OZRI2018, Australian Esri User Conference, Sydney

13th November 2018

A hub of smart thinking: The National Australian GeoSpatial Health Hub

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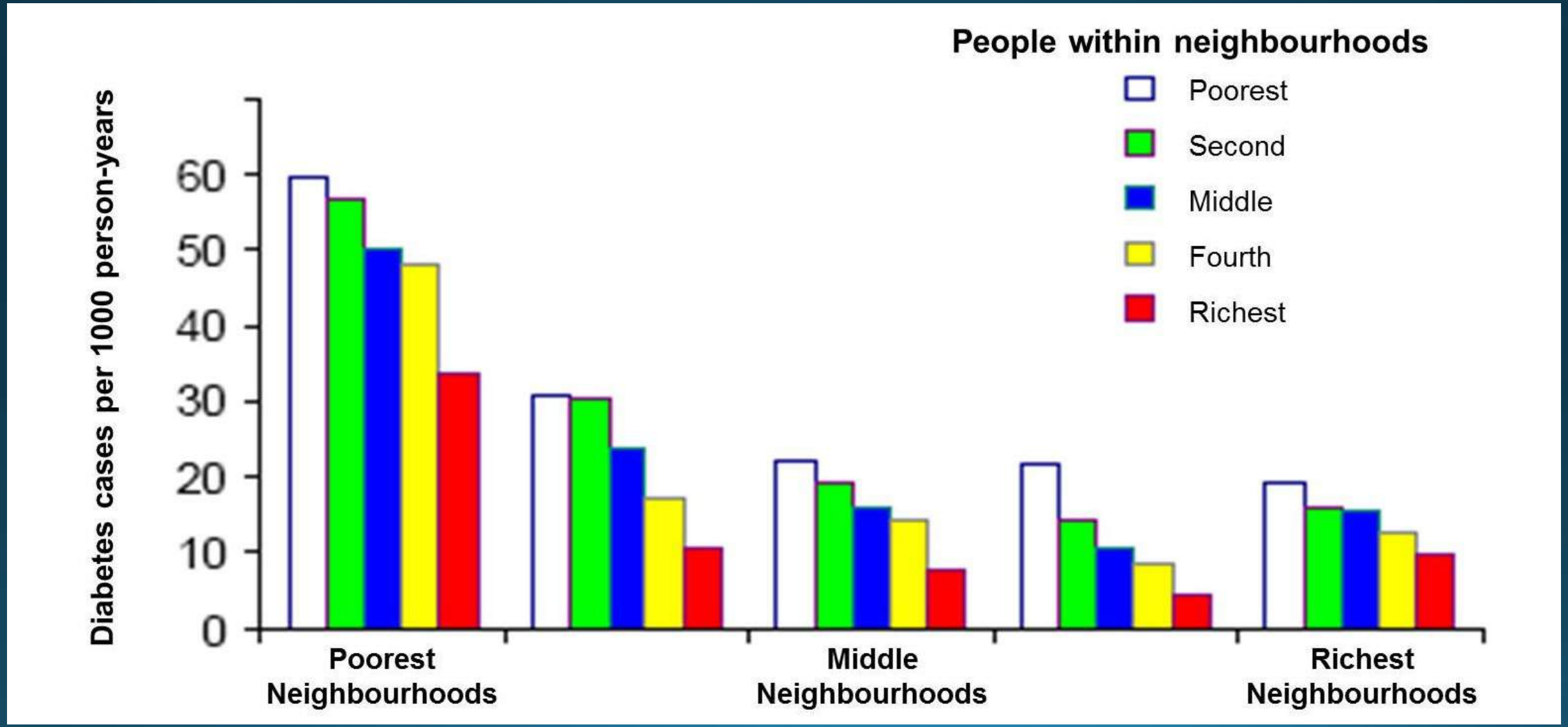
Focal point: spatial variations in health *between* and *within* geographic areas, from states, regions and communities, to neighbourhoods



Geospatial Epidemiology

Study of the patterns of the *spatial* distribution and determinants of disease in human populations

Geospatial epidemiology is to public health what actuarial analysis is to the insurance industry

Risk Factors cause *cases* (diseased individuals)

Properties of the *individual* that exacerbate an underlying vulnerability to ill health or disease

Risk Conditions cause *incidence* (diseased populations)

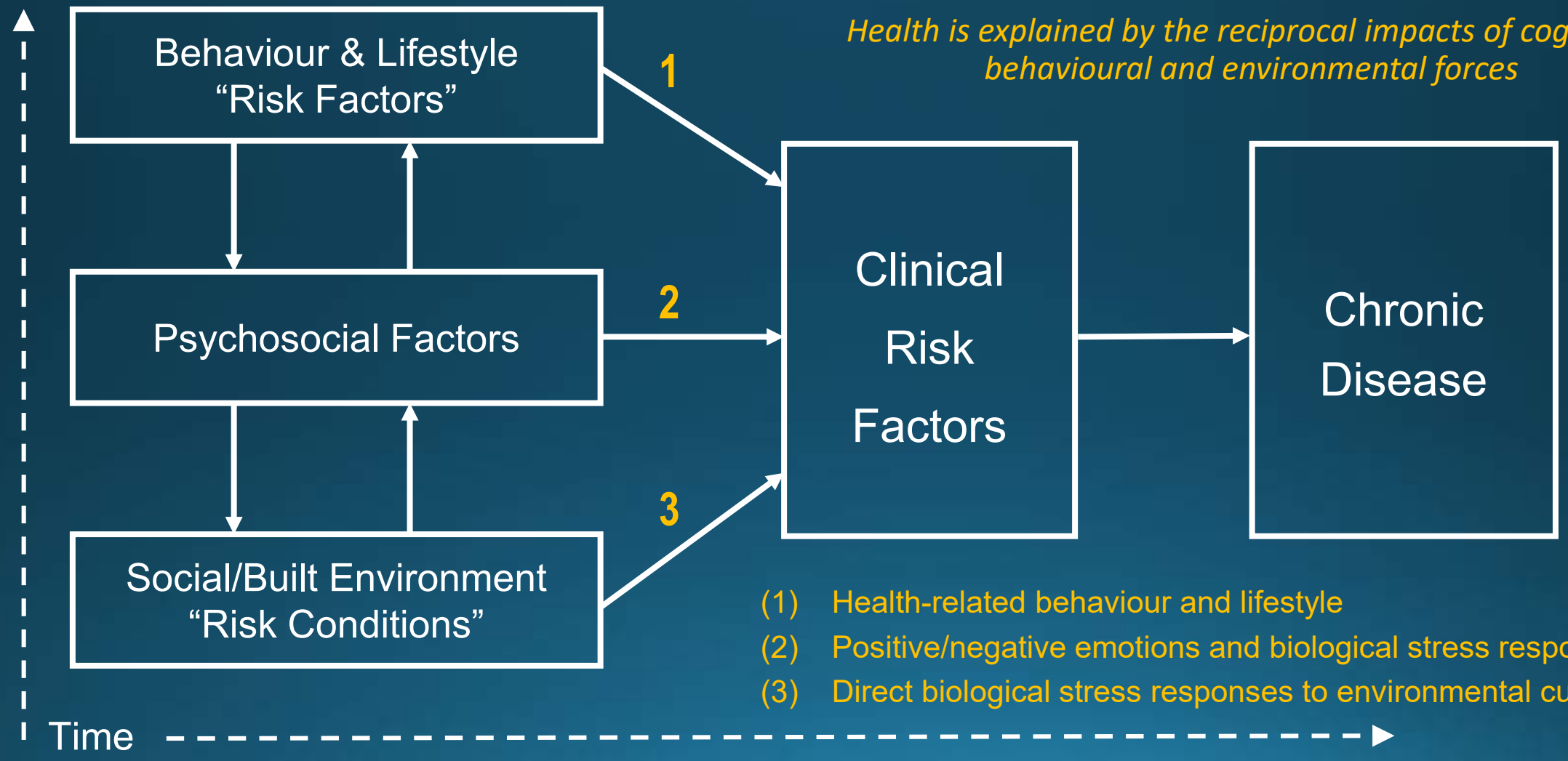
Properties of environments that exacerbate the risk factors and vulnerability of people exposed to places

Daniel M et al. (2008). Framing the biosocial pathways underlying associations between place and cardiometabolic disease. *Health & Place*; 14(2): 117-132

Explanatory model for population health: space and time

Reciprocal Determinism – Social Cognitive Theory

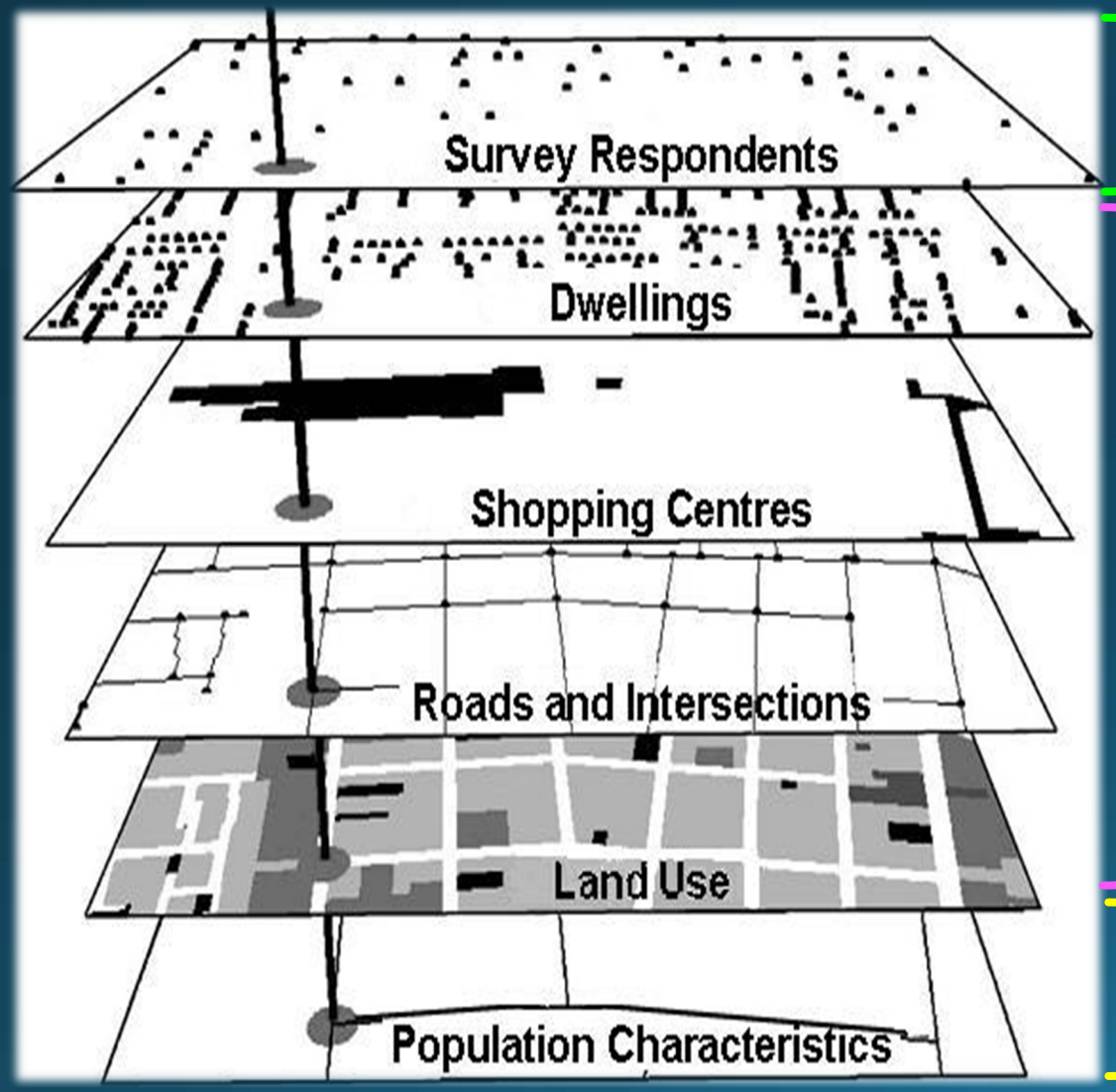
Health is explained by the reciprocal impacts of cognitive, behavioural and environmental forces



(1) Health-related behaviour and lifestyle
(2) Positive/negative emotions and biological stress responses
(3) Direct biological stress responses to environmental cues

Daniel M, Lekkas P, Cargo M (2010). Environments and cardiometabolic diseases. *Heart, Lung and Circulation*; 19(5-6): 306-315

GIS: Georeference links survey or cohort participants to area-level exposures



Individual-level characteristics

Two sets of *spatial structures*

1) Context
   Characteristics of places:
   - *resources*
   - *opportunities,*
   - *living conditions*

2) Composition
   Population characteristics
   - *socio-demographic*
   - *socioeconomic*
   - *collective behaviour/norms*
   - *collective wellbeing*

Leslie E, et al. Walkability of local communities: Using GIS to assess relevant environmental attributes. *Health & Place. 2007;13:111-22.*

Adelaide: 5-year analysis of context and incident CMR (*n*=3,205)

- accounting for area-SES

Participant-centred 1600 metre network buffers

Public Open Space

Fast-food outlets

Retail Food Environment Index

Context

RR per SD: 0.76
95% CI: 0.69, 0.84
p < 0.0001

RR per SD: 1.14
95% CI: 1.07, 1.21
p < 0.0001

RR per SD: 1.11
95% CI: 1.03, 1.20
p < 0.008

Pre-diabetes/ diabetes

Hypertension

Abdominal obesity

Paquet C … Daniel M (2013). Are accessibility and characteristics of public open spaces associated with a better cardiometabolic health? *Landscape and Urban Planning*; 118(October): 70-78

Paquet C … Daniel M (2014). Food environment, walkability, and public open spaces are associated with incident development of cardio-metabolic risk factors in a biomedical cohort. *Health and Place*; 28: 173-176

Adelaide: 10-y analysis of *local descriptive norms* and ΔHbA1c

- accounting for area-SES

Participant-centred 1600 metre network buffers

Context

Urban Form Environment

Composition

Area-Level Norms

Area-level SES

=

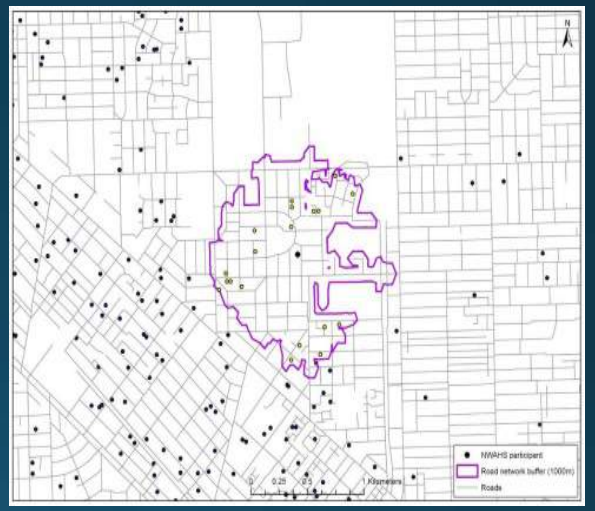
Local descriptive norms

Separate state-wide pop^{n} surveillance data (SAMSS)

Concordance of *1600m buffer* for cohort+SAMSS participants

Buffer-specific prevalence rates:

