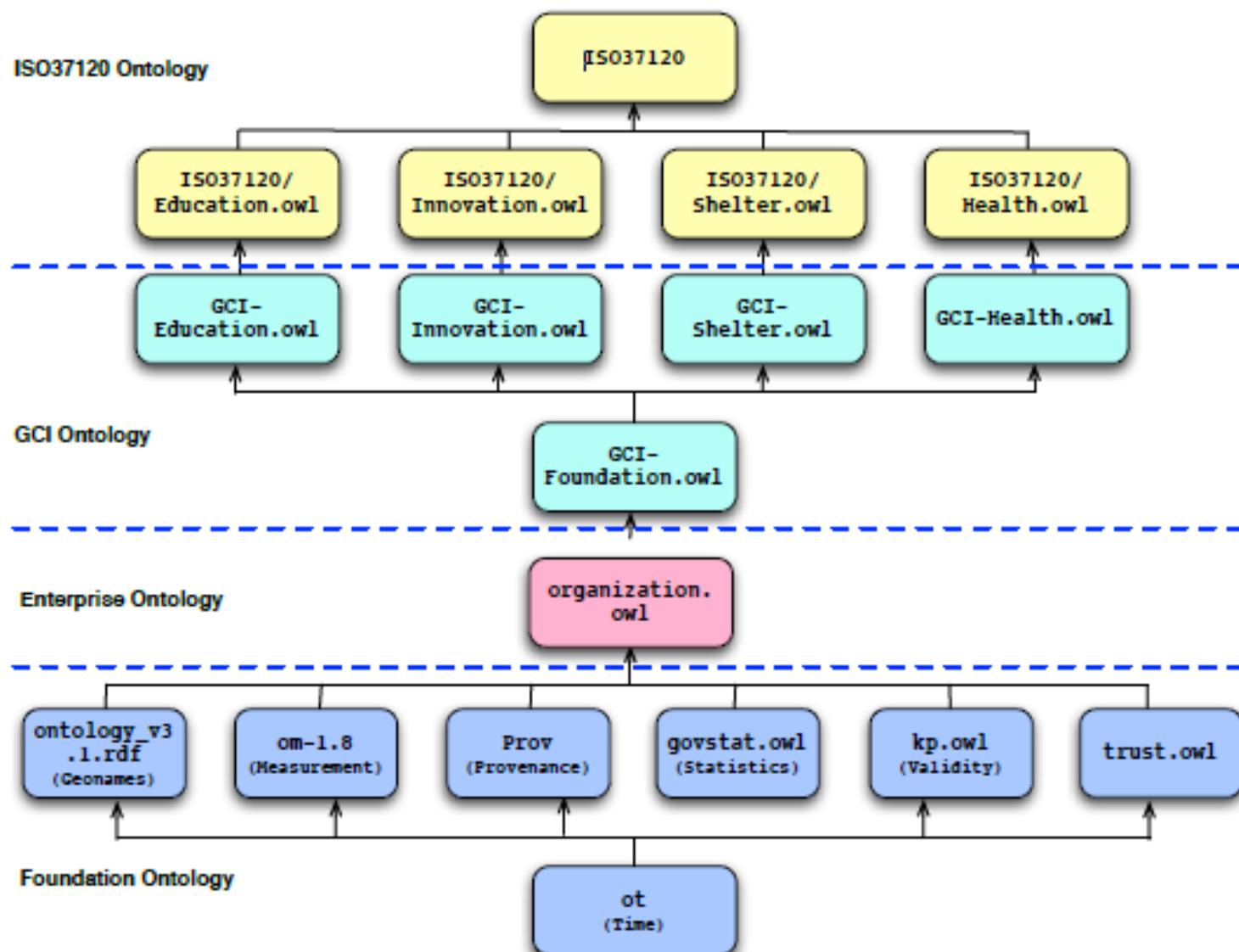


Ontological Representation?

- Ontology – in OWL/RDFS - capture definitions of different indicators
- Document categories of indicators and relationships between indicators/sub-indicators/indices
- Provides resource for choosing indicators for new projects – design monitoring programs
- Documents the provenance
- Enables dynamic calculation of indicators from data sources e.g. SDMX interface to ABS
- JSON APIs to gov data, wireless sensors, industry data, crowd sourced data -> near real-time
- Statistical analysis -> similarities, rule & relationship extraction?
 - Extract/document causal or other relationships/links between indices/indicators
 - overcrowding -> poor educational outcomes;
 - long commute time -> poorer health

Related Ontologies/Projects

- Foundation Ontology for Global City Indicators (Mark Fox)
- Open City Data Pipeline
 - City Data Ontology
 - <http://citydata.wu.ac.at/ontology.html#>
- QuerioCity
- CitySDK



Urban Analytics Data Infrastructure (UADI)



Australian Government
Australian Research Council



THE UNIVERSITY OF
MELBOURNE



UNSW
AUSTRALIA



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA



THE UNIVERSITY OF
WESTERN
AUSTRALIA



UNIVERSITY OF
CANBERRA

UOW
AUSTRALIA

ARC LIEF LE160100174

A digital data infrastructure:

- to enable the **integration, harmonisation, connectivity** and **scalability** of multi-source urban datasets.
- that will develop a **New ontological framework** and an **urban data dictionary** to underpin the **next generation** of **data driven modelling** and **decision-support tools** to enable **smart, productive** and **resilient cities**.

UADI Inputs: Scenario



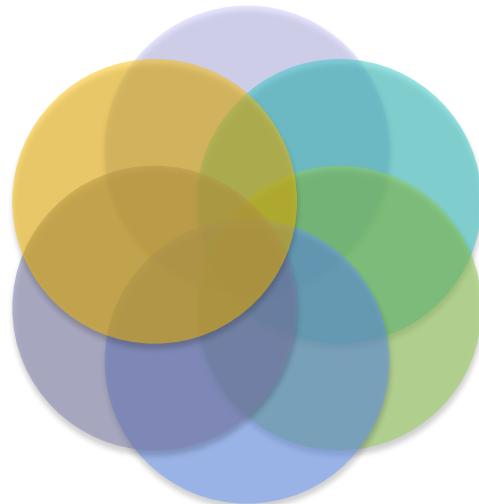
Australian Government
Australian Research Council



What are Policy implications of Housing Intensification across Metropolitan areas in Australia

- Housing**
- Housing size, type, and diversity
 - Housing/Rental affordability

- Transportation**
- Accessibility



- Infrastructure**
- Residential electrical energy use per unit of dwelling per year
 - Water consumption per capita/household/dwelling units (litres/day)

- Demographic**
- Relation of housing type and household size
 - Ratio of active age cohort to employment ratio

- Economic**
- Locational variation of property price
 - Number of jobs/full-time employment

- Environmental**
- Energy consumption and carbon emission in central cities
 - Urban Heat Island (UHI) Measures

Portal of Urban Analytics Data Infrastructure

Home

About project

Search datasets

City indicators

Analytics

Partners

City

MELBOURNE

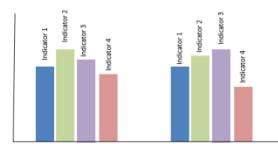
MELBOURNE
SYDNEY
BRISBANE
CANBERRA
PERTH
WOLLONGONG

+ COMPARE CITIES



GRAPH COMPARISON

Please select the indicators from the list to compare:



TRANSPORT

ECONOMY

ENVIRONMENT

URBAN PLANNING

SHELTER

ENERGY

WATER AND SANITATION

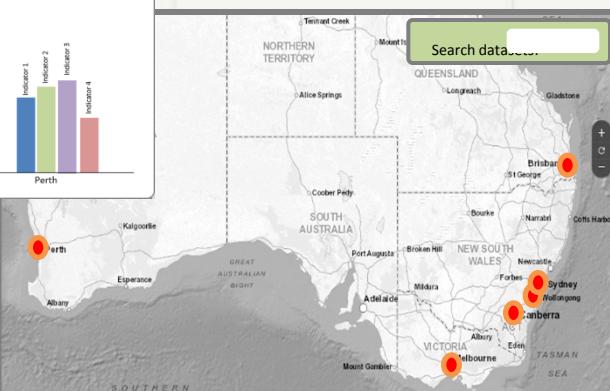
Housing Intensification

Environmental Implications



AUSTRALIA

Search datasets



MELBOURNE



Problems

- Majority of ISO37120 indicators not applicable
15.1 % of population living in slums
- Whole city-level only
- Need more fine-grained researcher-defined project specific indicators for the UADI project
- Users are researchers, planners, policy makers – not UN, World Bank
- Need to support local perspective not global

