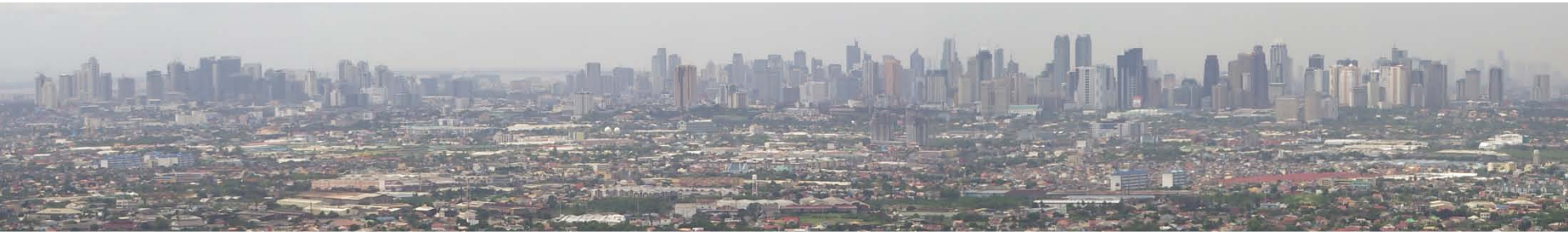
Australian Government
Geoscience Australia

Using Spatial Information For Natural Hazard Risk Analysis Of A Megacity

Matthew Jakab



Overview

- What is Geoscience Australia?
- What is natural hazard risk analysis?
- Engagement on Disaster Risk Reduction in the Philippines
- Risk analysis for the Greater Metro Manila Area
- LiDAR – a foundation dataset
- Spatial data for hazard modelling
- Spatial data for exposure information development
- The Building Geometry Model
- Summary

What is Geoscience Australia?

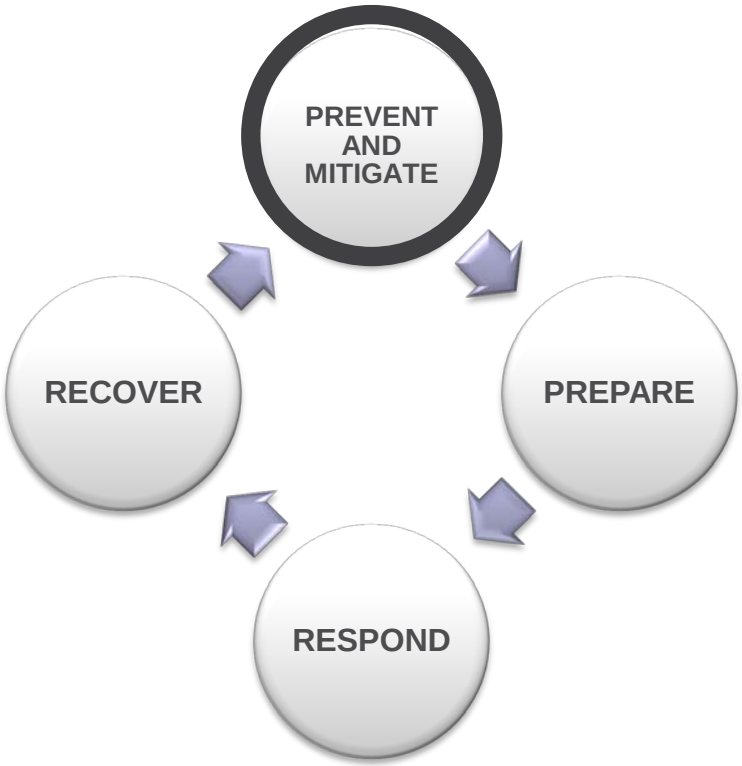
- Australian Government Agency within the Department of Industry
- Use geoscientific information and knowledge for the economic, social and environmental benefit of Australia, with an emphasis on:
  - Future energy and resource base for the economy;
  - Providing geoscience input into a range of environmental issues; and
  - Contributing to community safety through monitoring and research into natural hazards and climate change and their impact on society.
- GA partners with the Department of Foreign Affairs and Trade (DFAT) – formerly known as AusAID - to bring our capabilities to the Asia-Pacific region through the Regional Risk Section in the Community Safety Group

What is Geoscience Australia?

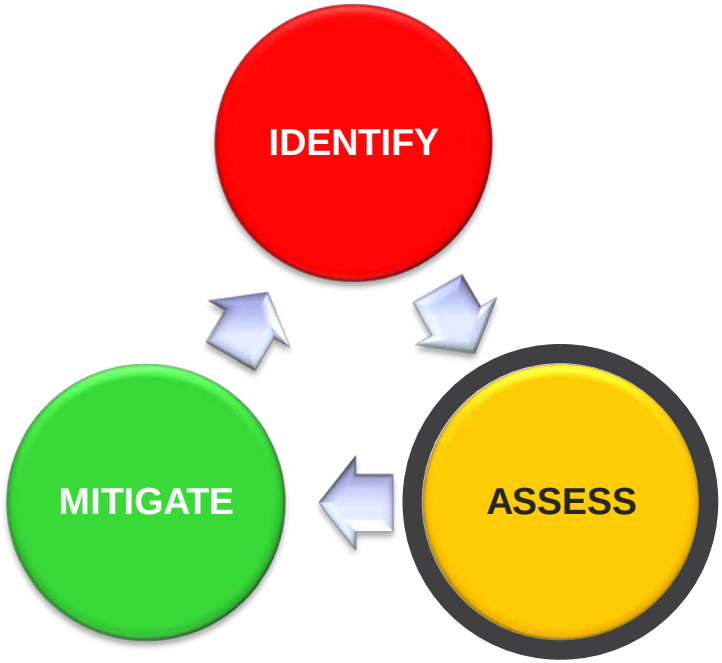
- Regional Risk Section engagements:
  - **The Philippines**
  - Indonesia - The Australia-Indonesia Facility for Disaster Reduction (AIFDR)
  - Papua New Guinea
  - Global Assessment of Risk – UNISDR
  - Global Earthquake Model
  - Natural hazard modelling training workshops (IGC - August 2012)

What is natural hazard risk analysis?

Emergency Management cycle:



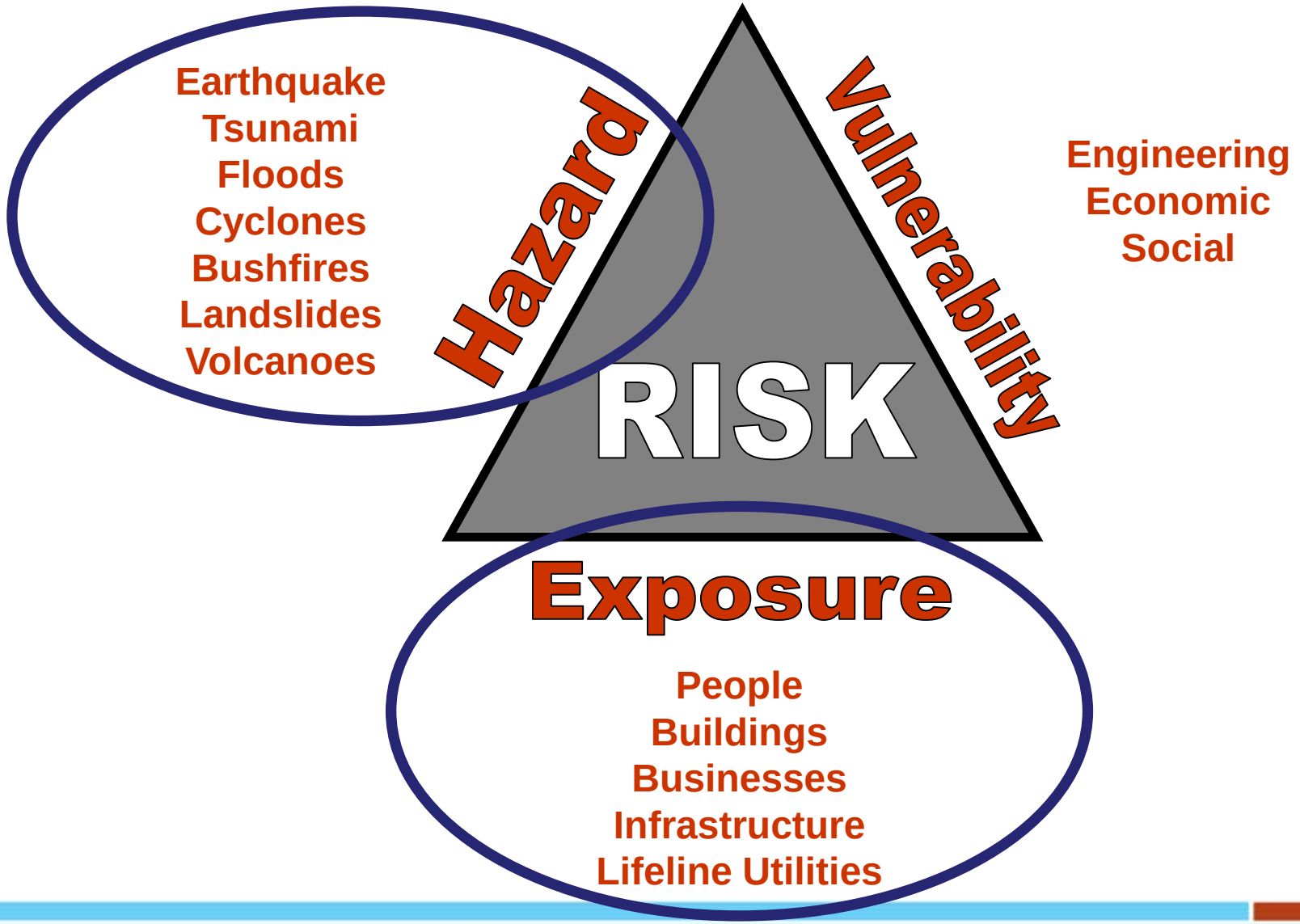
Disaster Risk Reduction:



What is natural hazard risk analysis?

- Calculation of the **direct** and **indirect effect** of numerous **natural hazard events** on:
  - The built and natural environments
  - People and communities
  - The economy
- Risk can be expressed in terms of:
  - Physical **damage** to buildings and infrastructure
  - Economic **losses** (both direct and indirect)
  - **Casualties** and societal effects
- Risk analysis requires information on:
  - **Hazard**
  - **Exposure**
  - **Vulnerability**

What is natural hazard risk analysis?



Engagement on Disaster Risk Reduction in the Philippines

Source: http://www.flags.net/

NDRRMC
NATIONAL DISASTER RISK REDUCTION AND MANAGEMENT COUNCIL
Proactive

CSCAND
Collective Strengthening of Community Awareness for Natural Disasters

Australian Aid

Australian Government
Department of Foreign Affairs and Trade
Geoscience Australia

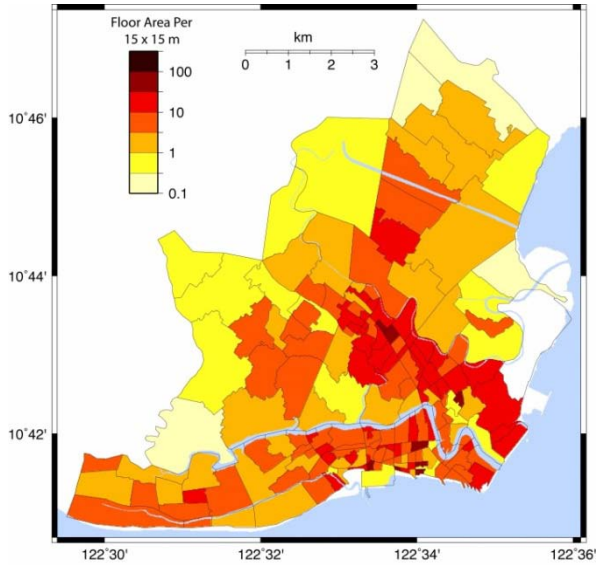
DEPARTMENT OF NATIONAL DEFENSE
REPUBLIC OF THE PHILIPPINES
OFFICE OF CIVIL DEFENSE

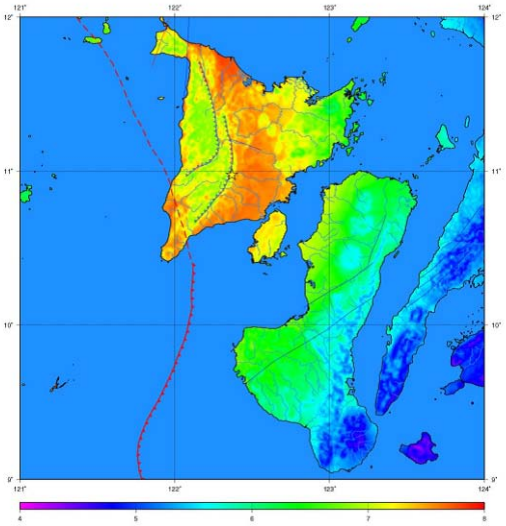
DOST
PHIVOLCS

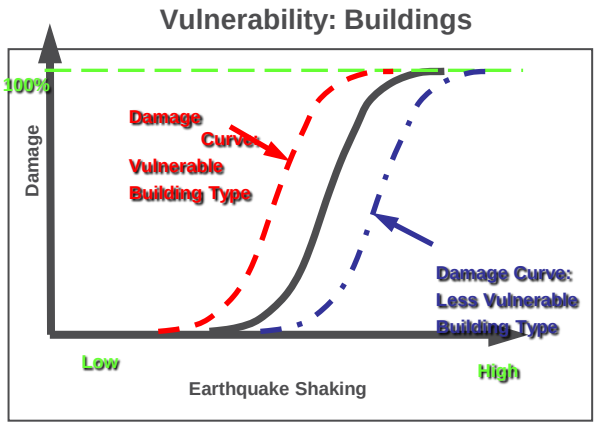
DOST
PAGASA
1865

NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
1987

Engagement on Disaster Risk Reduction in the Philippines – A Pilot Earthquake Impact Study (Iloilo City)







Engagement on Disaster Risk Reduction in the Philippines – Typhoon Ondoy


Source: UN-ISDR (2011)

