The Use of Geographic Information Systems in Risk Assessment

With Specific Focus on the RiVAMP Methodology

Presented by Nadine Brown
August 27, 2012
Climate Studies Group Mona
Climate Change Workshop

Presentation Outline

- What is GIS
- Components of a GIS
- What Can You do with GIS?
- GIS Data Types
- How GIS Works
- GIS Software
- GIS and Risk Assessment
- The Use of GIS in the RiVAMP Methodology

What is Geography

- Geography is the science of place and space.
  - Geographers ask where things are located on the surface of the earth, why they are located where they are, how places differ from one another, and how people interact with the environment.
- Two main branches of geography: human geography and physical geography.

What is an Information System?

- an integrated set of components for **collecting, storing, and processing data** and for **delivering information, knowledge, and digital products** for decision making, progress reporting, and for planning and evaluation of programs.

- It can be either manual or computerized, or a combination of both.

What is a GIS?

- A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

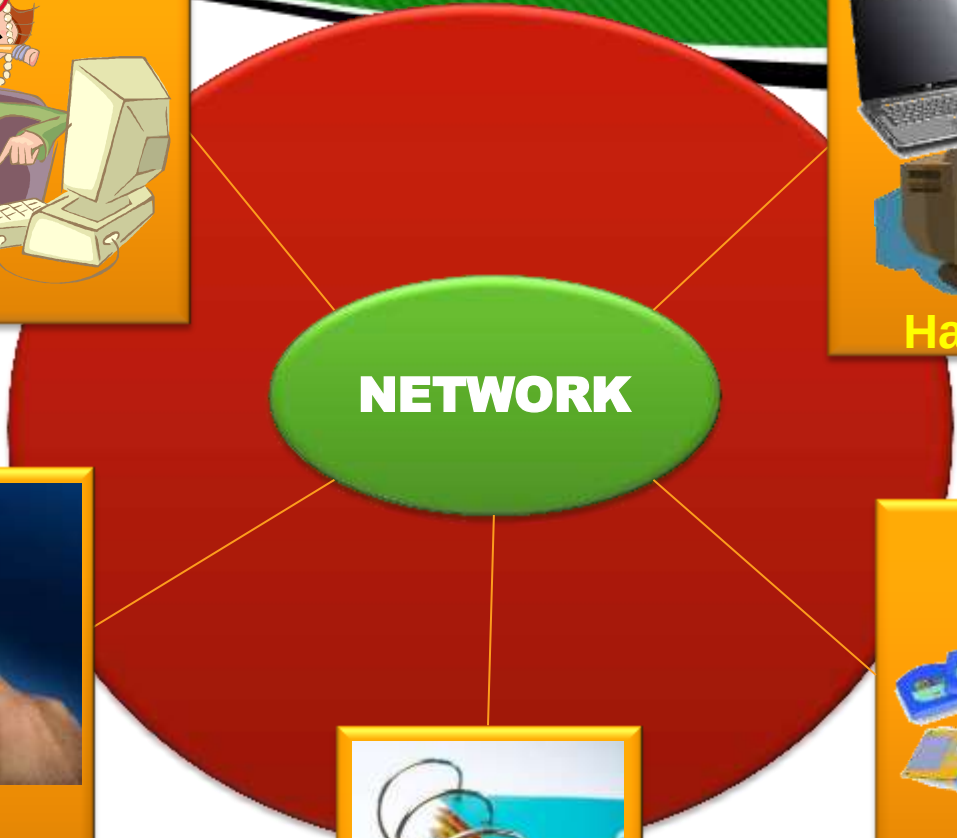
What is a GIS?

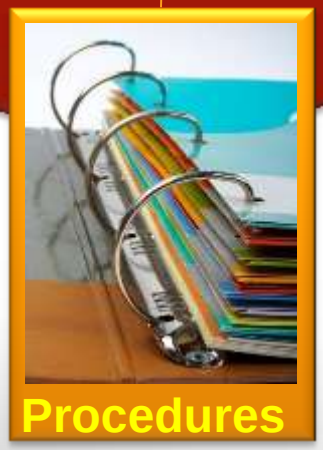
- GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

What is a GIS?

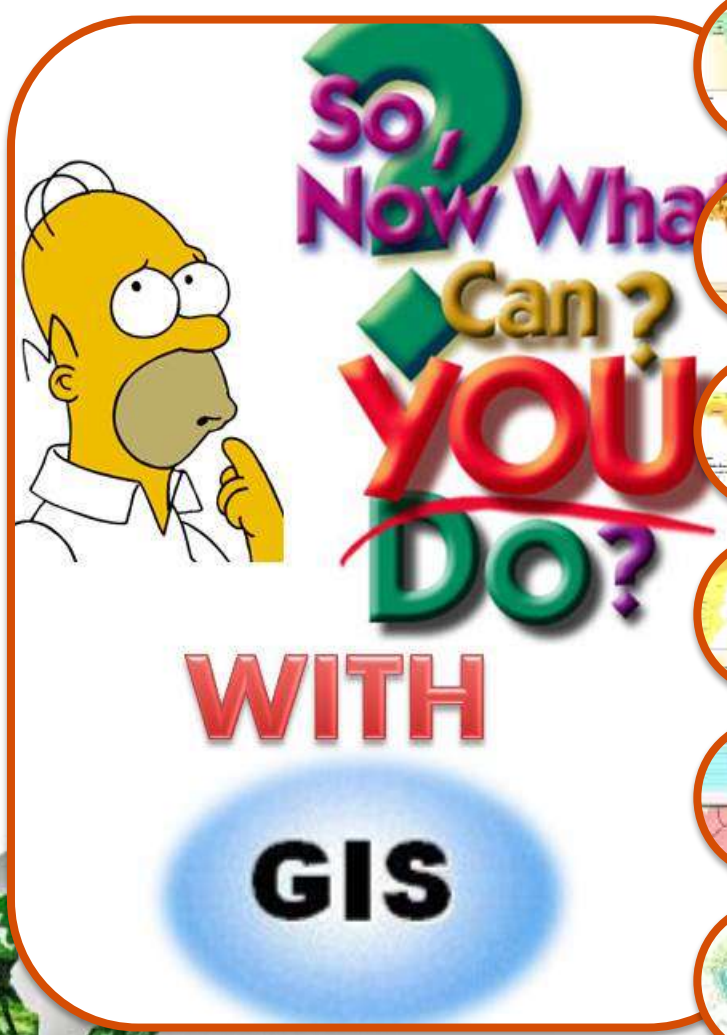
- A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

Anatomy of a GIS





What Can You Do With GIS?