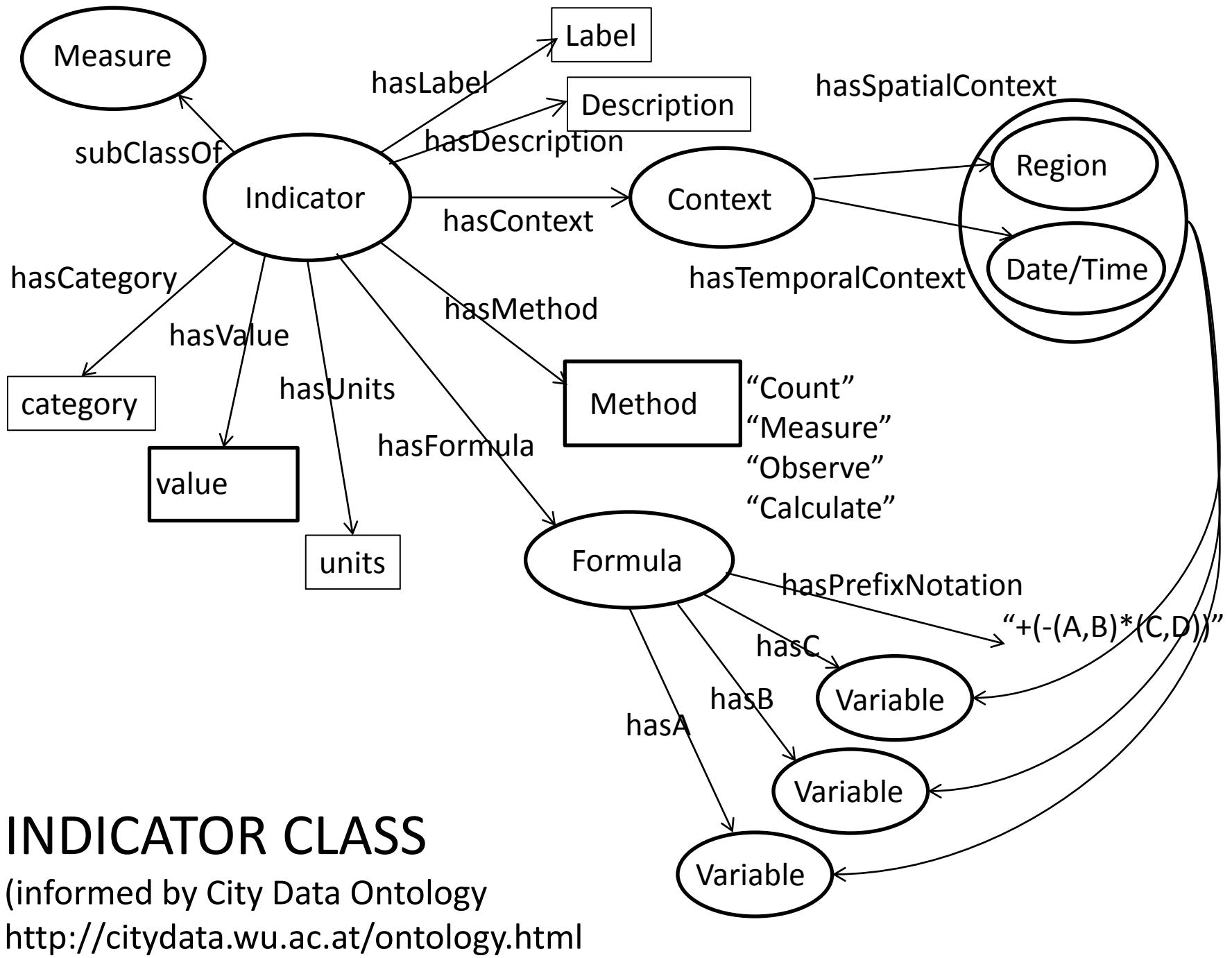
UADI Challenges – Shelter Indicators

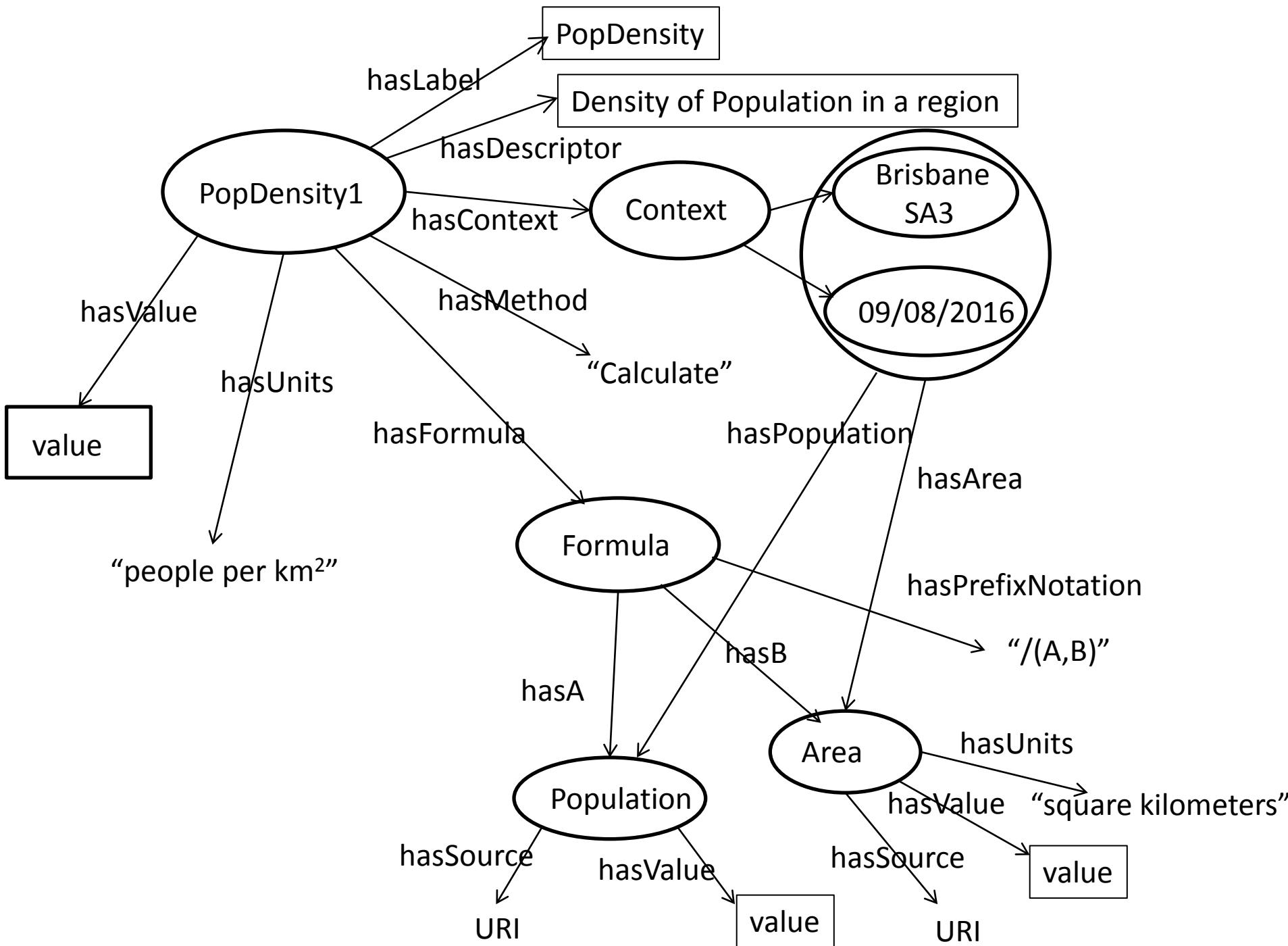
- Many of the required urban indicators not in ISO 37120
- Many indicators defined by researchers
- Underlying data is not available, or need it at finer geographic level
- 15 Shelter:
 - 15.1 - % of population living in slums – not relevant in Australia.
 - 15.2 – yes, relevant
 - 15.3 is not really relevant.
- We are interested in:
 - % of overcrowded households;
 - % of households that own their own home;
 - % of households that rent;
 - % of households in government/assisted housing;
 - Median mortgage
 - Affordability indicator

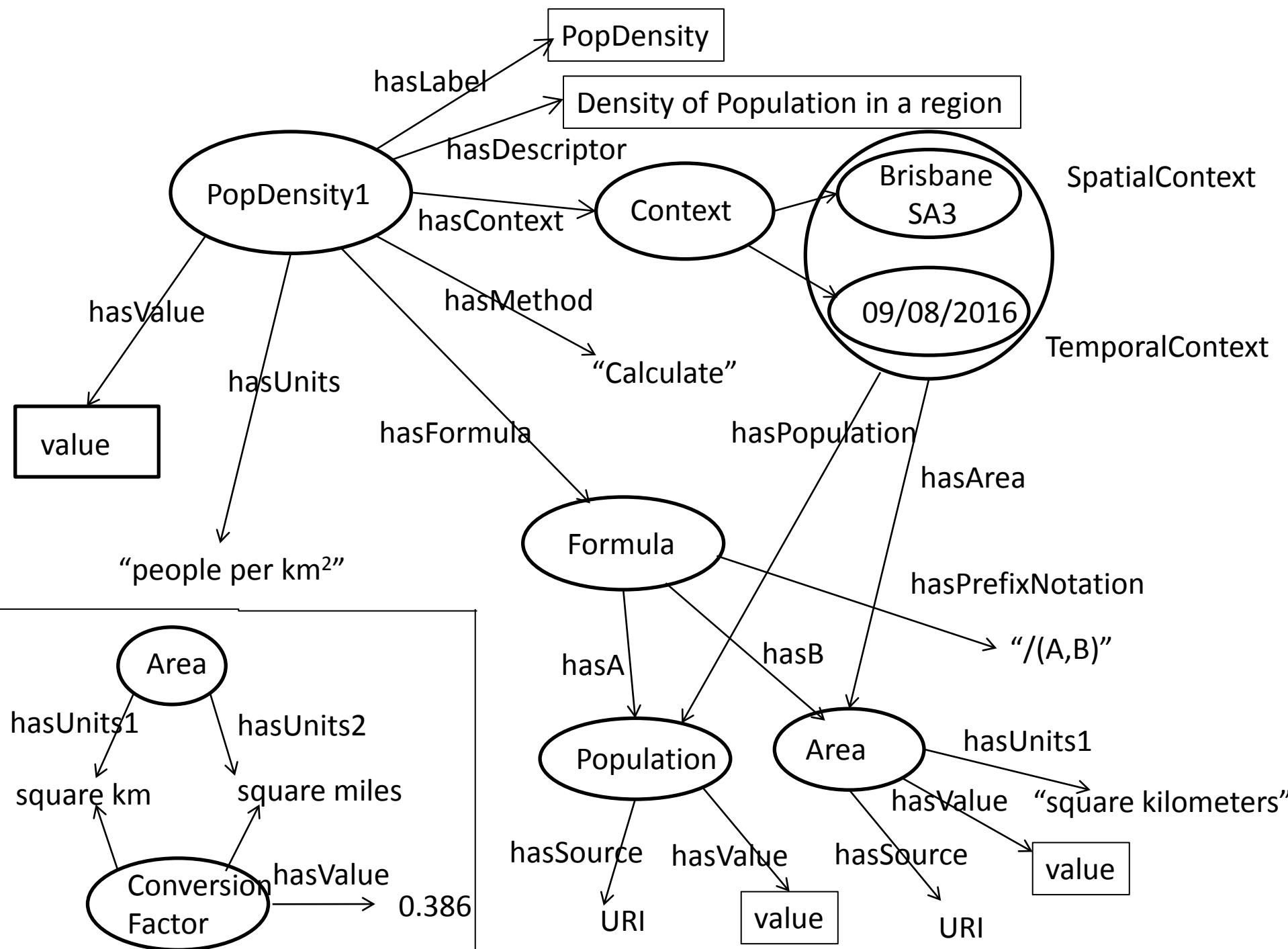
Transport Indicators

Regarding 18 Transportation:

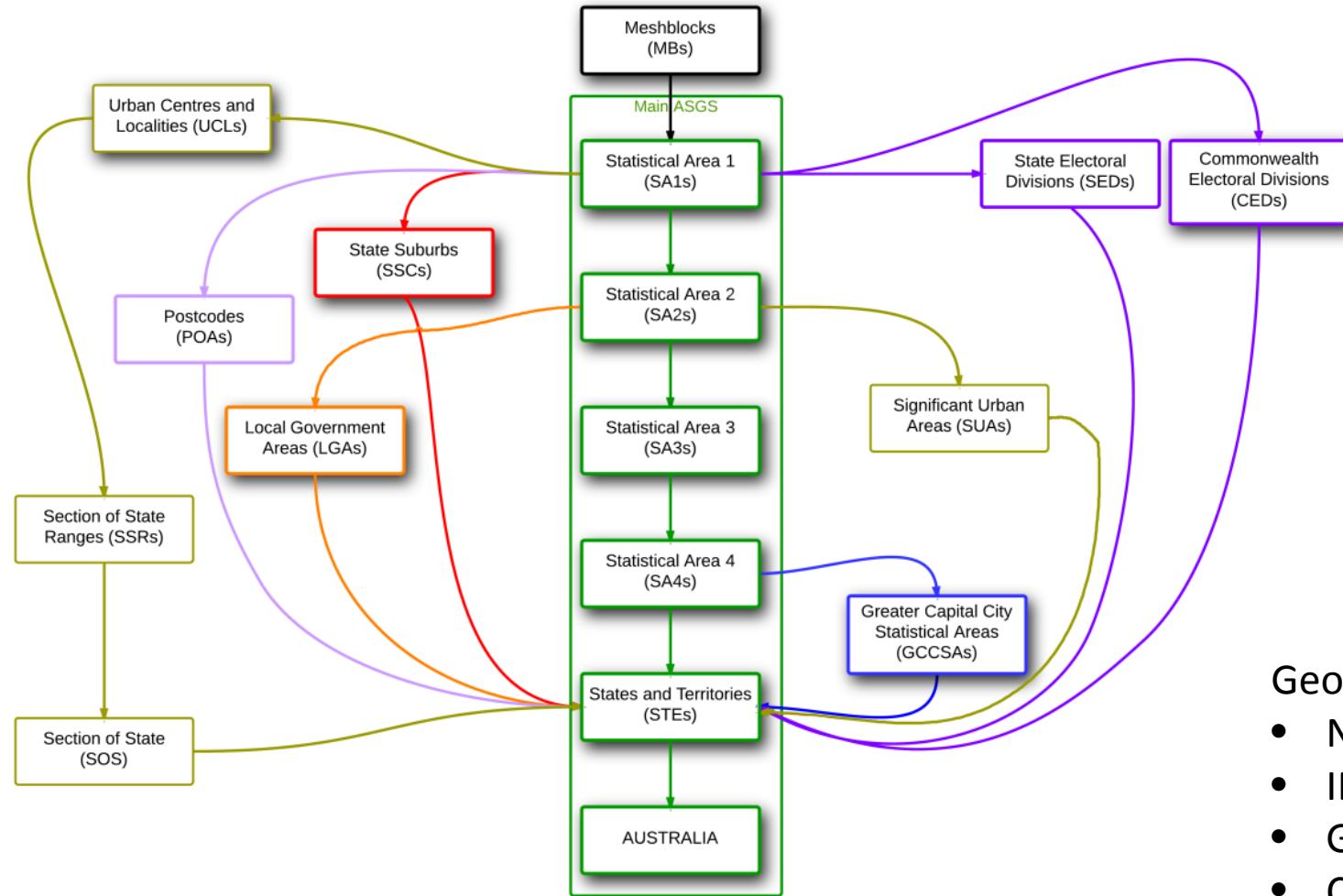
- 18.1 – no
- 18.2 – no
- 18.3 – yes we can calculate this
- 18.4 – no
- 18.5 – yes we can calculate this
- 18.6-18.9 – no
- Transport Indicators
 - Median Journey to Work Time
 - Median Journey to Work Distance
 - Median Carbon Emissions