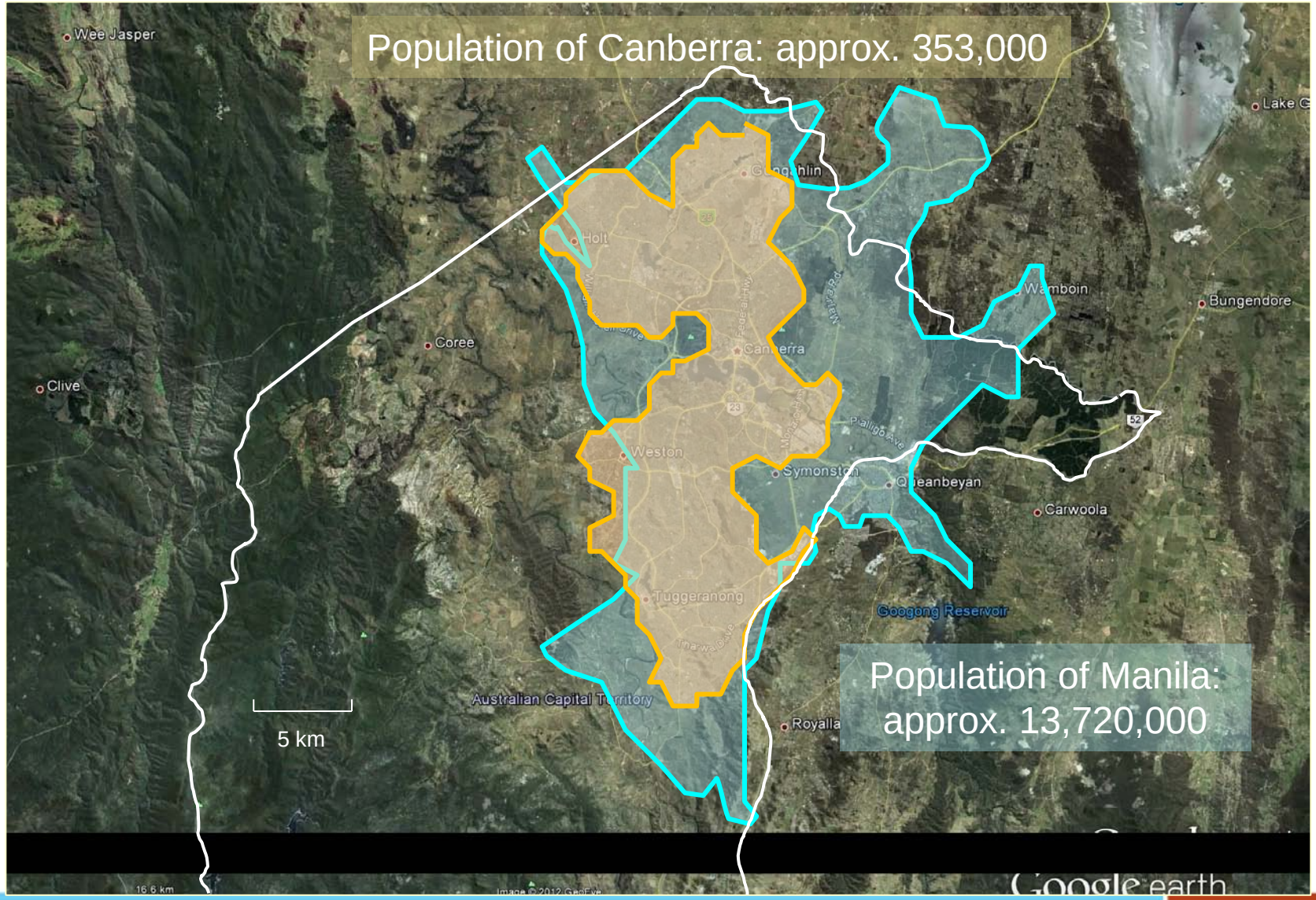
Risk analysis for the Greater Metro Manila Area

- "Enhancing Risk Analysis Capacities for Flood, Tropical Cyclone Severe Wind and Flood for the Greater Metro Manila Area"

- Collection and management of **high-resolution digital elevation data**
- Development of **exposure information** for the Greater Metro Manila Area
- Development of **hazard models** and associated **risk analyses** for:
  - **Flood** (Pasig-Marikina River Basin)
  - **Tropical Cyclone Severe Wind** (typhoons impacting on GMMA)
  - **Earthquake** (emanating from the West Valley Fault)

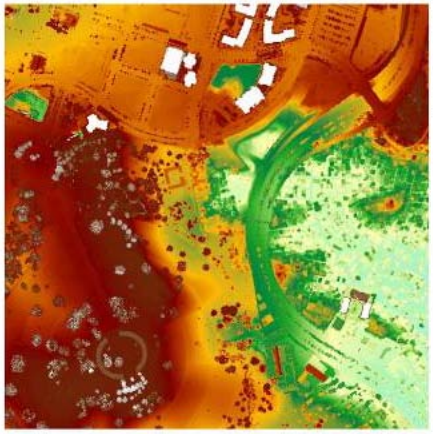
Risk analysis for the Greater Metro Manila Area

Risk analysis for the Greater Metro Manila Area

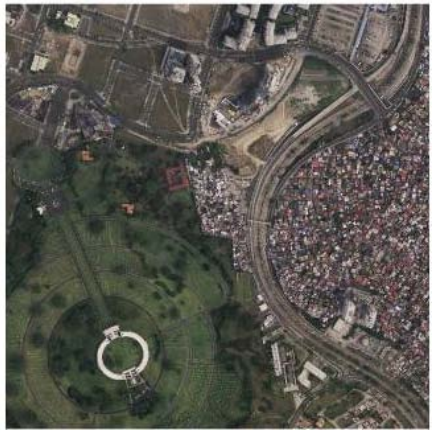


LiDAR – a foundation dataset

- Pre-2011 elevation data for GMMA:
  - 3” SRTM data
  - Unsuitable for detailed hazard modelling
- Elevation data for GMMA in 2011:
  - LiDAR data collected over area
  - 1 metre resolution DEM and DSM from LiDAR
  - Well suited to detailed hazard modelling and spatial analysis of urban environments
- Imagery for GMMA in 2011:
  - 0.25m aerial imagery
  - Colour + infra-red



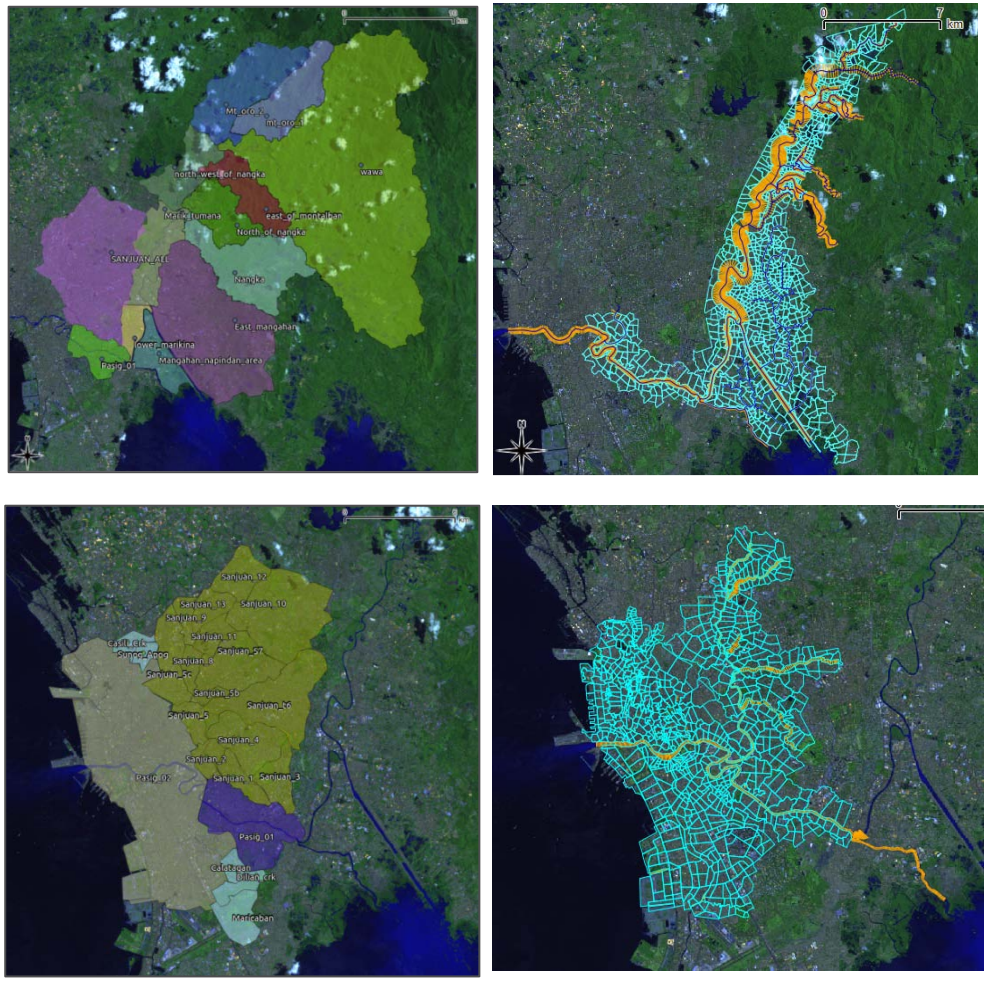
Digital Surface Model



High resolution aerial imagery

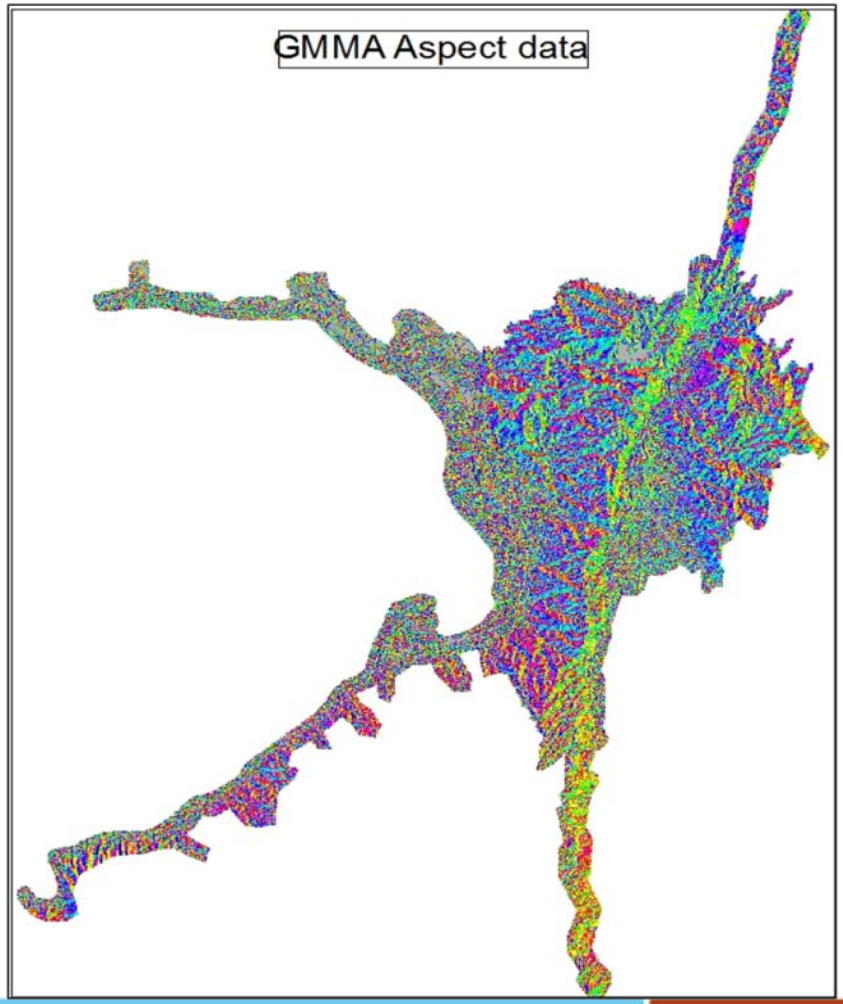
Spatial data for hazard modelling

- Flood Hazard modelling
  - LiDAR DSM used to determine catchments and sub-catchments
  - Improved accuracy in elevation permits better estimate of depths for various flood events
  - Length and slope of channels measured from LiDAR DEM and imagery
  - Cross section data across waterways used to estimate river bed elevations



Spatial data for hazard modelling

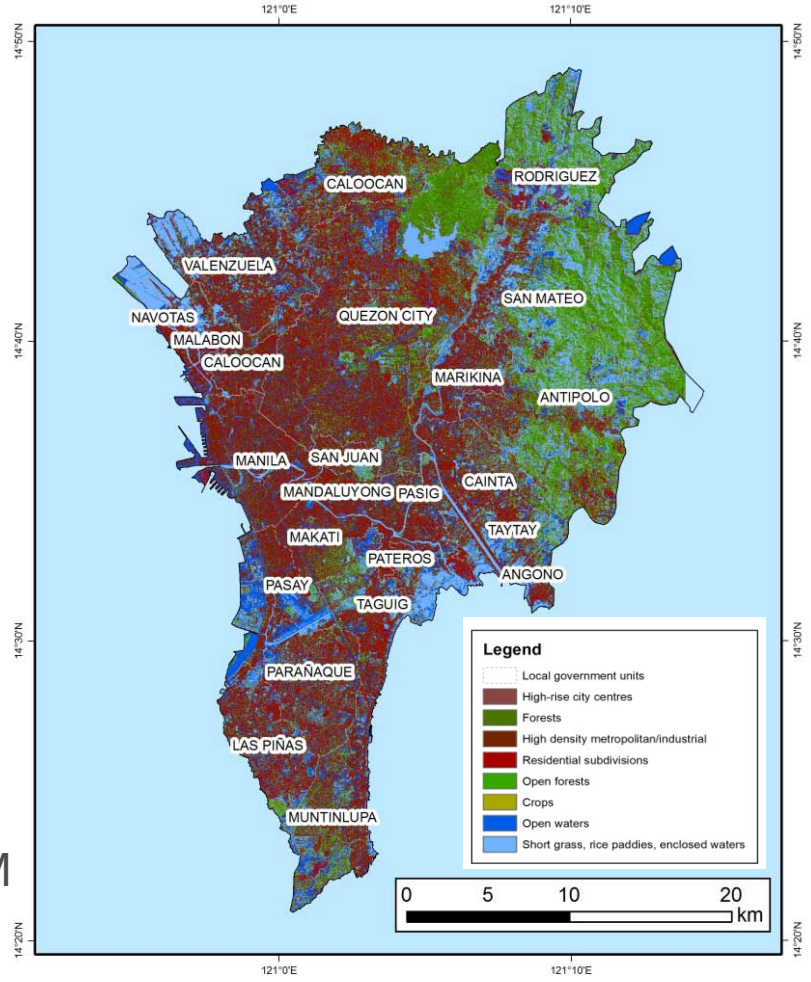
- Severe Wind Hazard modelling – topographic multiplier



Spatial data for hazard modelling

- Severe Wind Hazard modelling – terrain and shielding multiplier

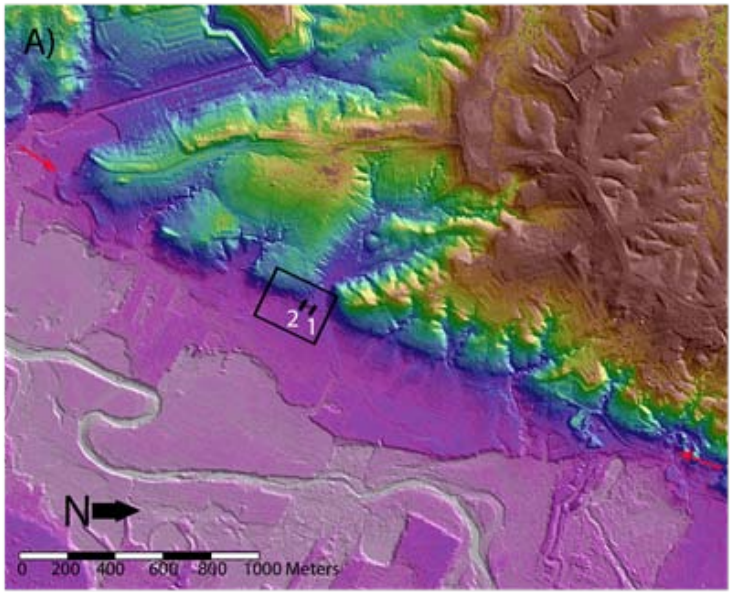
  - Land cover affects wind speed
  - Traditionally mapped by classification of remotely sensed imagery
  - Used NDVI values to define areas with vegetation
  - DSM from LiDAR used to ‘slice’ vegetation into classes according to height
  - For non-vegetated areas, DSM used to determine classes for built up areas
  - Reclassified rasters combined with polygons of water areas
  - Shielding multiplier derived from LiDAR DSM in built up areas only (tall buildings etc.)