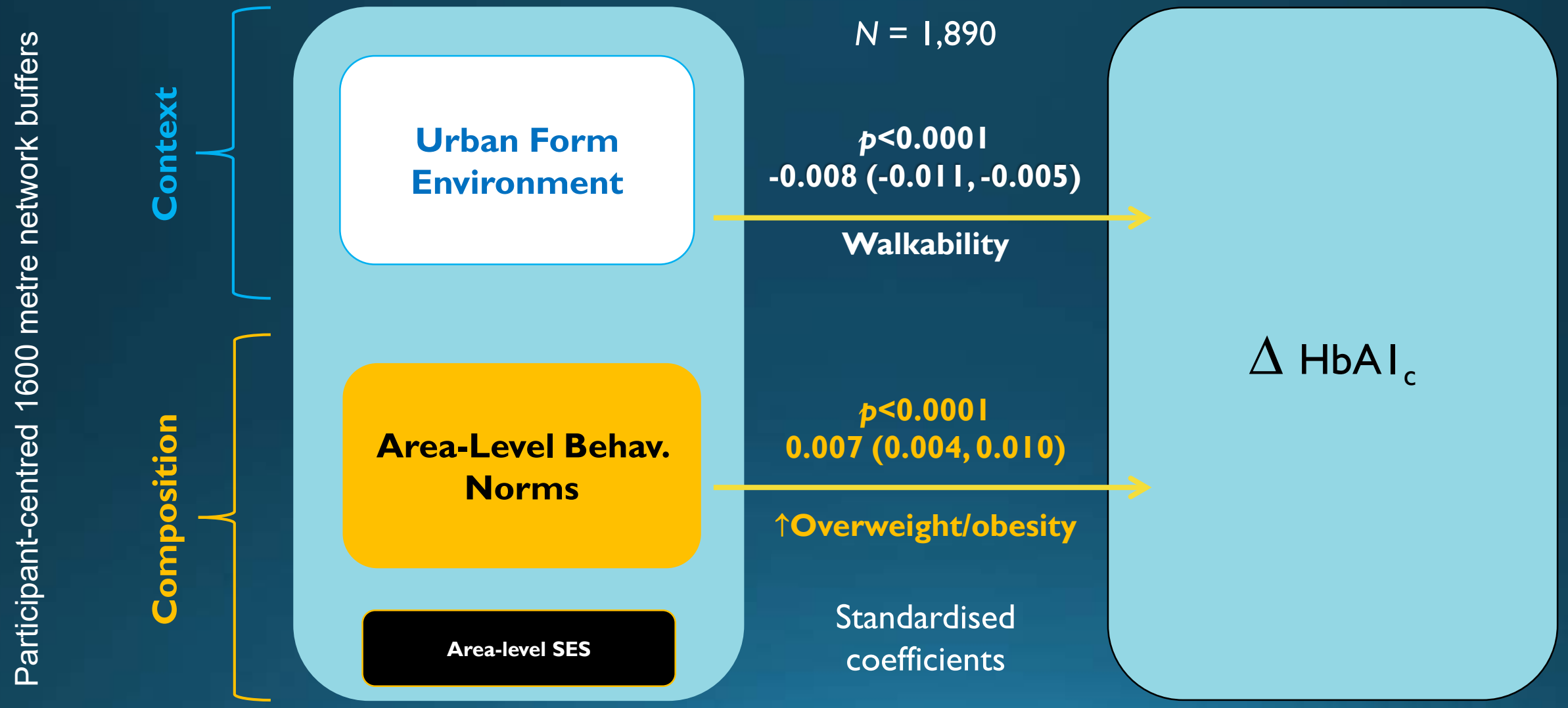
- **Overweight/obesity (≥25kg/m^2)**



Carroll S … Daniel M (2016). Local descriptive norms for overweight and physical activity, the built environment and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *Social Science & Medicine*; 166: 233-43

Adelaide: results of 10-y analysis, accounting for area-level SES

- accounting for area-SES



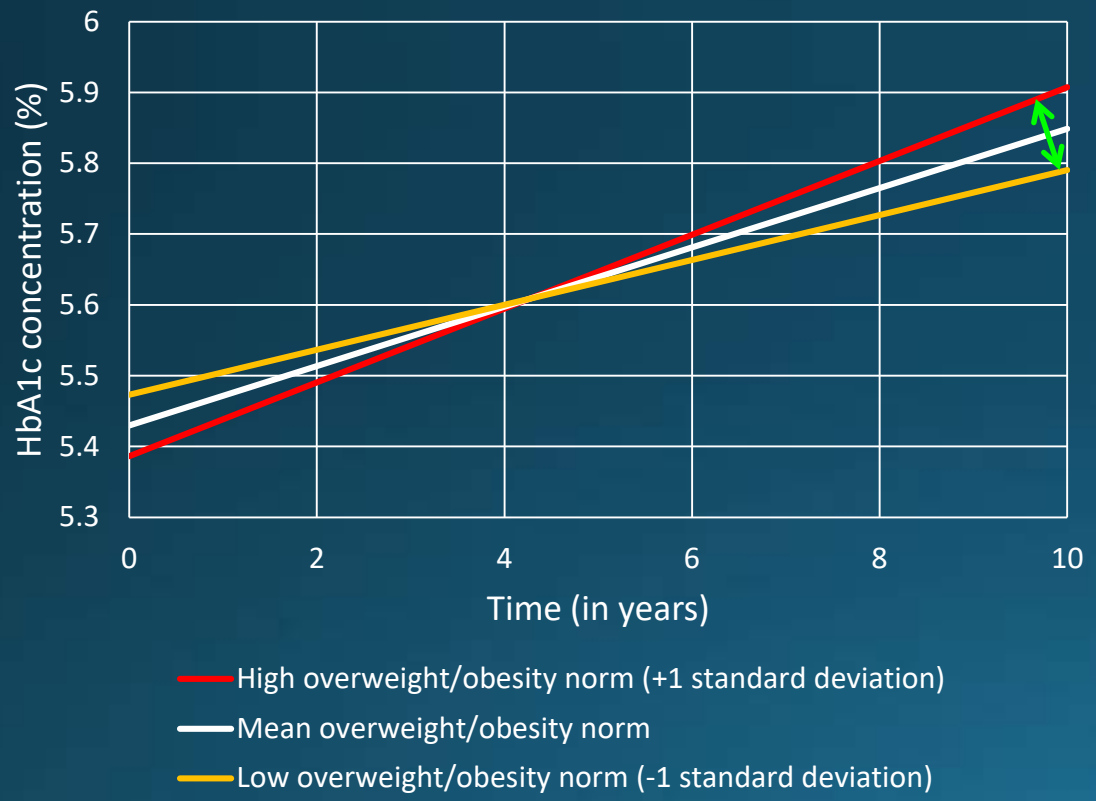
Carroll S … Daniel M (2016). Local descriptive norms for overweight and physical activity, the built environment and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *Social Science & Medicine*; 166: 233-43

Impact of spatial norms on $\Delta HbA1_c$ varies with walkability

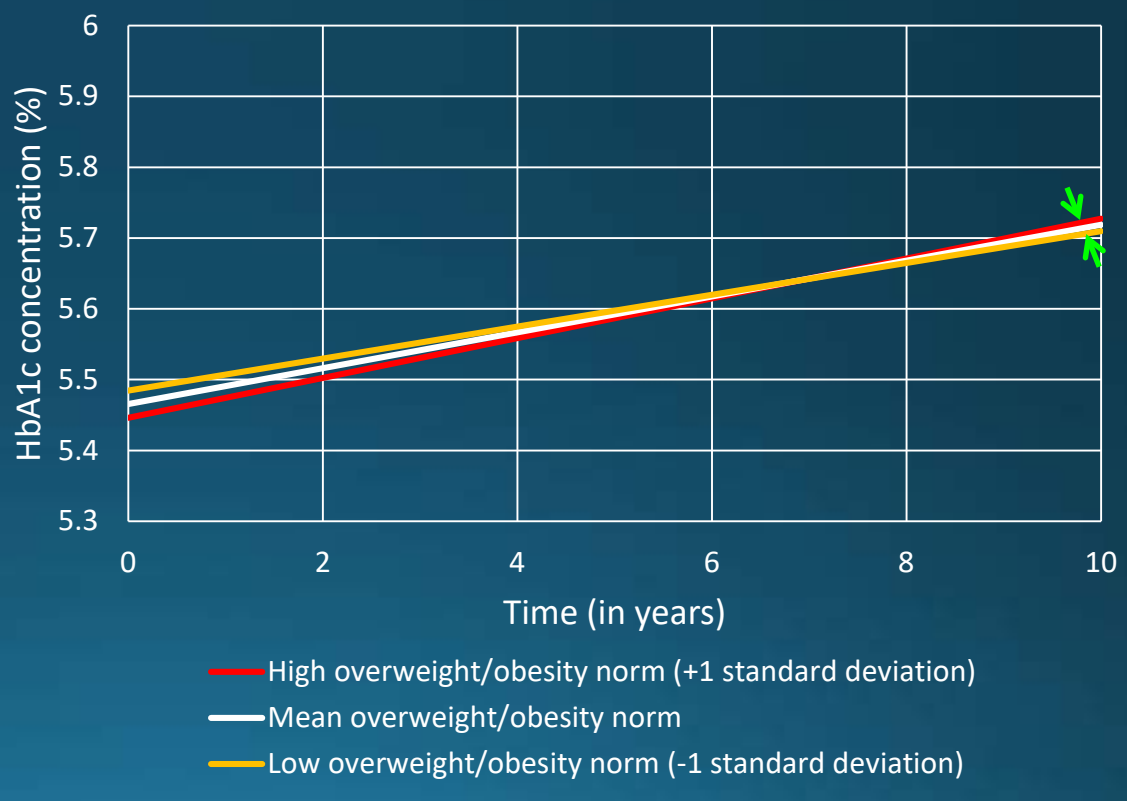
- Local descriptive overweight/obesity norm x walkability
  Estimate (standardised): -0.004 (-0.007 to -0.001), $p < 0.05$

N = 1,890

Low walkability condition
(-1 standard deviation)

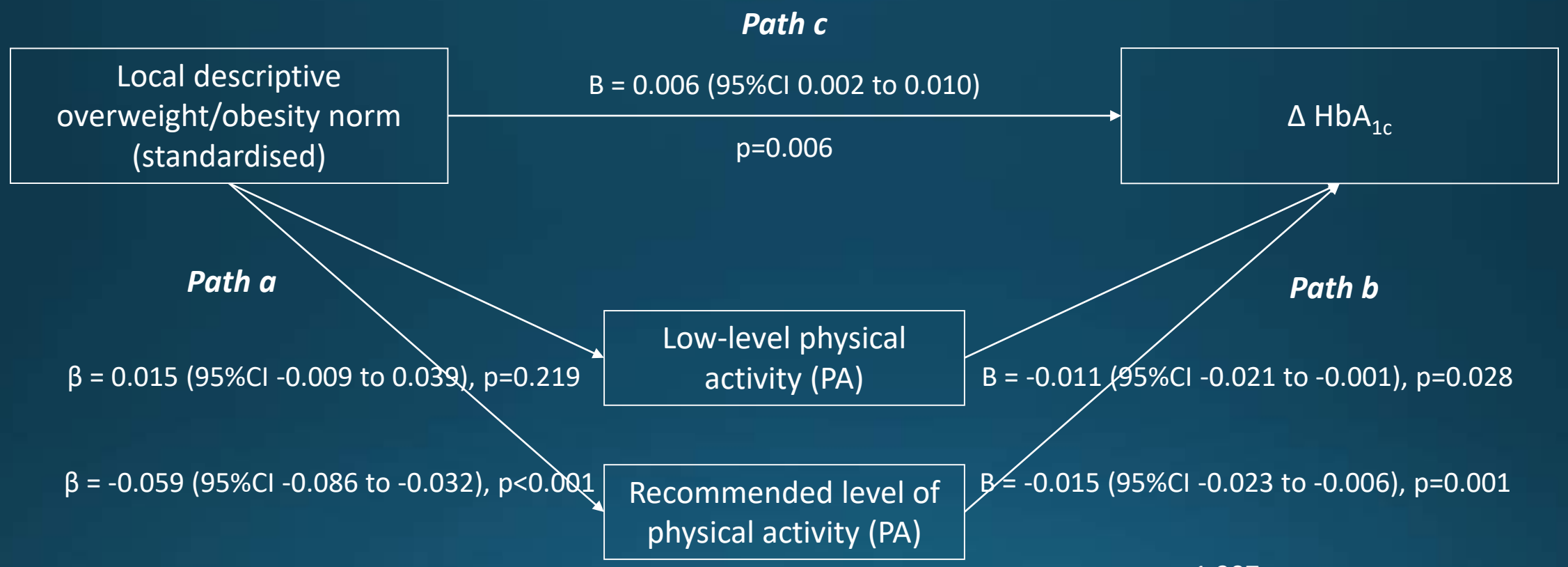


High walkability condition
(+1 standard deviation)



Carroll S … Daniel M (2016). Local descriptive norms for overweight and physical activity, the built environment and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *Social Science & Medicine*; 166: 233-43

Mediation by healthful *versus* unhealthful behaviour of association between area-level collective norms and $\Delta HbA1_c$ across 10 years



n=1,907

Models adjusted for individual-level covariates and area-level median household income

PA=physical activity; reference category is sedentary (i.e., no physical activity)

Indirect effects (*path a* x *path b*):

Through low PA (x100)	β = -0.016 (-0.048 to 0.016), p=0.313 ns
Through recommended PA (x100)	β = 0.085 (0.019 to 0.151), p= 0.011
Total indirect effects (x100)	**β = 0.069 (0.013 to 0.125), p=0.016**

Carroll SJ ... Daniel M (2017). Does physical activity mediate the associations between local-area descriptive norms, built environment walkability and cardiometabolic risk? *Int J Envir Res Pub Health*; 14(953): 1-17

GeoSpatial Health Hub

National Australian Geospatial Infrastructure

"MAPPING OUR WAY
TO HEALTHY POPULATIONS"

- Place and health research
  - Spatial epidemiology of chronic disease
    - Design and evaluation of community-based prevention programs
      - Health services research