Australian Statistical Geography Standard ASGS



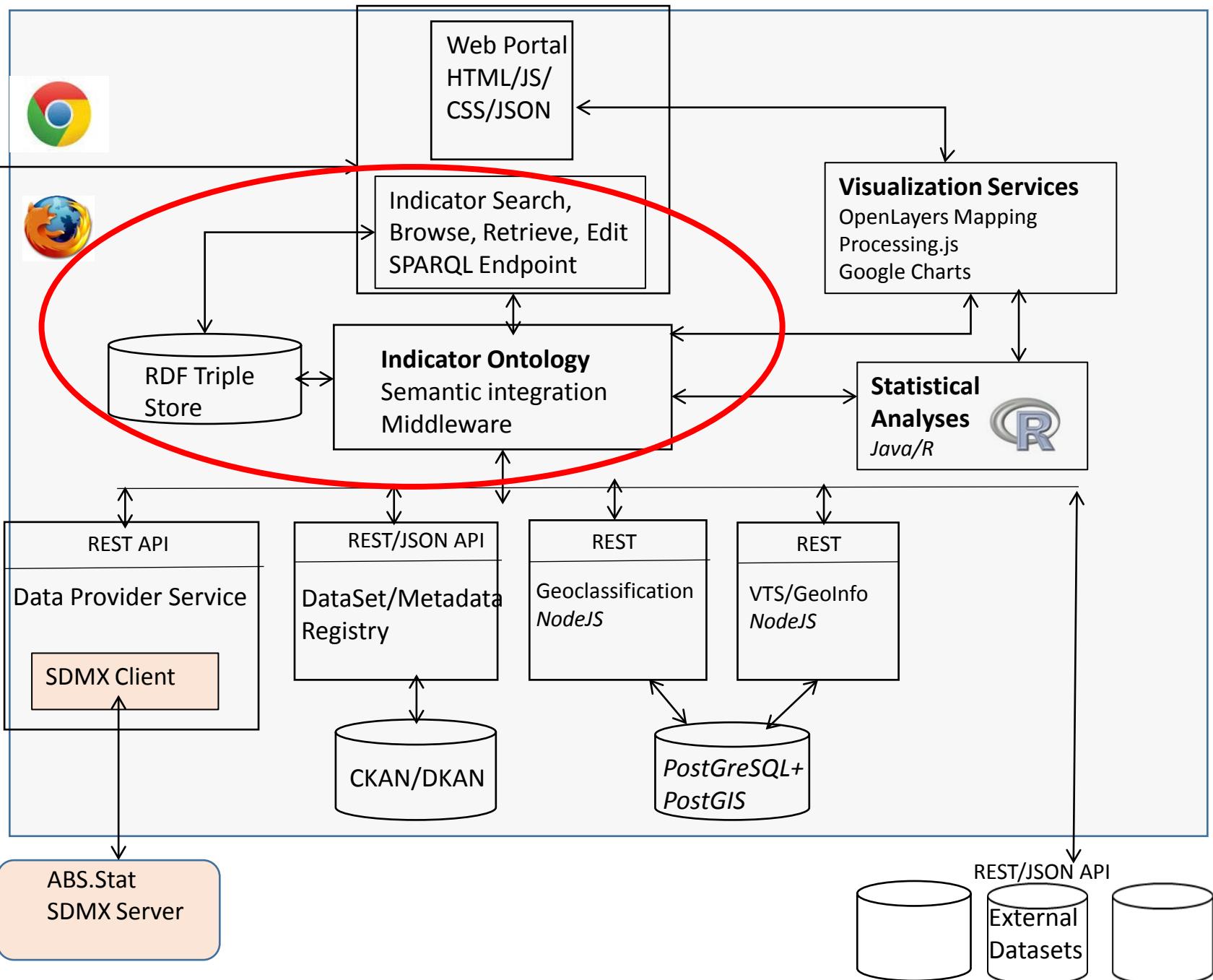
GeographicRegion

- Name (geonames)
- ID
- GeographicLevel
- Centroid
- Boundary (shape file)
- Area
- Contains
- ContainedWithin

Proposed Approach – Dynamic Interoperability between Indicators

- Develop user interface (not ontology editor) that allows users to
 - Search, browse existing indicators in UADI ontology
 - Find similar indicators
 - Modify existing indicators & define their own
- Indicator definition
 - Label, Description
 - Category (Transport, Economy, Environment, Housing, Health)
 - Method (Count, Calculate, Statistic, Observe, Measure, Complex)
 - **Input Variables**
 - URIs link to raw data via APIs (**SDMX to Census data**)
 - **Mathematical formula**
 - **Relationships** to other indicators (`owl:equivalentProperty`)
- User interactively specifies:
 - Spatial context - region/city, geographic level (SA2, SA3, LGA)
 - Temporal context (2001, 2006, 2011)
- Preferred Indicator values are dynamically generated and displayed on choropleths/graphs/tables

User Access
via Browser



Example I – Journey to Work Data

ABS Journey to Work Data (Multi-Dimensional)

- Retrieve using slices via ABS SDMX API
- Source SA3 → Destination SA3
- Number of trips:
 - By Mode (Car, Bike, Public Transport, Walk)
 - By Gender

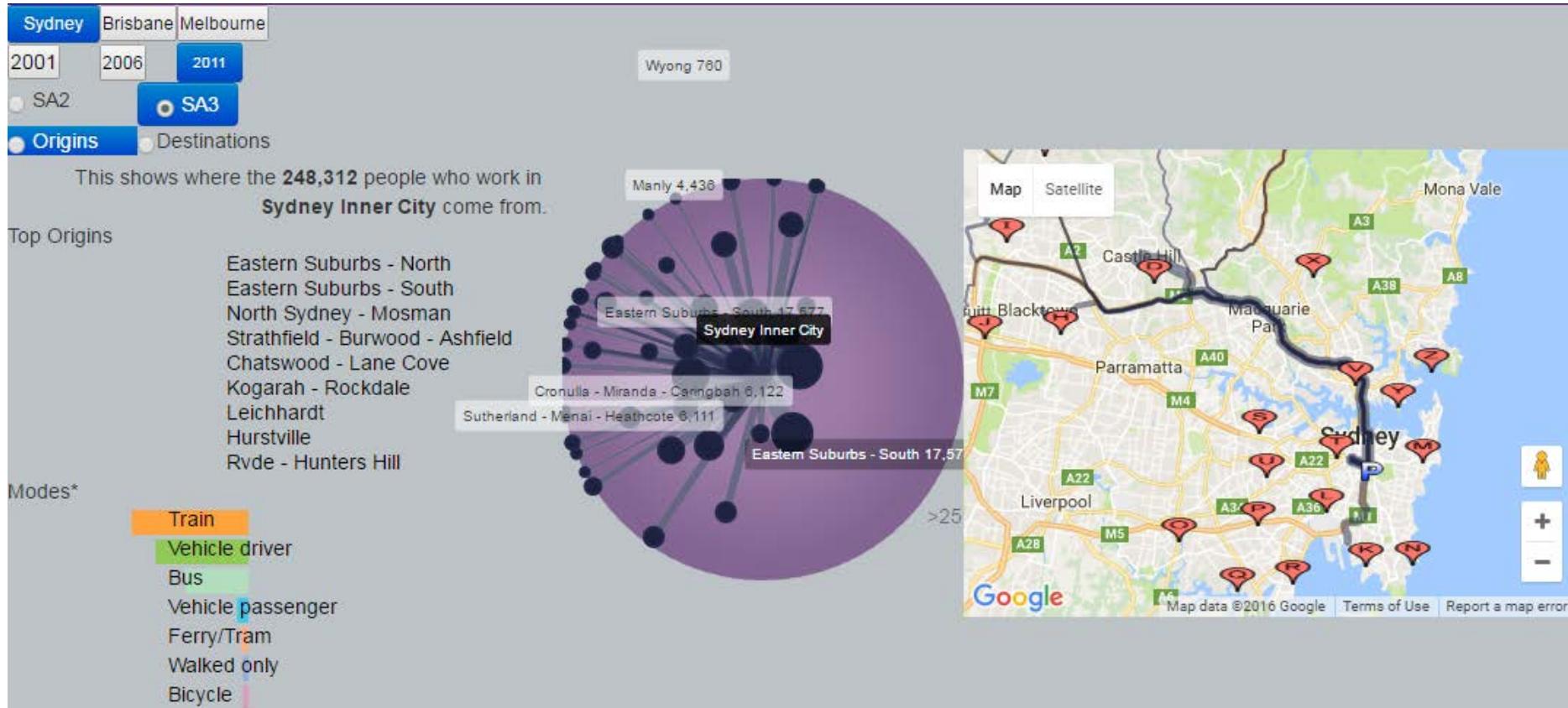
State Govt Transport Depts – Vehicle Registration data

- Vehicle model ownership in each SA3
- Vehicle model → approx. CO2 emissions

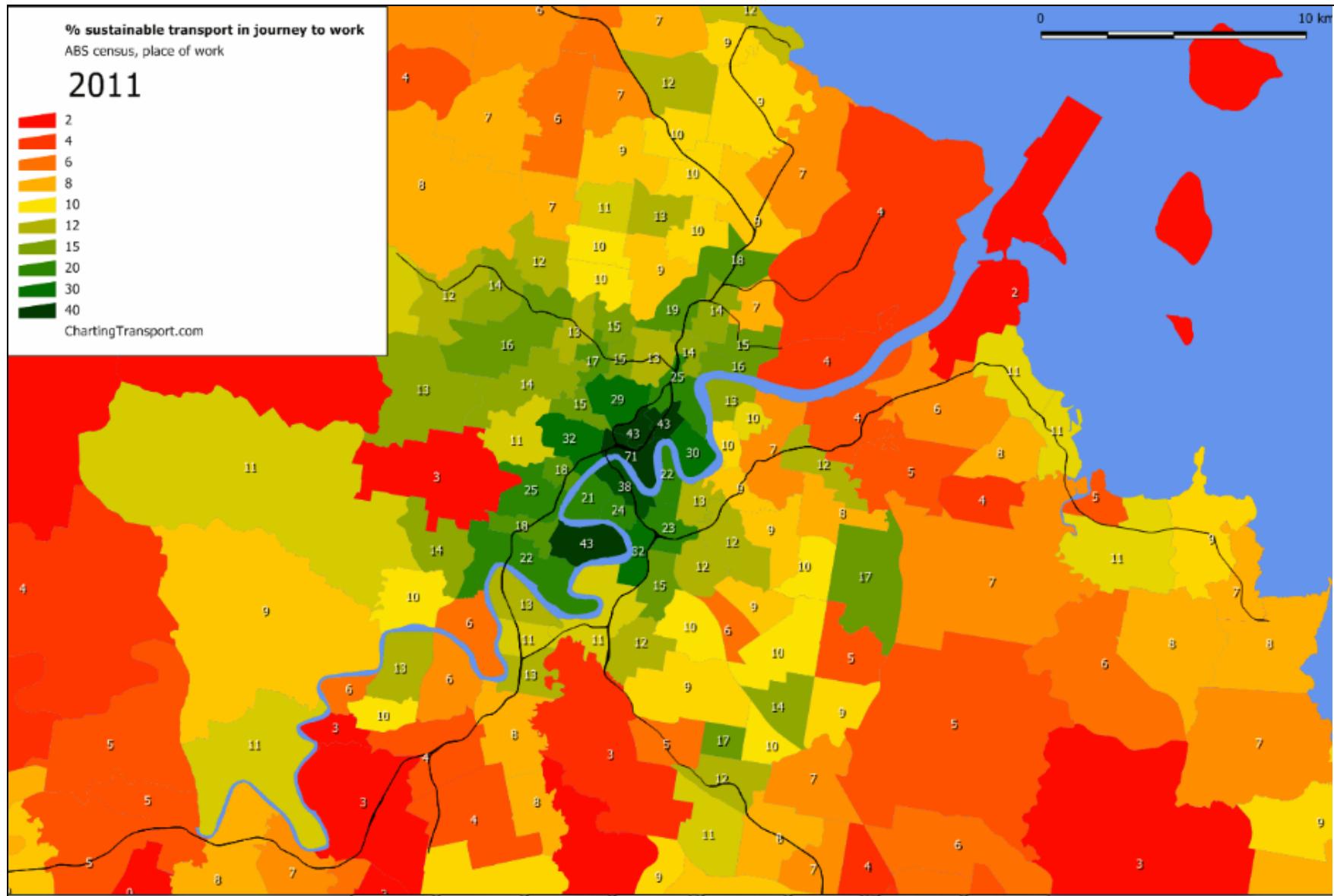
Derived Urban Mobility Indicators (for each SA3)