Map Where Things Are

Map Quantities

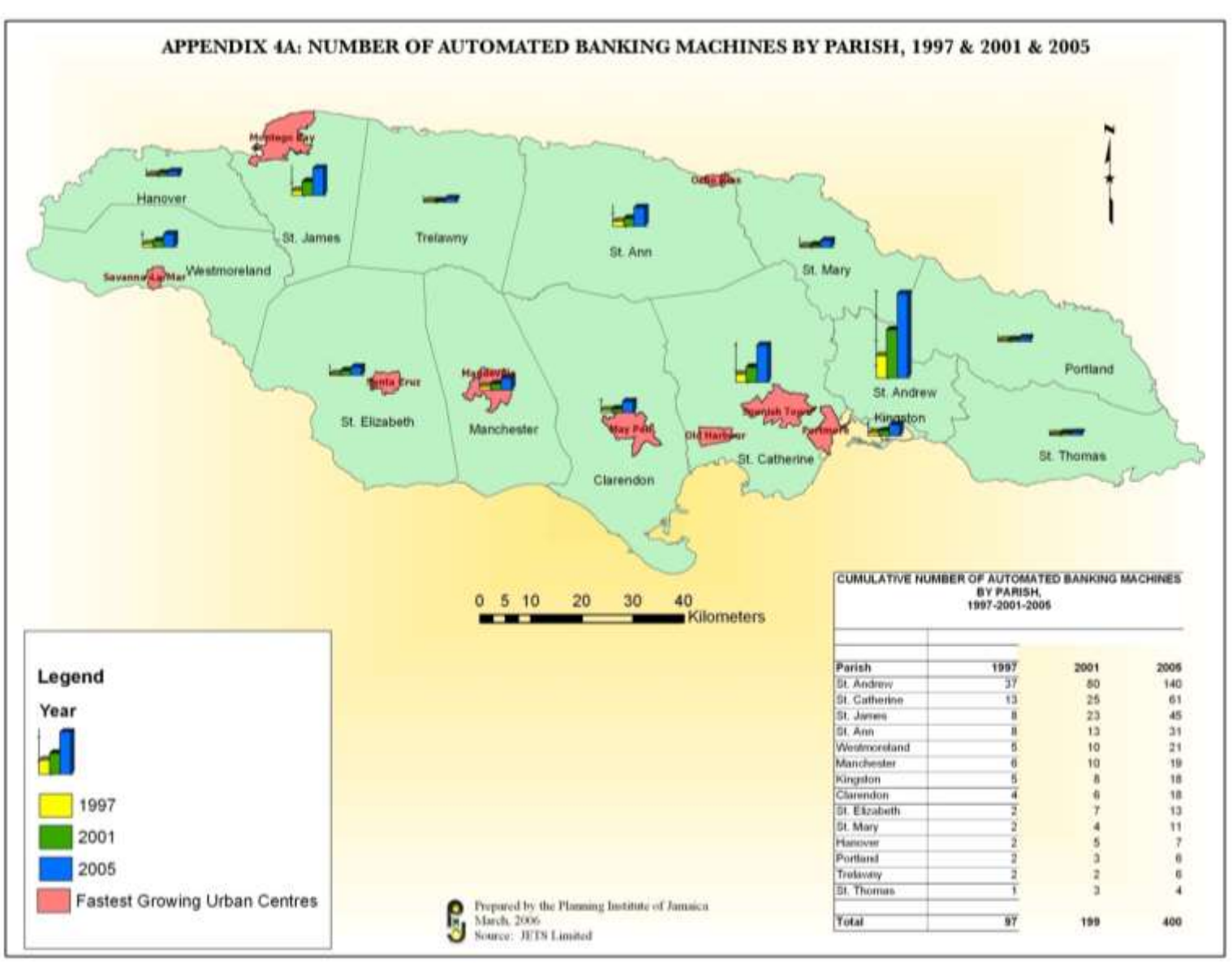
Map Densities

Find What's Inside

Find What's Nearby

Map Change

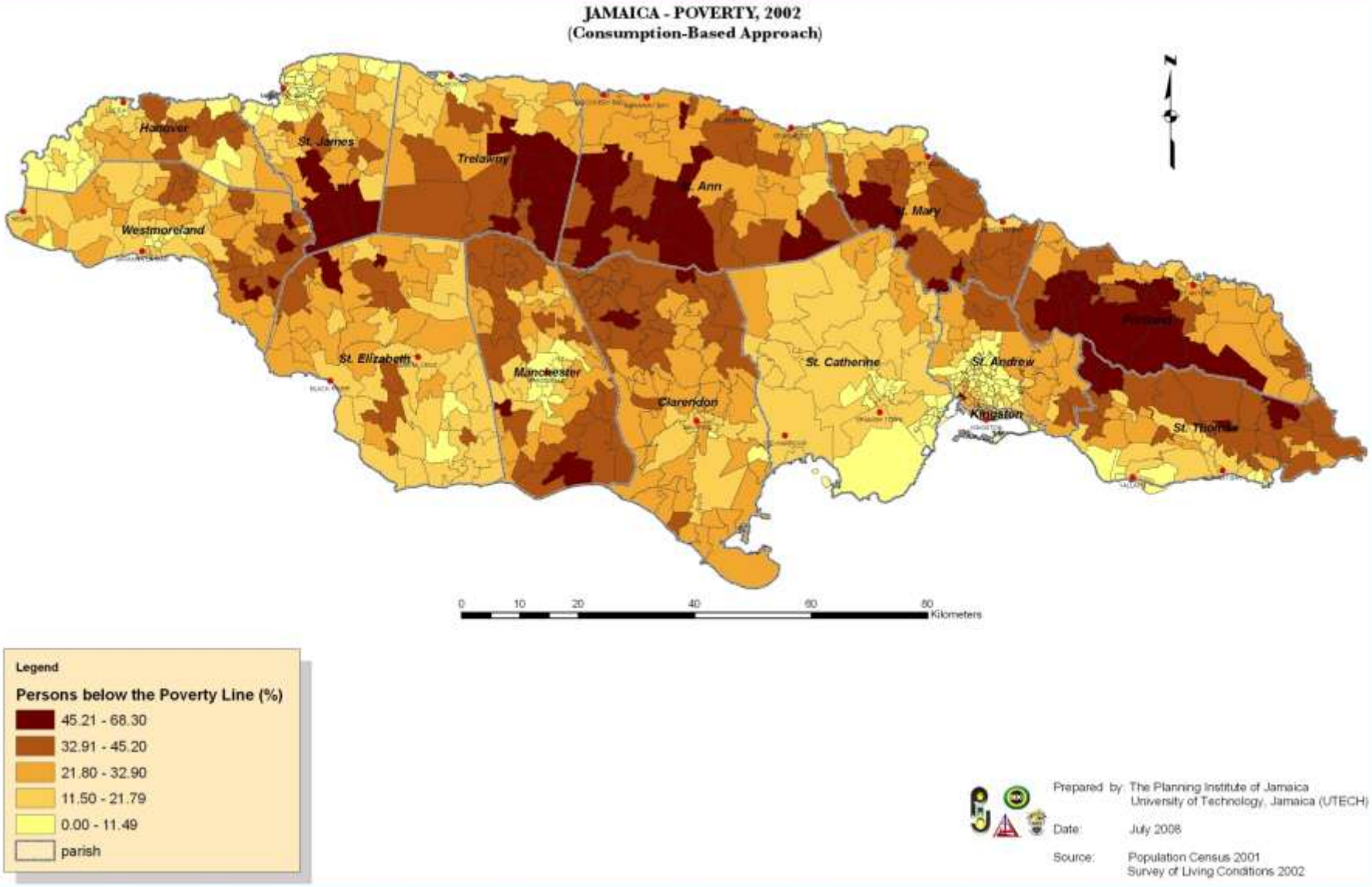
Map Where Things Are



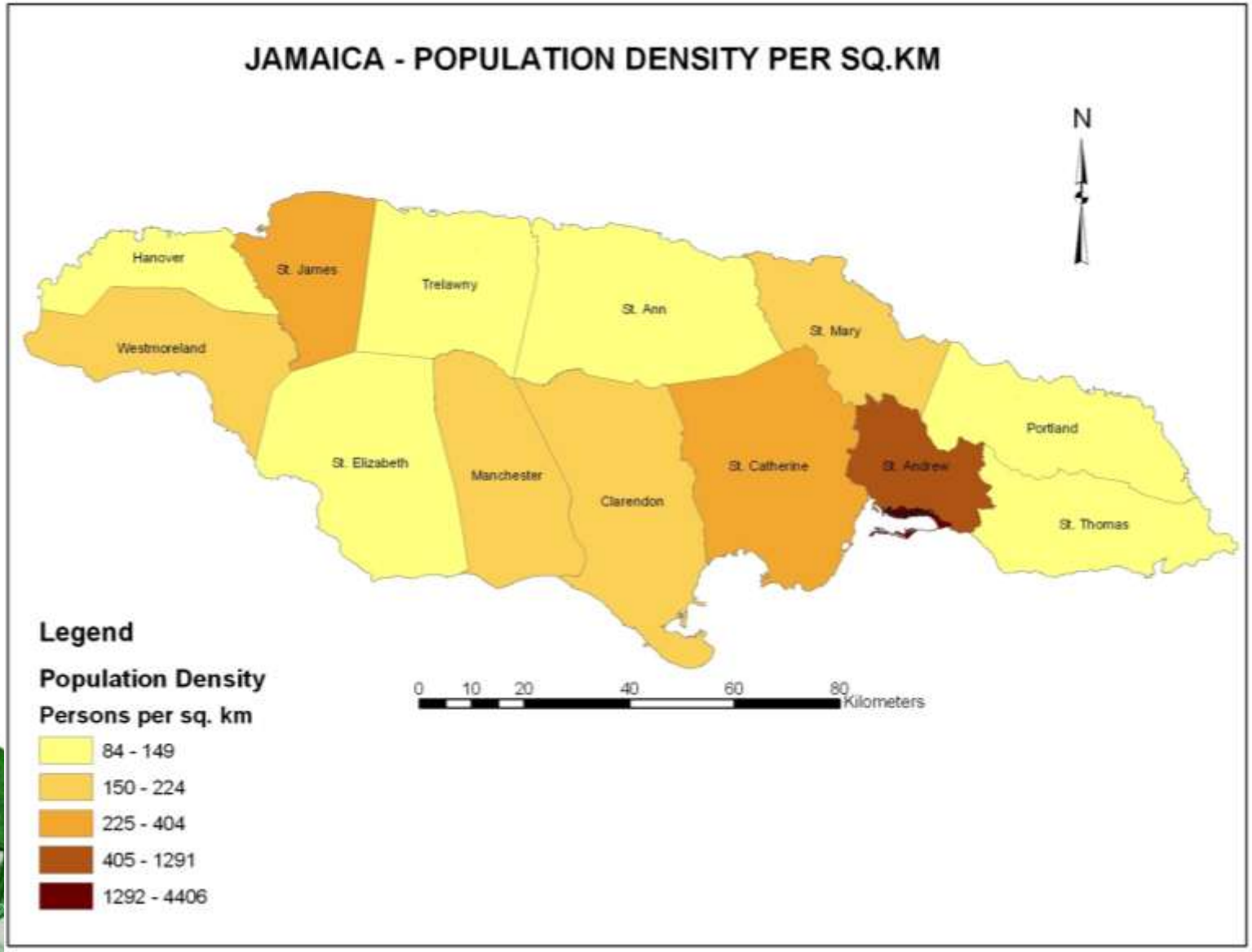
CUMULATIVE NUMBER OF AUTOMATED BANKING MACHINES BY PARISH, 1997-2001-2005

Parish	1997	2001	2005
St. Andrew	37	80	140
St. Catherine	13	25	61
St. James	8	23	45
St. Ann	8	13	31
Westmoreland	5	10	21
Manchester	6	10	19
Kingston	5	8	18
Clarendon	4	6	18
St. Elizabeth	2	7	13
St. Mary	2	4	11
Hanover	2	5	7
Portland	2	3	6
Trelawny	2	2	6
St. Thomas	1	3	4
Total	97	199	400