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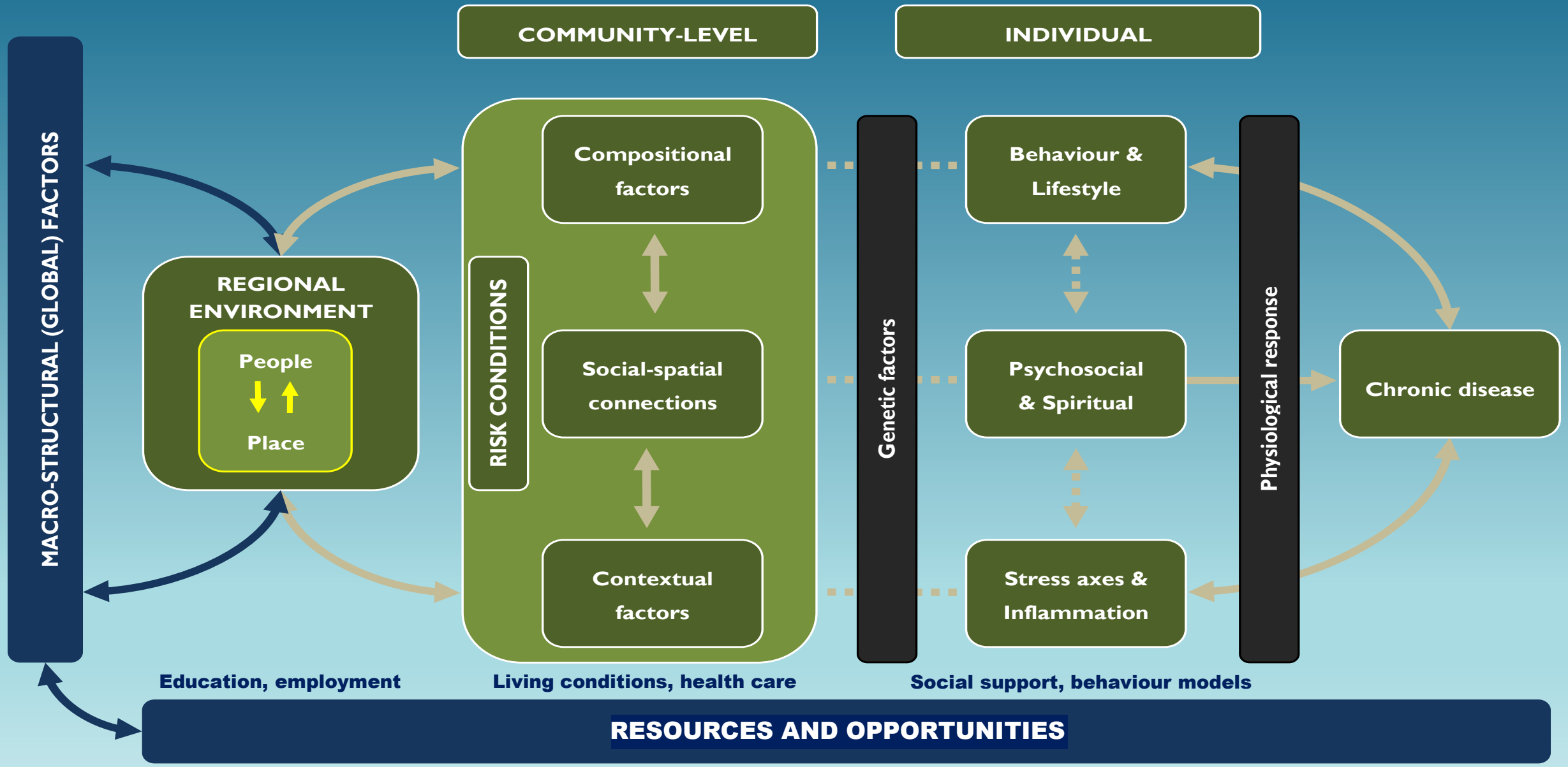
Spatially explaining and understanding the evolution of chronic disease over time



Adapted from: Daniel M et al. (2011). *Annual Review of Public Health*; 32: 327-347

Australian GeoSpatial Health (AGeo-H) Research Hub:

(i) data, (ii) unique spatial infrastructure, (iii) spatial analytic expertise

Collaboration between University of Canberra & *Esri Australia*

Industry – technological means and high-level expertise for GIS development

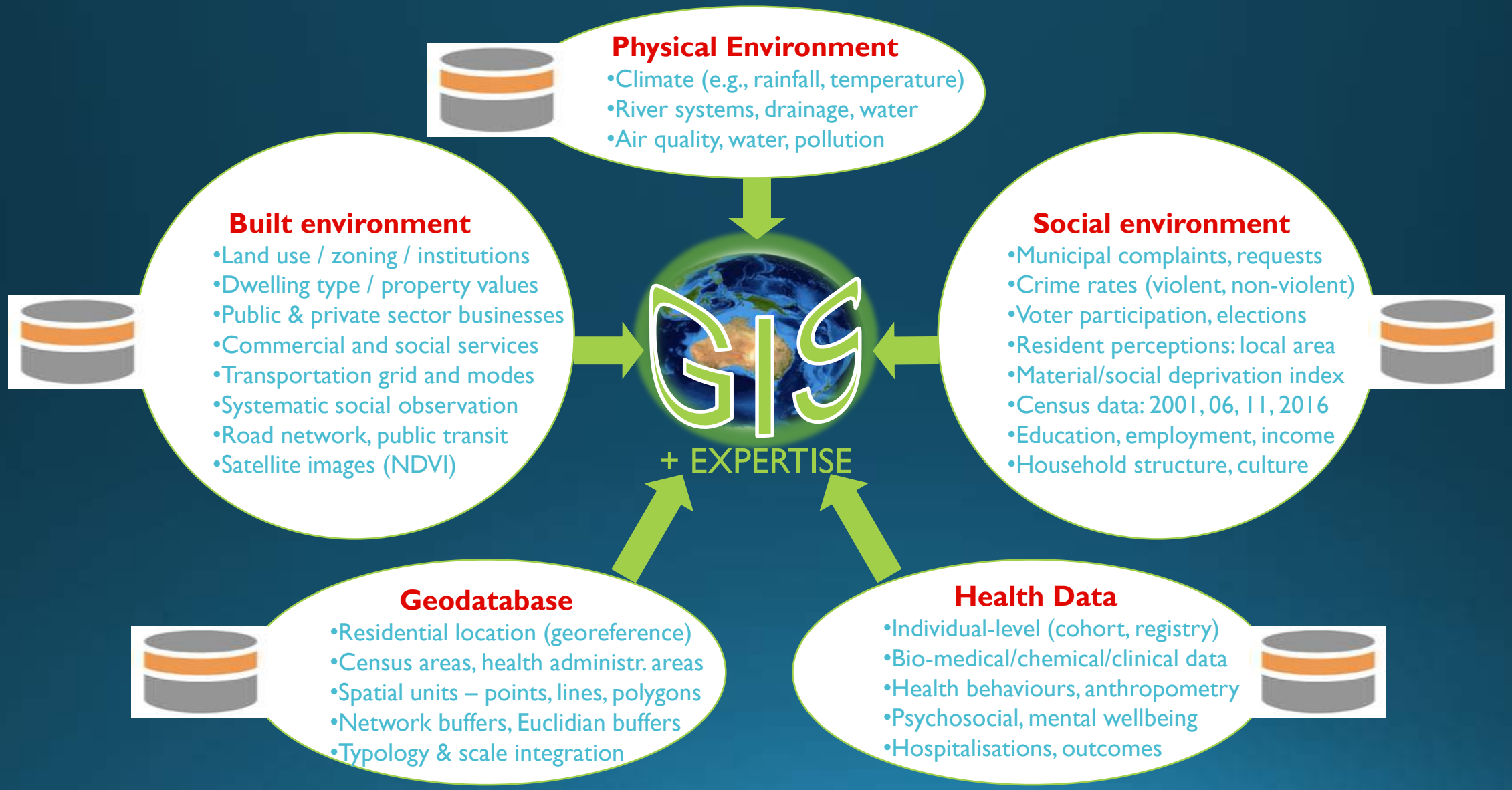
Academe – Data, conceptual IP, basis for application, GIS training program

- ***Partnerships***: A resource for public and private sector initiatives applying spatial analysis to population health and health care relevant data
- Facilitate development of new approaches and methodologies to ***support effective decision-making*** to improve public and population health
- Foremost ***collaborative*** effort to facilitate geospatial analysis of public health prevention research involving internal and external partner agencies
- Support and co-ordinate existing expertise in ***inferential*** geo-spatial analysis and health policy, health planning and environmental health analysis

GeoSpatial Health Hub: Built on ArcGIS Enterprise

Using scalable, enterprise-grade GIS to explain built, social and physical environments

AGeo-H ***basics***: Environmental data, health data, and geodatabase



AGeo-H *unique* components

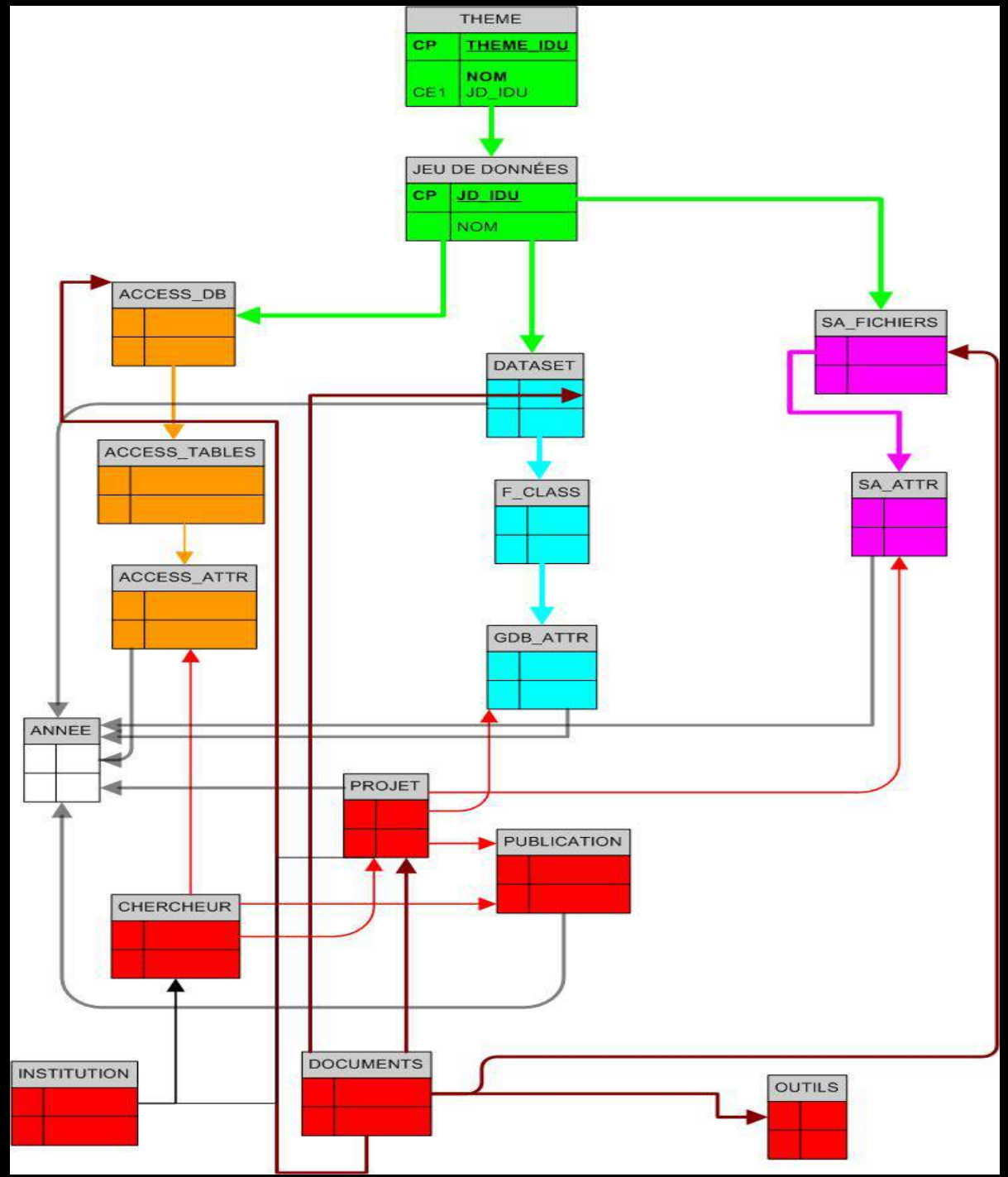
Data management:

1) Information centralising platform (relational data warehouse)
2) CATALOGUE documents information and links between data Spatial data analytics, mapping, **defence industry data security standards**
3) Planned integration with SAP-HANA (in-memory predictive analytics)

4) Web portal for retrieval, editing and sharing of metadata/ data
5) Integration of web-based services for querying, mapping and analysing data
6) Hierarchical indicator classification typology for coding measures

Catalogue relational system

- Themes
- Database
- Spatial data
- Other types of documents
- Stand-alone tables (researchers, projects publications, etc.)
- Year

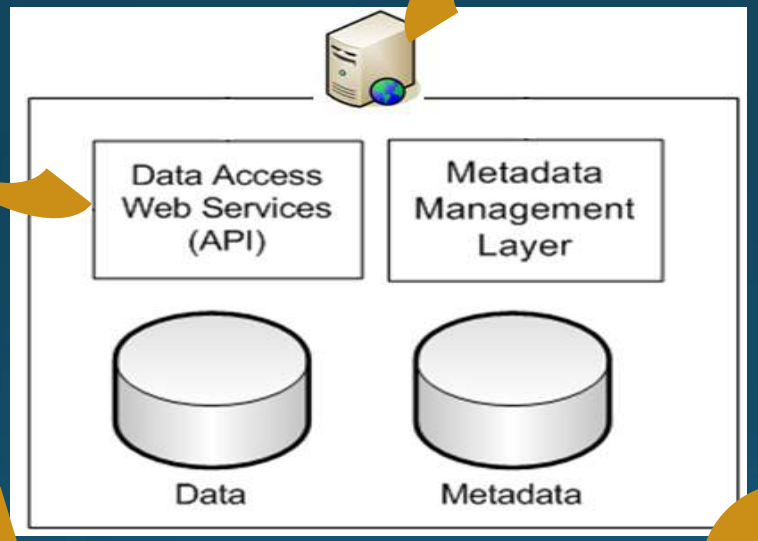


AGeo-H: Resolving challenges to multi-site collaborative research

Geospatial Web services (WFS, WCS, WMS, etc.)

Web portal

Local files
Lack of linkage to metadata
Non standardised
Non interoperable
Poorly organised
Poor capacity for comparative work