- Median Commute Distance
- Median Commute Time
- Proportion of People who use Public Transport
- Median CO2 emissions

Journey to Work Visualization



Identify where PT Investments needed



Example 2: Aboriginal Housing

Aboriginal communities:

- Inferior housing
- Inferior neighbourhoods
- Low home ownership
- Overcrowding, greater homelessness
- More live in public housing
- Frequently move house

-> Adverse impact on health, well-being and education of children

Budget 2015: \$2bn for Indigenous housing and investment in remote areas



Researcher-defined Hypotheses

- High overcrowding -> poor educational and health outcomes -> crime, domestic violence
- Areas with the greatest housing demand are not necessarily the most remote
- Current housing services (loans, commonwealth rental schemes, housing programs) – aren't focussed on areas with greatest demand
 - Palm Island – vacant new houses
 - Doomadgee, Nhulunbuy – adequate housing – discrete communities
 - Winton, Dubbo – high homelessness, high overcrowding – rural towns

Midja Web Portal System

Web Interface enables users to:

1. Select regions of interest (e.g. States) and geographic level (LGAs)
 - Australia, Queensland, Tasmania
2. Filter out LGAs that don't meet criteria (no. of Indig. Households<20; Remoteness)
3. Select indicators/variables of interest – e.g., Overcrowding, Year 12, PIHO index, No. of IBA Loans
4. Overlay selected indicators on a map – using choropleths and bubbles
 - Pan and zoom using map interface
 - Left click on an LGA -> Displays all data/indicators for that LGA
5. Graphically present indicators/variables on scatter plots
6. Apply simple statistical analyses to the data sets (e.g. Linear Regression)

Places

Choose a Place Required

Australia COUNTRY

Remoteness

Only show ILOCs with this remoteness level.

- All
- Remote Australia
- Inner Regional Australia
- Very Remote Australia
- Major Cities of Australia
- Outer Regional Australia

Topics of interest

Choose topic(s) of interest Required

Pp Bdsm Tot X Age 5 14 Indigenous People X

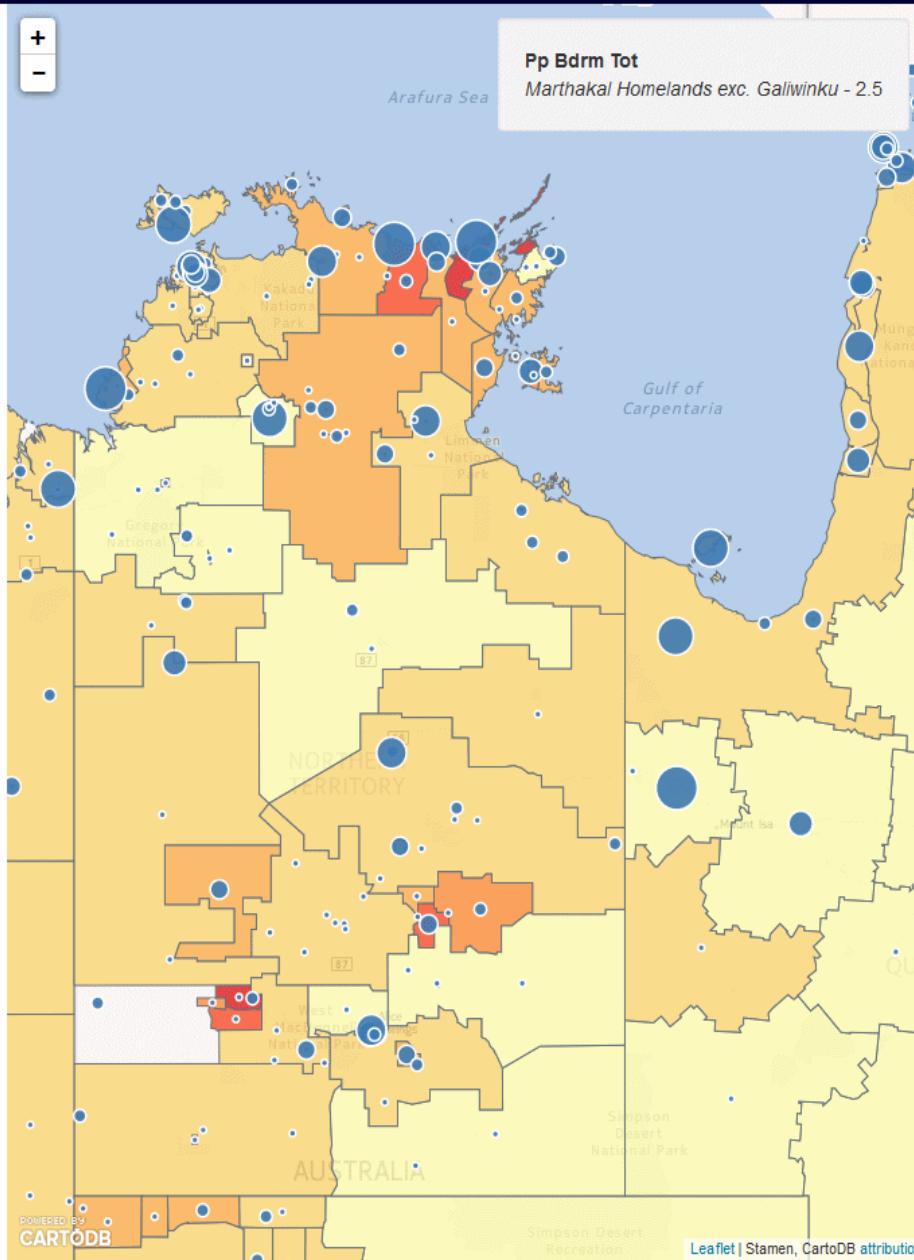
Map Visualization

Choose topic for bubble Optional

Age 5 14 Indigenous People

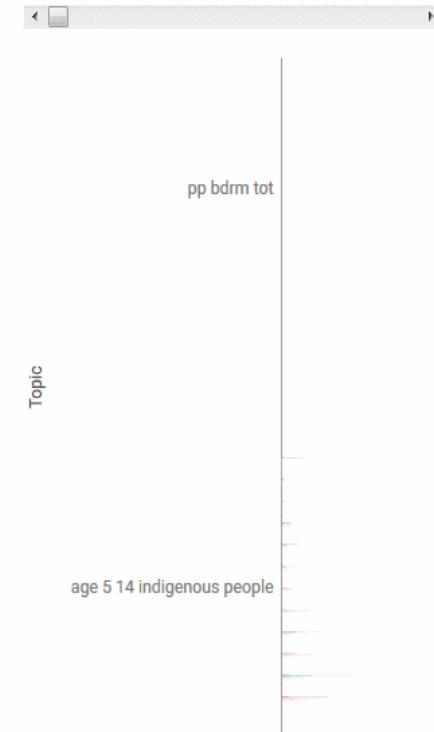
Choose topic for choropleth Optional

Pp Bdsm Tot



Data

Topic	Upper Hunter	Bakewell - Rosebery	Ashfield - Mitchell
pp bdsm tot	0.8	0.7	1.1
age 5 14 indigenous people	33	18	202



Midja

About People Contact Groups Data Registry Bibliography Visualisations

Search

Login Register

Choose a Place Required

New South Wales STATE

Choose a comparison place Optional

Search for a place

291 ILOCs are selected.

Remoteness

Only show ILOCs with this remoteness level.

- All
- Remote Australia
- Inner Regional Australia
- Major Cities of Australia
- Very Remote Australia
- Outer Regional Australia

Topics of interest

Choose topic(s) of interest Required

Percentage Of Indigenous Persons

Year 12 Completion Indigenous

Show only proportional variables

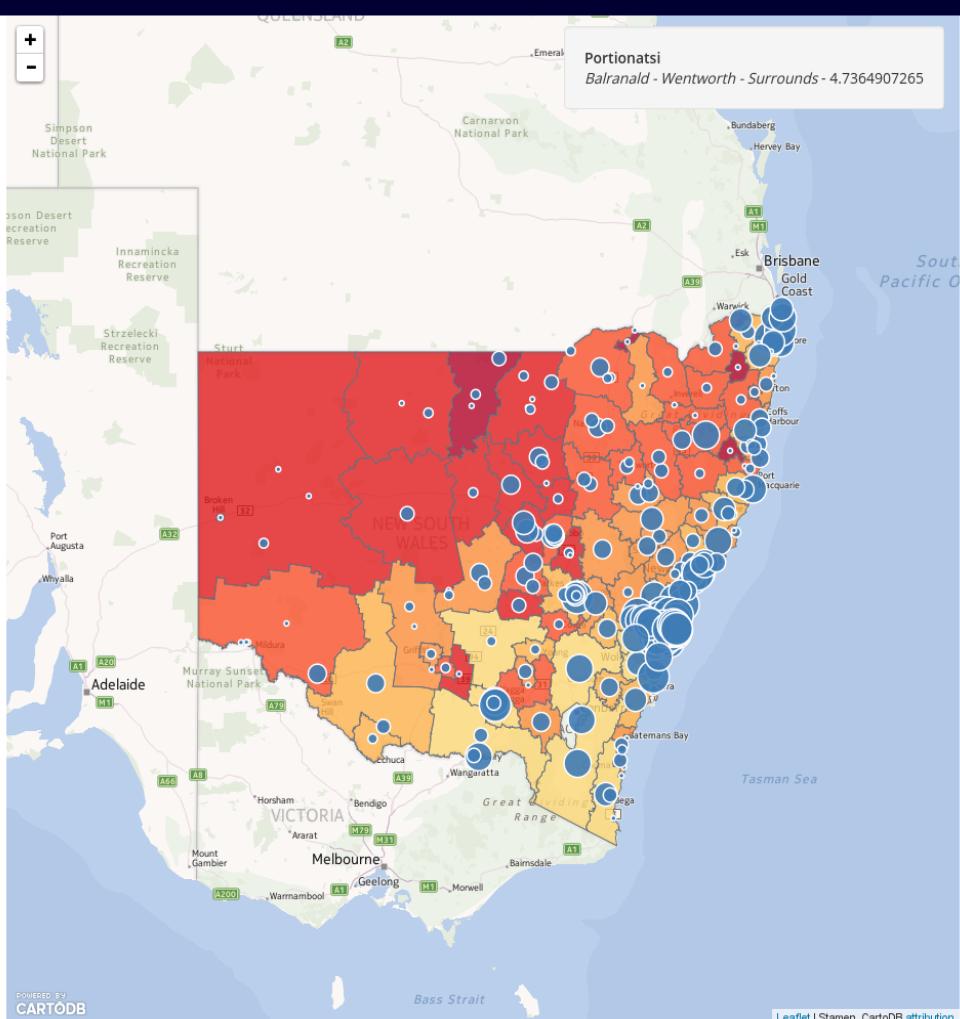
Click in the box again to add another topic of interest.