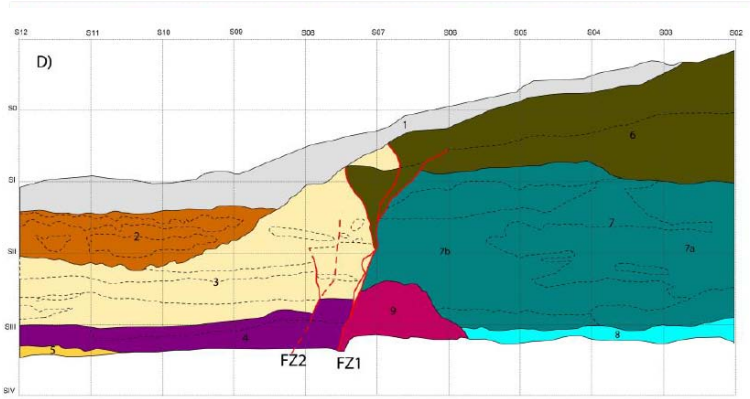


Spatial data for hazard modelling

- Earthquake Hazard modelling – supporting paleoseismic studies

  - Historical movement along a fault can help determine frequency of earthquakes
  - Mapping and analysis of samples (e.g. dating of organic material) across fault profile helps describe movement history
  - High resolution elevation data is helpful for locating a fault and determining suitable sites for opening of trenches
  - Three trenches opened after site determination, aided by interpretation of the LiDAR DEM and DSM

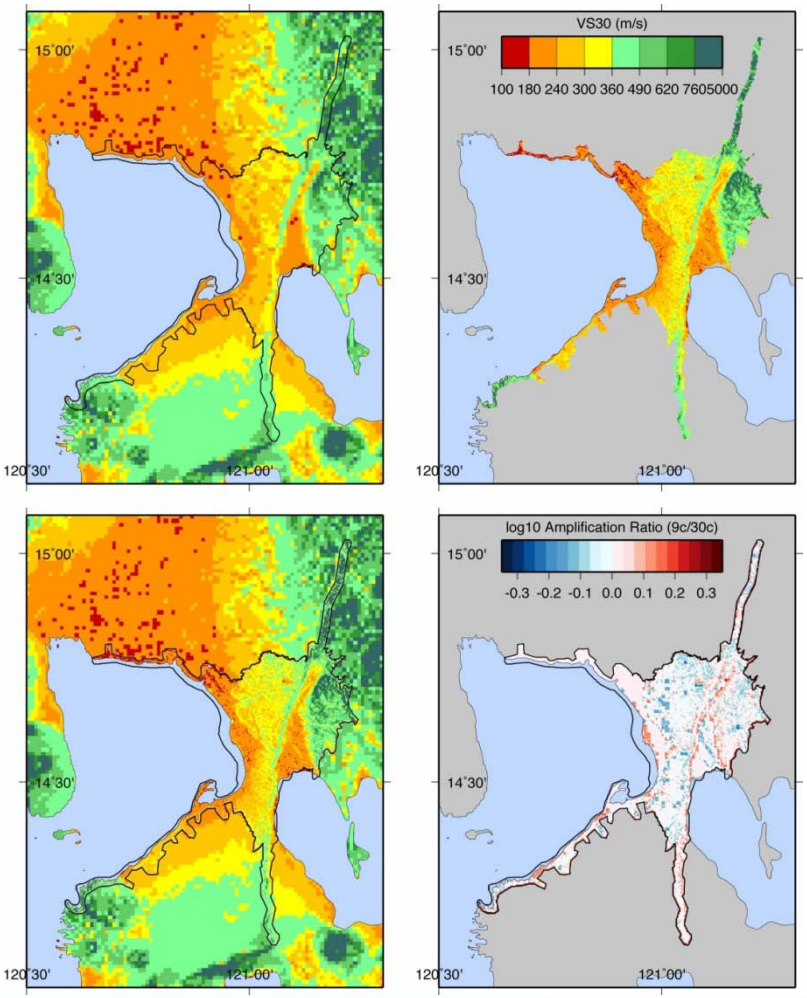




Spatial data for hazard modelling

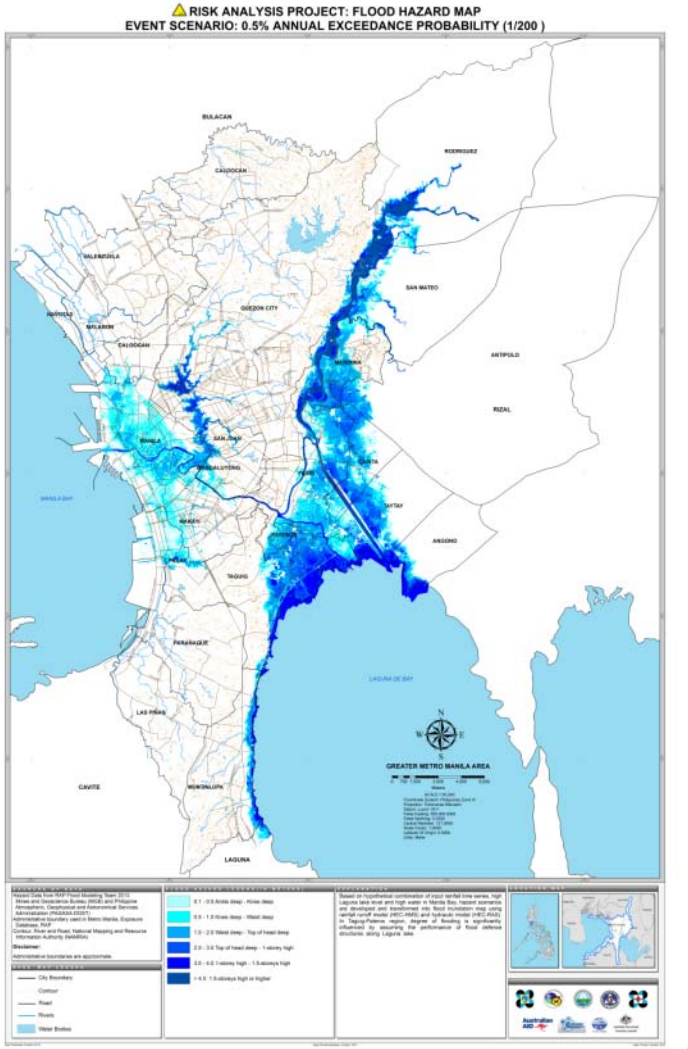
- Earthquake Hazard modelling – site class

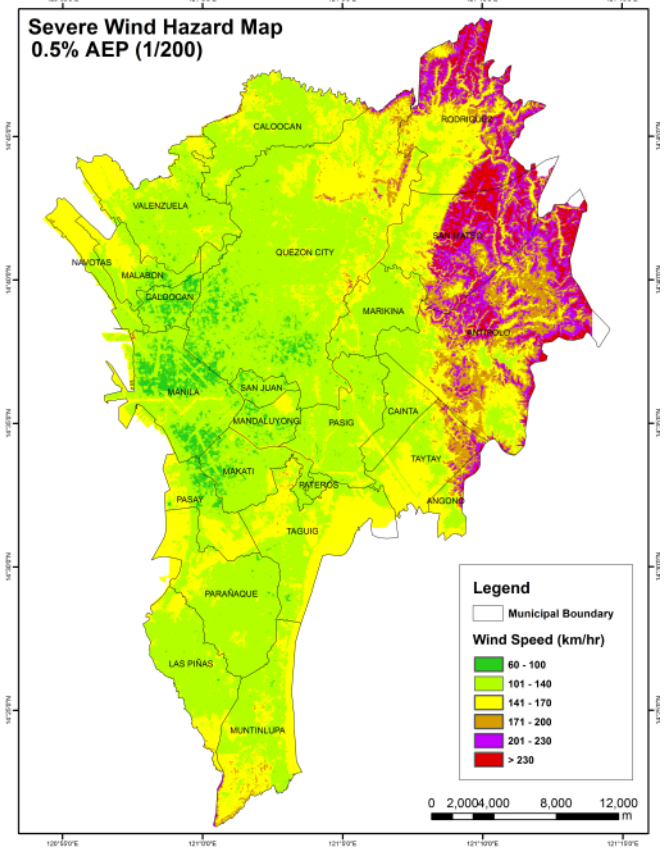
  - Topographic gradient can help to understand seismic site conditions
  - DEM data used to estimate time-averaged shear velocity to 30m depth (V_s30)
  - LiDAR DEM improved on estimates made from SRTM data
  - Improved definitions of transition between sedimentary basins and steep slopes



Spatial data for hazard modelling

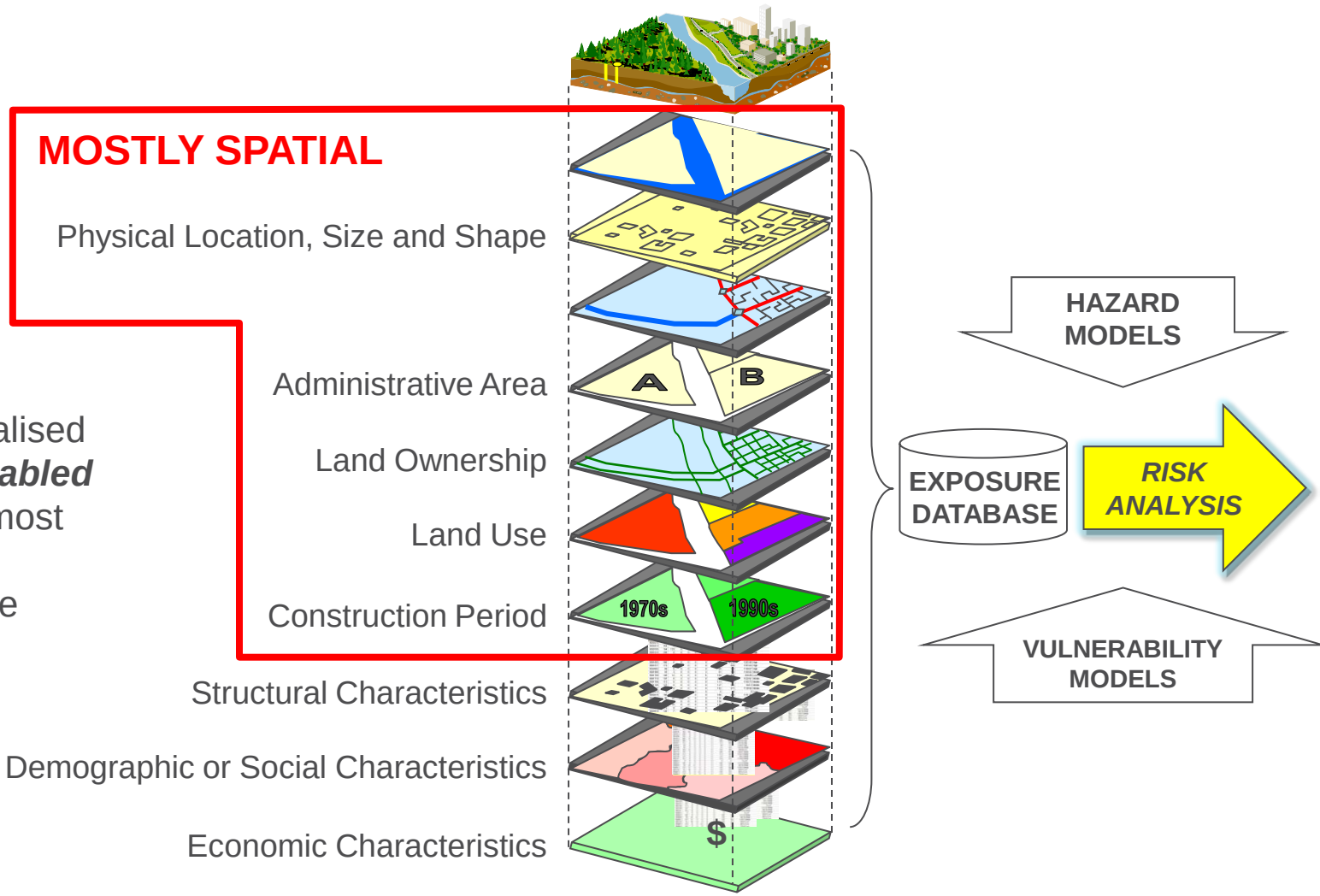
- Example outputs of hazard modelling





Spatial data for exposure information development

Building and maintaining an integrated, centralised and ***spatially-enabled*** database is the most effective way to manage exposure information