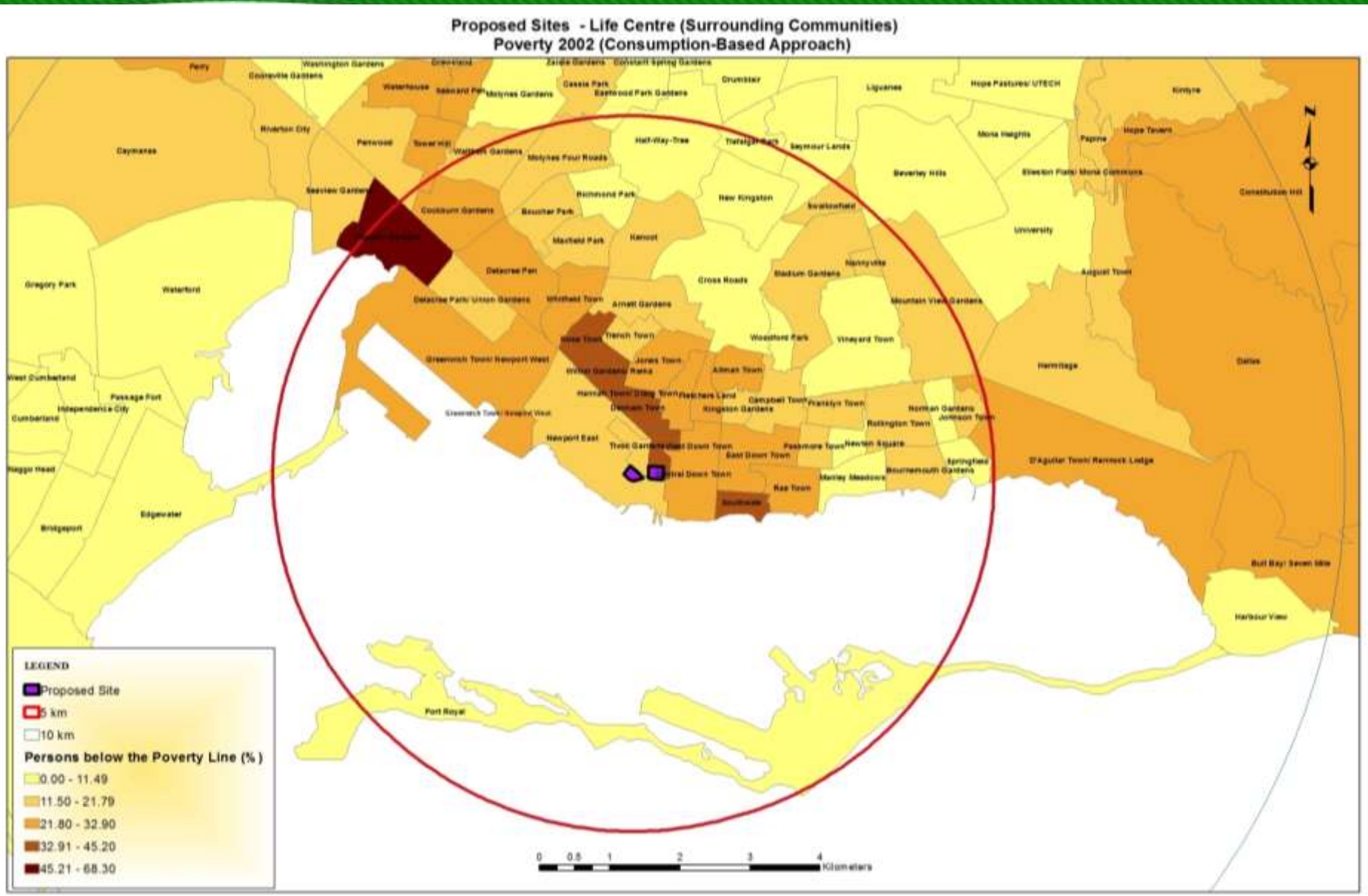
Map Quantities



Map Densities

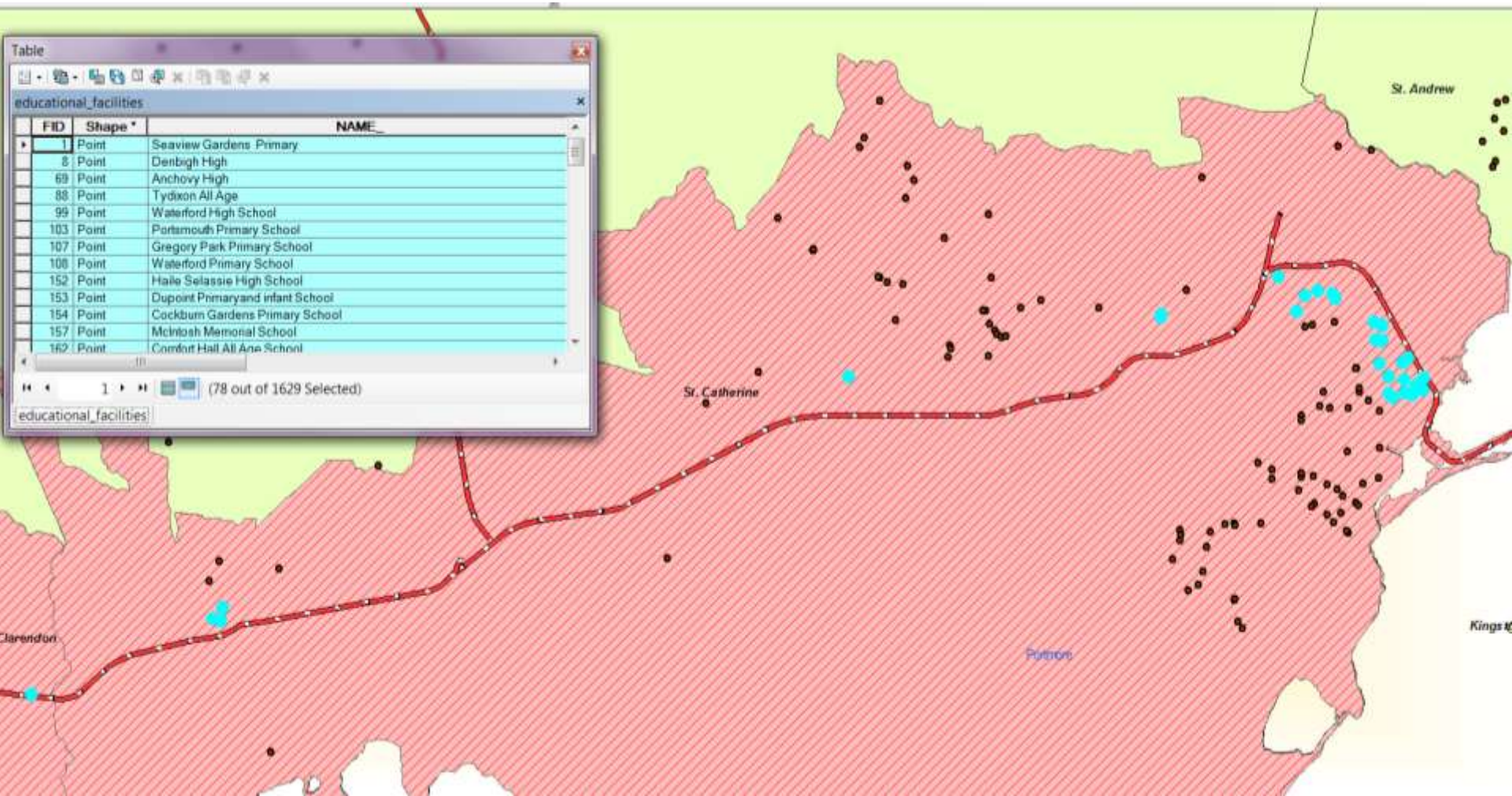


Find What's Inside

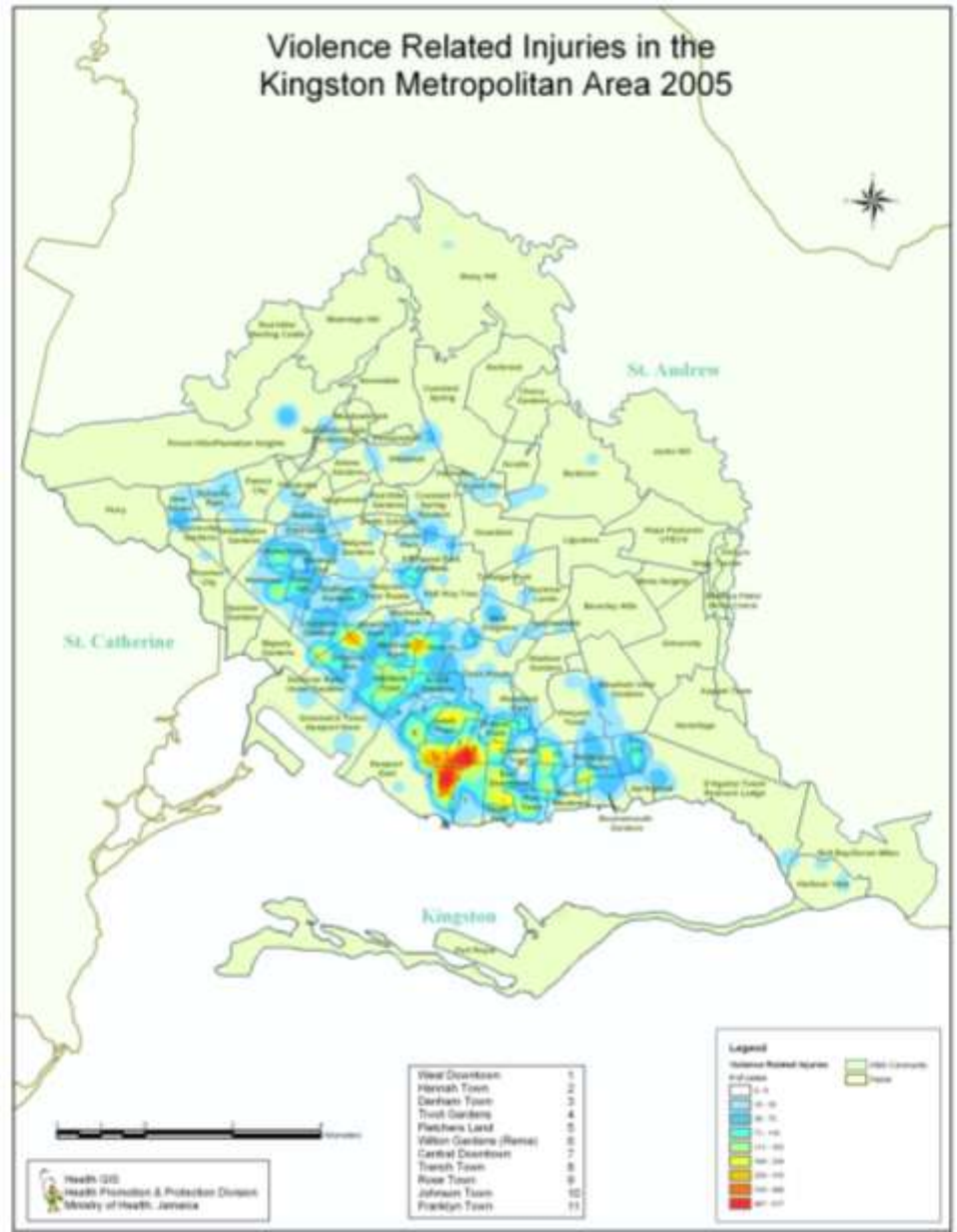


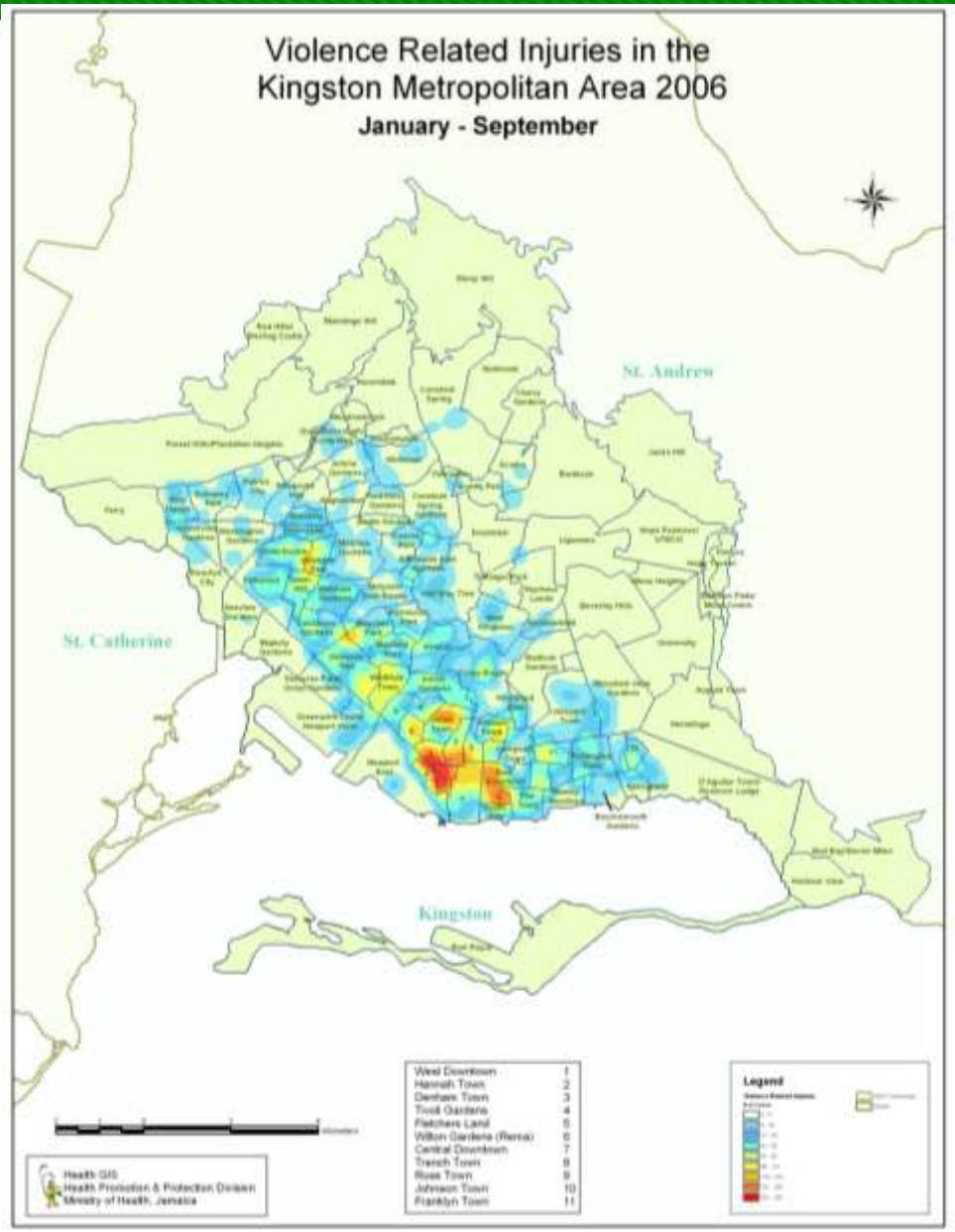
Find What's Nearby

Schools within 1km of the Proposed Highway 2000 Alignment



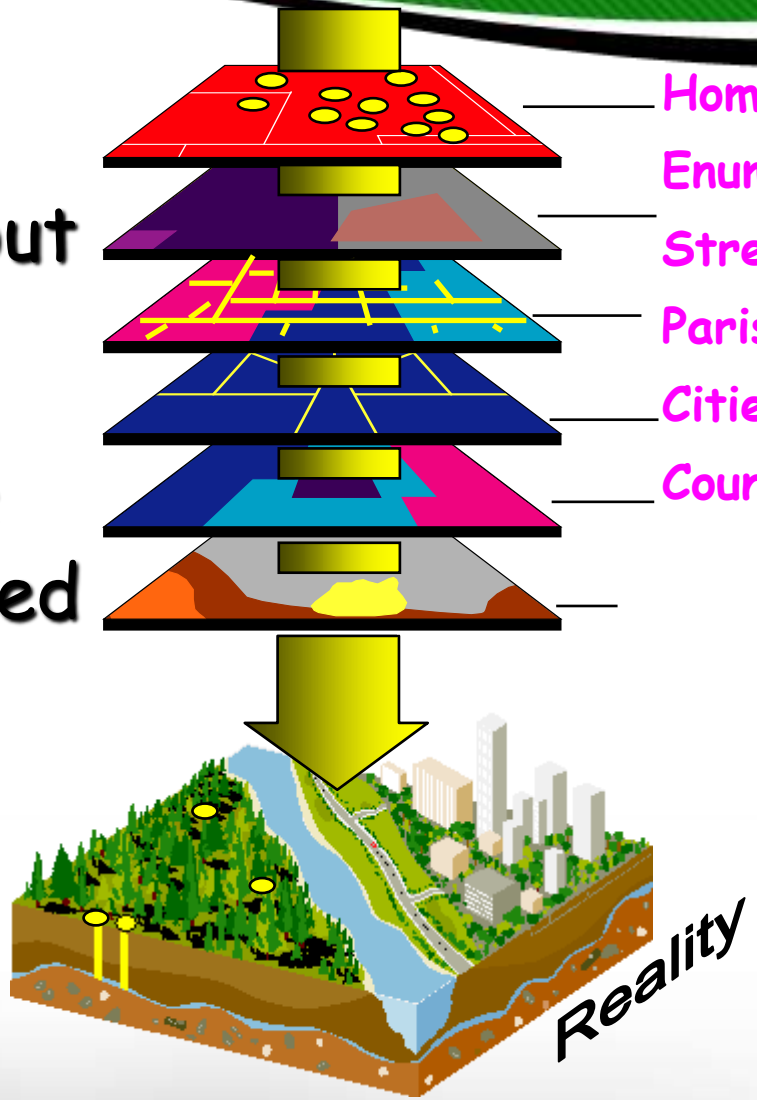
Map Change


Violence Related Injuries in the
Kingston Metropolitan Area 2005
St. Andrew
St. Catherine
Kingston


Violence Related Injuries in the
Kingston Metropolitan Area 2006
January - September
St. Andrew
St. Catherine
Kingston

HOW GIS WORKS