Map Visualisation

Choropleth

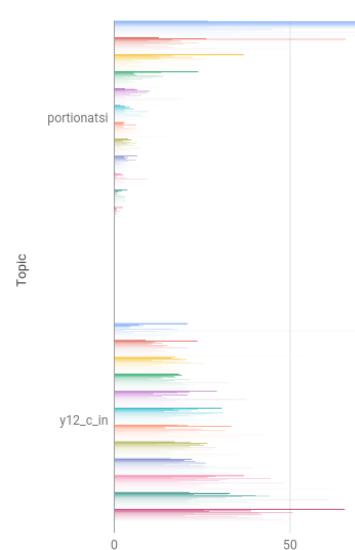
Percentage Of Indigenous Persons

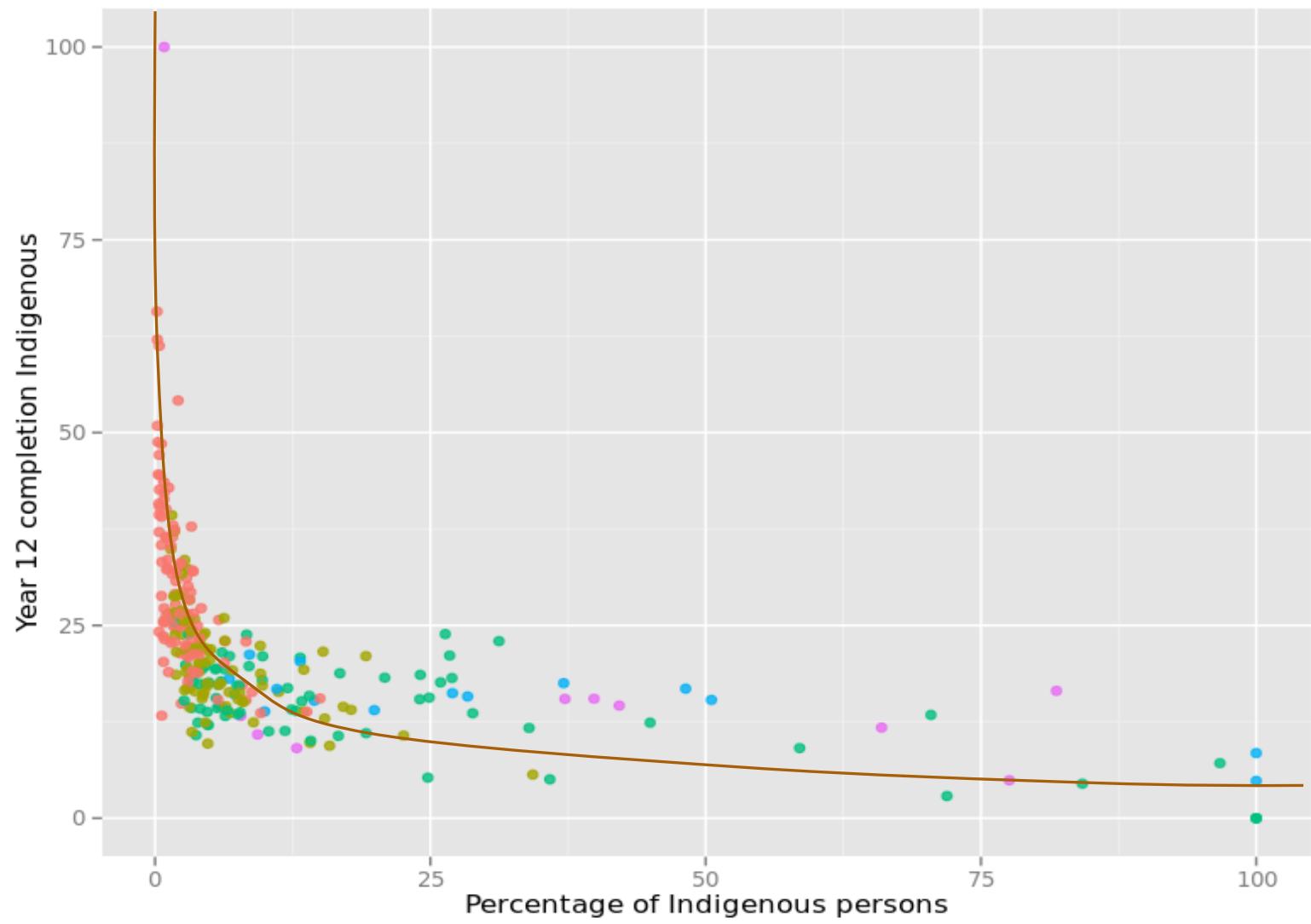
Bubble Optional



Data

Topic	La Perouse	Upper Hunter	Ashfield	Bo
Percentage of Indigenous persons (portionatsl)	26.7549667358	100	96.7033004761	10
Year 12 completion Indigenous (y12_c_in)	21.09375	0	7.142857143	8.

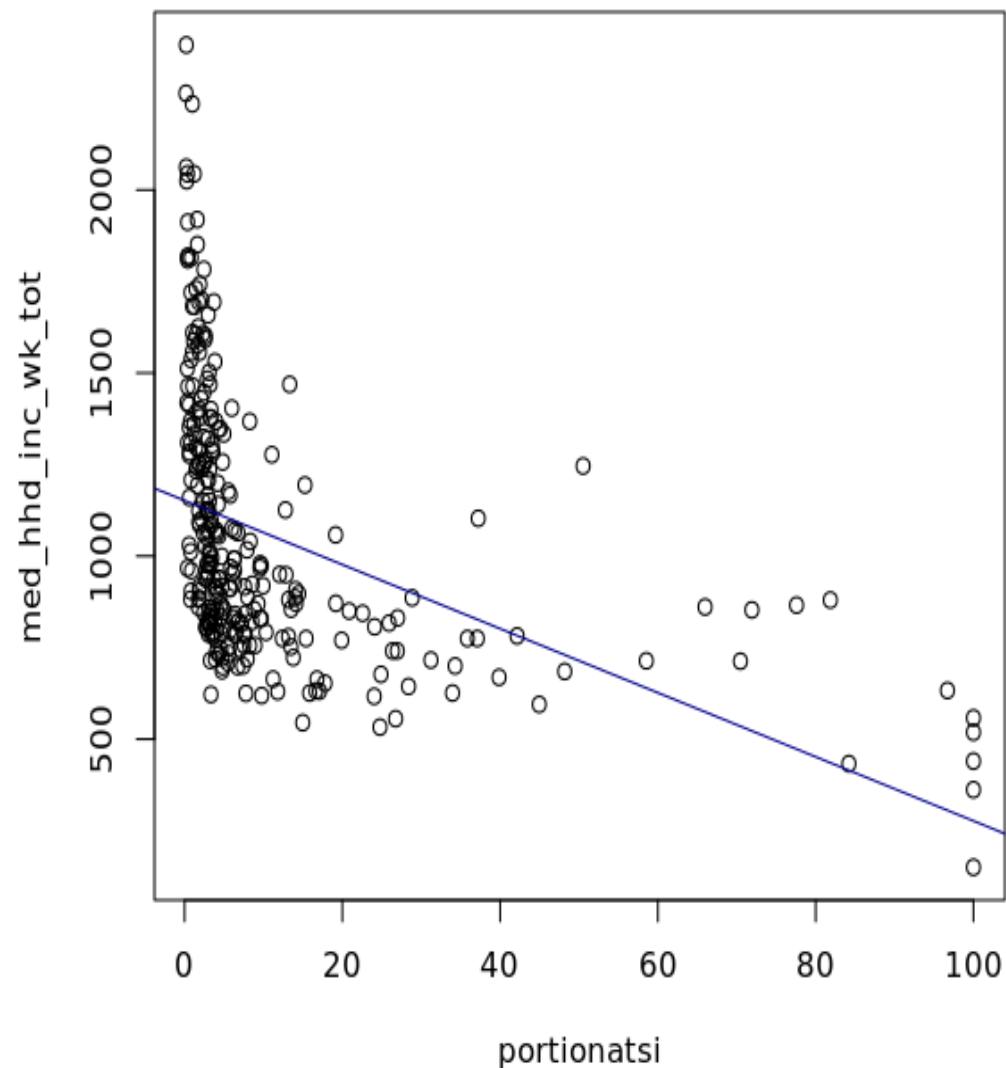




Remoteness Area

- Major Cities of Australia
- Inner Regional Australia
- Outer Regional Australia
- Remote Australia
- Very Remote Australia

Line fitting



Midja Map Maker - Chromium

uq-eresearch.github.io/midja-map/#/ Midja Midja file73c4 x file51a7 x file4f7a x file13c5 x file13c6 x overcro x untitled x iloc_me x G add ne x Adding x FAQs x Tips an x Mergin x SQL Al x CartoDB x New Tab x Domain x

Midja

Map Visualisation

Choropleth

Percentage Of Indigenous Persons

Bubble Optional

Year 12 Completion Indigenous

Plots

Scatter plot

X-axis: Percentage Of Indigenous Persons

Y-axis: Year 12 Completion Indigenous

Use Remoteness

Remoteness Area	Approx. X (Percentage Of Indigenous Persons)	Approx. Y (Year 12 completion Indigenous)
Remote Australia	28	25
Very Remote Australia	25, 50, 75	10, 12, 18
Non-Remote Australia	30	29

Portionatsi
Mount Isa exc. Camooweal - 14.7575302124

Data

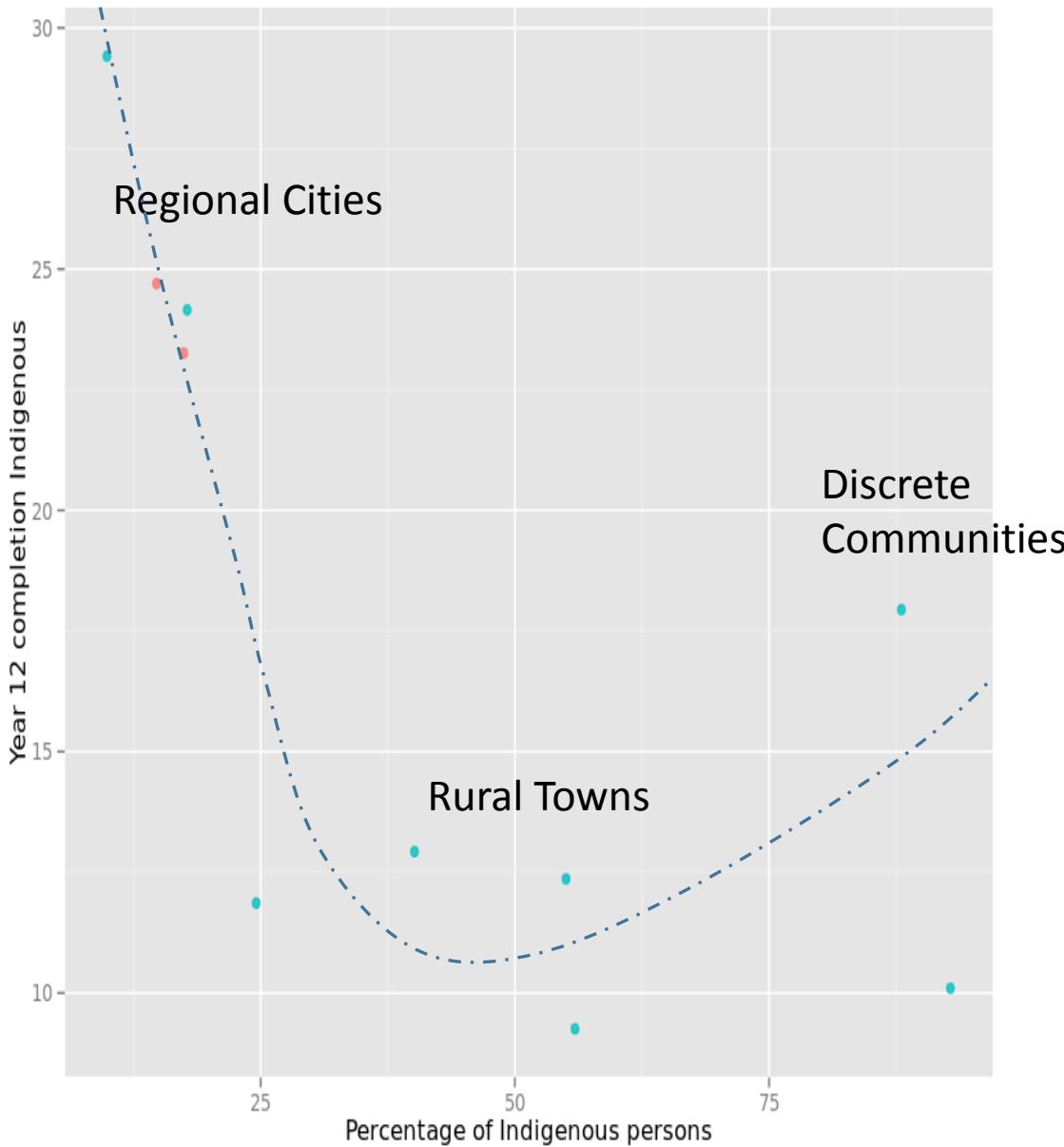
	Winton	Carpentaria exc. Doomadgee	Normanton	Cloncurry - McKinlay
39	55.0247116089	92.84009552	9.8802394867	17.77934072
3	370	272	533	645
3	545	281	545	676
3	18.20199778	16.49616368	33.76503238	29.941127
7	12.36442516	10.09957326	29.41176471	24.15730337