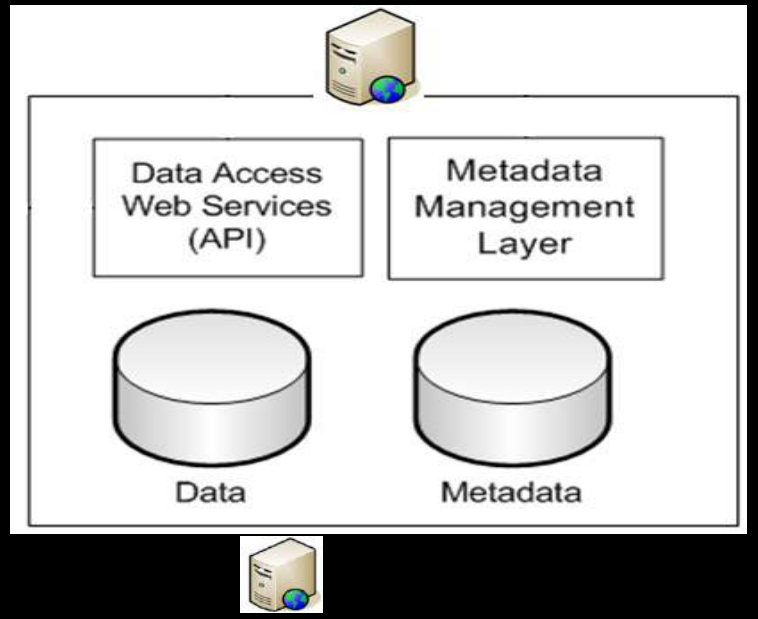


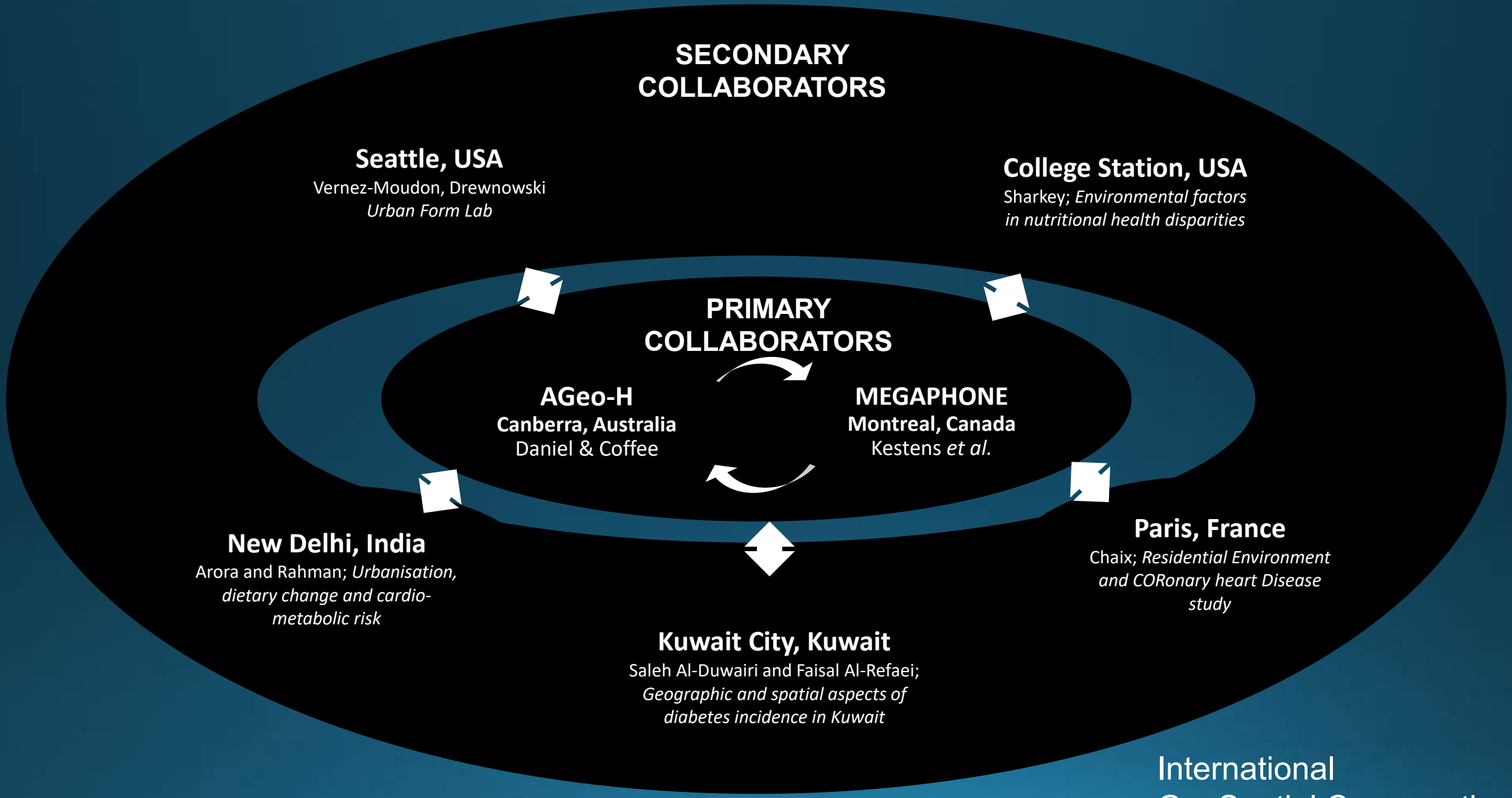
Respects standards (ISO) Interoperable Secured

Geospatial Database Management System

Comprehensive indicator typology and classification system

Ageo-H: Enabling collaborative national and international research





International GeoSpatial Co-operative

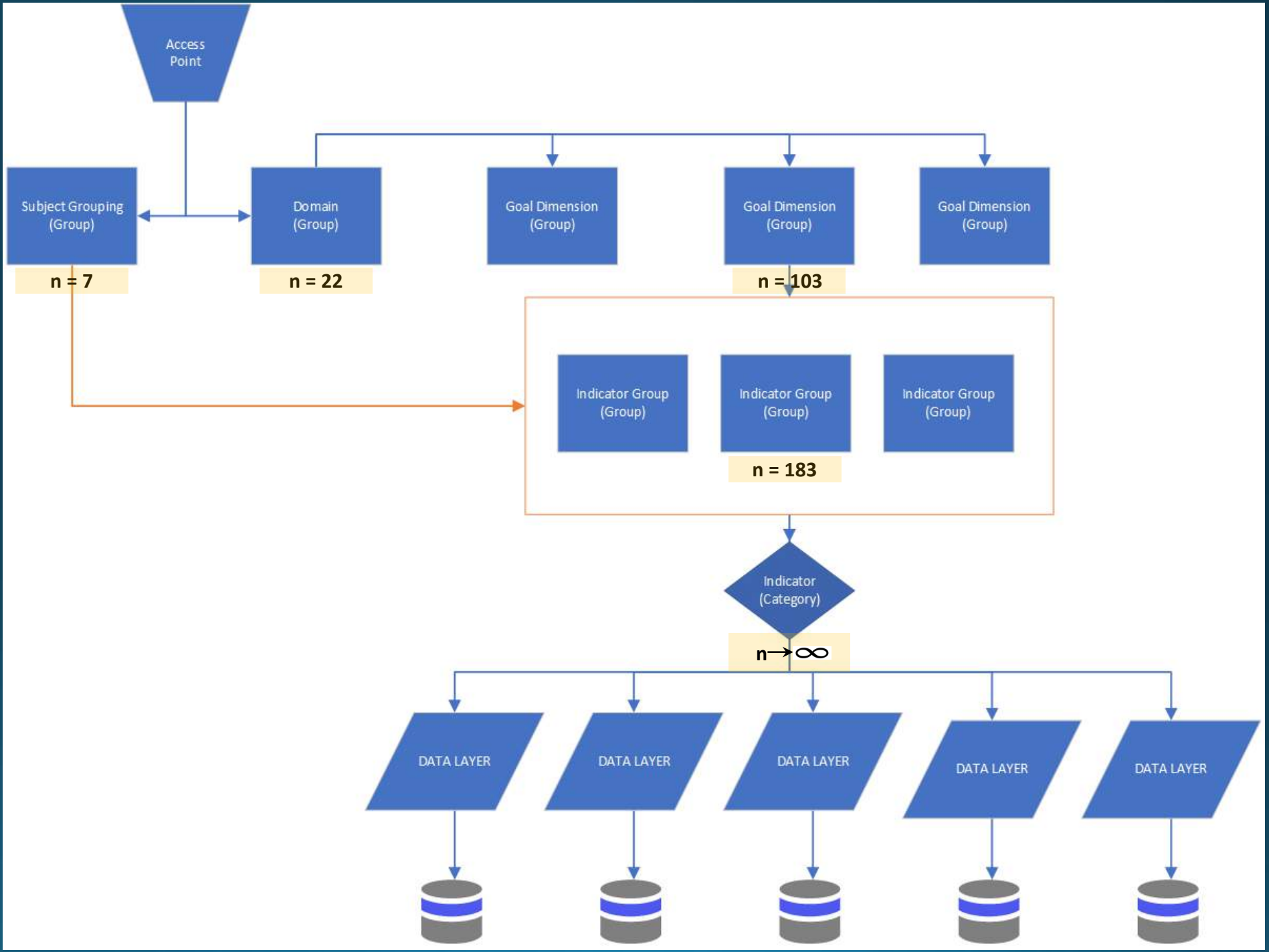
Relational

Hierarchical

Indicator

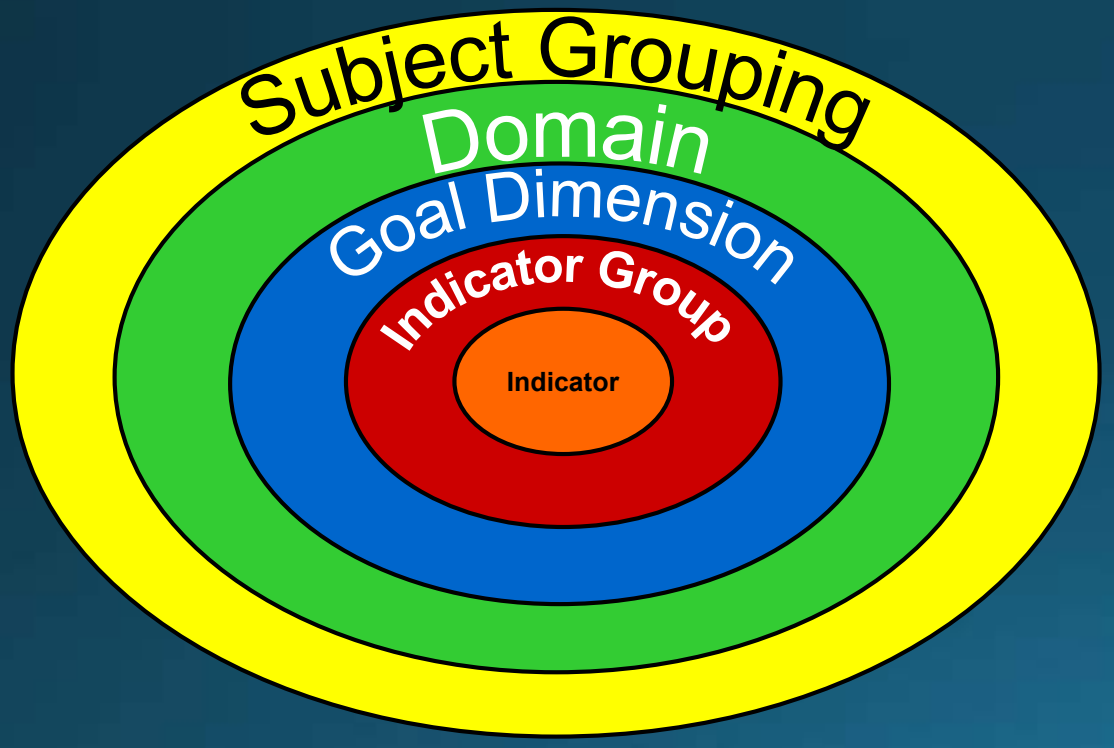
Classification

System



Indicator catalogue: variables classified per indicator framework

Adaptation of "German System of Social Indicators" extended to include attributes relevant to marginalised communities



All AGeo-H variables are classified in the Indicator Framework

- Scientific and objective system for classification
- Permits assessment of coverage of data included in AEGIS
- Discriminates comparability of different measures
- Allows identification of themes or data that are missing in AEGIS

Marks E, Cargo MD, Daniel M. (2007) Constructing a health and social indicator framework. *Social Indicators Research* 82: 93-110.
Daniel M et al. (2009). Rating health and social indicators. *Social Indicators Research*; 94(2): 241-256.

Indicator classification framework

7 thematic categories comprise "Subject Groupings"

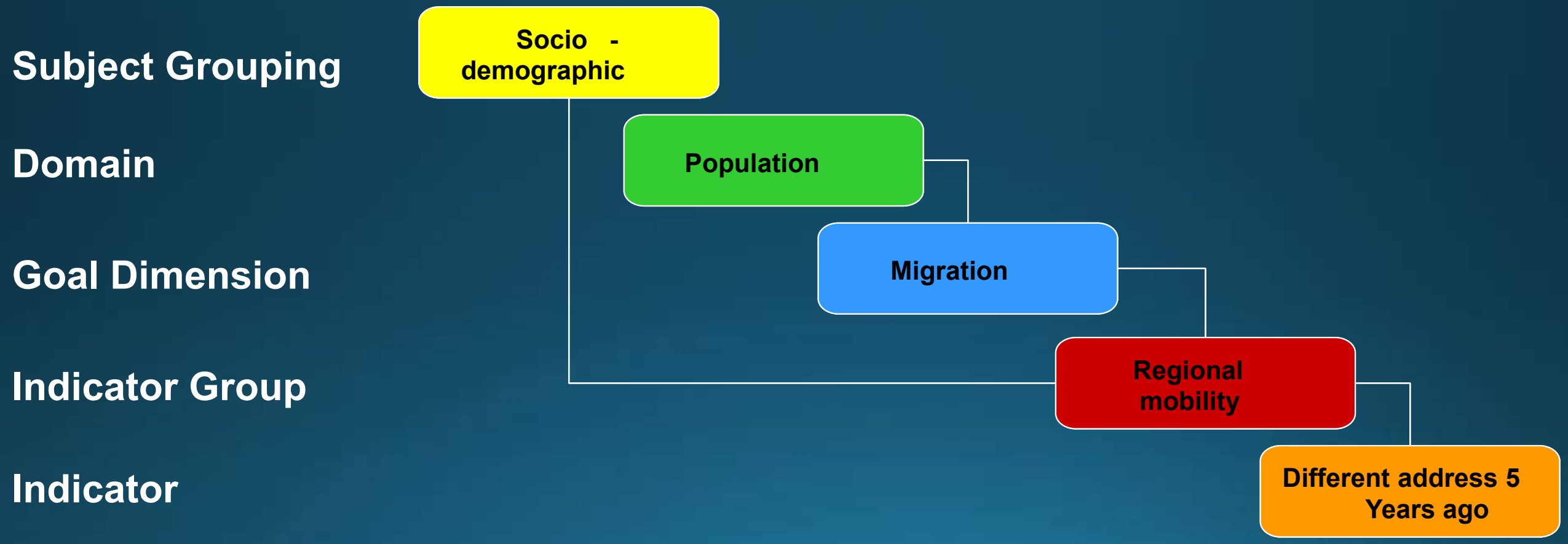
- **Built and Natural Environment**
- **Culture**
- **Psycho-Social**
- **Social Service Systems**
- **Socio-Demographic**
- **Socio-Economic**
- **Socio-Political**

22 Domains

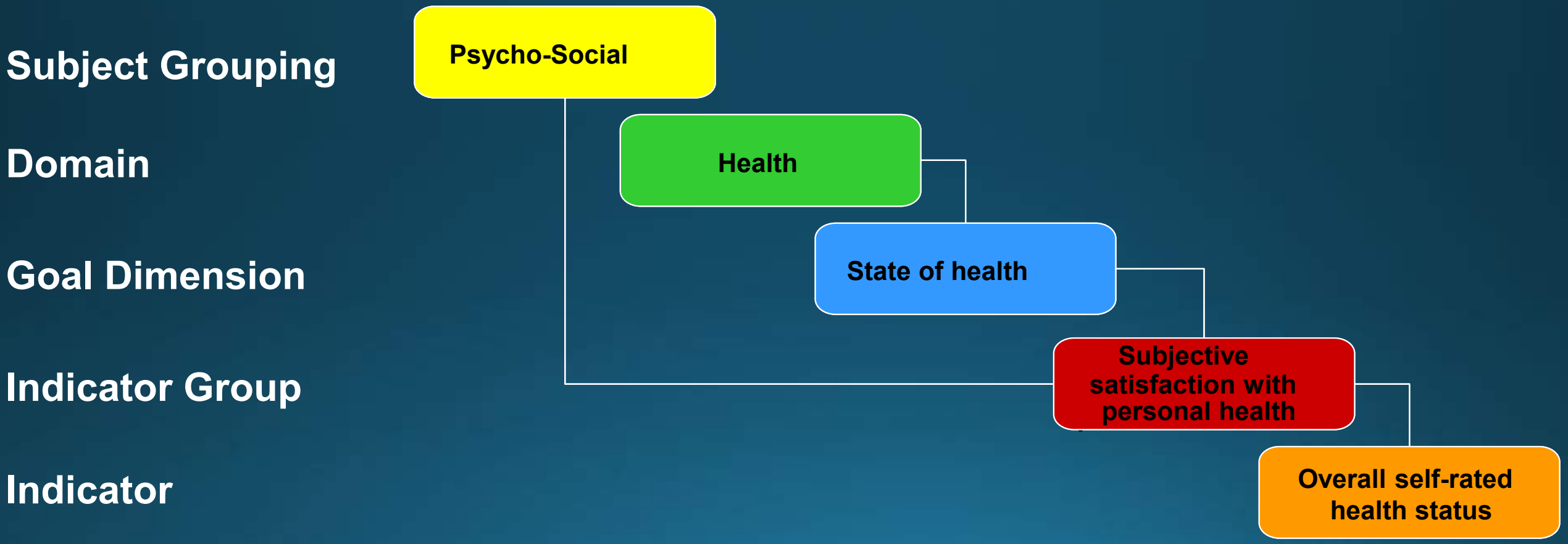
- **Background and History**
- **Community Economic Resources**
- **Community Well-Being**
- **Consumption and Supply**
- **Education**
- **The Environment**
- **Health**
- **Housing**
- **Income and Income Distribution**
- **Indigenous Self-Government and Autonomy**
- **Individual Well-Being**
- **The Labour Market and Working Conditions**
- **Leisure and Media Consumption**
- **Language**
- **Participation**
- **Population**
- **Public Safety and Crime**
- **Social Welfare**
- **Socioeconomic Status and Subjective Class**
- **Traditional Activities and Cultural Responsibilities**
- **Transportation**
- **Visibility and Representation**

Marks E, Cargo MD, Daniel M. (2007) Constructing a health and social indicator framework. *Social Indicators Research* 82: 93-110.
Daniel M et al. (2009). Rating health and social indicators. *Social Indicators Research*; 94(2): 241-256.