A GIS stores information about the world as a collection of thematic layers that can be linked by geography



www.esri.com

GIS DATA TYPES

- The basic data type in a GIS reflects traditional data found on a map. Accordingly, GIS technology utilizes two basic types of data. These are:

  - **Spatial data** - describes the absolute and relative location of geographic features.

  - **Attribute data** - describes characteristics of the spatial features. These characteristics can be quantitative and/or qualitative in nature..

GIS DATA TYPES

SPATIAL DATA

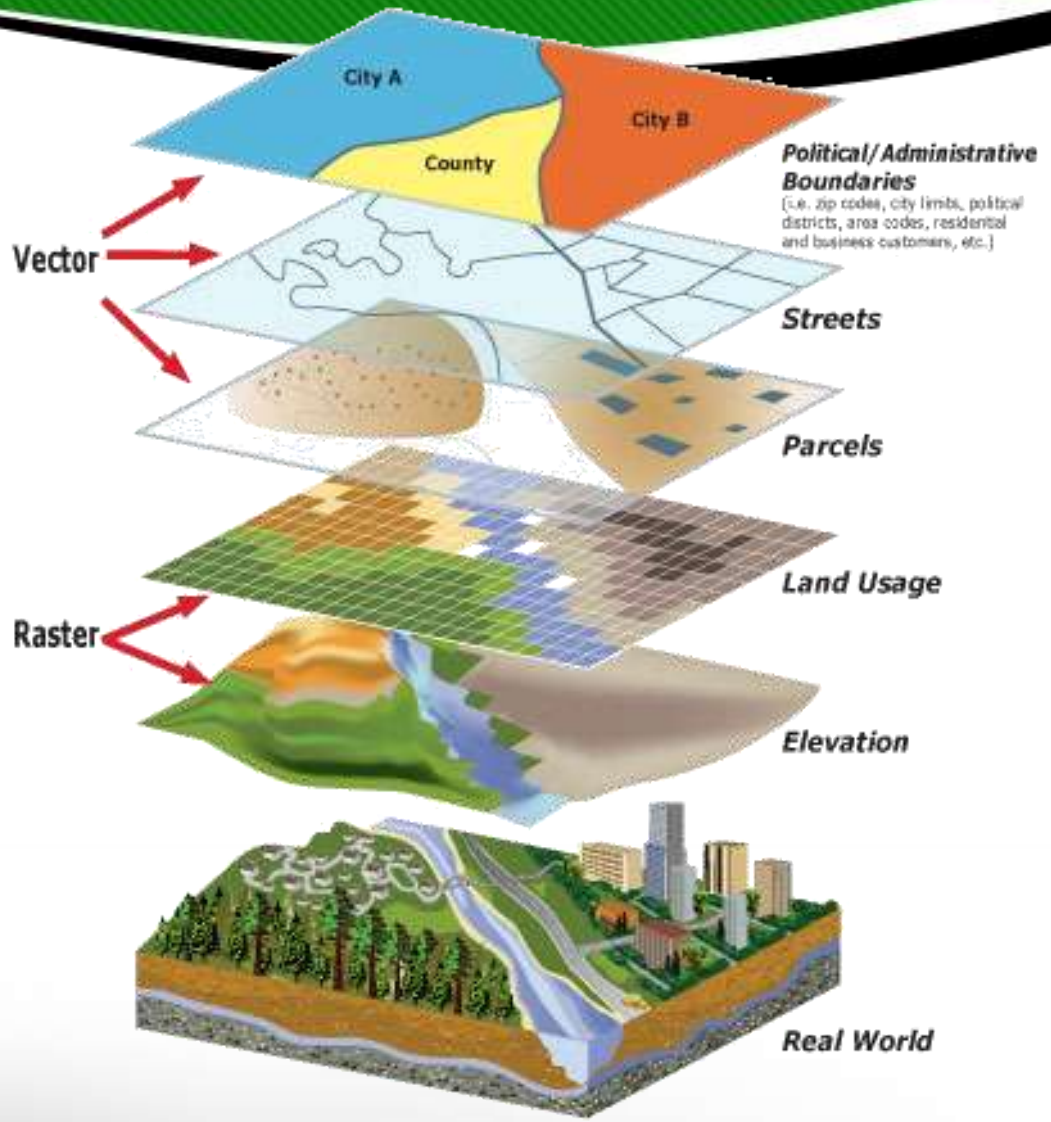
ATTRIBUTE DATA

Parish Name	Capital