portionatsi

me_p_in_wk_in_ps_hh_in_p

med_psnl_inc_wk_tot

y12_c_tot



Worst housing, educational and health outcomes for Indigenous people
Living in Rural Towns

- approx. 50% Indigenous
- few services

Indigenous Business Australia



IBA IN DIGENOUS
BUSINESS AUSTRALIA

Home About Us Homes Business Investments Leasing Careers Email Us

Buying a Home

- IBA Housing Loans
- Remote Indigenous Housing Loans
- Loan Products
- Loan Interest Rates
- Loan Fees
- Home ownership information session dates
- Housing Loan Calculator
- Applying for an IBA Housing Loan

 A photograph showing two individuals, a woman and a man, sitting at a desk in an office environment. They appear to be reviewing documents together.

 Home Ownership

IBA Housing Loans

IBA offers housing loan products to enable eligible customers to buy:

- an established residential property
- an established residential property and upgrade
- land and construct a new home
- in a remote area (or relocate from a remote area)

In the first instance you should check if you qualify for a housing loan from another lender (for example, a bank or credit union). If you do not qualify for a loan from another lender or are unable to borrow all the funds required to purchase a suitable home, you may be eligible for assistance from IBA. An IBA Home Lending Officer can talk to you about your requirements and tell you what information you will need to



Federal indigenous Affairs Minister Nigel Scullion. Picture: Britta Campion

National

Housing program set up to help disadvantaged indigenous Australians gives majority of loans to high and middle income earners

 A close-up portrait of Nigel Scullion, a man with a beard and grey hair, looking slightly upwards and to the side.

Calculate Potential Indigenous Home Ownership

- For each LGA in Australia, calculate the Potential Indigenous Home Ownership (PIHO) Index
- PIHO Index is a composite of three variables for each LGA:
 1. Affordability Index (= Median Indig. Income/Median Mortgage)
 2. % of Indigenous Households who don't own their own home
 3. % of Indigenous Population in Full-time Employment

(Note – the PIHO calculation can easily be modified/refined)

Overlay IBA data and PIHO Data Spatially

- Using aggregated IBA Data from 1981 – 2014
- Each Customer is geocoded by matching their postcode to an LGA
- Calculate *Total Number of IBA Loans* and *Total Amount of IBA Loans* – for each LGA - by aggregating data for postcodes in that LGA
- Link data to Midja system

Choose a Place Required

Australia COUNTRY

156 locations are selected.

Topics of interest

Category filter Optional

Select one or more categories to filter topics

Choose topic(s) of interest Required

Composite

IBA Total Number Of Loans

 Show only proportional variables

Click in the box again to add another topic of interest.

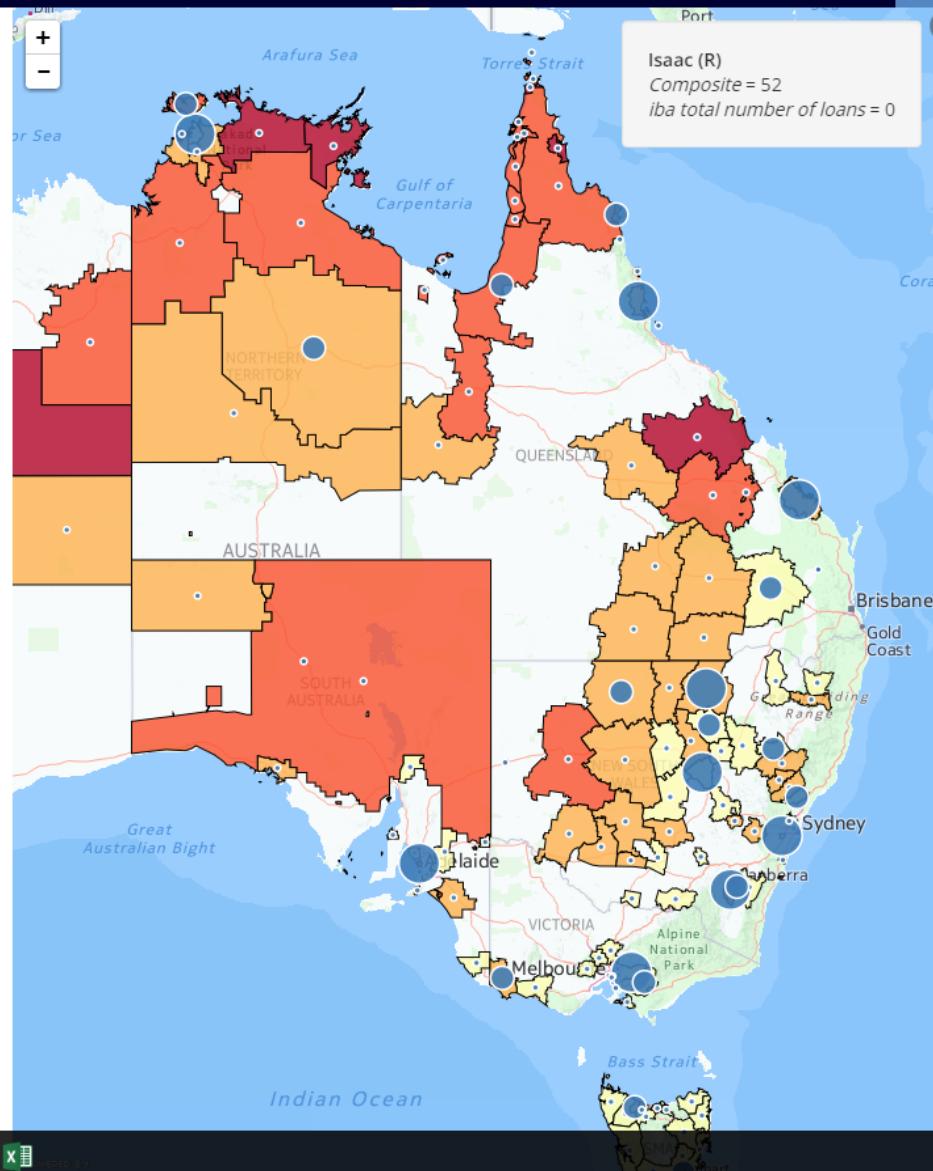
Map Visualisation

Choropleth

Composite

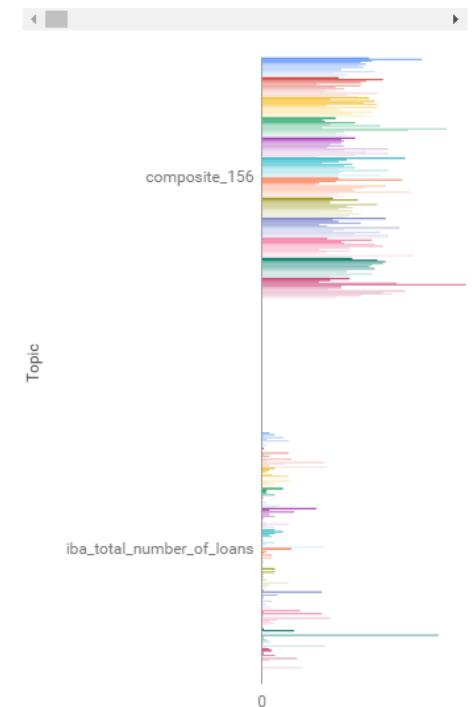
Bubble Optional

IBA Total Number Of Loans



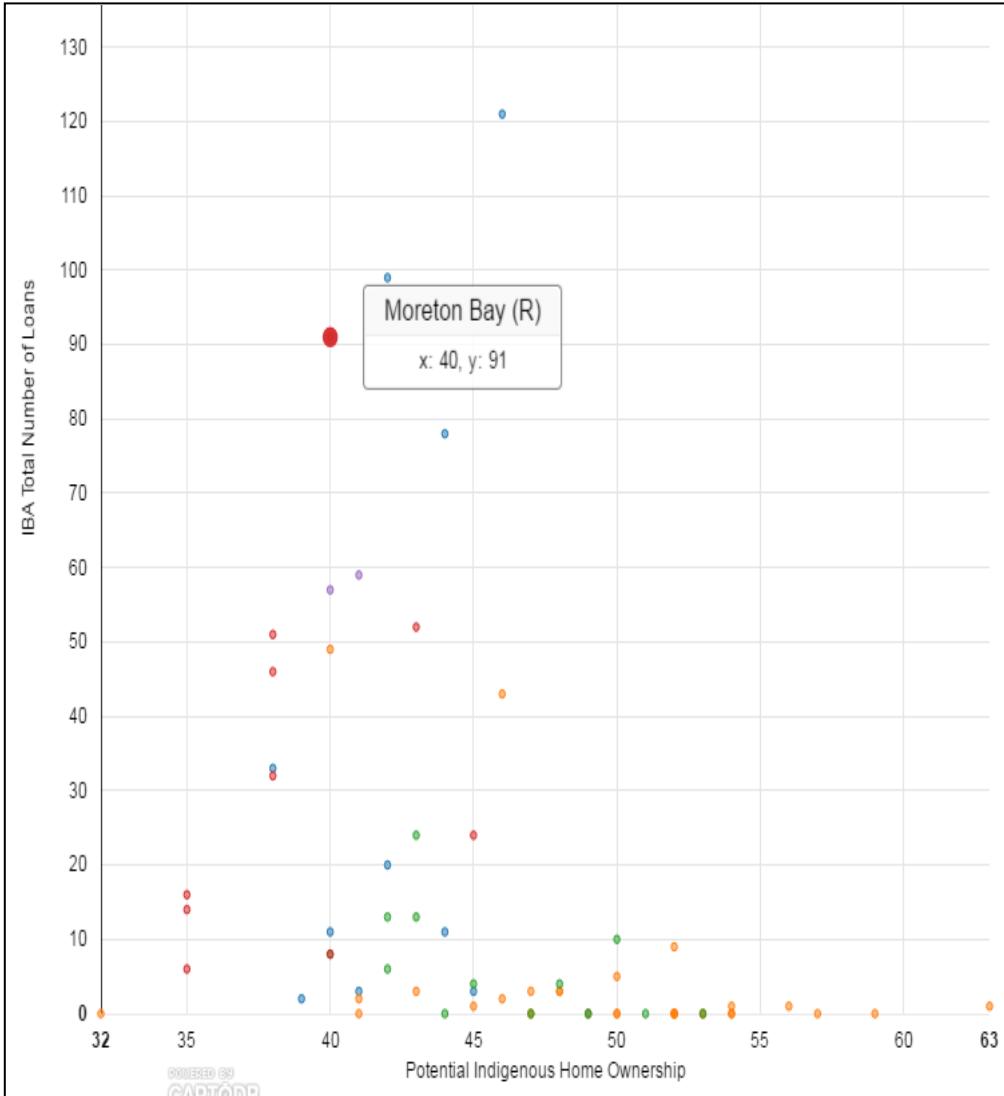
Data

Topic	Anangu Pitjantjatjara (AC)	Ast (S)
Composite (composite_156)	39.00	58.1
IBA Total Number of Loans (iba_total_number_of_loans)	0.00	0.01