Spatial data for exposure information development

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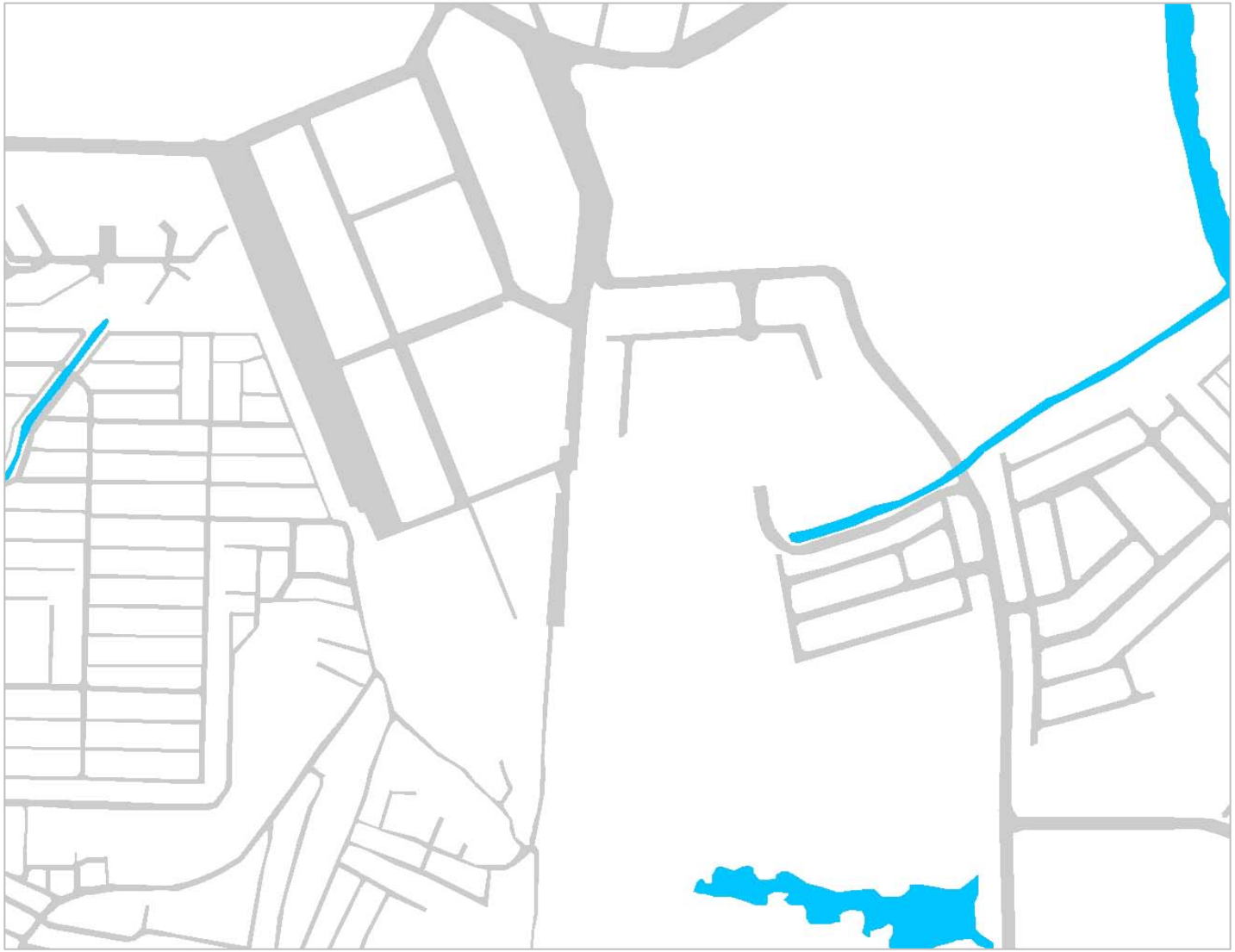

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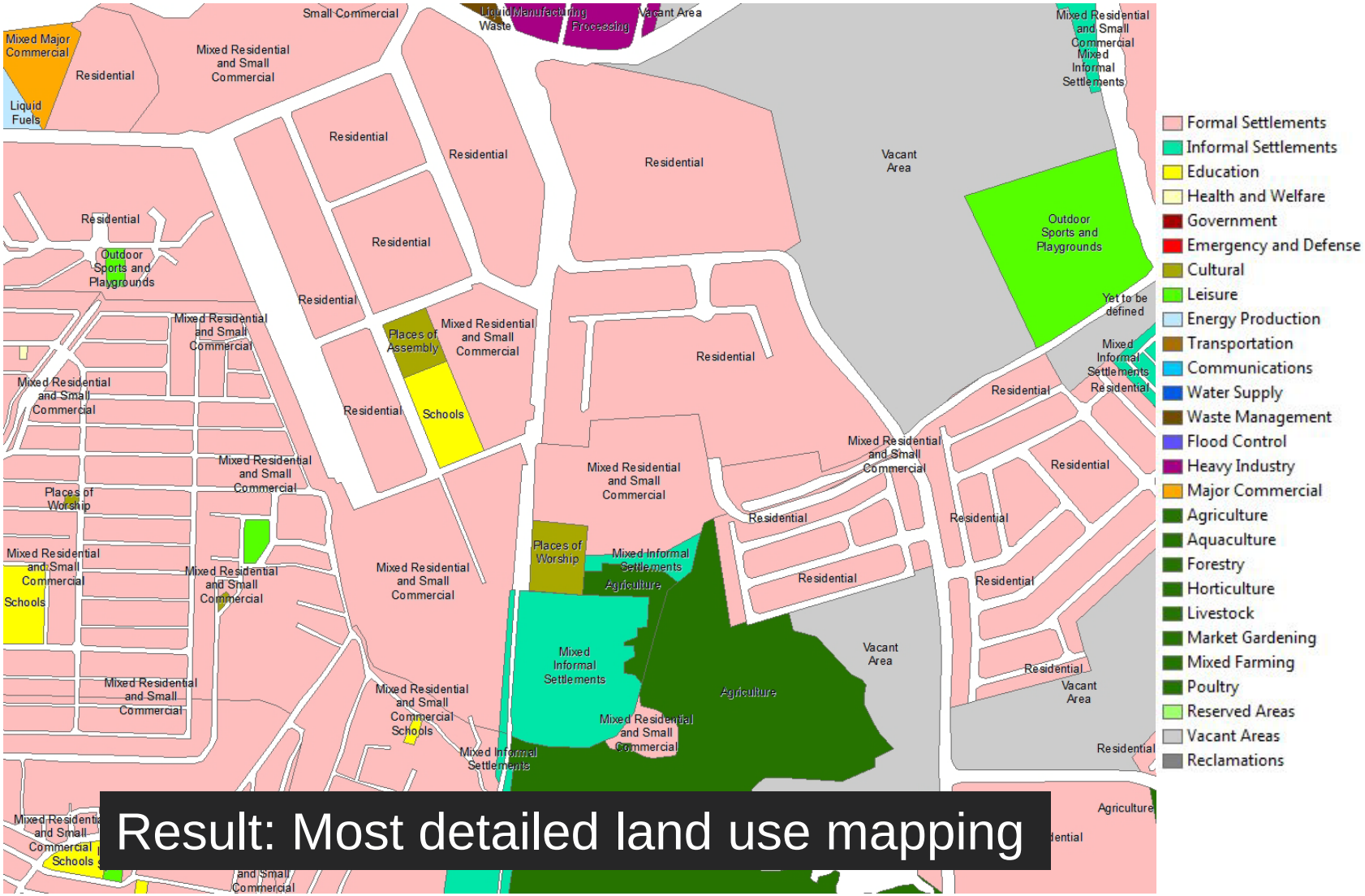
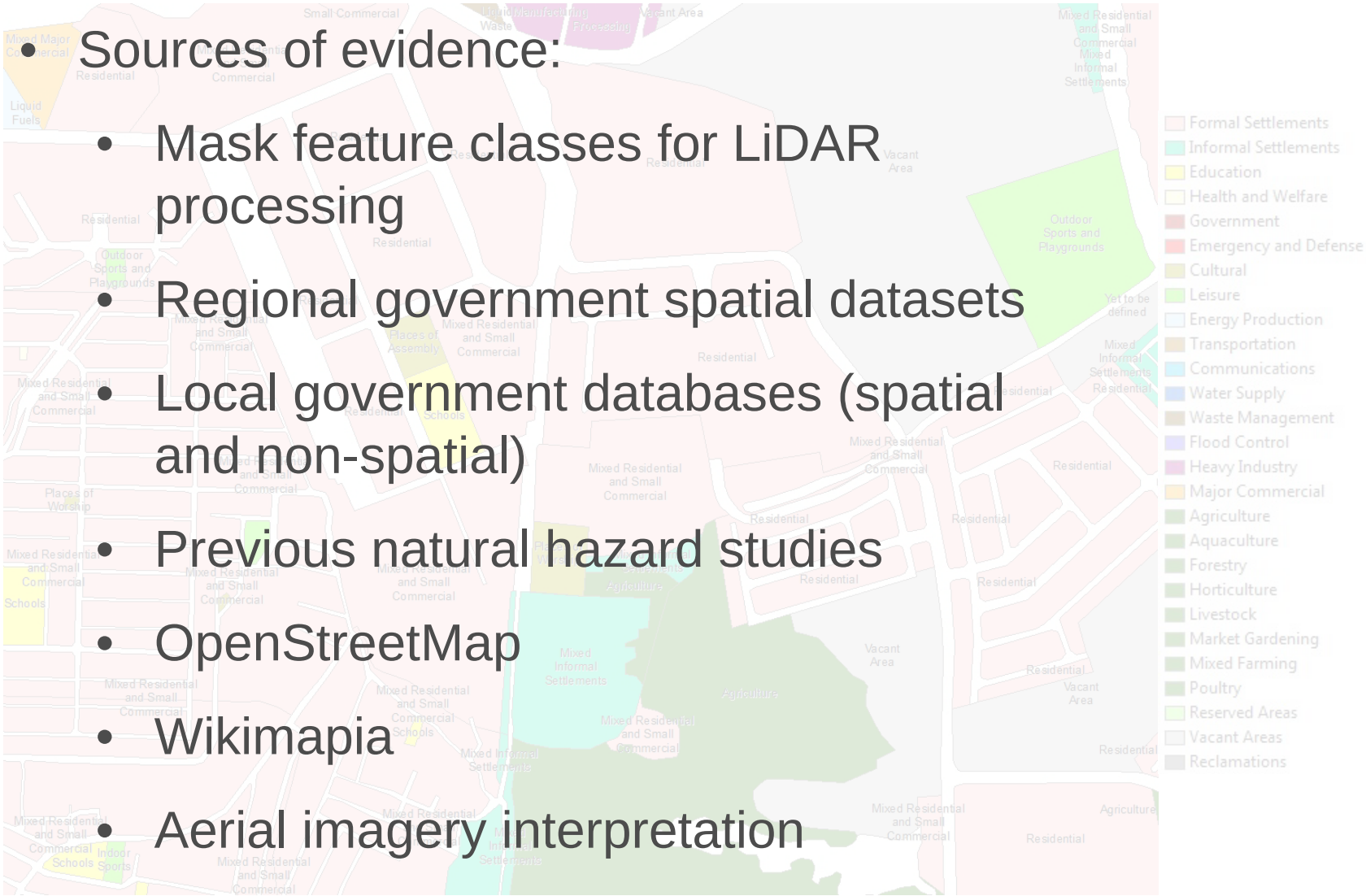


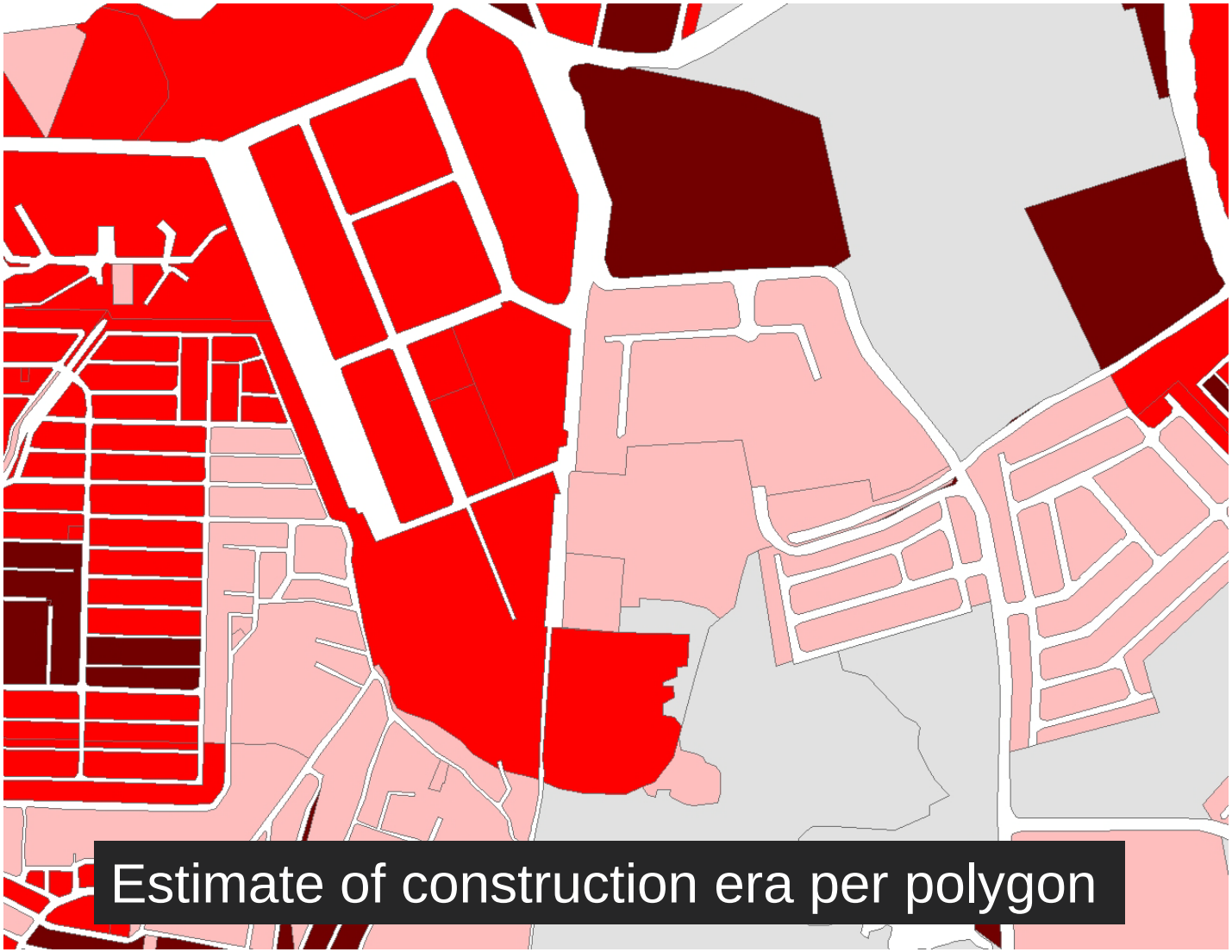
Result: Most detailed land use mapping

Spatial data for exposure information development

- Sources of evidence:
  - Mask feature classes for LiDAR processing
  - Regional government spatial datasets
  - Local government databases (spatial and non-spatial)
  - Previous natural hazard studies
  - OpenStreetMap
  - Wikimapia
  - Aerial imagery interpretation