St. Thomas	Morant Bay
St. James	Montego Bay

SPATIAL DATA MODELS

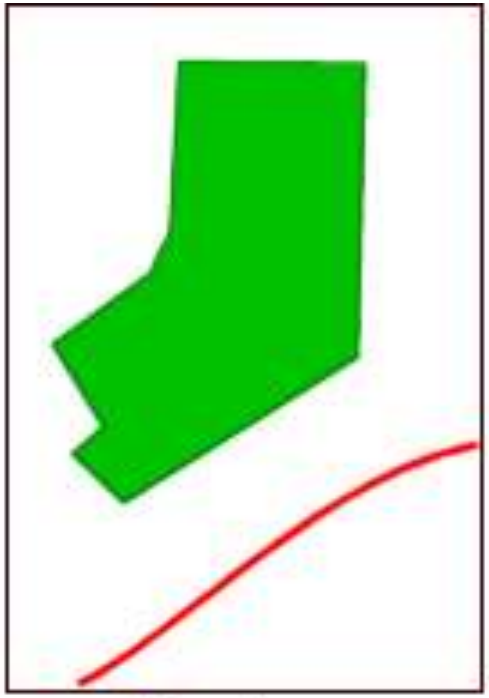
Two basic types of spatial data models have evolved for storing geographic data digitally. These are referred to as:

- **VECTOR**
- **RASTER**

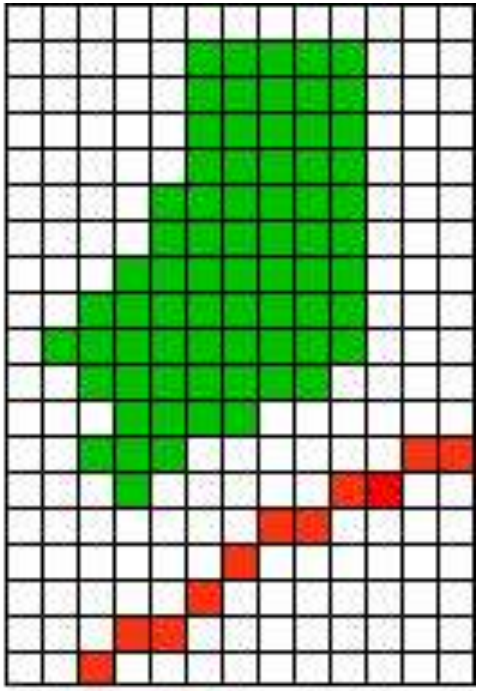


Raster and Vector Data Models

Real World



Vector



Raster

ATTRIBUTE DATA MODELS

- A separate data model is used to store and maintain attribute data for GIS software.
- These data models may exist internally within the GIS software, or may be reflected in external commercial Database Management Software (DBMS).