Scatter Plots

- Interactively generated by user
- PIHO Index - X-axis
- No of IBA Loans - Y-axis
- Reveals LGAs with high potential but no loans
- Mouse over point
 - displays LGA name + X, Y values





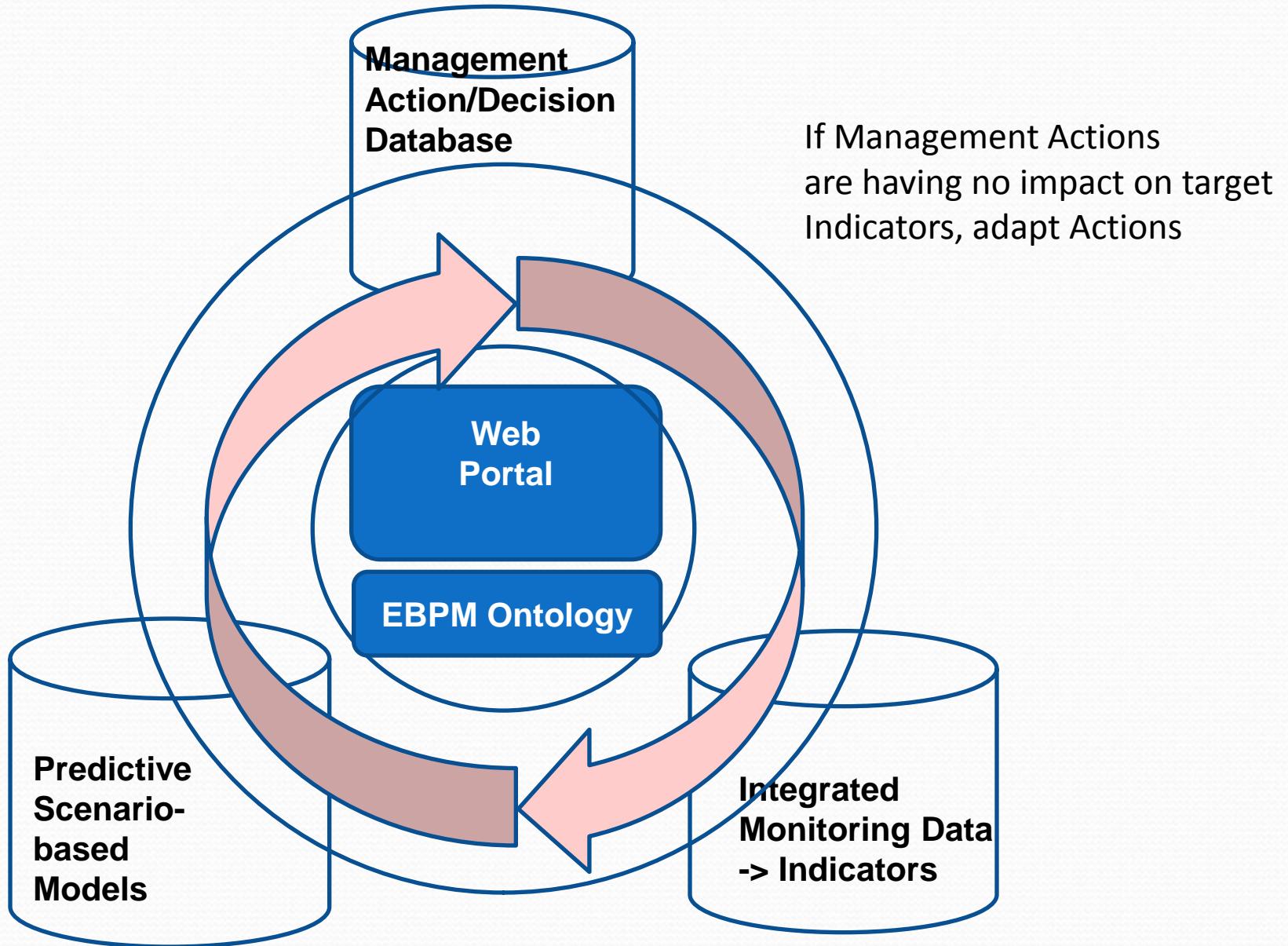
Significance to IBA?

Reveals LGAs with high Potential Indigenous Home Ownership but few IBA loans

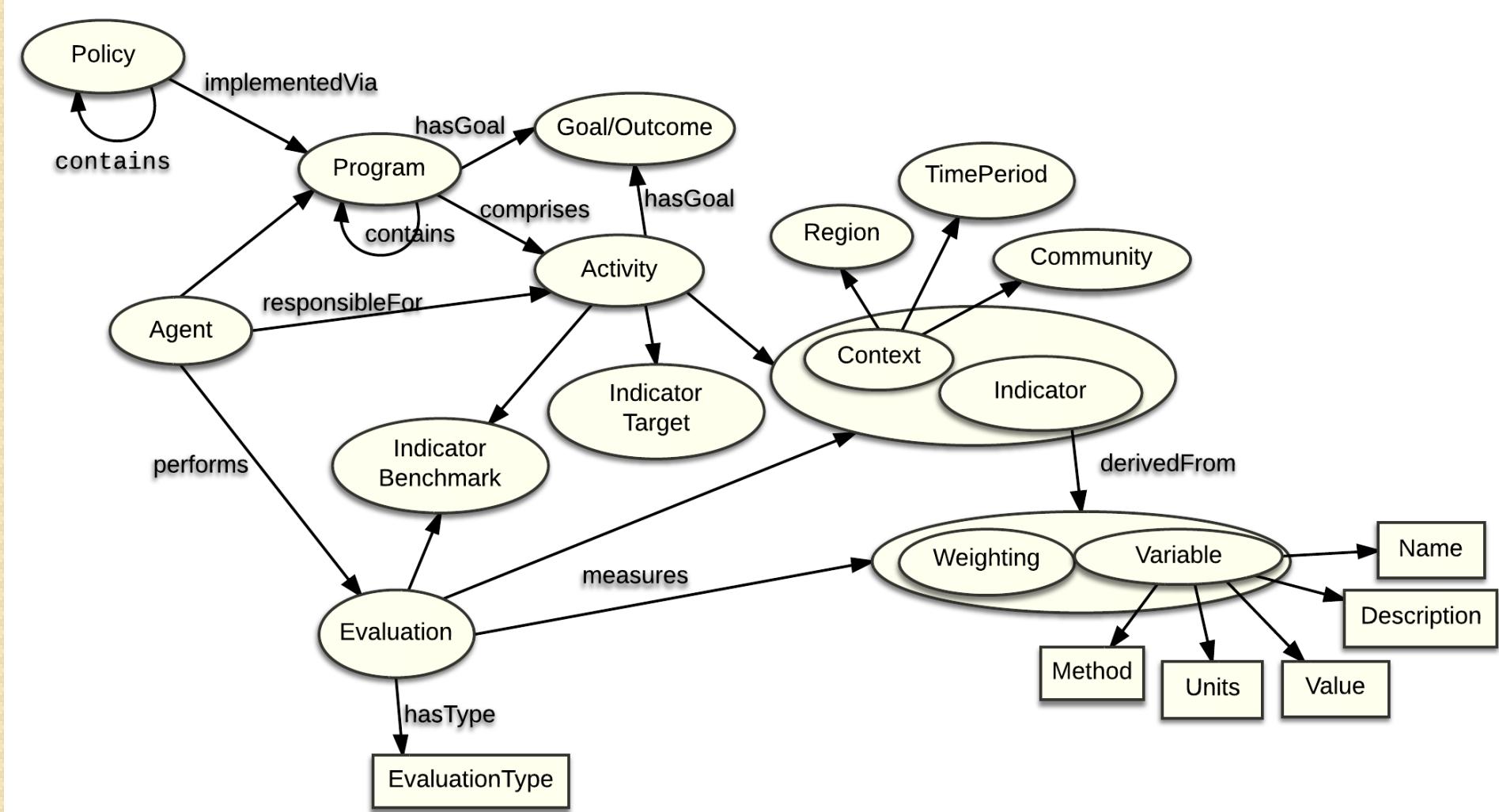
- Qld – Isaac, Lockhardt River, Aurukun, Barcoo, Cherbourg, McKinlay
- NSW – Central Darling, Balranald,
- Victoria - Horsham
- Tasmania – Launceston, Flinders, King Island
- South Australia – Kimba, Wudinna, Elliston
- Western Australia – Ashburton, Perenjori
- Northern Territory – West Arnhem, East Arnhem

Identifies areas for targeting Future Marketing

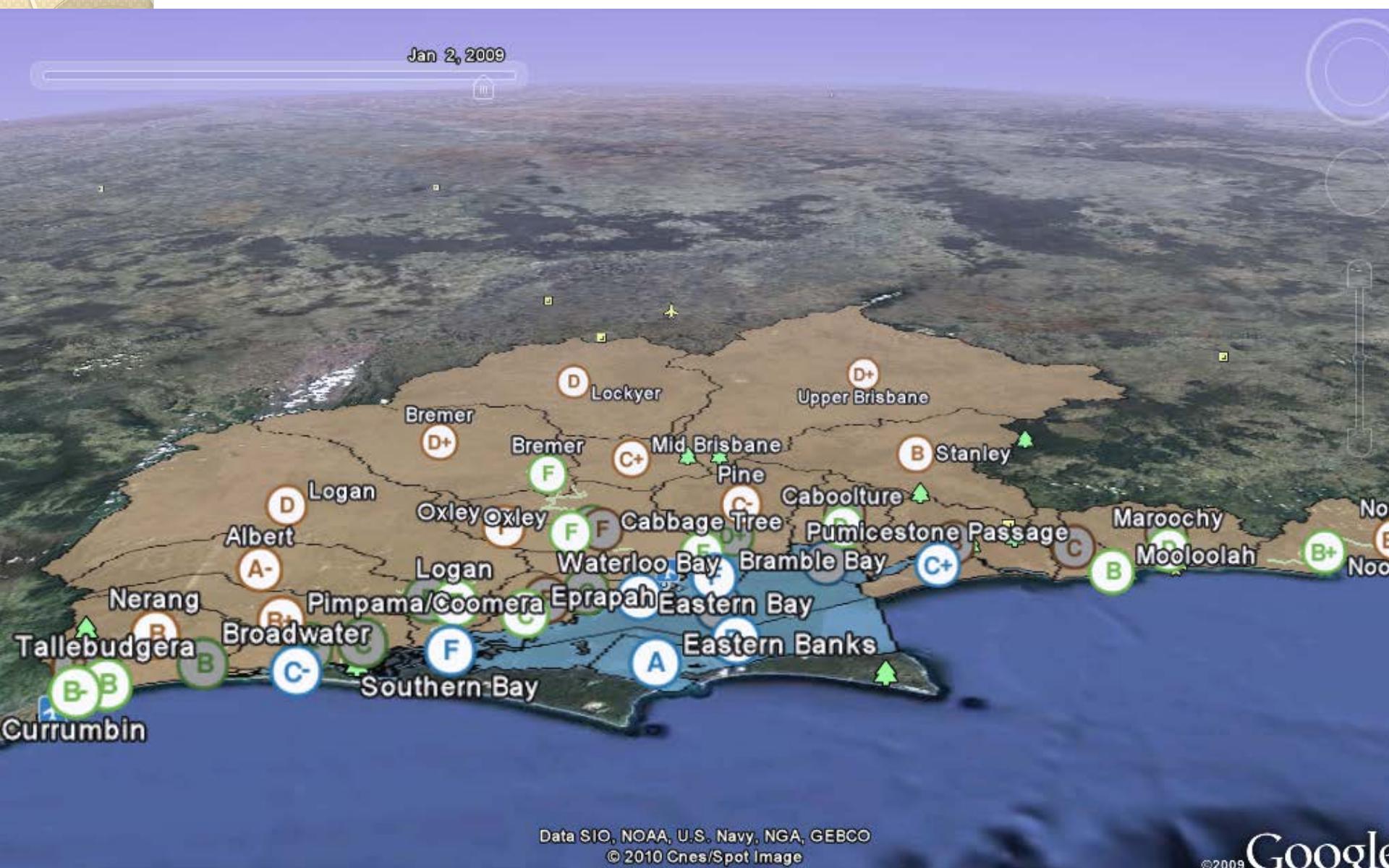
Example 3 – EBPM & Adaptive Management Cycle