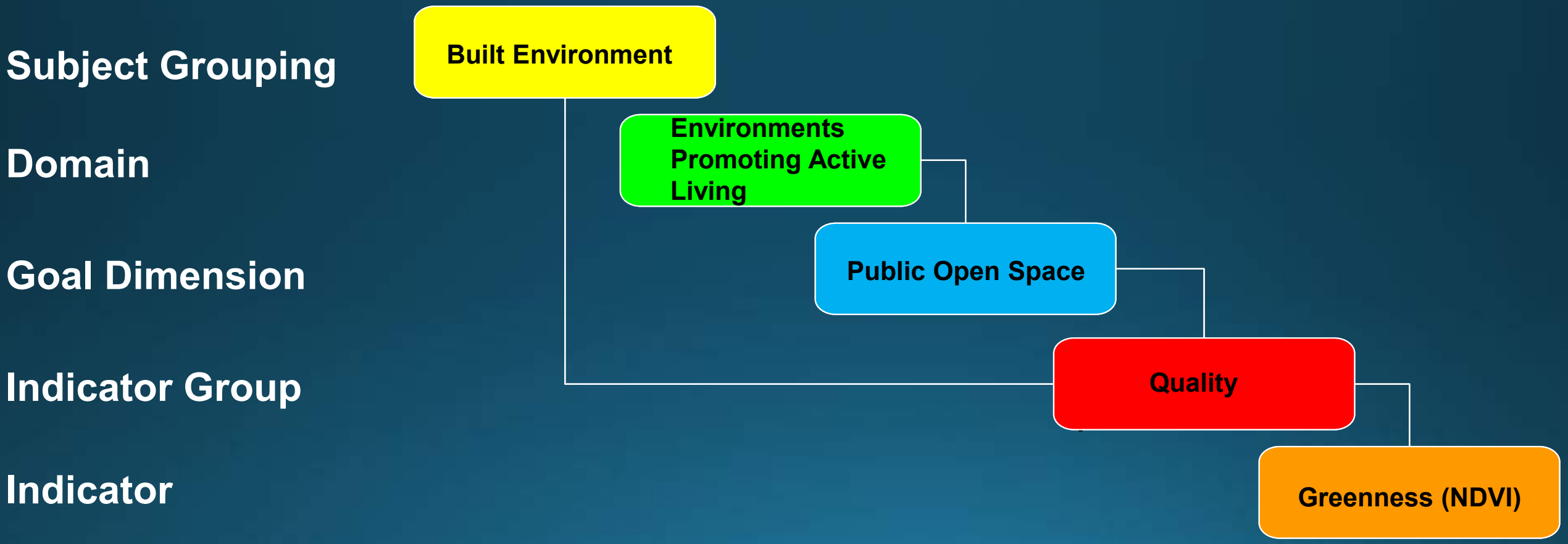
Example: indicator in framework



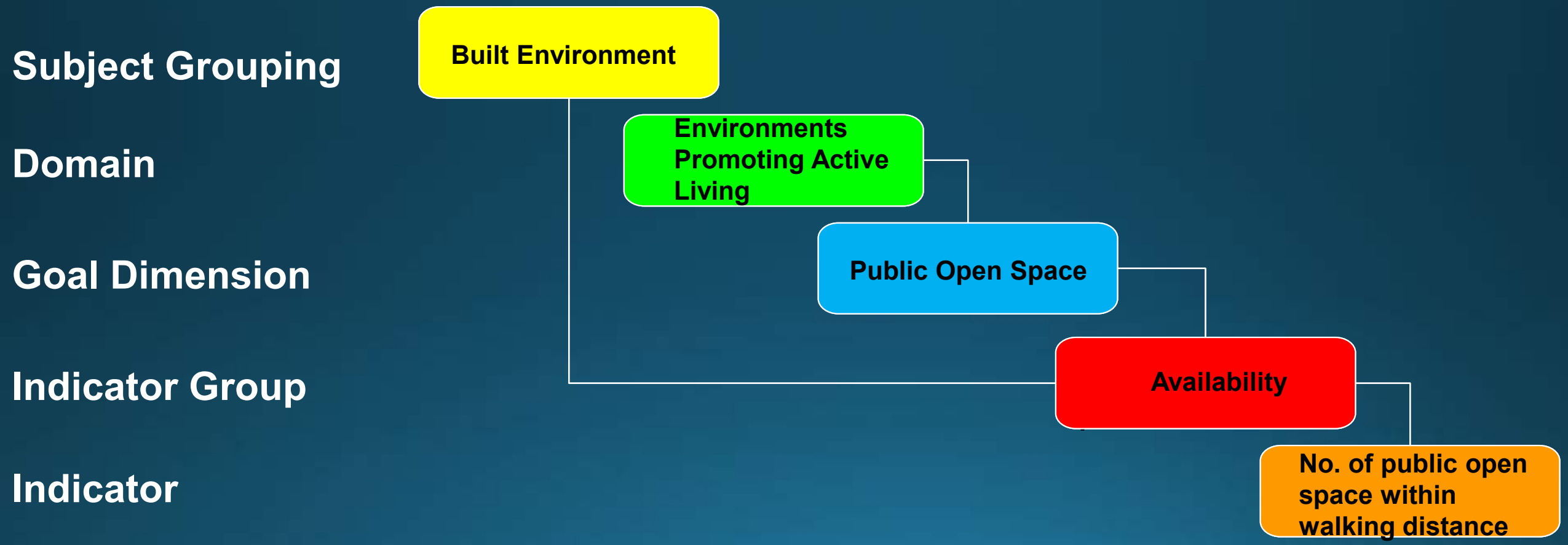
Example: indicator in framework



Example: indicator in framework

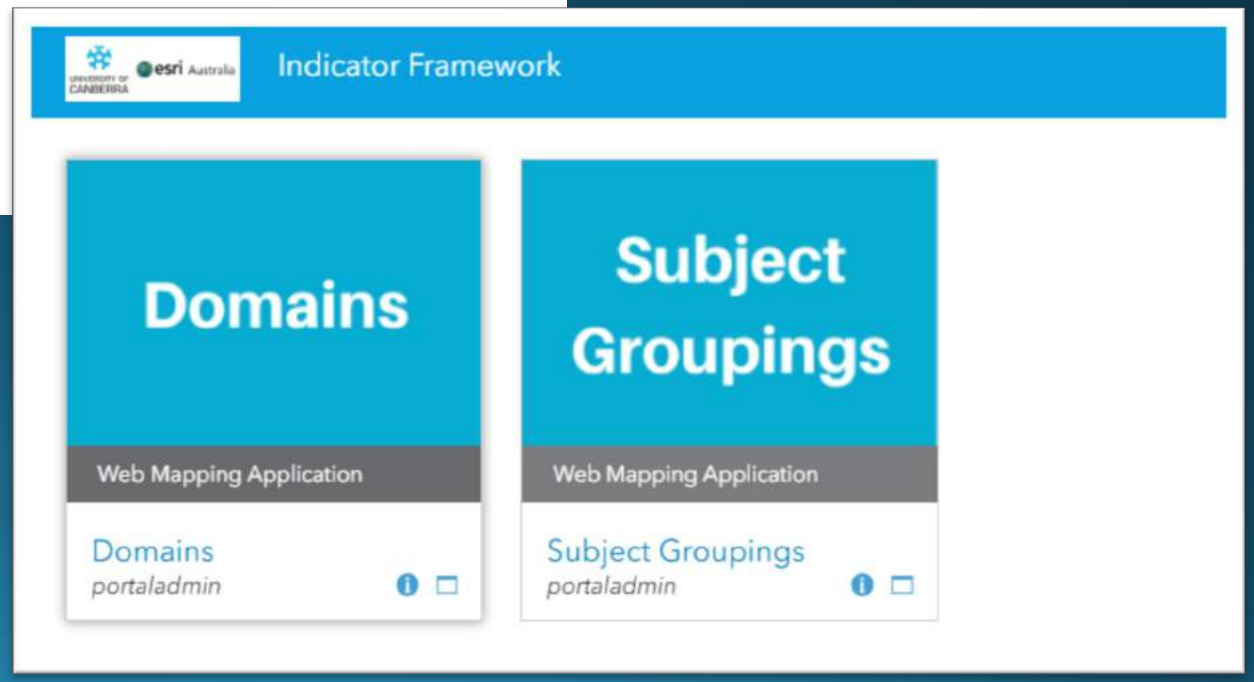


Example: indicator in framework



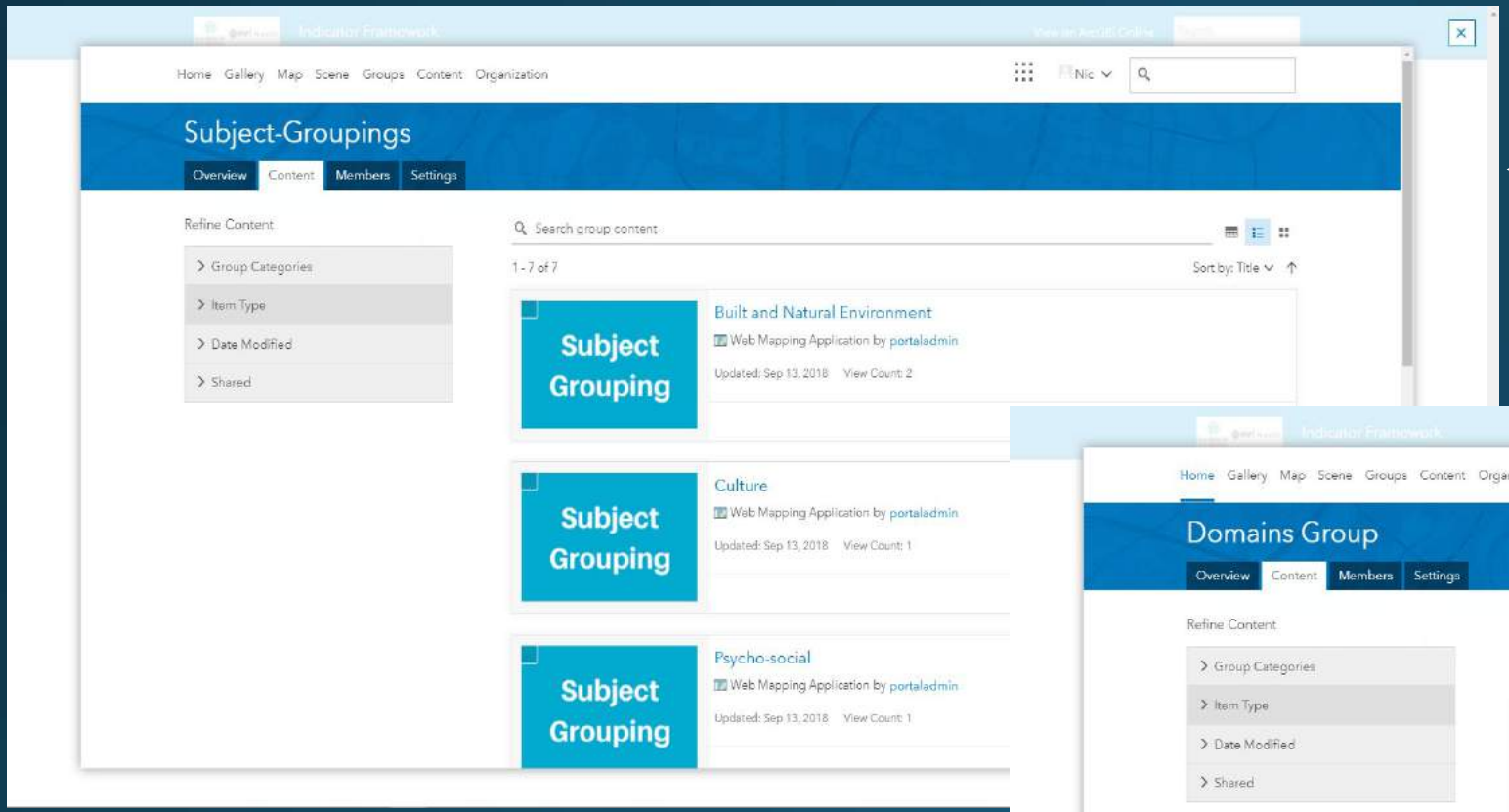
AEGIS catalogue: data consultation interface