ATTRIBUTE DATA MODELS

- A variety of different data models exist for the storage and management of attribute data. The most common are:
    - Tabular
    - Hierarchical
    - Network
    - Relational
    - Object Oriented

How GIS organizes data

In summary GIS are mapping applications linking data about

WHERE things are,

with data about **WHAT** things are like,

to create

Spatial data
Location
[Map]

+

Attribute data
Description, properties, features, etc
[Database]

=

Maps and analysis output

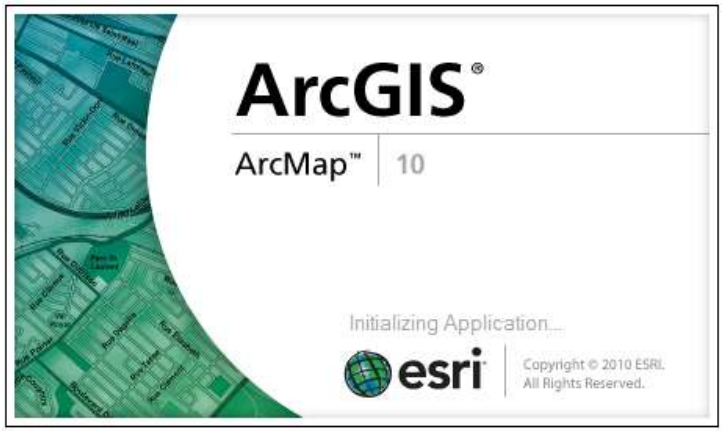
GIS SOFTWARE

- The processing engine and a vital component of an operational GIS
- Made up of integrated collections of computer programs that implement geographic processing functions

GIS SOFTWARE

- Three key parts
  - The user interface
  - The tools (functions)
  - Data manager
- Many different types of GIS software
  - Desktop
  - Server (including internet)
  - Developer
  - Hand-held
  - Raster based – focus primarily on raster data and raster analysis

GIS SOFTWARE



special areas.mxd - ArcMap - ArcView

File Edit View Insert Selection Tools Window Help

Editor Task: Create New Feature Target:

Layer: kmaspecareas

1:81,167

69_46.img
69_47.img
69_48.img

KMA Special Areas
kmaspecareas
<all other values>
Comm_Name
Acadia
Allman Town
Arlene Gardens
Arnett Gardens
August Town
Barbican
Beverley Hills
Boucher Park
Bournemouth Gar
Bull Bay/Seven Mi
Campbell Town
Cassia Park
Central Downtow
Cherry Gardens
Cockburn Garden

Display Source

Drawing

Attributes of kmaspecareas

FID	Shape*	PARISH	Comm_Name	Population	No_Dwellin	AF
0	Polygon	St. Andrew	Forest Hills Gardens	1214	393	
1	Polygon	St. Andrew	Meadowbrook Estate	1359	413	
2	Polygon	St. Andrew	Three Oaks/Glendale	2784	871	
3	Polygon	St. Andrew	Patrick City	7402	2523	
4	Polygon	St. Andrew	Waterhouse	12635	3176	
5	Polygon	St. Andrew	Seaward Pen	4967	1255	
6	Polygon	St. Andrew	Penwood	10940	2528	
7	Polygon	St. Andrew	Tower Hill	10979	2800	
8	Polygon	St. Andrew	Drewsland	4875	1274	
9	Polygon	St. Andrew	Washington Gardens	5987	1933	
10	Polygon	St. Andrew	Waltham Gardens	8052	1983	

THE GEOGRAPHIC APPROACH

- A new way of thinking and problem solving that integrates geographic information into how we understand and manage our planet.

- allows us to create geographic knowledge by measuring the earth, organizing this data, and analyzing and modeling various processes and their relationships.

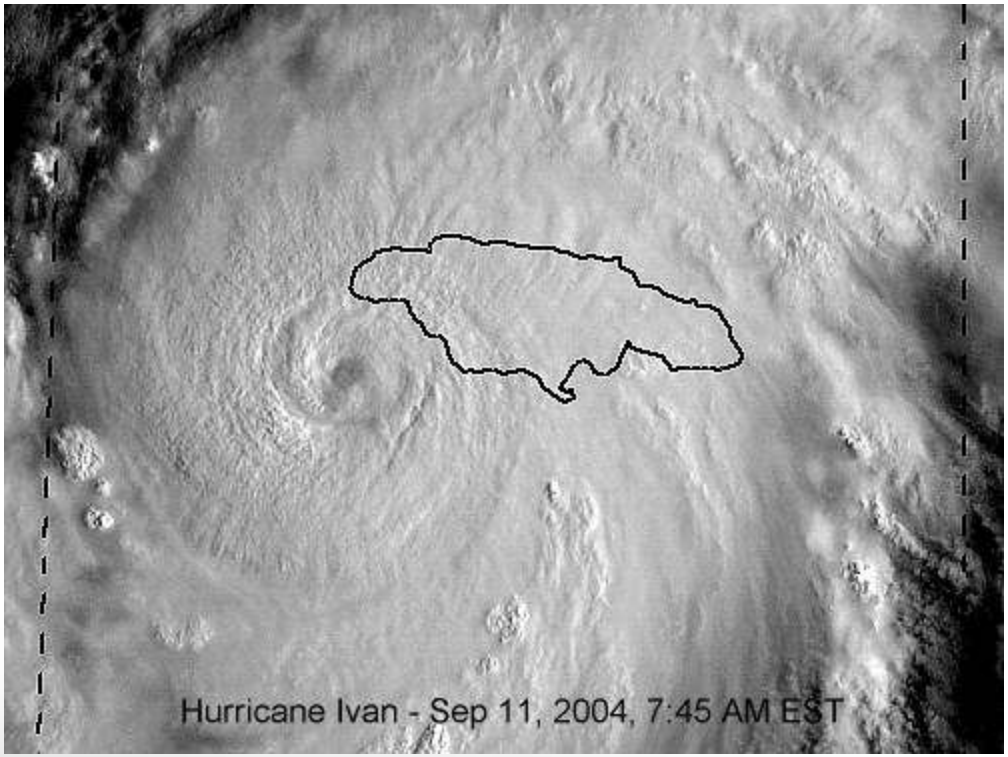
- allows us to apply this knowledge to the way we design, plan, and change our world – e.g. assessing risk

GIS and Risk Assessment

- Spatial data are uniquely suited to study and assess multi-hazard risk
- All aspects of risks that we need to consider are spatial in nature
  - they have a certain location and extent and can be put in relation with one another
  - They can be associated with attributes that are linked to a geographic place or area

Hazards and Elements of Risk

- There are two important components of Risk which should be spatially represented:
  - Hazards
  - Elements at Risk



Hazards and Elements of Risk

- Hazards have a spatial component related to both the initiation of the hazard and the spreading of the hazardous phenomena
  - Eg – a volcano and the areas affected by volcanic products
- Elements at risk are the population, properties, economic activities or any other defined values exposed to hazards in a given area