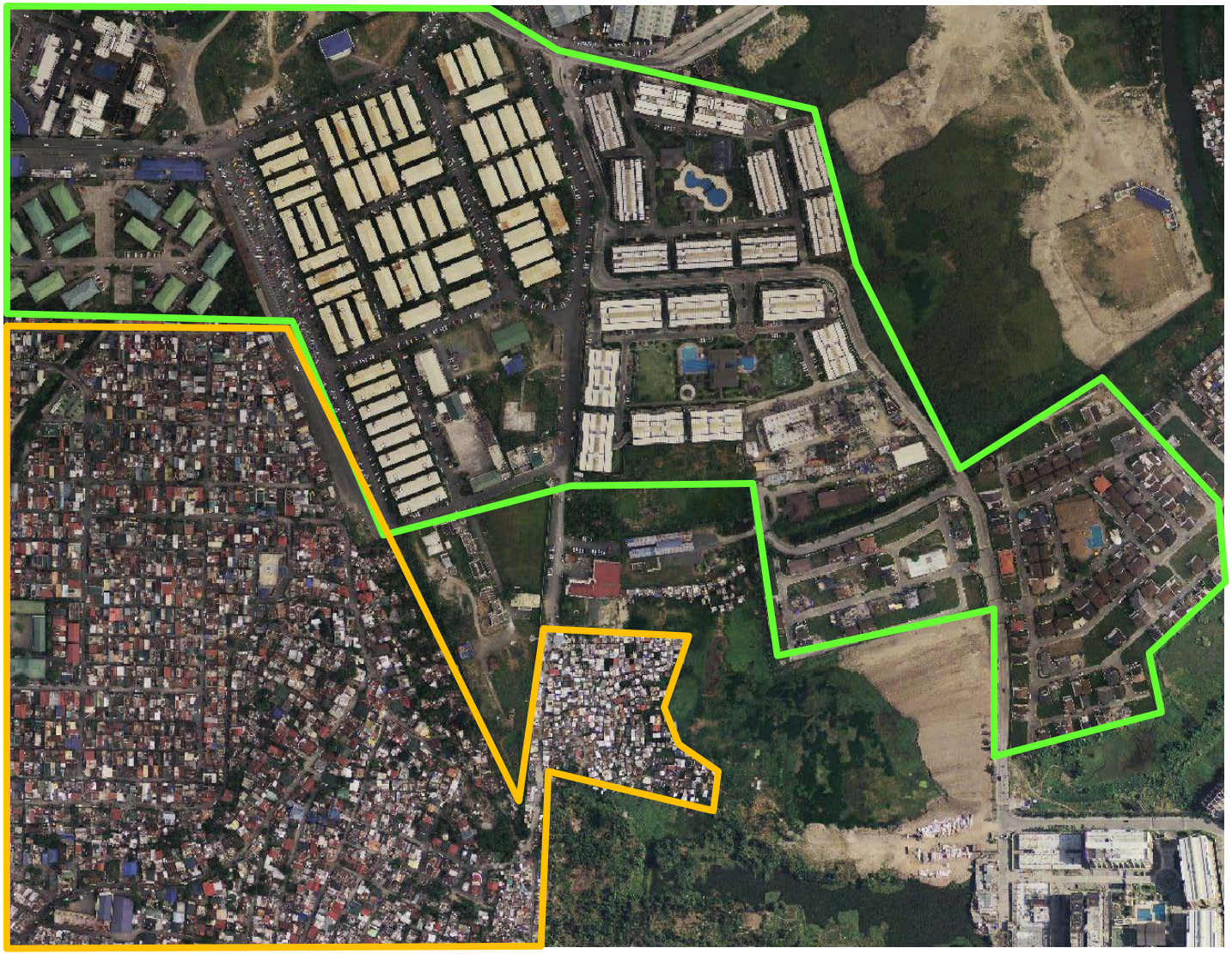
Spatial data for exposure information development



Spatial data for exposure information development

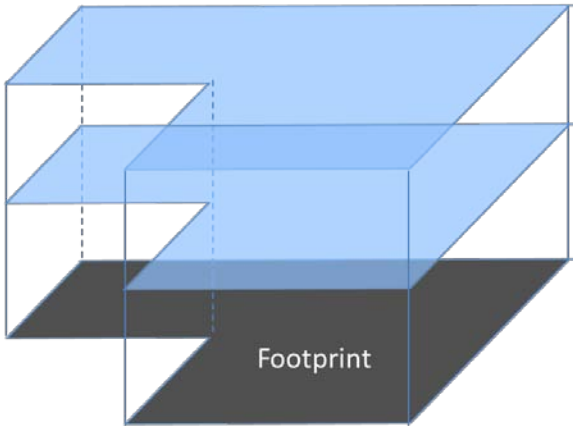
- At this point in the process:
  - Areas capable of supporting development
  - Actual land use
  - Construction vintage
- Challenges of quantifying the buildings:
  - Large number of buildings
  - Limited existing data on building location and size
  - Limited access to records on building construction
- How then to quantify buildings:
  - By count?
  - By Floor Area? – preferred approach for exposure in Australia