← 1) Home

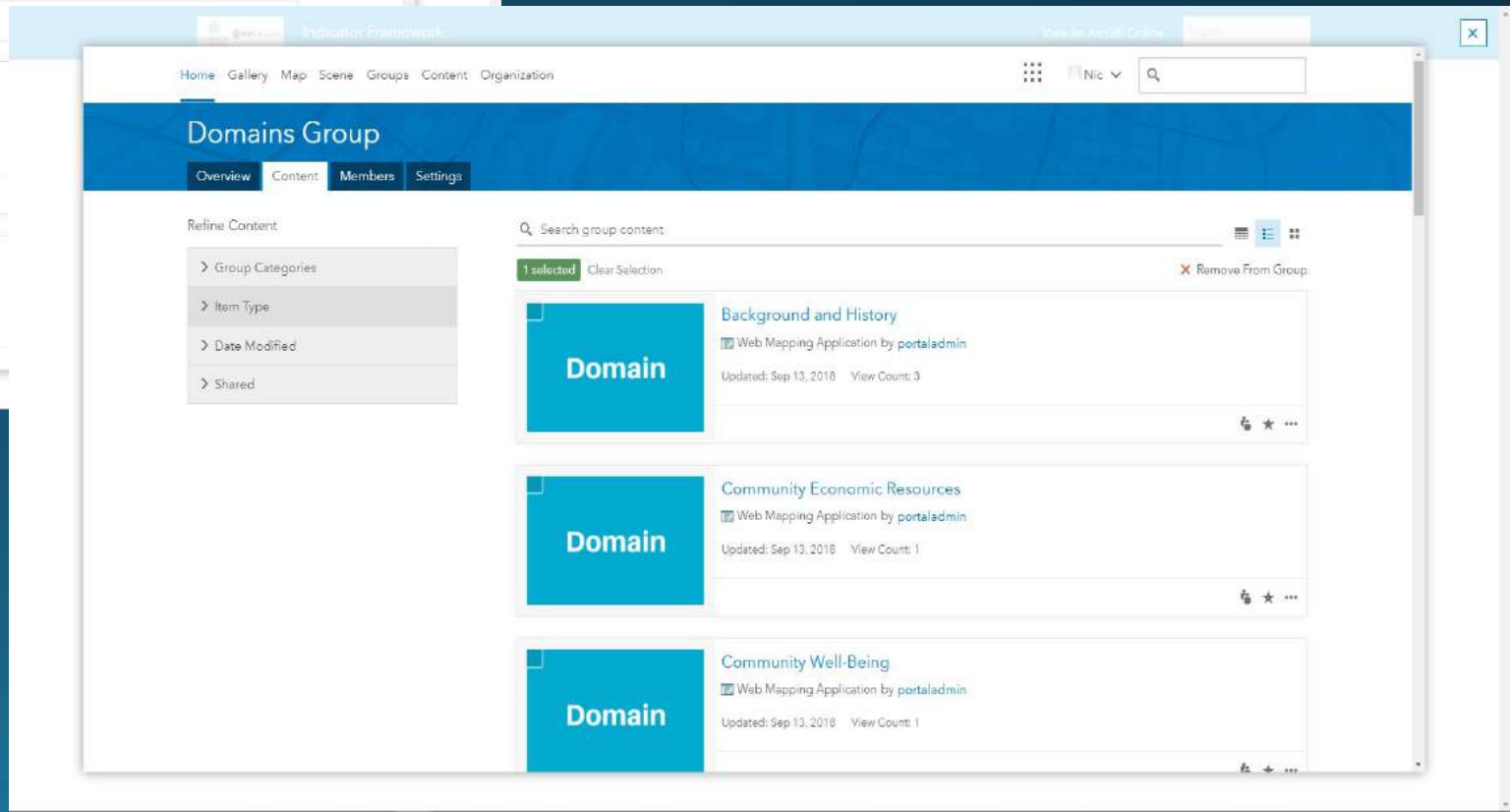


2) Access indicator classification framework →

AEGIS catalogue: data consultation interface

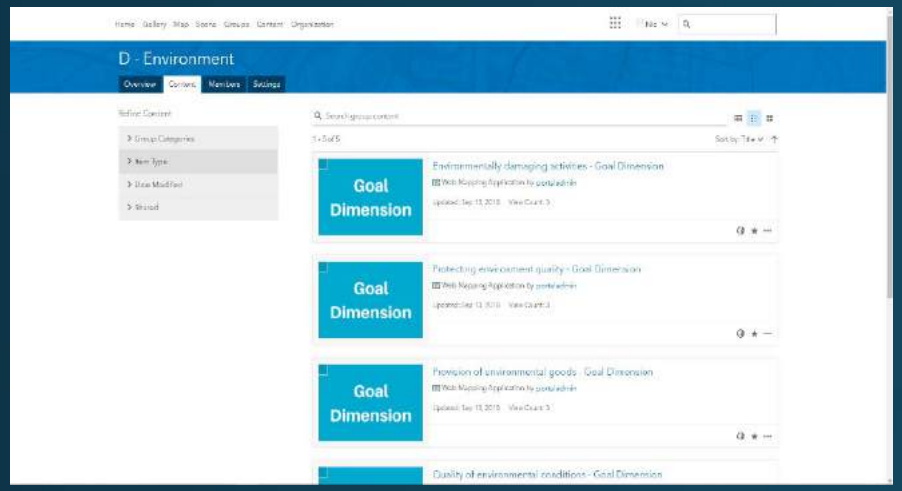


3a) Subject group leading to indicator group

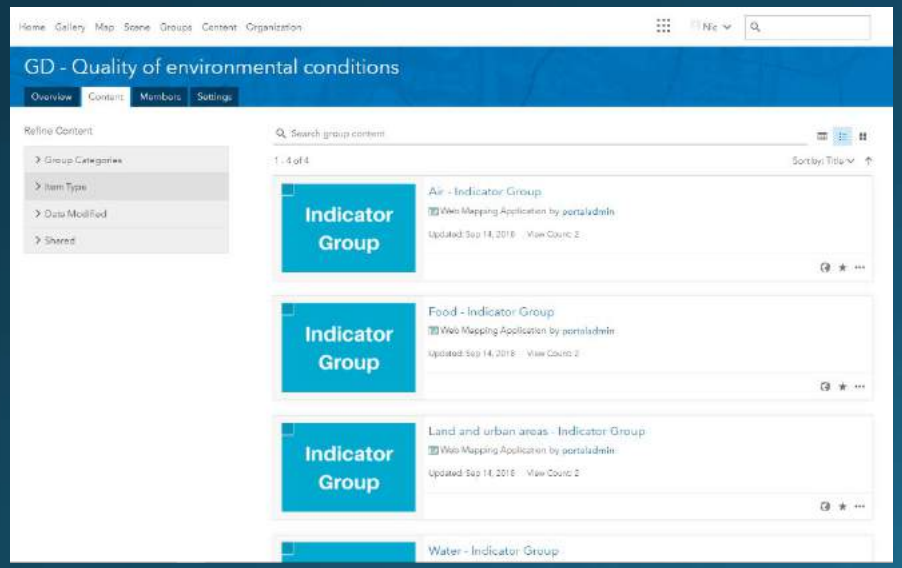


3b) Domain leading to goal dimension

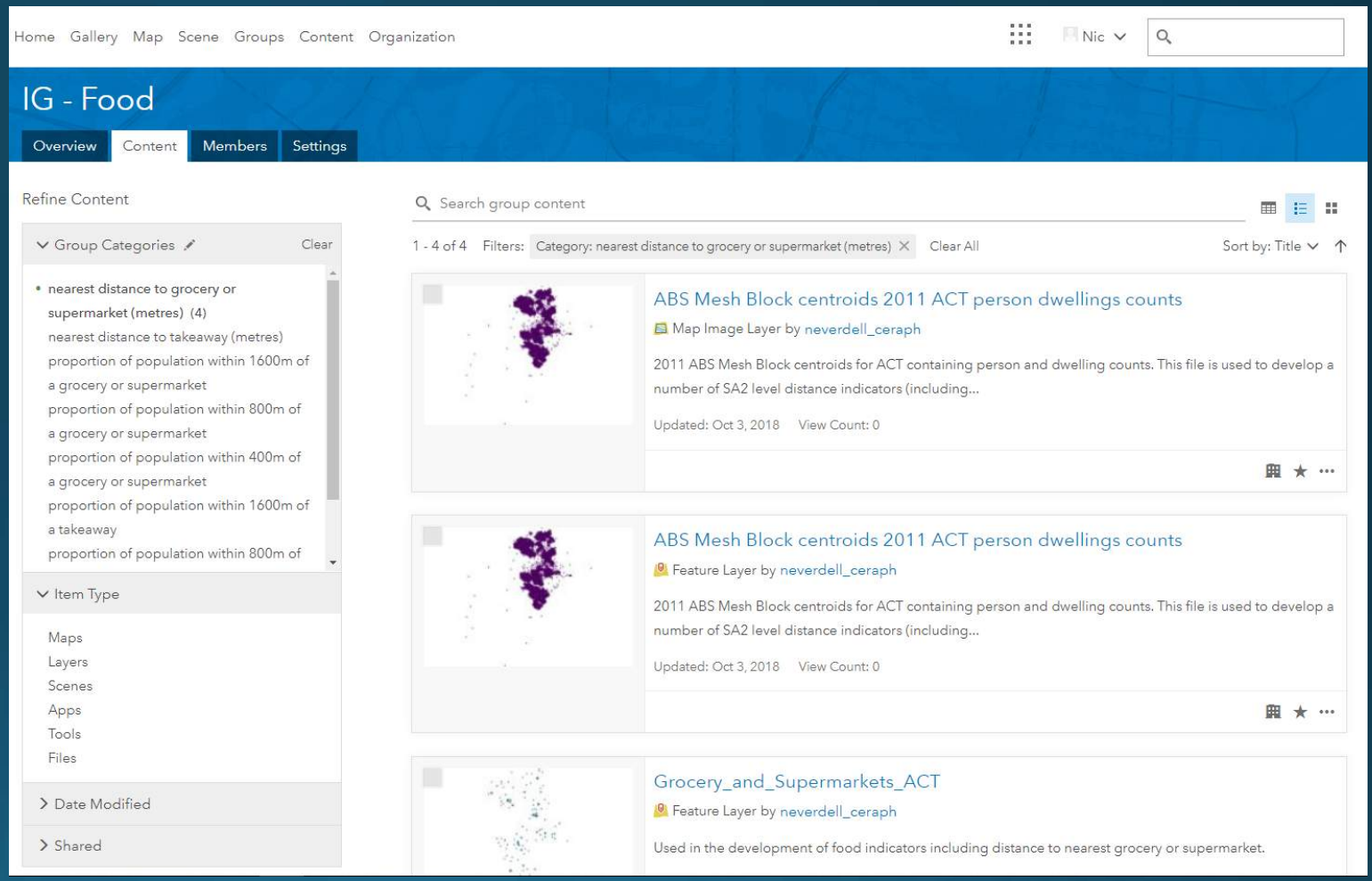
AEGIS catalogue: data consultation interface



4) Domain → **Goal Dimension** → Indicator Group



5) Goal Dimension → **Indicator group** → Indicator



6) Indicator group → **Indicator** → measure (data)

Research Paper:

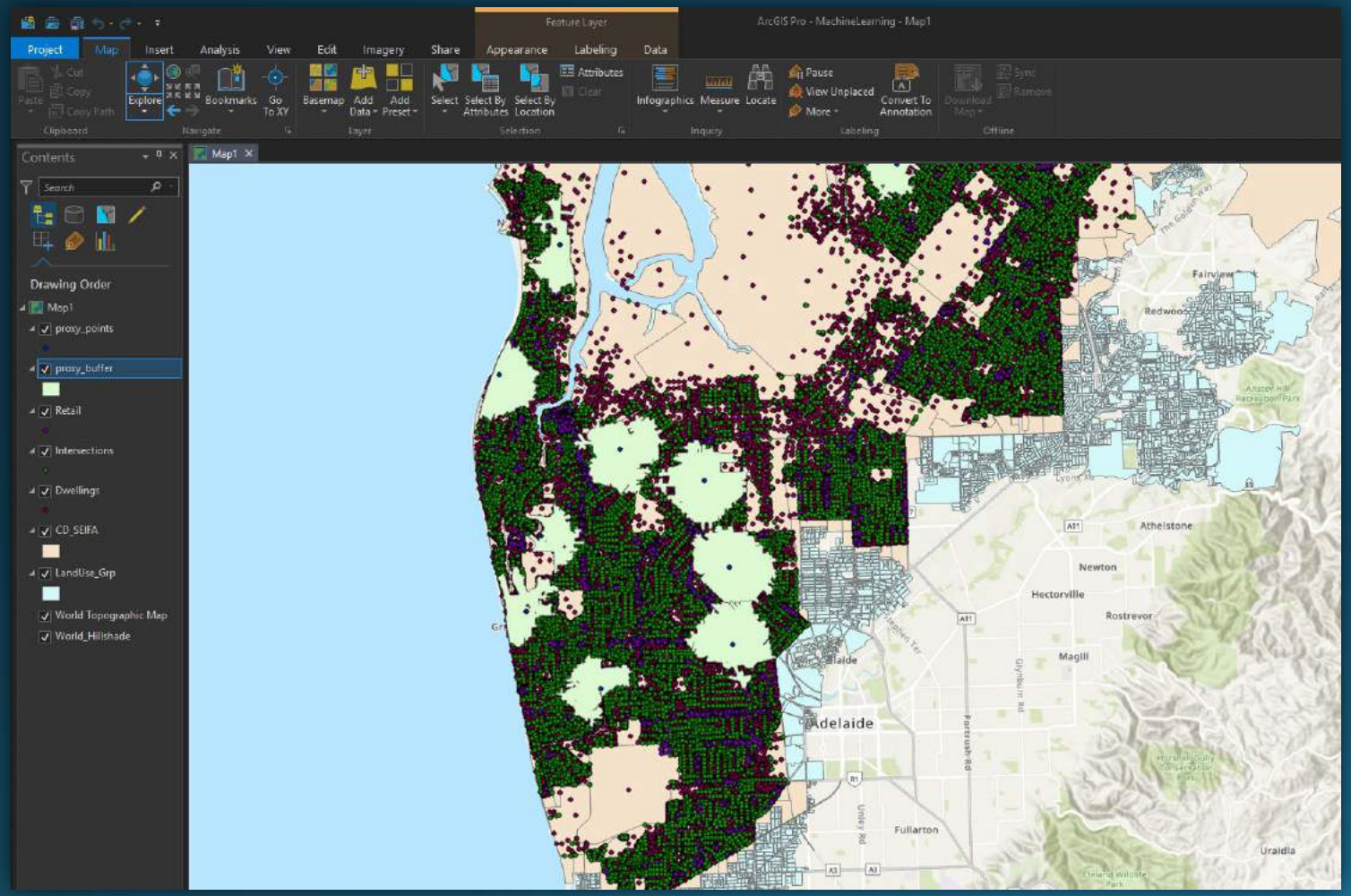
"… Local descriptive norms for overweight/obesity and physical inactivity, features of the built environment, and 10-year change in glycosated hemoglobin in an Australian population-based biomedical cohort…"

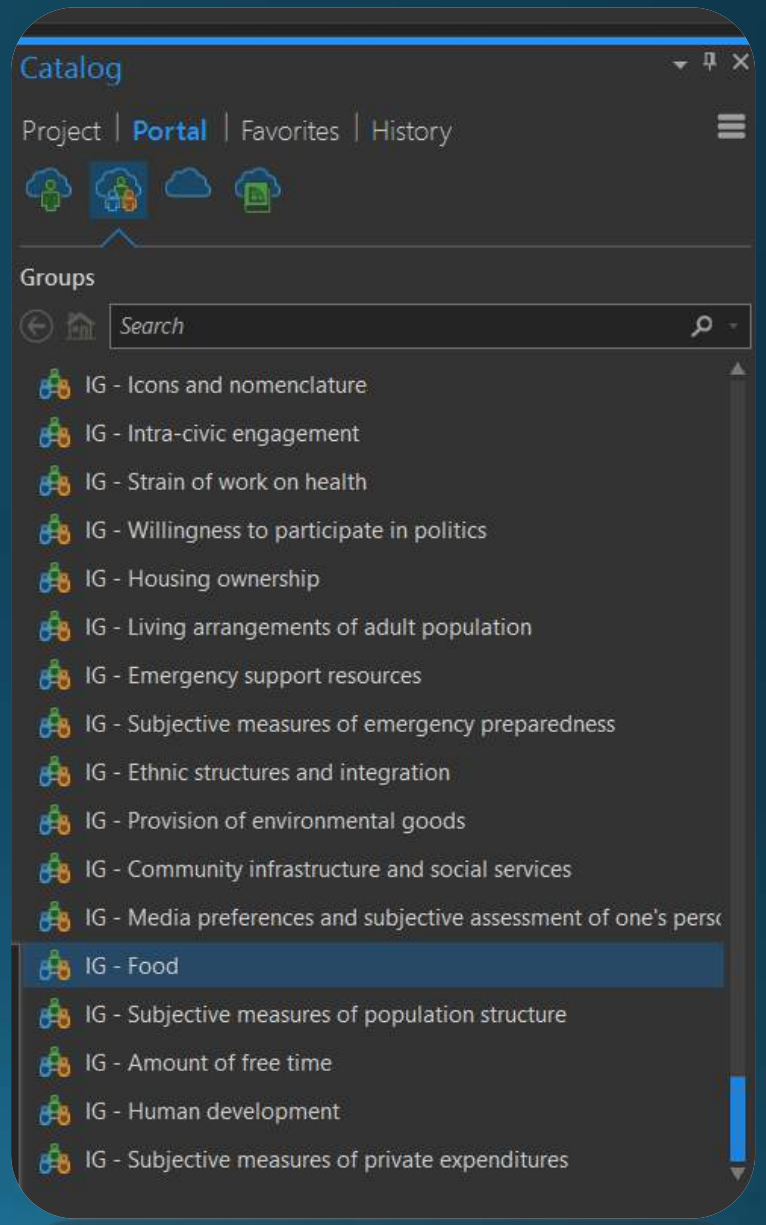
Walkability & Obesity

Carroll S … Daniel M (2016). Local descriptive norms for overweight and physical activity, the built environment and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *Social Science & Medicine*; 166: 233-43