Hazards and Elements of Risk

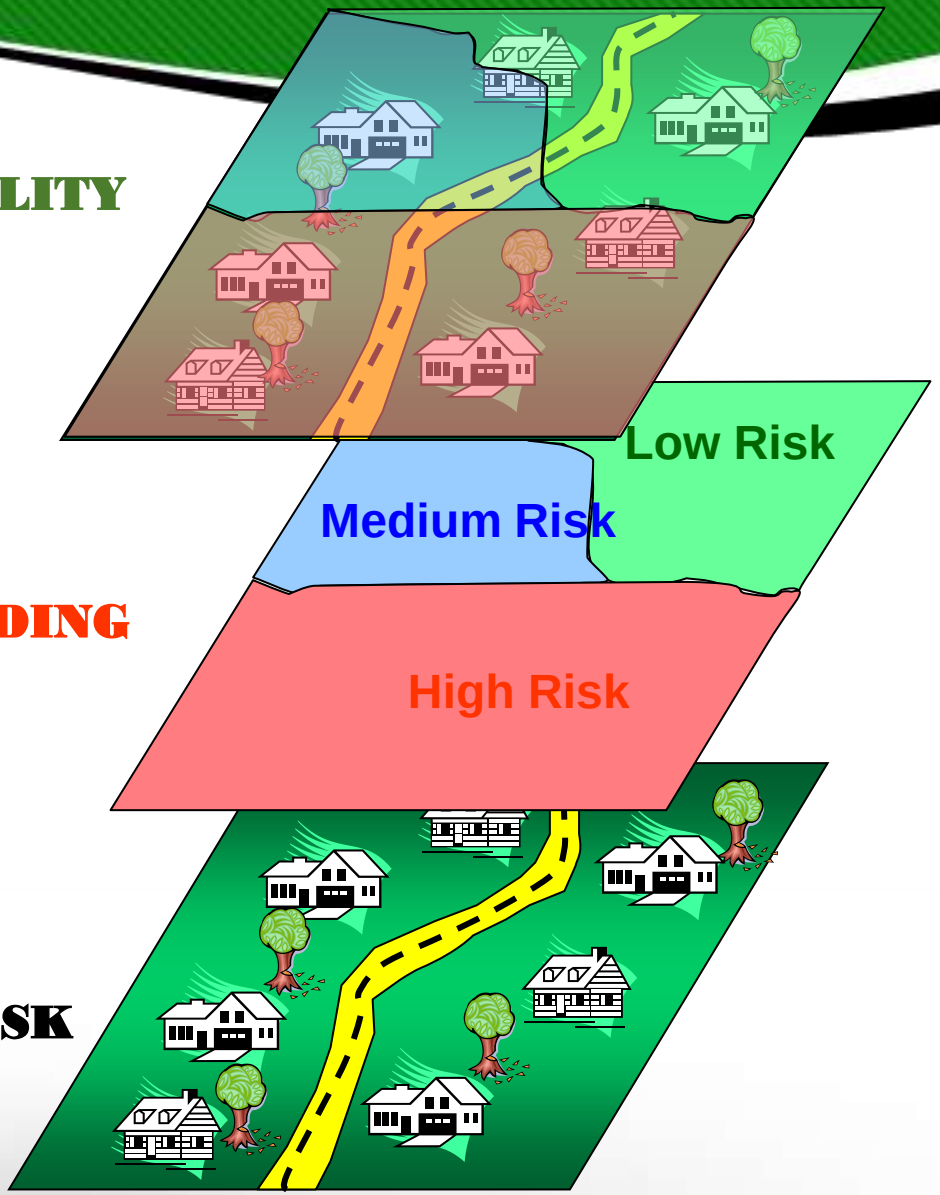
- The interaction of elements at risk and hazard defines the exposure and the vulnerability of the elements at risk.
- Exposure indicates the degree to which elements at risk are exposed to a particular hazard

Hazards and Elements of Risk

- The spatial interaction between the elements at risk and the hazard footprints are depicted in a GIS by simple map overlaying of the hazard maps with the elements at risk map
- This is an integral component of GIS-based risk assessment.

Hazards and Elements at Risk

EXPOSURE/VULNERABILITY



HAZARD - FLOODING

ELEMENTS AT RISK

Spatial Data Requirements for Risk Assessment

- Dependent on the type of hazard
- Different hazard types have different spatial, spectral and temporal characteristics
  - Spatial – Location and extent, distance from source, scale of object
  - Spectral – Surface materials, distribution, tone, pattern
  - Temporal – length of event, possible repeats, delayed effects

How to decide which data are suitable?

- There are different ways to do risk assessment with geodata and your requirements or chosen methodology can shift quickly, depending on:
  - **the specific hazard situation**
  - **types of elements at risk**

How to decide which data are suitable?

- Identify data type needed (thematic layers, images, maps)
- Date of data acquisition (archived, current future)
- Number of datasets/images needed
- Identify possible cost, check budget
- Identify relevant source and search for appropriate data
- Order data, download directly, sign data sharing agreement

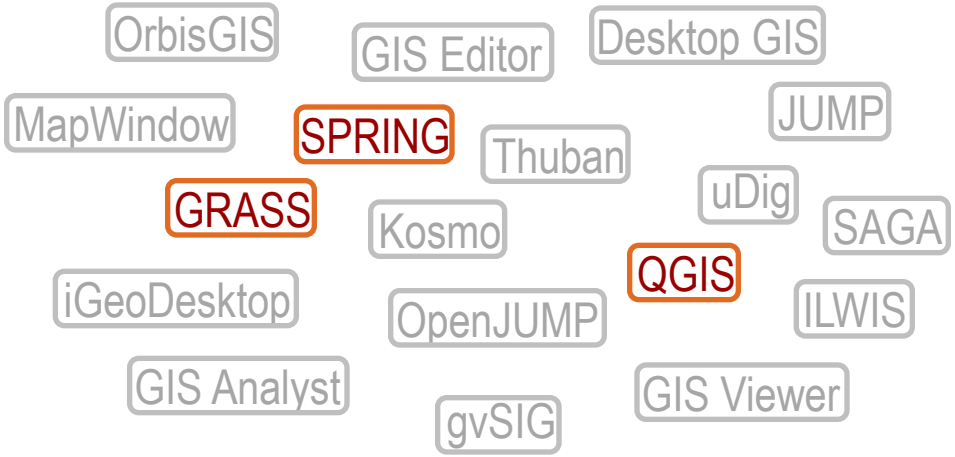
Spatial Data for Risk Assessment

- Data on Hazards – Flood vulnerability maps, landslide susceptibility maps
- Maps of elements at risk – Population data, buildings, transportation networks, essential facilities, agriculture, ecological data
- Statistical data
- Free or low cost thematic data – digital chart of the world, FAI Geonetwork, geocommunity
- Free or low cost image data – Google Earth, Global Digital Elevation Models (DEM)
- Commercial Image sources – GeoEye
- Aerial photography

Software Selection for RIVAMP

The selection focused on:

- Open source
- Desktop GIS or Remote Sensing
- Windows applications
- Various level of userfriendliness

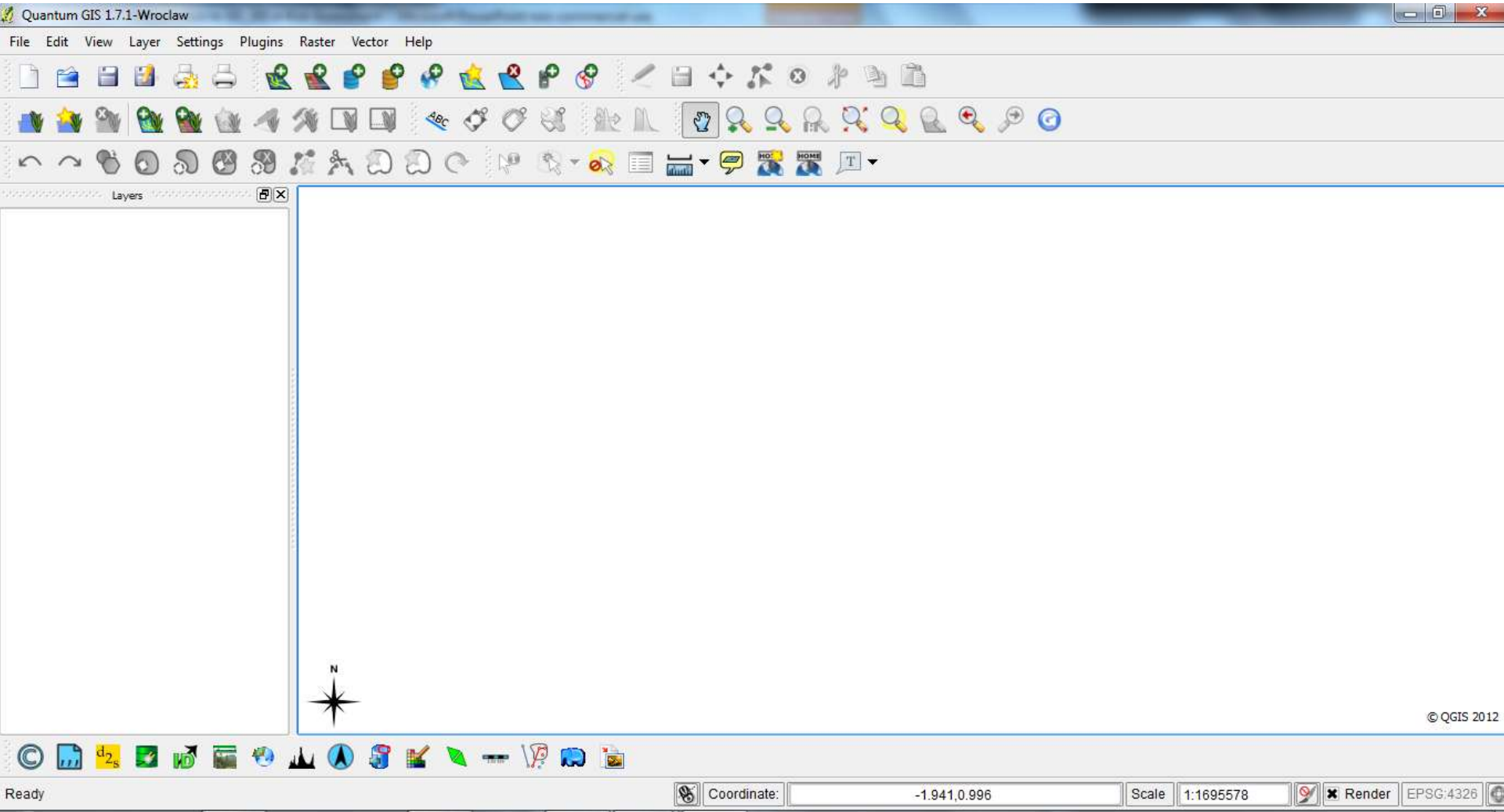


QGIS — User friendly (GUI) but powerfull (plugins, connection with GRASS)