Evidence-Based Policy Making Ontology



Online Ecosystem Health Report Cards

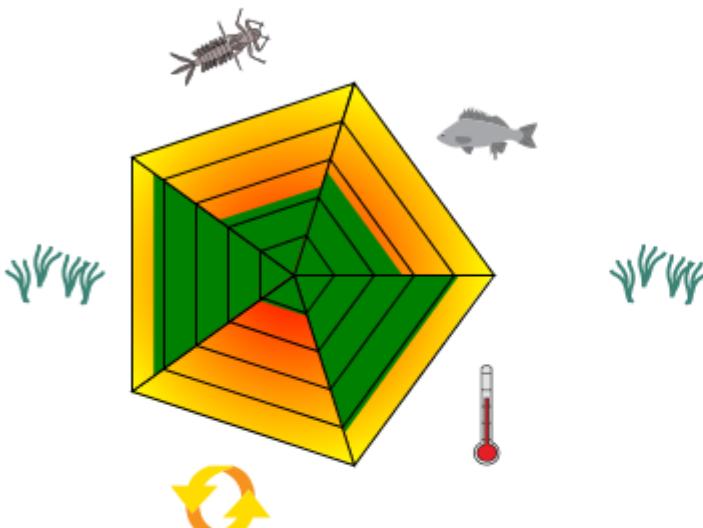


Oxley Catchment

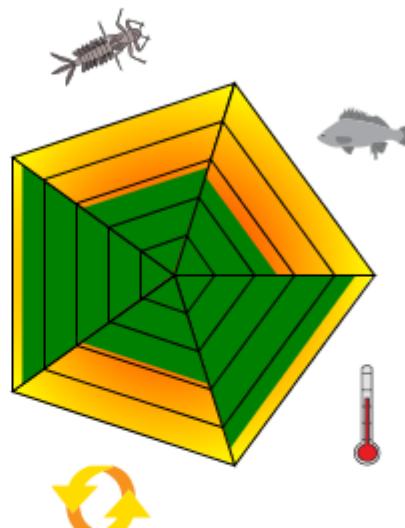
D- 2001 *	D 2002 *	F 2003 *	F 2004 *	D- 2005 *	F 2006 *	F 2007 *	F 2008	F 2009
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EcoH plots Indices Comments Site scores Map

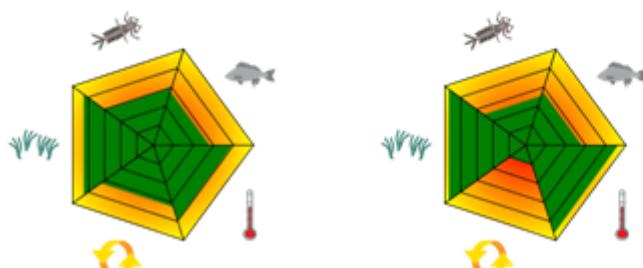
Spring 2008



Autumn 2009

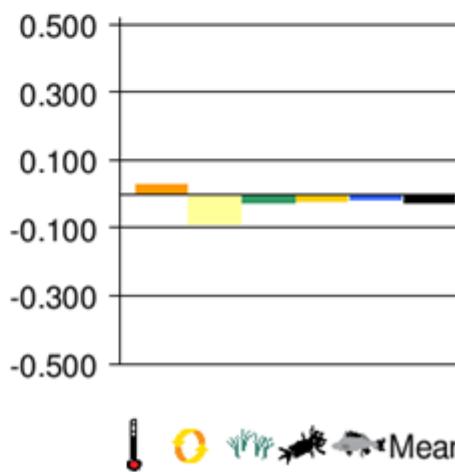


Previous Year
Spring 2007



Autumn 2008

Change over time



Legend

- Fish indicator
- Physical/Chemical indicator
- Nutrient Cycling indicator
- Ecosystem Processes indicator
- Invertebrates indicator

Substantial ecological impact

Good ecological condition

Insufficient data



Management Actions Linked to Environmental Outcomes/Targets

Bremer

Info	D+	F	D-	D
	2004	2005	2006	2007
Metadata				
Sites				
Trends				
Actions				

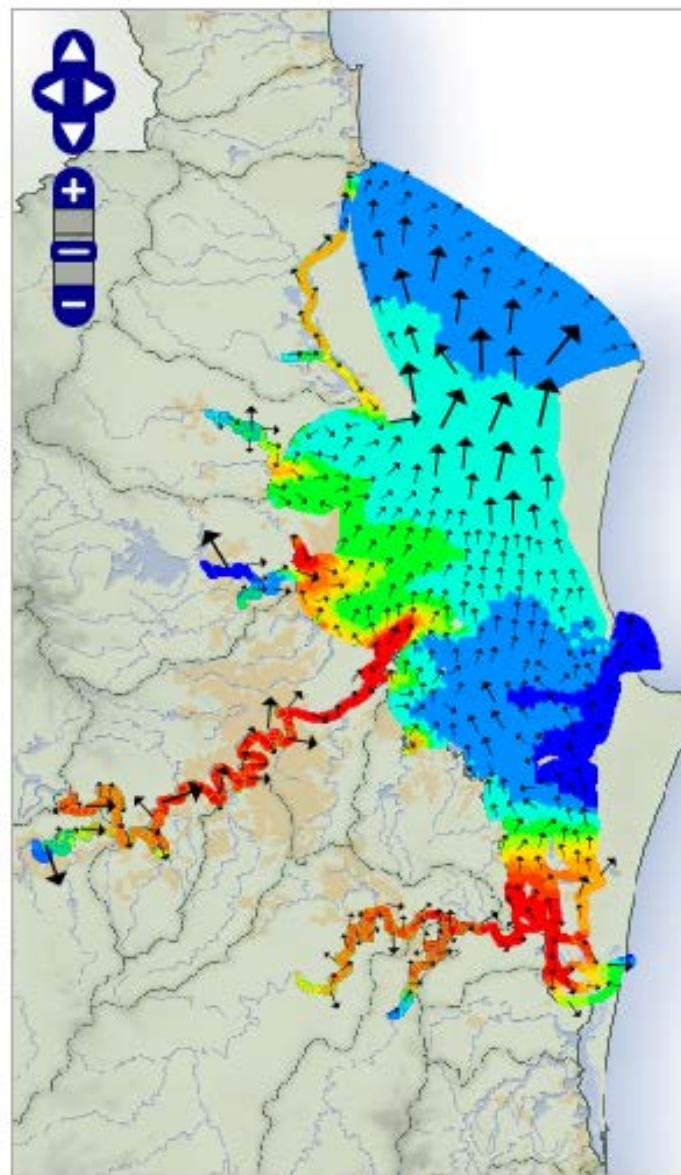
Management actions for Bremer catchment

- 117- Augmentation of the Rosewood Wastewater Treatment Plant
- 118- Improvement of wastewater management at Swanbank Power Station
- 119- Upgrade of Goodna Wastewater Treatment Plant
- 120- 50% reduction in wet weather sewage overflows from pump stations
- 121- Riparian revegetation in Upper Bremer

The figure consists of five separate box plots, each representing a different environmental variable over the years 2004, 2005, 2006, and 2007. The variables are indicated by icons above each plot:

- Plot 1 (Red Drop): Shows a general downward trend from approximately 80 in 2004 to 60 in 2007.
- Plot 2 (Yellow Swirl): Shows a slight increase from approximately 70 in 2004 to 80 in 2007.
- Plot 3 (Green Grass): Shows a slight decrease from approximately 85 in 2004 to 75 in 2007.
- Plot 4 (Black Insect): Shows a slight increase from approximately 75 in 2004 to 85 in 2007.
- Plot 5 (Blue Fish): Shows a slight decrease from approximately 80 in 2004 to 70 in 2007.

“Reduce the nutrient level at sites 123-130 in the Bremer River by 25%”

[Water quality](#)[Bathymetry](#)

Snapshot 1
Sat Jan 01 2000 04:00:00 GMT+1000 (EST)

Select model scenario

▶ Existing load mitigation for 2004 population

▼ Existing load mitigation for 2026 population

Time span: 01/01/2000 to 01/02/2000

Population: 2026 estimate

Waste water treatment: Existing

Urban diffuse loads: Existing

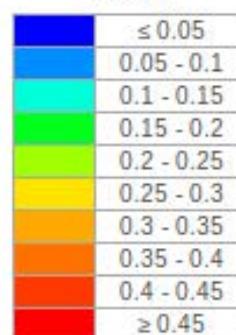
Rural diffuse loads: Existing

▶ Next-best case load mitigation for 2026 population

▶ Best case load mitigation for 2026 population

Oxidised Nitrogen

Oxidised Nitrogen
(mg/L)



Animate model

Loaded: 20/186 snapshots

Speed: 1.5 fps

Buffer: 20 frames

Layers: Water quality

Water velocity

Play

Pause

Note: on slower connections, you may need to reduce the speed or increase the buffer.

Generate chart

Generate a water quality chart for a point on the map:

Generate chart

Research Areas with Significant Need/Potential

- Automate discovery of data/variables to underpin indicators
- Extend Indicator Ontology to:
 - link indicators and monitoring data to targets, action plans and policies (EBPM)
- Use regression analysis & PCA to enhance data quality, detect/document relationships/correlations between indicators
 - overcrowding -> poor educational outcomes;
 - long commute time -> adverse health impact

Research Areas with Significant Potential

- Model indicators/data over time & space
 - Develop and integrate predictive models
- Estimate/document certainty/uncertainty associated with inferred RDF triples/facts
- Hypothesis Testing for researchers
- Apply & Evaluate in the context of Smart Sustainable Cities

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- Mark Moran, Institute for Social Science Research

ARC LIEF LE160100174 Urban Analytics Data Infrastructure

<http://www.csdlila.unimelb.edu.au/projects/UADI/>

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THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

CfP Special Issue of JWS Semantic Statistics

- Submission deadline: 15 Dec, 2016
- Author notification: 1 March 2017
- Final version: 1 May, 2017
- Publication: 3rd quarter, 2017

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SCImago Journal Rank (SJR): **2.435** ⓘ

Special Issue on Semantic Statistics

The Journal of Web Semantics seeks submissions for a special issue on **Semantic Statistics** to be edited by Jane Hunter, Armin Haller and Franck Cotton.

Topics of interest include the following:

- The application of Semantic Web technologies and standards to the formalization, publishing, analysis and linking of statistical and census datasets and metadata;
- The application of statistical methods to Linked Data;
- Representing and inferring the quality of linked data using statistically rigorous methods;
- Vocabularies and ontologies to support the publishing, discovery, linking and re-use of statistical metadata (code lists and classifications).