Describing the Physical world

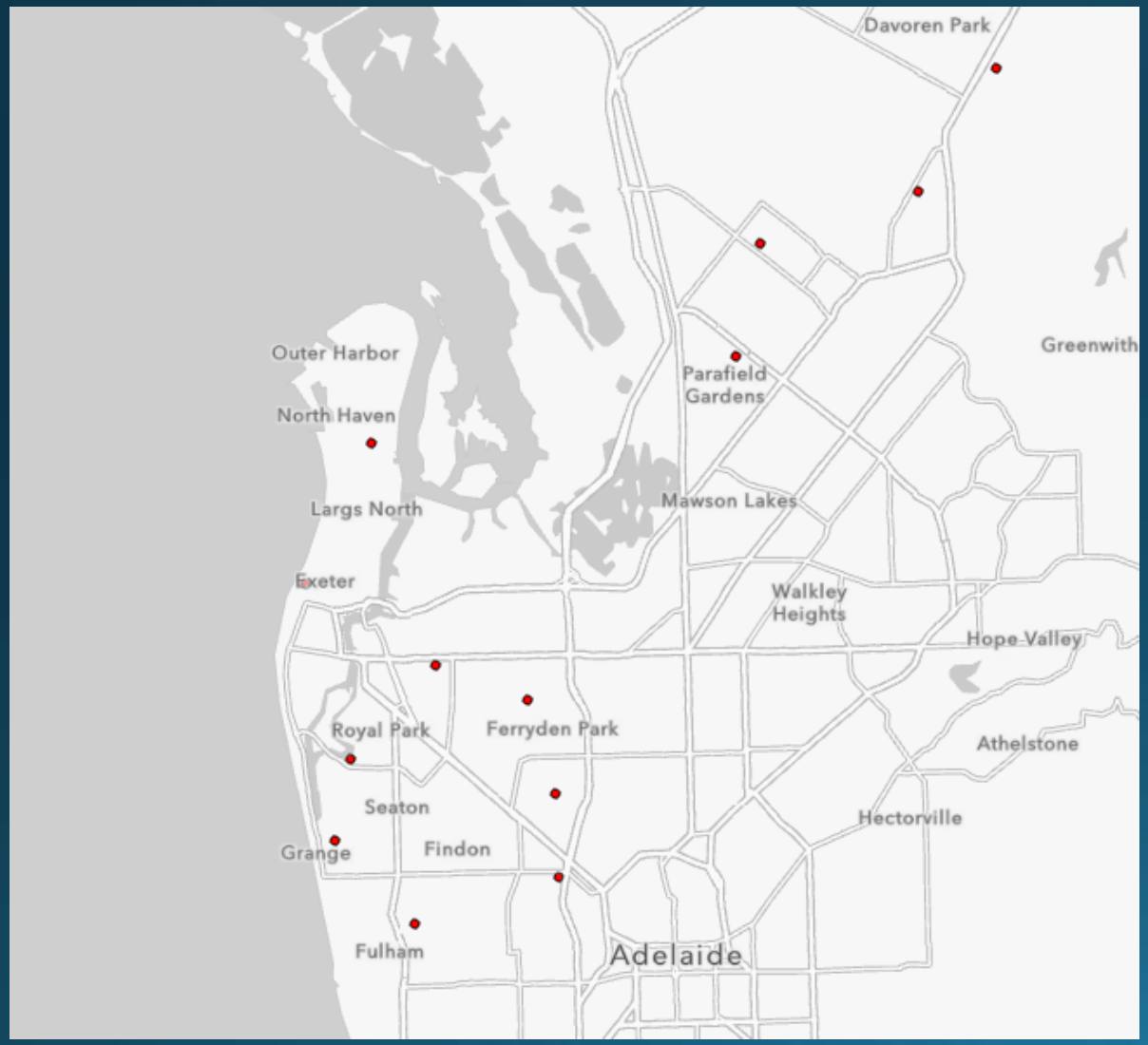
…Spatial analytics with ArcGIS Pro





Walkability & Obesity

Surveying the state of obesity…



Walkability is a construct with four components

1. Intersection Density
2. Dwelling Density
3. Land Use Mix
4. Retail Footprint

Applied to a spatial unit

Walkability & Obesity

Defining the Study Area…

For this research the units were Walk-Time Polygons (19min - 1600m)

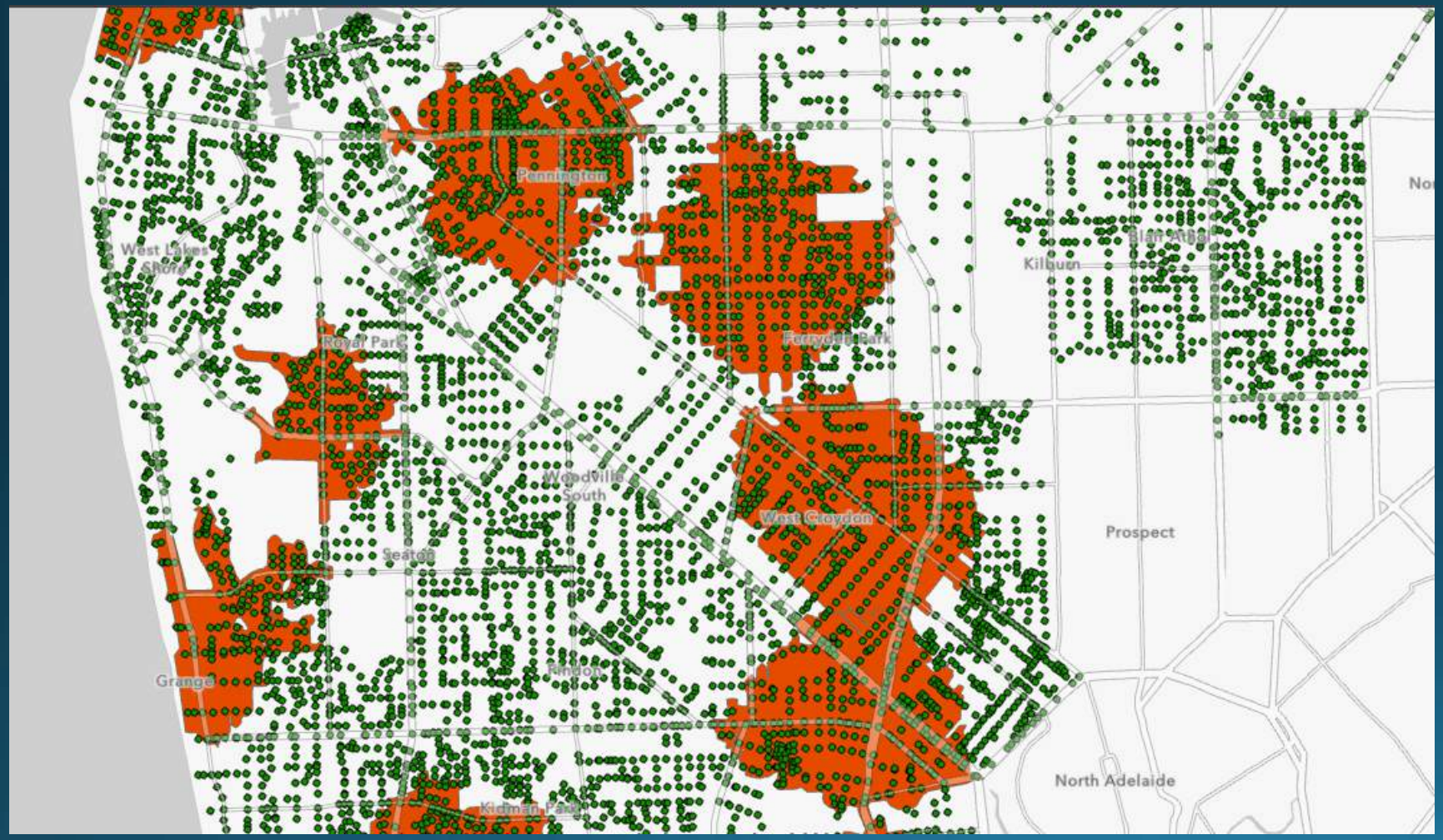
ction: Zoom To Switch Clear Delete Copy

	LGA	MSR	POA	RA	SD	SDI	SED	SLA	SOS	SR	SRS	SSC	SSD	SSR	STE	UCL
0	LGA45890	41	POA5017	RA40	405	0	SED40037	405105895	SOS40	4108	41081	SSC42211	40510	SSR401	4	UCL400200
0	LGA45890	41	POA5019	RA40	405	0	SED40026	405105895	SOS40	4108	41081	SSC42516	40510	SSR401	4	UCL400200
0	LGA45890	41	POA5013	RA40	405	0	SED40006	405105898	SOS40	4108	41081	SSC42406	40510	SSR401	4	UCL400200
0	LGA41060	41	POA5021	RA40	405	0	SED40026	405101061	SOS40	4108	41081	SSC42786	40510	SSR401	4	UCL400200

Filters:

Walkability & Obesity

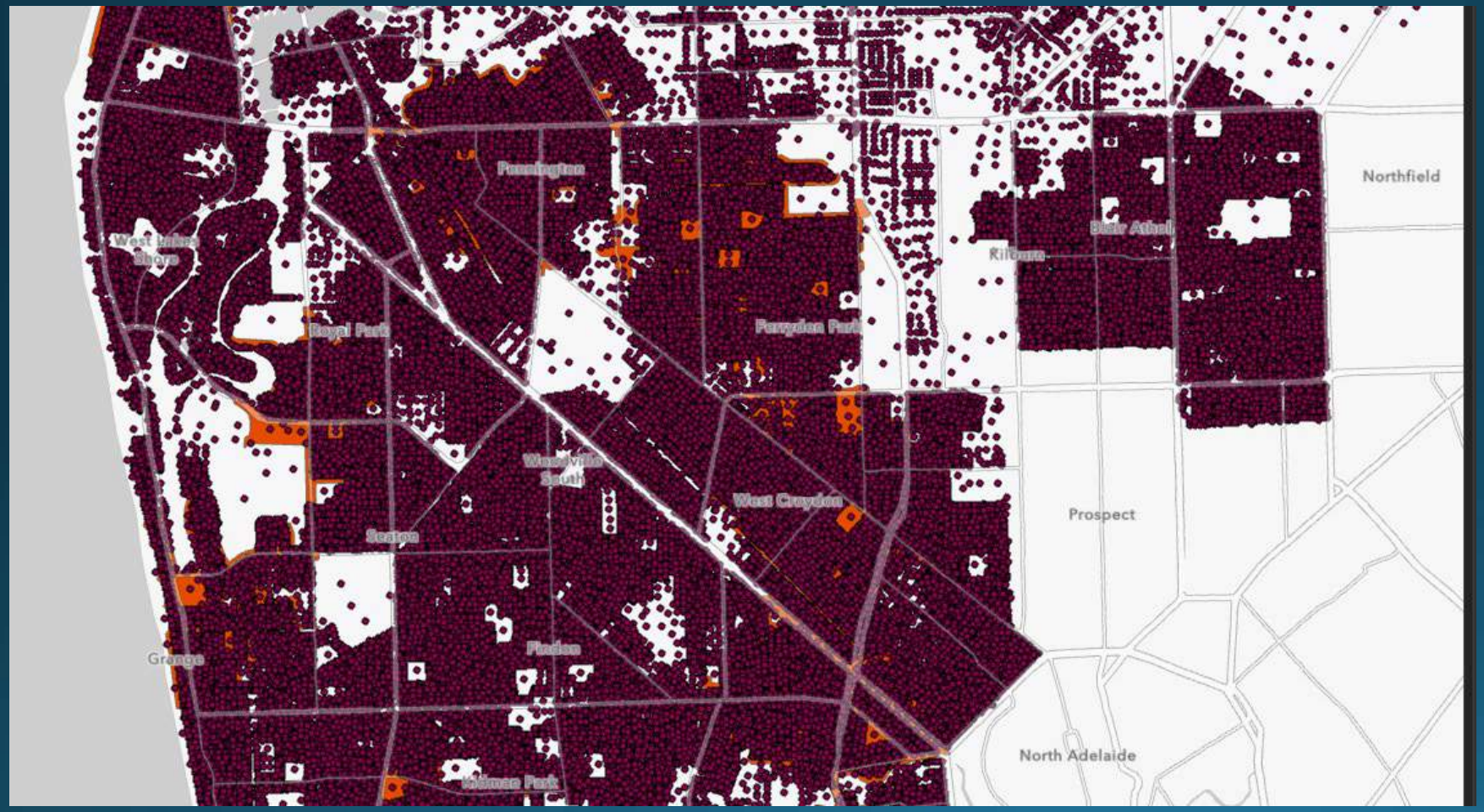
Calculating expressions of walkabilty …



Intersections
>3 dir int/area

Walkability & Obesity

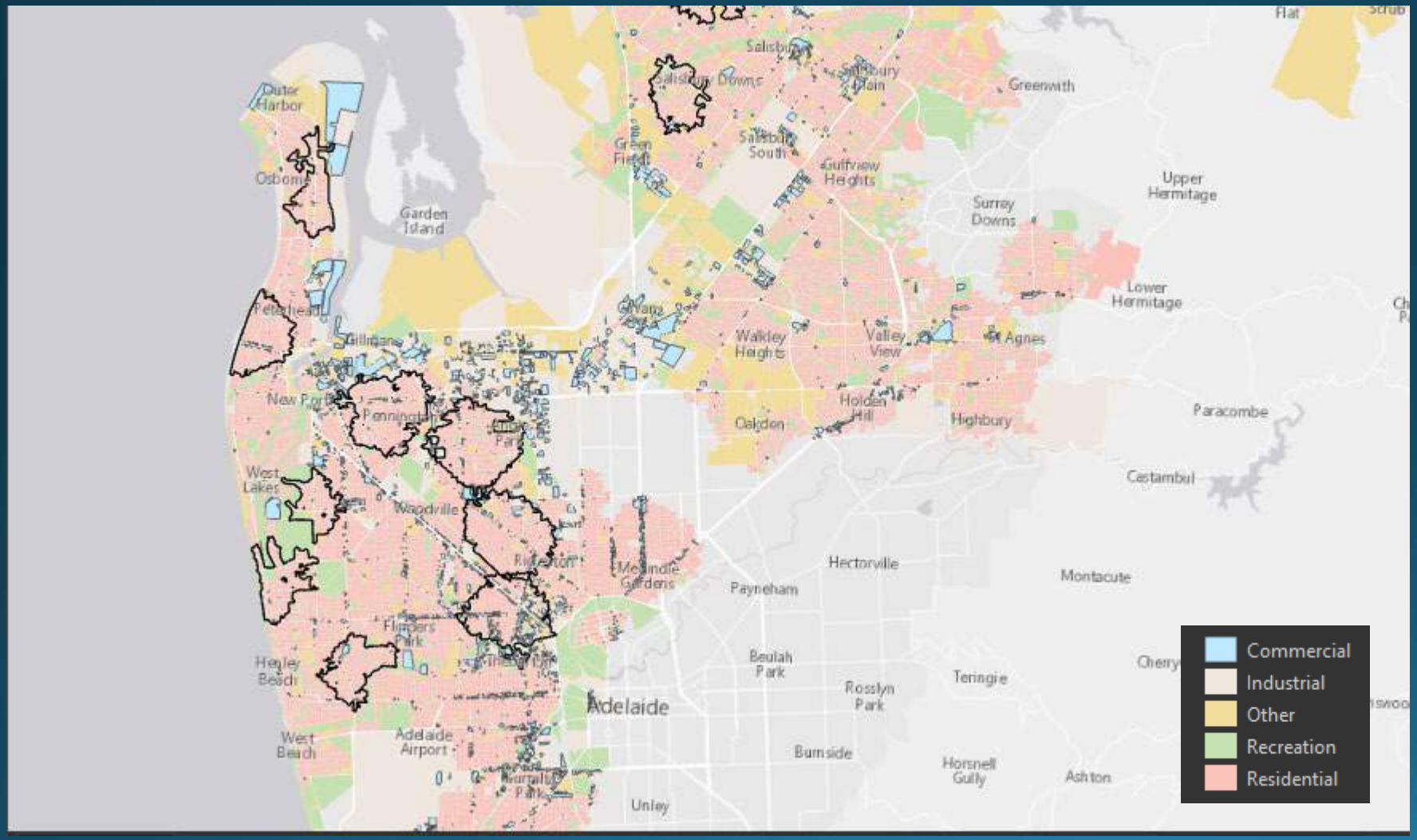
Calculating expressions of walkabilty …



Dwelling Count Dwg/ residential area

Walkability & Obesity

Calculating expressions of walkabilty …



Land Use

Diversity measure

Entropy equation

Walkability & Obesity

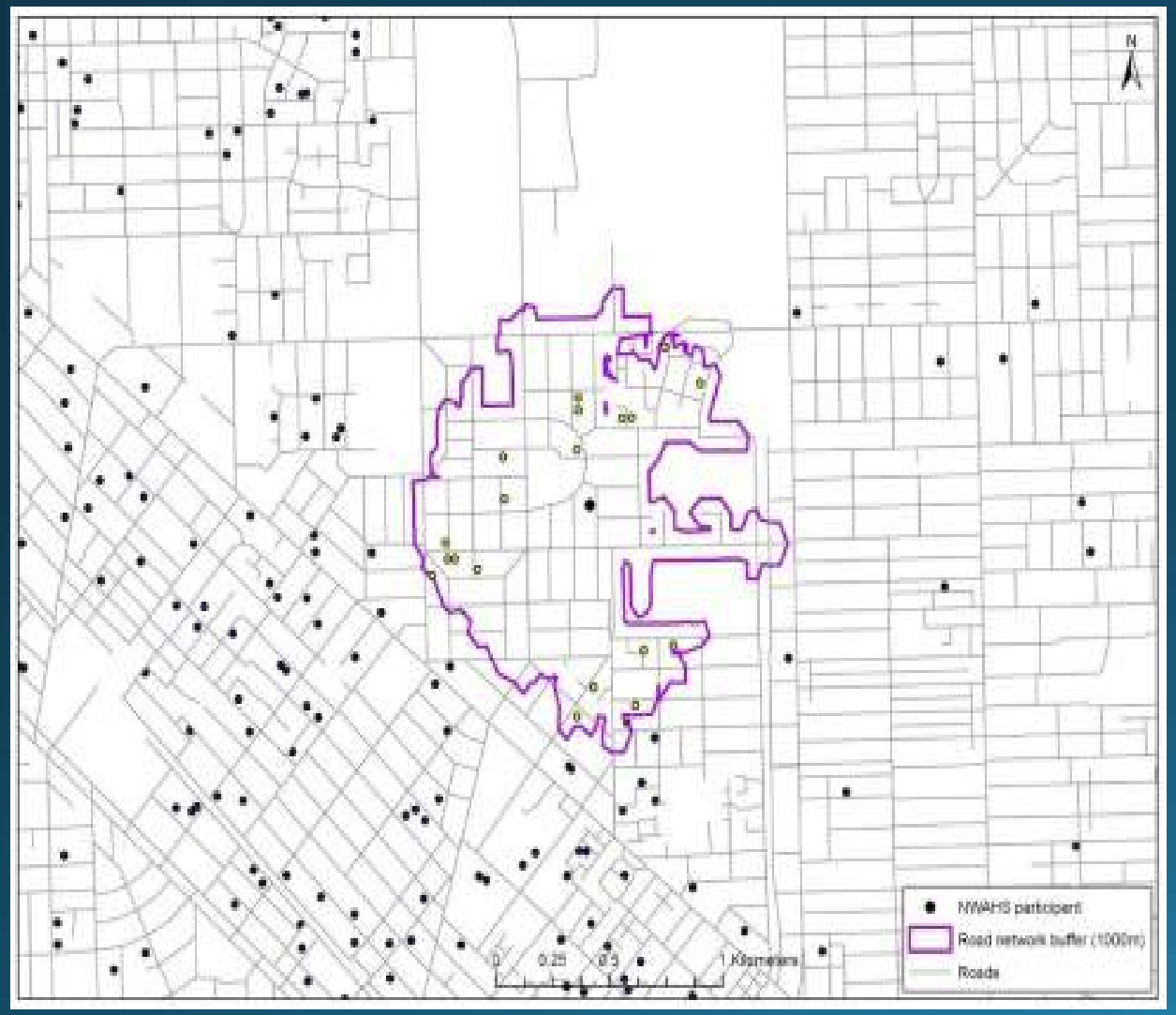
Calculating expressions of walkabilty …

Retail

Gross retail Floorspace/ Parcel area

Walkability & Obesity

Calculating Spatial Area Norms …

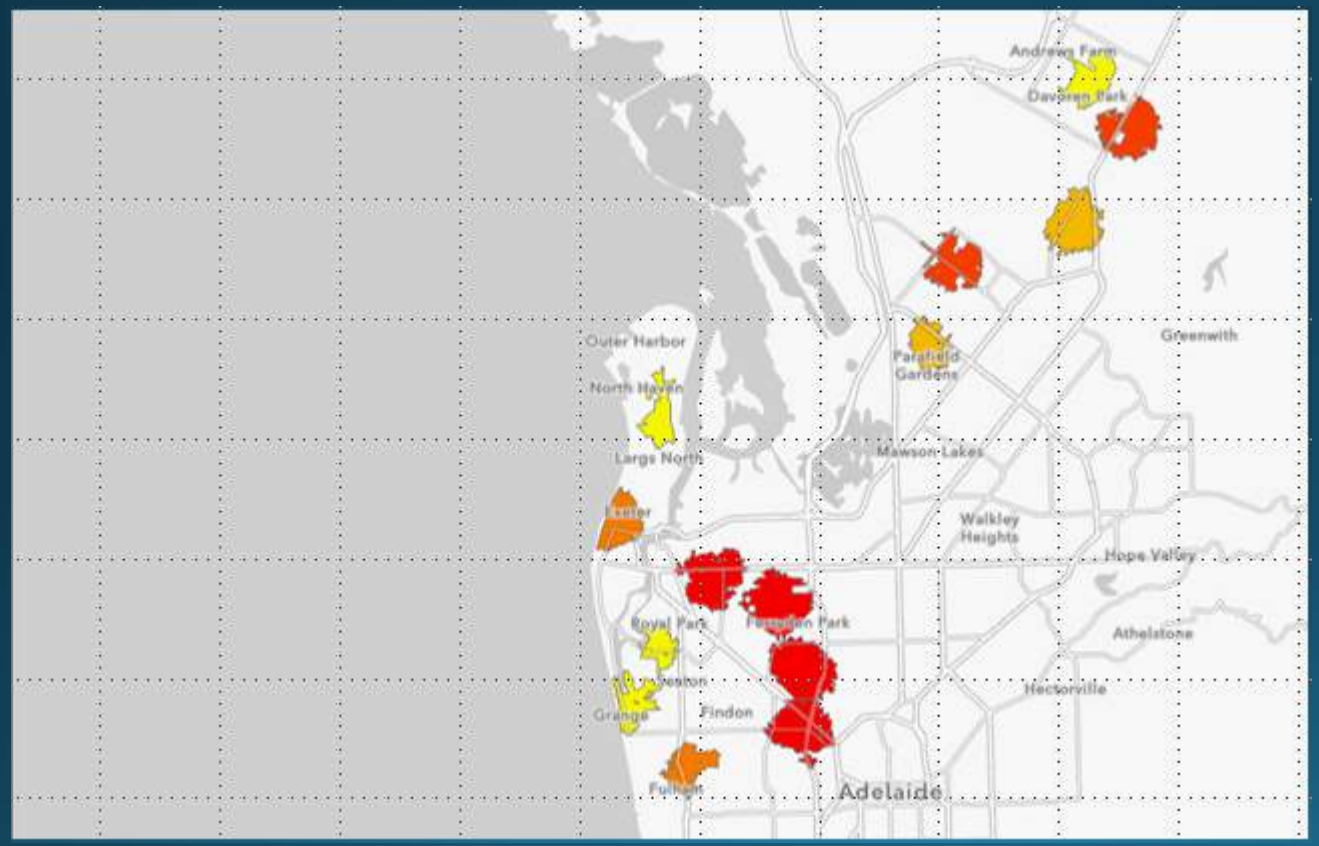


SAMSS

SAMSS responses within participant buffer used to calculate NORMS

Walkability & Obesity

Calculating expressions of walkabilty …



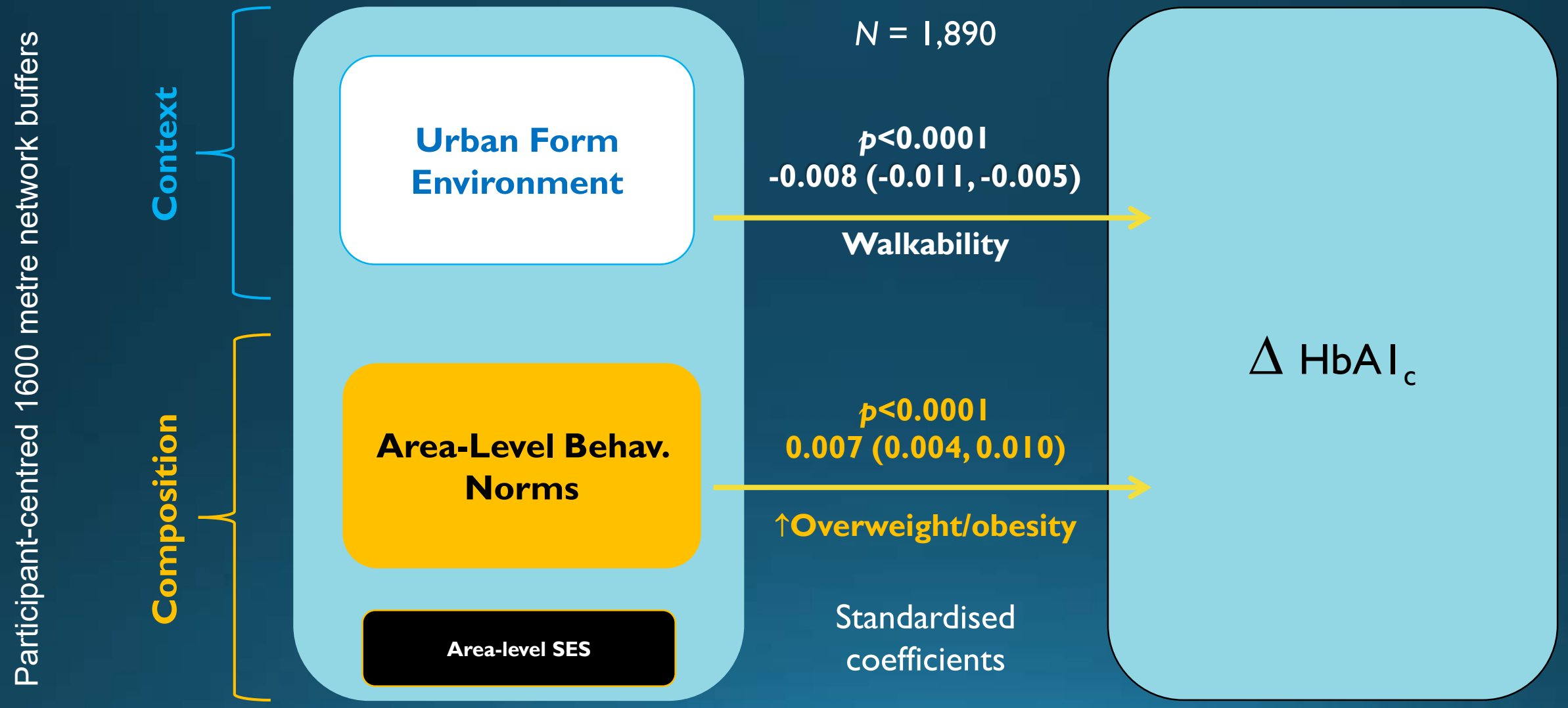
Walkability and Norms can be expressed for each participant buffer.

Statistical modelling was used to analyse these data.

Refresh of results!

Adelaide: results of 10-year analysis

- accounting for area-SES



Carroll S … Daniel M (2016). Local descriptive norms for overweight and physical activity, the built environment and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *Social Science & Medicine*; 166: 233-43

UC Geo-Spatial Health Hub

- The Geo-Spatial Health Hub is the enabler
- It is not just a data warehouse
- It provides a validated international classification system as a standard framework for health and environment research that is repeatable, consistent and cross jurisdictional
- Sensitive data are NOT stored in the portal but collaborators can link with the Geo-Spatial Health Hub portal to search and access measures

Challenges? What Next?

So that's awesome yeah?!

Rise of the Machines

Machine Learning for classifying large number of indicators

Rise of The Machines

Appropriate use of your tools

- **Natural Language Processing**
- **Machine Learning**
- **Deep Learning**
- **Convolutional Neural Networks (CNN)**
- **Recursive Neural Networks (RNN)**

STUDY A GRADUATE CERTIFICATE IN GEO-SPATIAL HEALTH

Here are a few examples of career opportunities in Geo-Spatial Health:

POTENTIAL OCCUPATIONS

- Data scientist
- Geographic information systems officer (GIS officer)
- Data analyst
- Geographic information systems analyst (GIS analyst)
- Data manager
- Environmental health
- Health data analyst
- Urban planning
- Health geographer
- Geographic information systems technician (GIS technician)
- Epidemiologist
- Programme analyst
- Public Health/Population health
- Disaster management

UNIVERSITY OF CANBERRA

UC's postgraduate Health Services and Support study area is ranked number one nationally for student satisfaction *

GEO-SPATIAL HEALTH

UNIVERSITY OF CANBERRA

GRADUATE CERTIFICATE IN GEO-SPATIAL HEALTH

Whether you're a recent graduate within the field of Public Health or Town/Urban Planning, or an established professional in the health sector, the Graduate Certificate in Geo-Spatial Health will broaden and deepen your understanding of the role that place plays in health outcomes and give you advanced skills in spatial and statistical analysis of geographically distributed health data.

COURSE CODE	379JA
ATAR	PG
DURATION	12 MONTHS

UNIQUE FEATURES

You'll be taught by a diverse team of nationally and internationally experienced geographers, epidemiologists and statisticians with backgrounds in the private and public sectors, and exceptional research and teaching expertise.

A range of Work-Integrated Learning (WIL) in-course opportunities.

Strong links with government and public sector e.g. *Australian Bureau of Statistics, Australian Institute of Health and Welfare, Geoscience Australia.*

Collaboration with industry partners e.g. ESRI and SAP.

International collaboration with research organisations in India, China and Kuwait.

STREAMS OF STUDY

Master by Research

FURTHER STUDY

Doctor of Philosophy (254LC)

Australian Geo-spatial Health Research Hub

- ***Partnerships***: A resource for public and private sector initiatives applying spatial analysis to population health and health care relevant data
- ***collaborative*** to facilitate geospatial analysis of public health prevention research involving internal and external partner agencies
- Support and co-ordinate existing expertise in ***inferential*** geo-spatial analysis and health policy, health planning and environmental health analysis
- Facilitate development of new approaches and methodologies to ***support effective decision-making*** to improve public and population health

Thank you

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For information on the University of Canberra Geo-Spatial Health Hub

Go to **https://esriaustralia.com.au/health-hub**