Spatial data for exposure information development



Spatial data for exposure information development

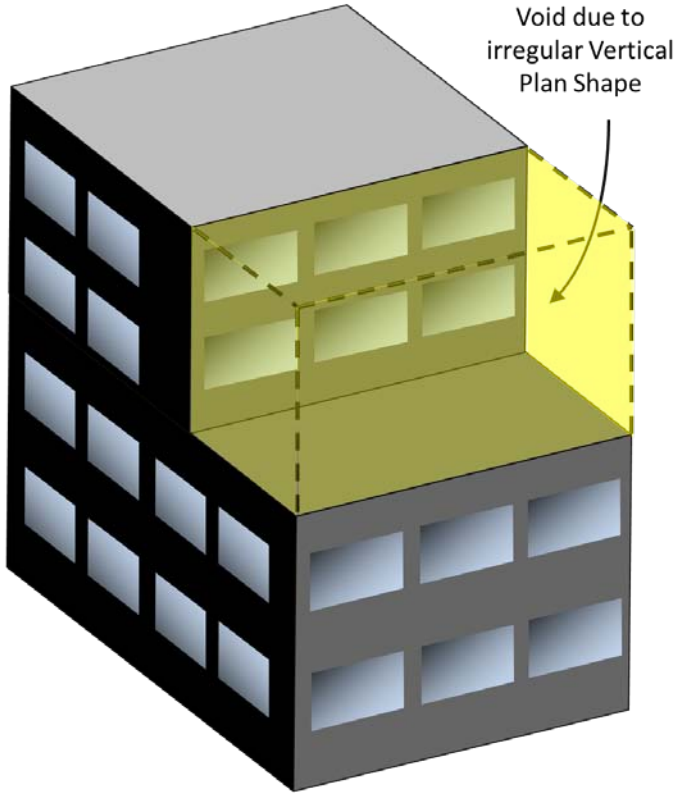
Calculating floor area



Footprint Area = 150m²

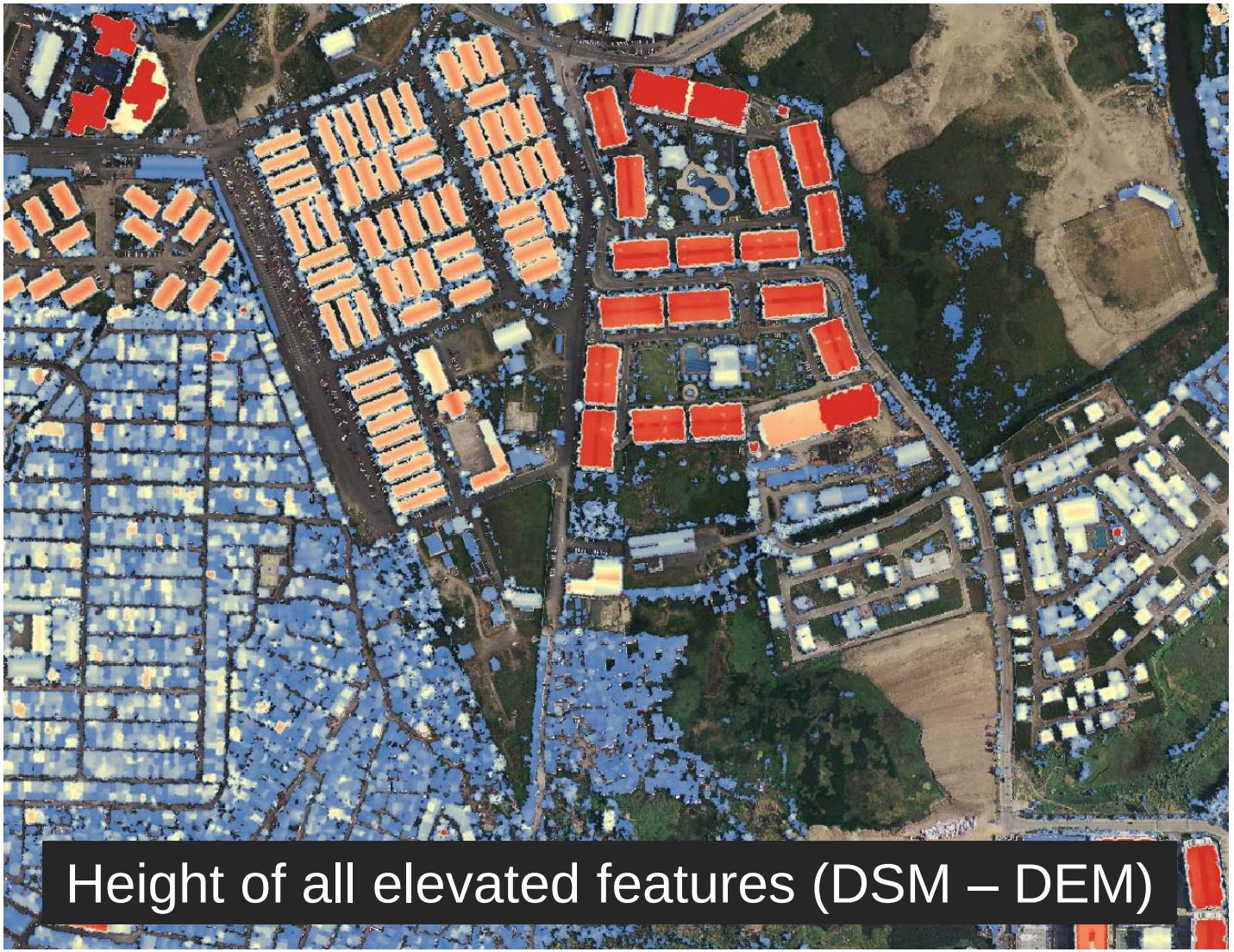
Number of Storeys = 3

Total Floor Area = 450m²



Floor Area ≠ Footprint Area x Number of Storeys

Spatial data for exposure information development



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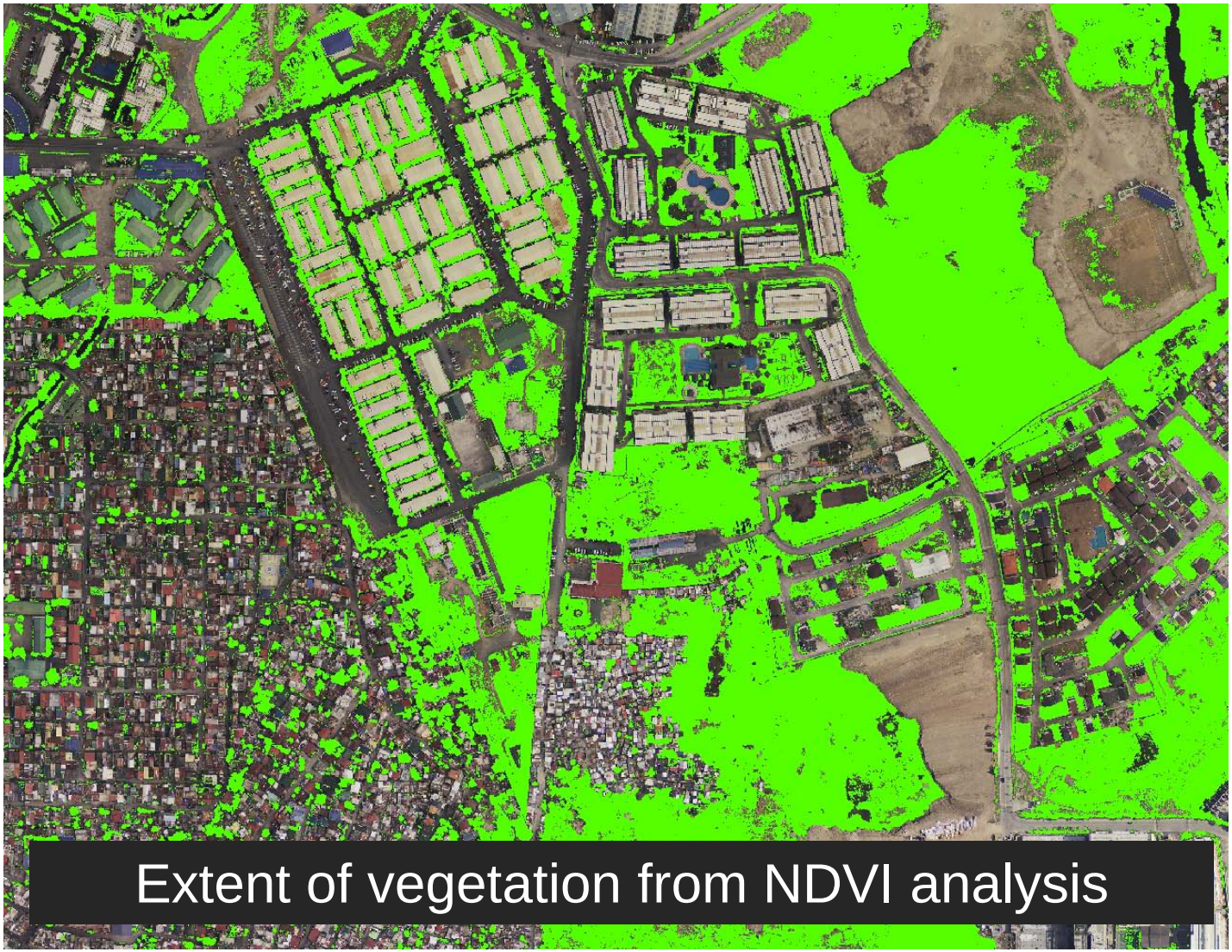
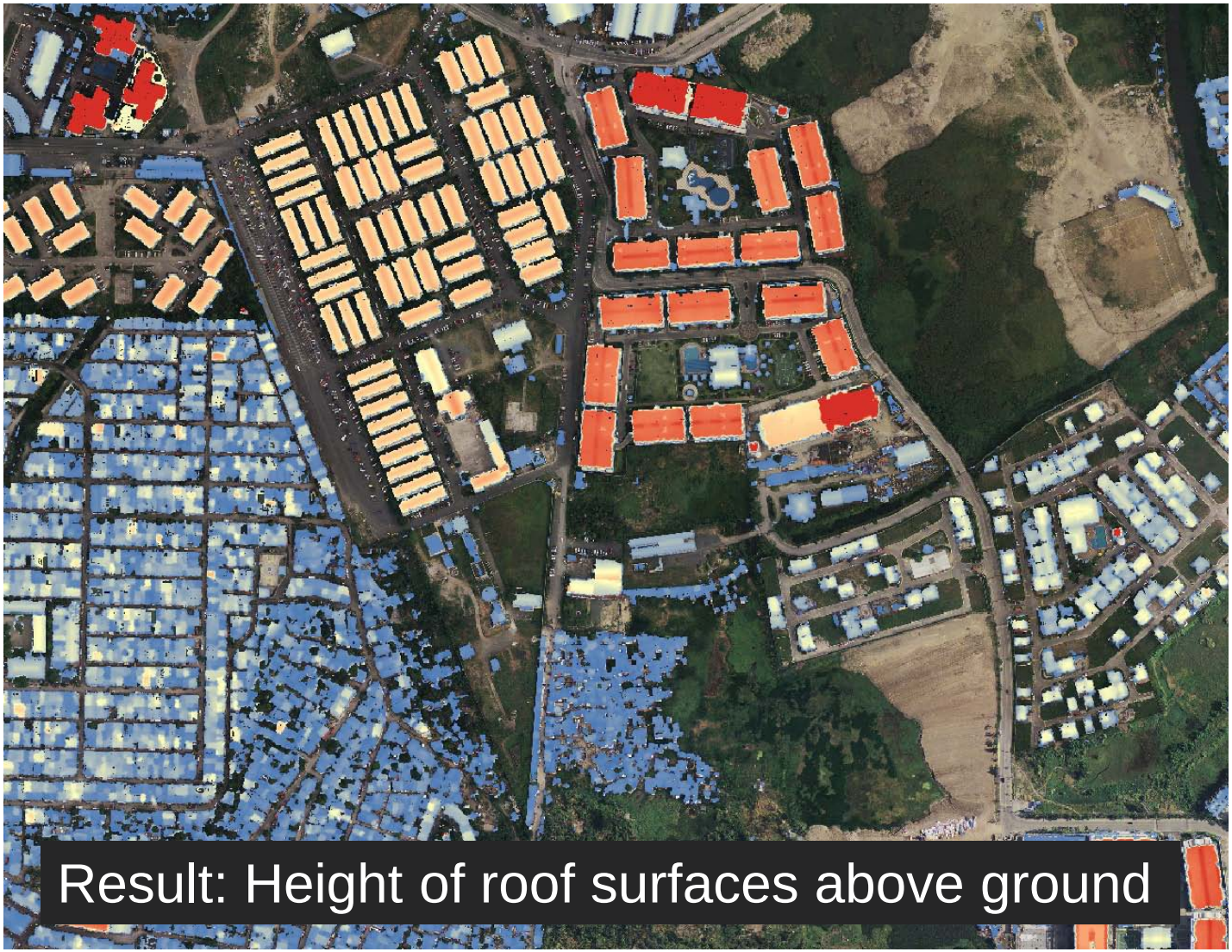


Extent of vegetation from NDVI analysis

Spatial data for exposure information development



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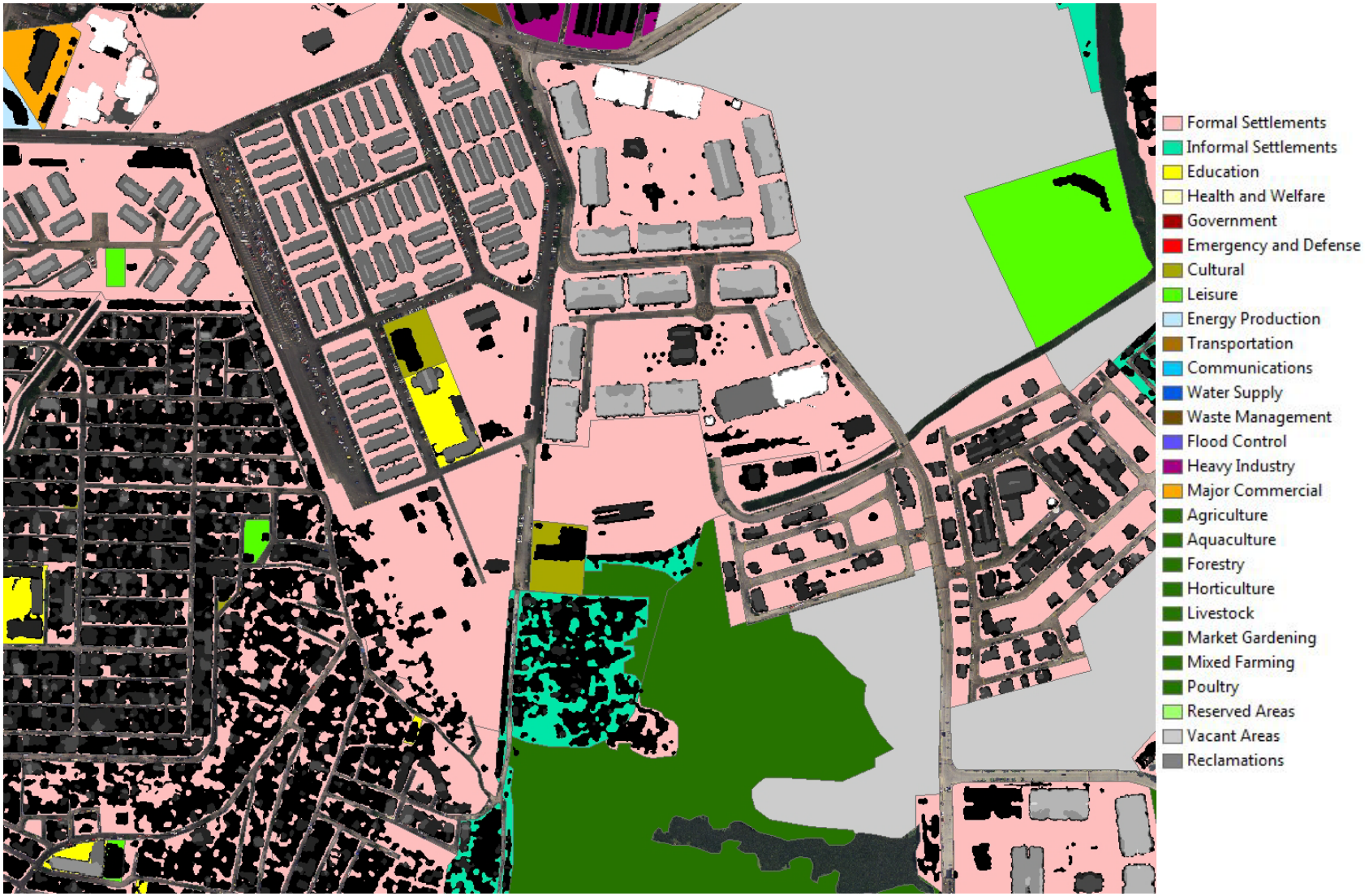
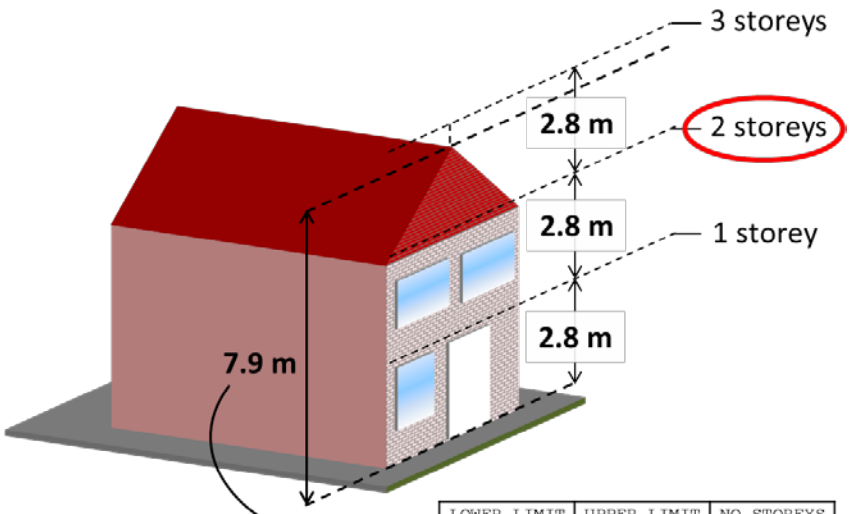


Spatial data for exposure information development

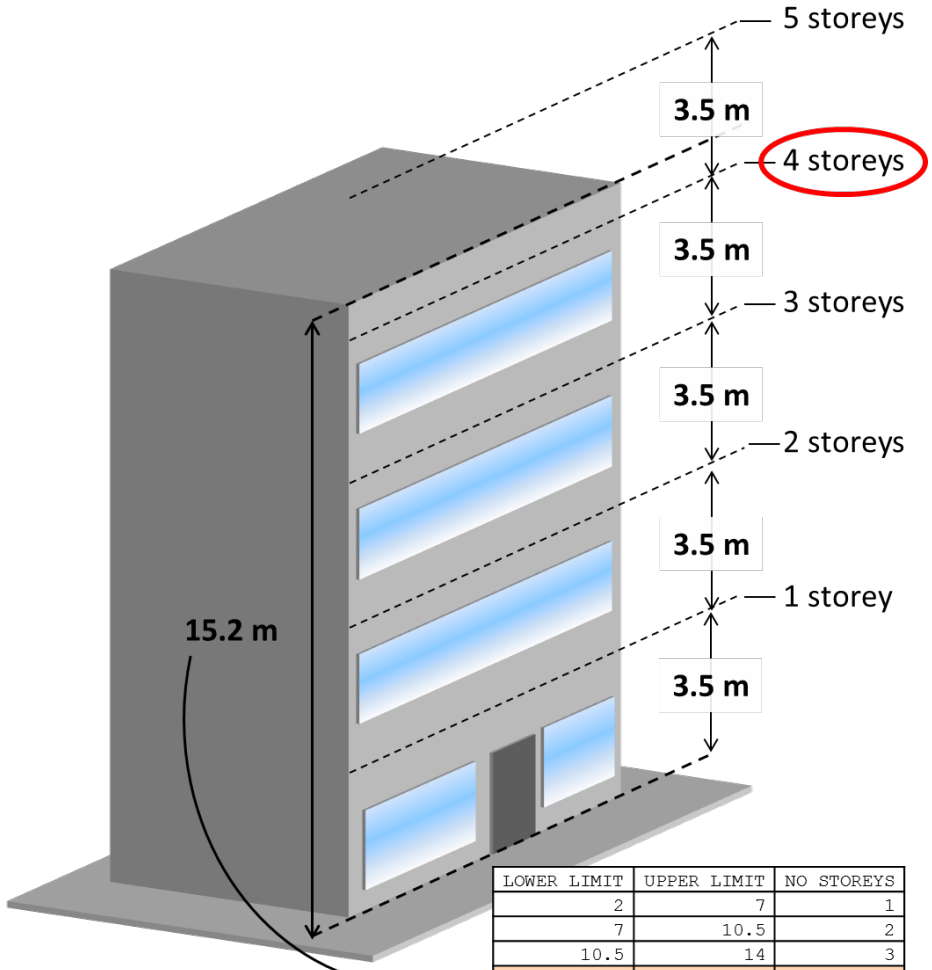
Inter-Storey Heights:

Converting height values to estimated number of storeys



LOWER_LIMIT	UPPER_LIMIT	NO_STOREYS
2	5.6	1
5.6	8.4	2
8.4	11.2	3

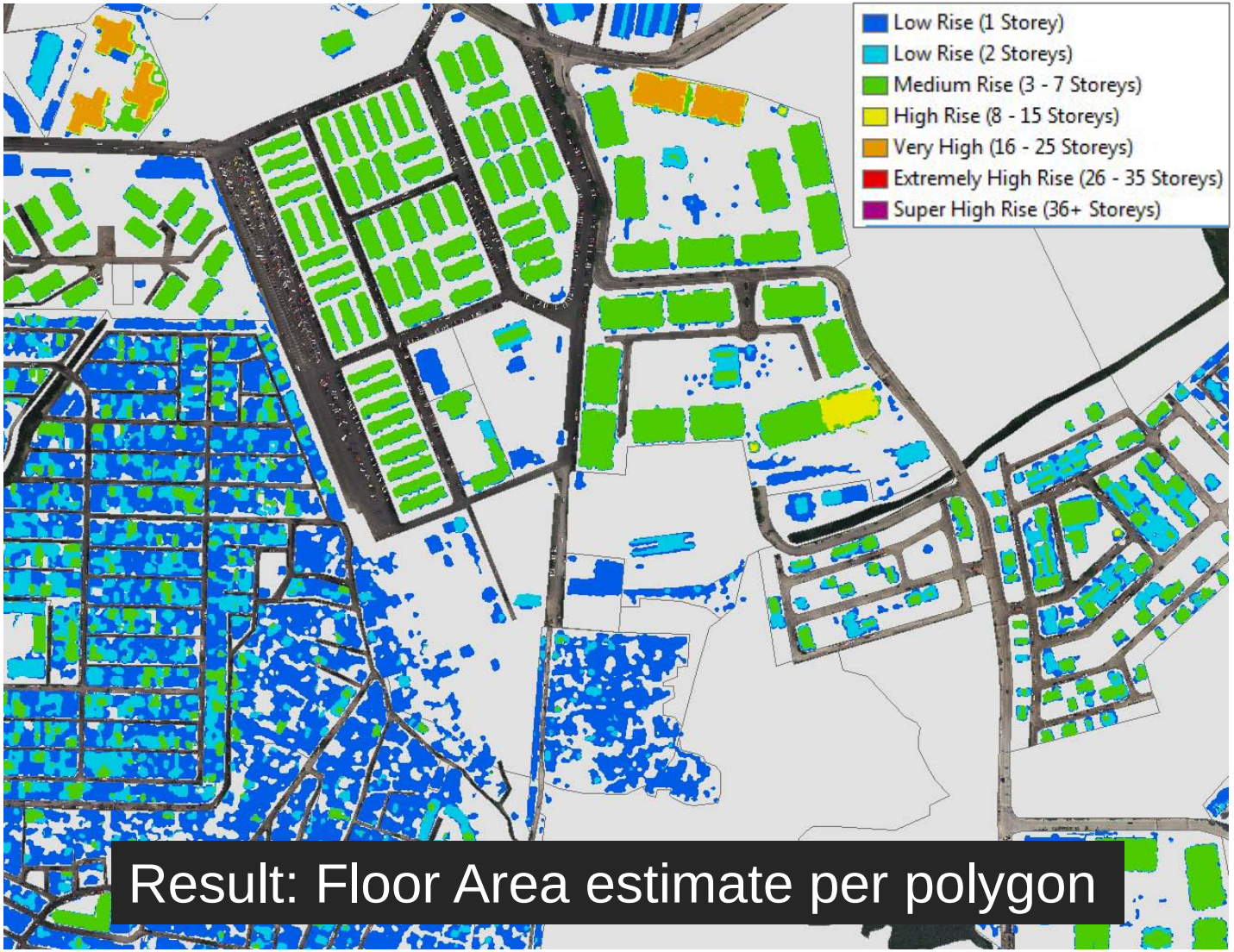
Typical residential building



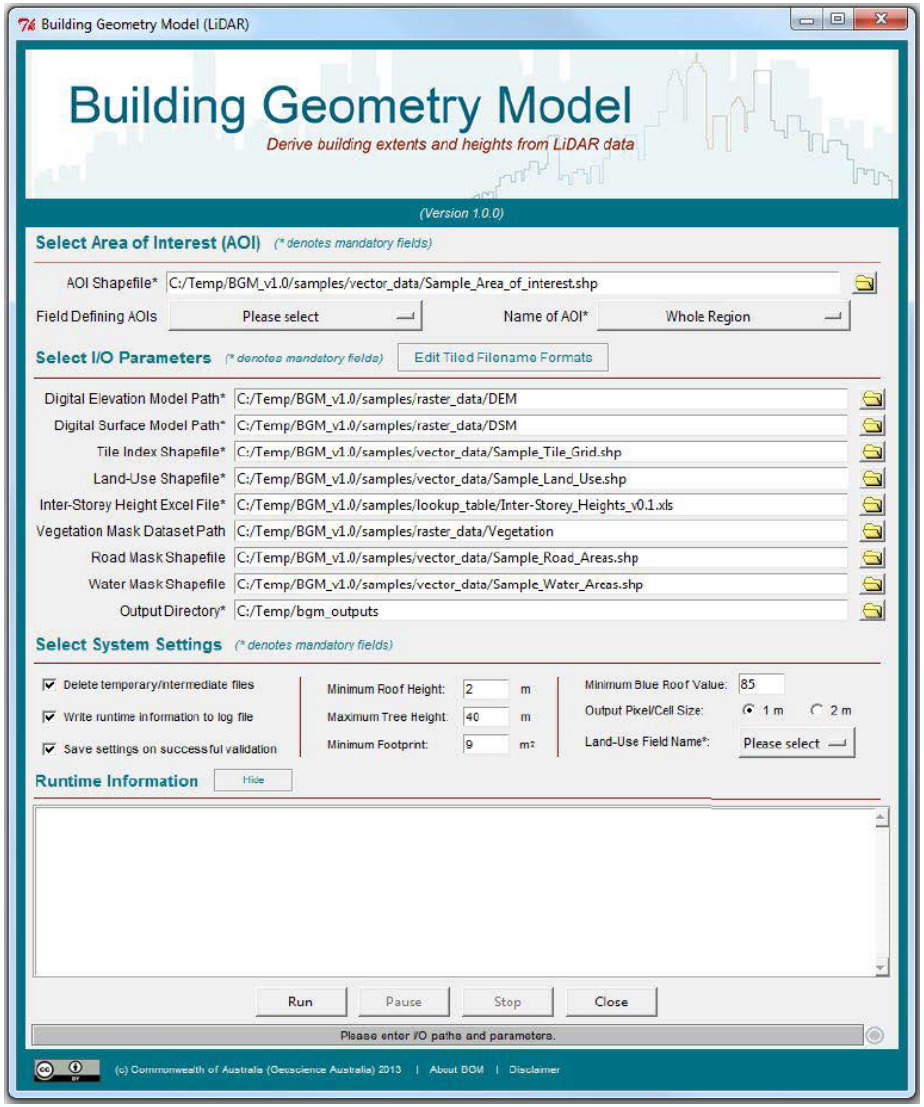
LOWER_LIMIT	UPPER_LIMIT	NO_STOREYS
2	7	1
7	10.5	2
10.5	14	3
14	17.5	4
17.5	21	5

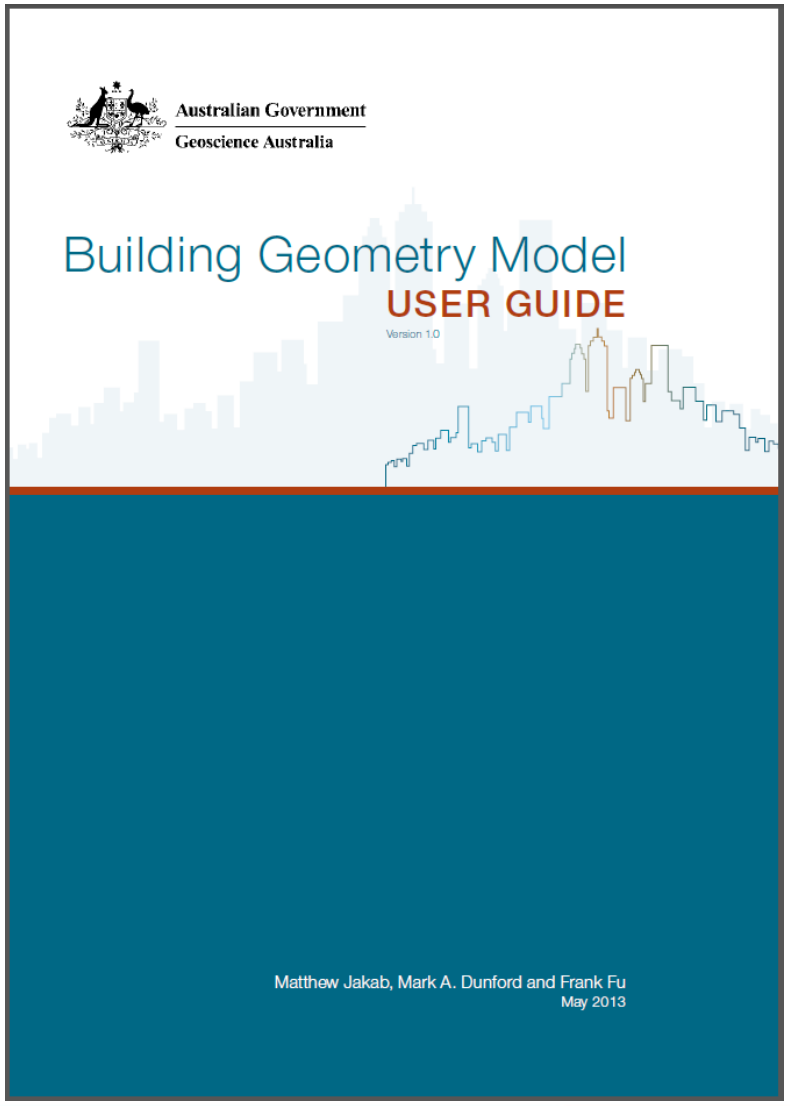
Typical commercial building

Spatial data for exposure information development



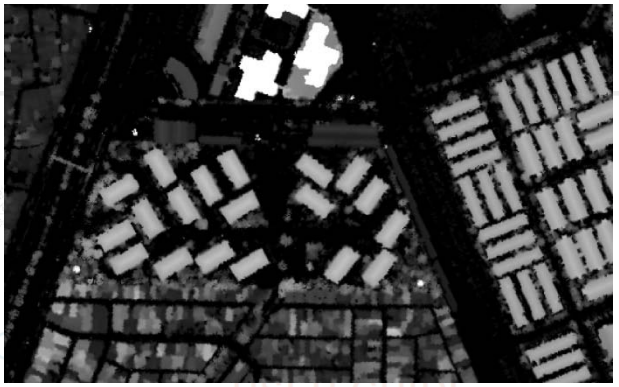
The Building Geometry Model

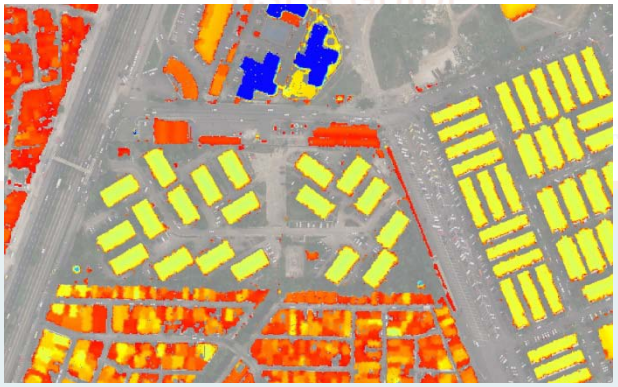


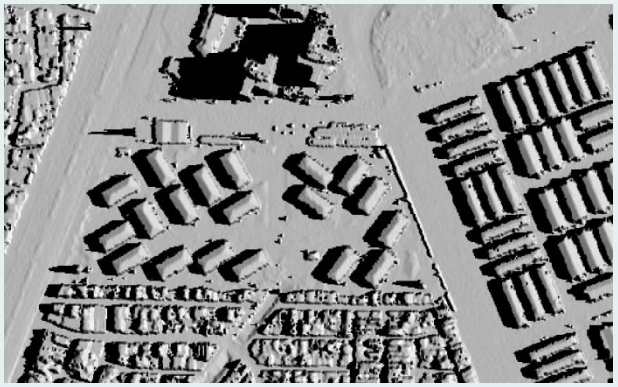


The Building Geometry Model

- Requires ArcGIS 10 (with Spatial Analyst extension) and Python 2.6
- Python code is open source
- Users can modify as needed
- Much faster than feature extraction from point cloud
- Produces various useful intermediate datasets







The Building Geometry Model

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Building Geometry Model

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Jakab, M., Fu, F. & Dunford, M.A., 2013. *Building Geometry Model*. Geoscience Australia, Canberra.

ABSTRACT

It has been widely recognised that Light Detection And Ranging (LiDAR) data is a valuable resource for estimating the geometry of natural and artificial features. While the LiDAR point cloud data can be extremely detailed and difficult to use for the recognition and extraction of three dimensional objects, the Digital Elevation Model and Digital Surface Model are useful for rapidly estimating the horizontal extent of features and the height variations across those features. This has utility in describing the characteristics of buildings or other artificial structures. LiDAR is an optical

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PRODUCT TYPE/SUB TYPE

nonGeographicDataset - Application - Software Package

CONSTRAINTS

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IP OWNER

Commonwealth of Australia (Geoscience Australia)

AUTHOR(S)

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Fu, F.
Dunford, M.A.

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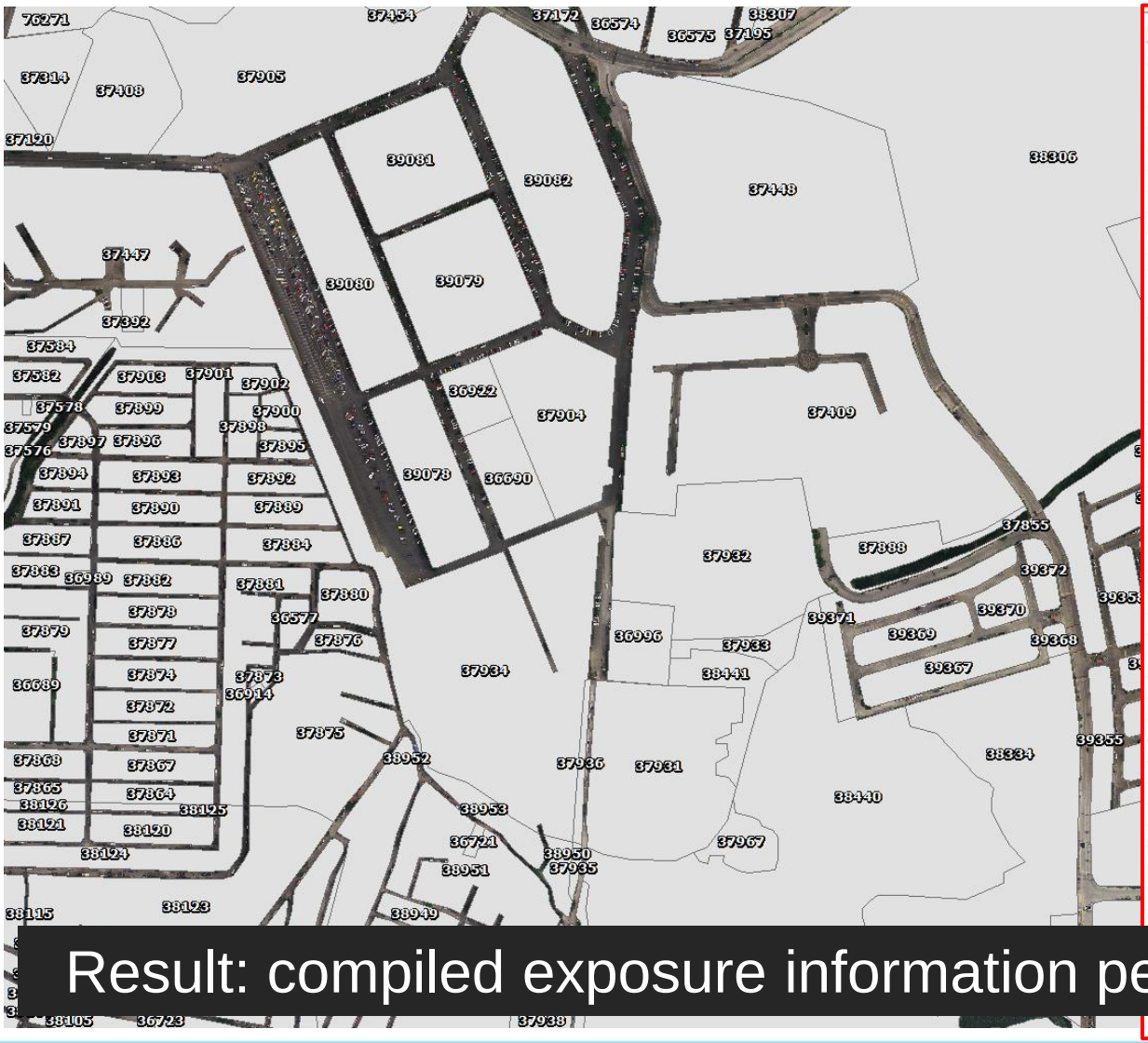
Spatial data for exposure information development



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L4_USE	Formal Settlements
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OID1	37934
FOOTPR_PC	0.235599
FLAREA_SUM	12703
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STOR_RANGE	2
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STOR_MAJ	1
STOR_MNR	3
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W3	0
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CWS	2826.328579
C1	4558.47155
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C4	0
PC1	0
PC2	0
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S2	0
S3	0
S4	0
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FLAREA_L2	3118
FLAREA_M	1281
FLAREA_H	0
FLAREA_V	0
ERA_CONST	1972-1992

Result: compiled exposure information per polygon

Spatial data for exposure information development

Building Density

100%

0%

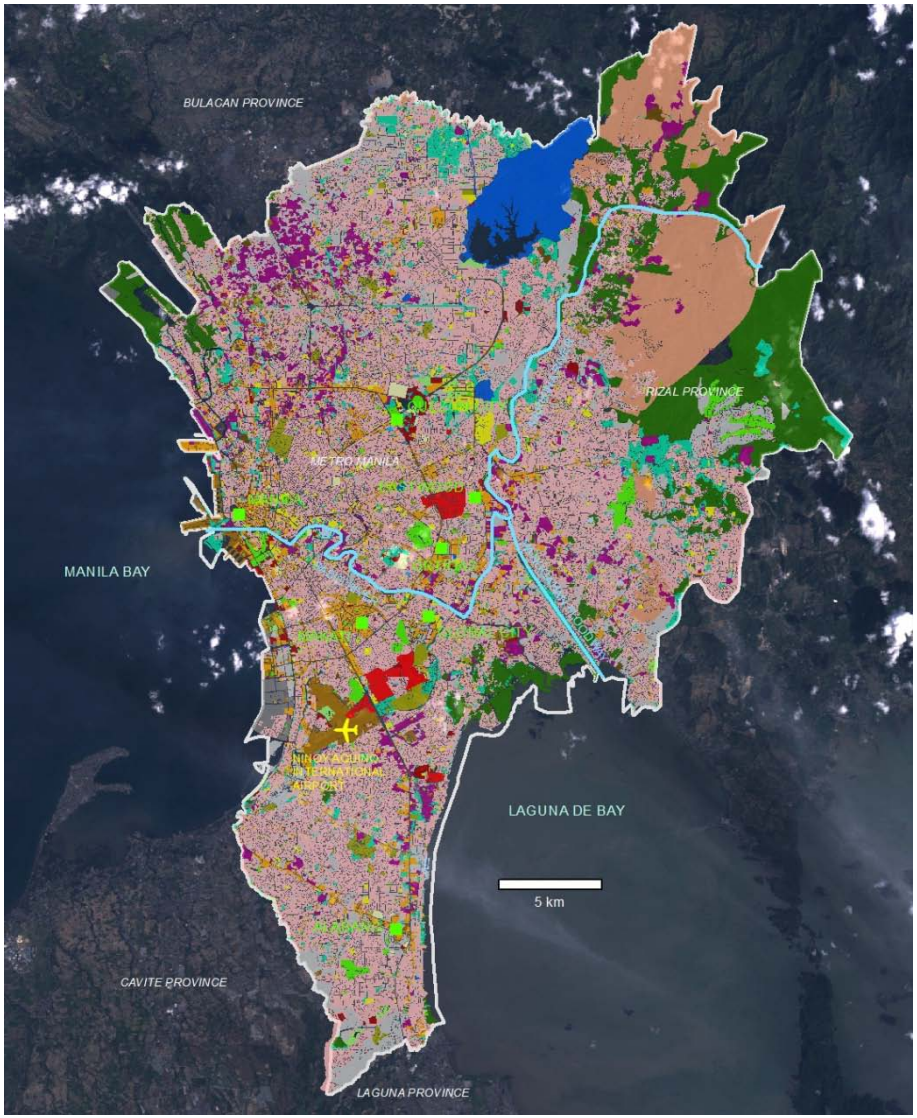
Percentage of land covered by buildings

Determined from Building Geometry Model

Spatial data for exposure information development

Land Use classification

- Formal Settlements
- Informal Settlements
- Education
- Health and Welfare
- Government
- Emergency and Defense
- Cultural
- Leisure
- Energy Production
- Transportation
- Communications
- Water Supply
- Waste Management
- Flood Control
- Heavy Industry
- Major Commercial
- Agriculture
- Aquaculture
- Forestry
- Horticulture
- Livestock
- Market Gardening
- Mixed Farming
- Poultry
- Reserved Areas
- Vacant Areas
- Reclamations

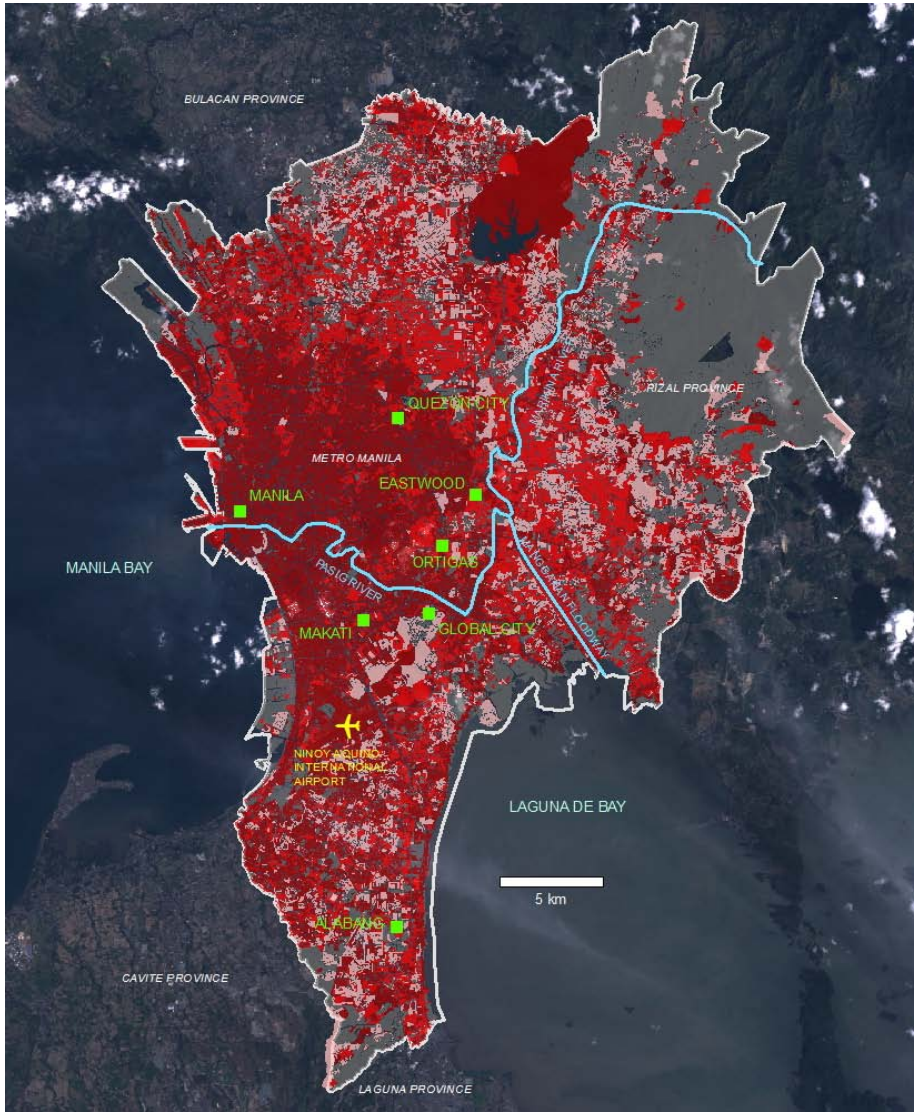


Prepared using existing data and local knowledge

Spatial data for exposure information development

Era of Construction mapping

- Pre-1972
- 1972-1992
- Post-1992
- No Devt



Determined from Landsat Time-Series Analysis

Validated with local knowledge

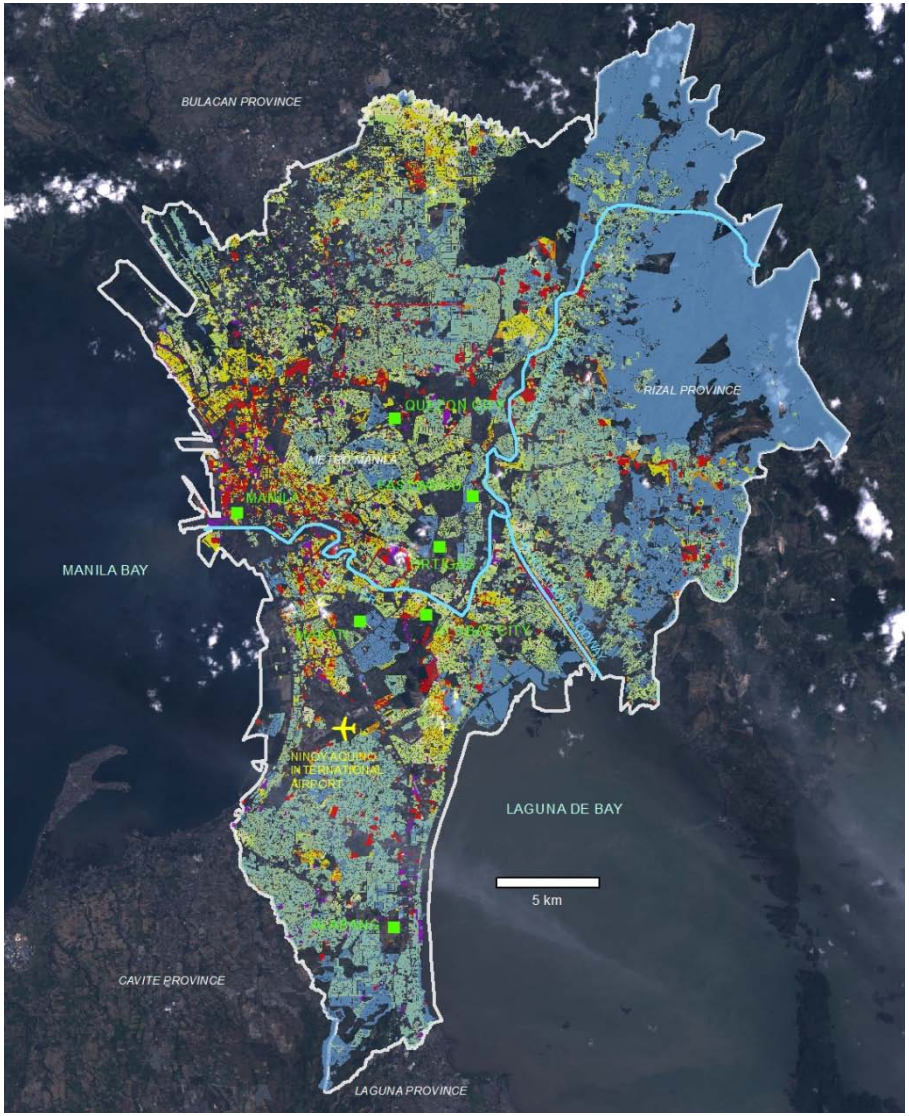
Spatial data for exposure information development

Population Density

100,000

0

People per km²



Determined from estimates of people per m² of floor area

Summary

- **Foundation spatial data** is a crucial input for modelling natural hazards and development of exposure information
- Many challenges for characterising the elements at risk in a megacity such as the Greater Metro Manila Area
- High resolution elevation data and imagery has had, and will continue to have, significant benefits for risk analysis
- **Open source** analysis methods such as the Building Geometry Model are helpful for rapidly quantifying aspects of the built environment

Summary

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04 March 2014
New standards for the surveying and geospatial industries
The surveying and spatial communities working in Australia will be able to ensure greater integrity in their work following the release of a new standard.

26 February 2014
Kalgoorlie-Boulder earthquake
A magnitude 4.6 earthquake shook Kalgoorlie-Boulder residents on the morning of Wednesday 26 February 2014, shaking buildings and parked cars and causing minor damage near the epicentre.

12 February 2014
New building assessment tool supports better risk analysis
Geoscience Australia has released new open source software, produced as part of a recently completed international capacity building project in the Philippines, which can rapidly and remotely assess the geometric properties of buildings.

23 January 2014
International work helps build safer communities in the Philippines
Scientists from Geoscience Australia recently completed a major project working together with technical agencies and local authorities in the Greater Metropolitan Manila Area in the Philippines, to develop Philippine capacity for assessing the impacts of natural hazards.

21 January 2014
A lifetime of rock solid achievement
The former Chief Executive Officer of Geoscience Australia, Dr Neil Williams PSM, FTSE, has today been awarded the Australian Academy of Science's prestigious Haddon Forrester King Medal, in recognition of a long and distinguished geoscience career.

09 January 2014
A groundwater challenge for Australia's future scientists
Top Year 11 science students are converging on Canberra this week to learn first-hand about a major challenge for Australia – how to secure the nation's future water resource needs.

Topic contact: media@ga.gov.au

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Thank you

Any questions?

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