GRASS — Easy to install through QGIS, excellent for process automation

SPRING — The unique real open source solution able to perform segmentation

QGIS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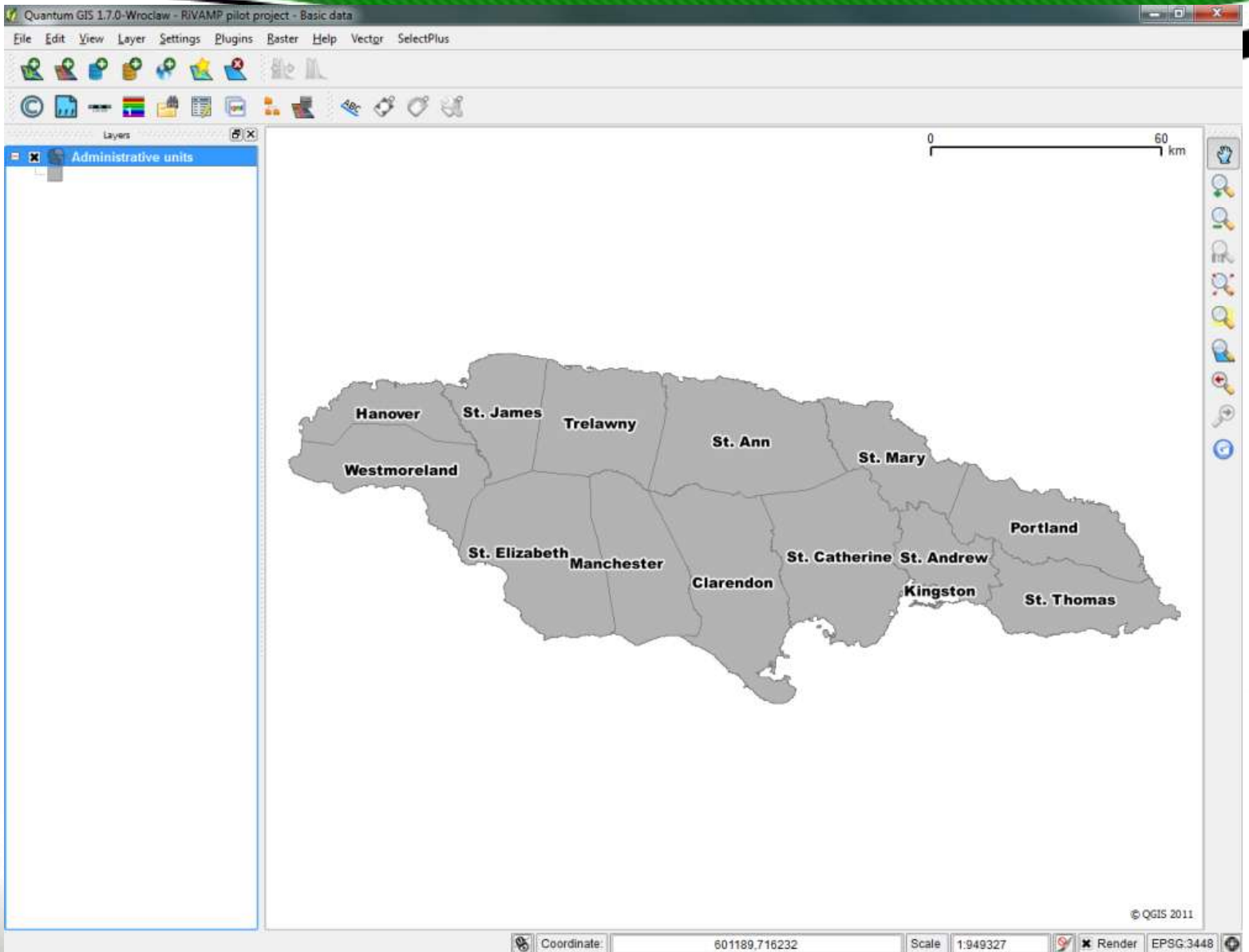
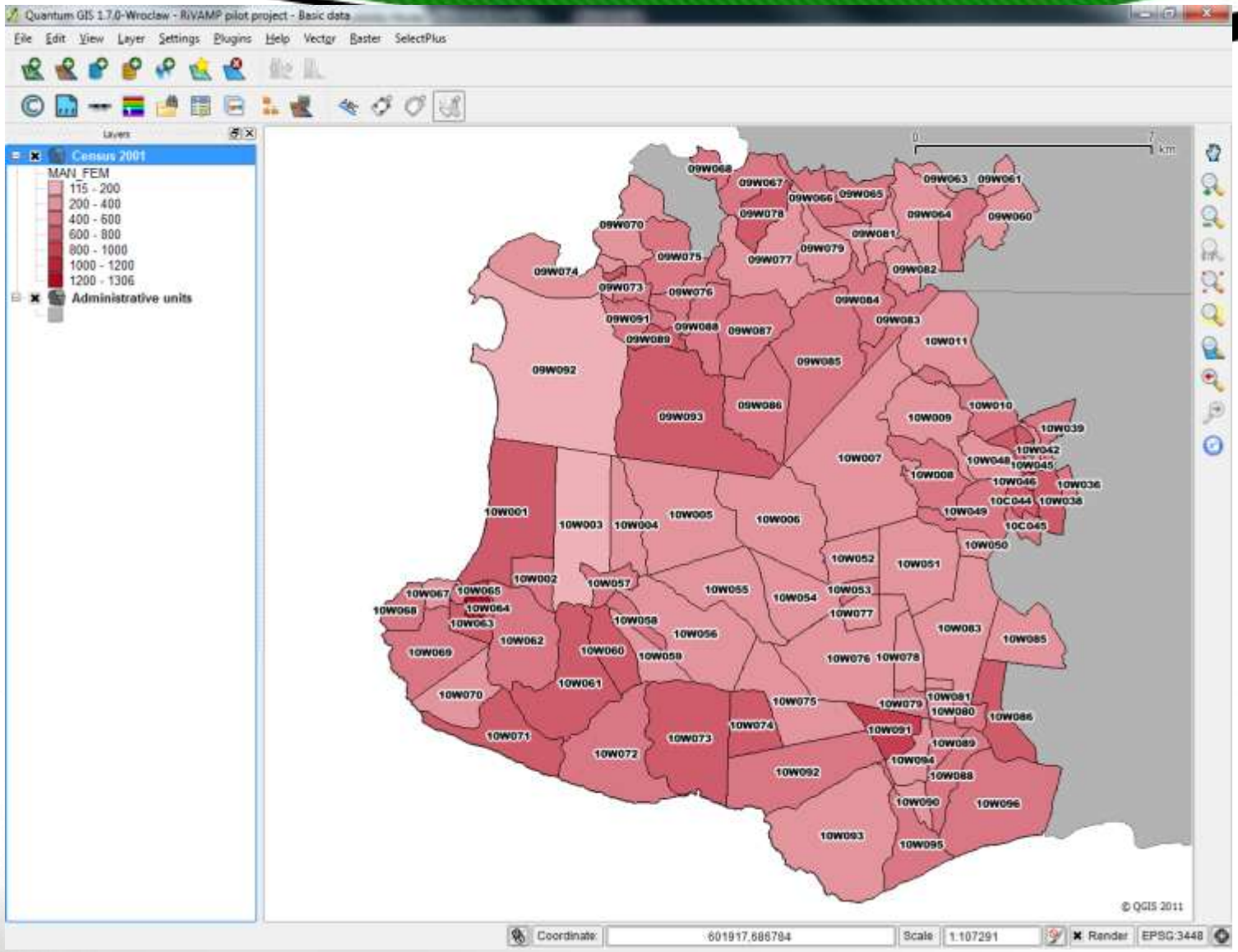
Administrative Units - Parishes



Census 2001


Quantum GIS 1.7.0-Wroclaw - RiVAMP pilot project - Basic data
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Layers
Census 2001
MAN_FEM
115 - 200
200 - 400
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1000 - 1200
1200 - 1306
Administrative units
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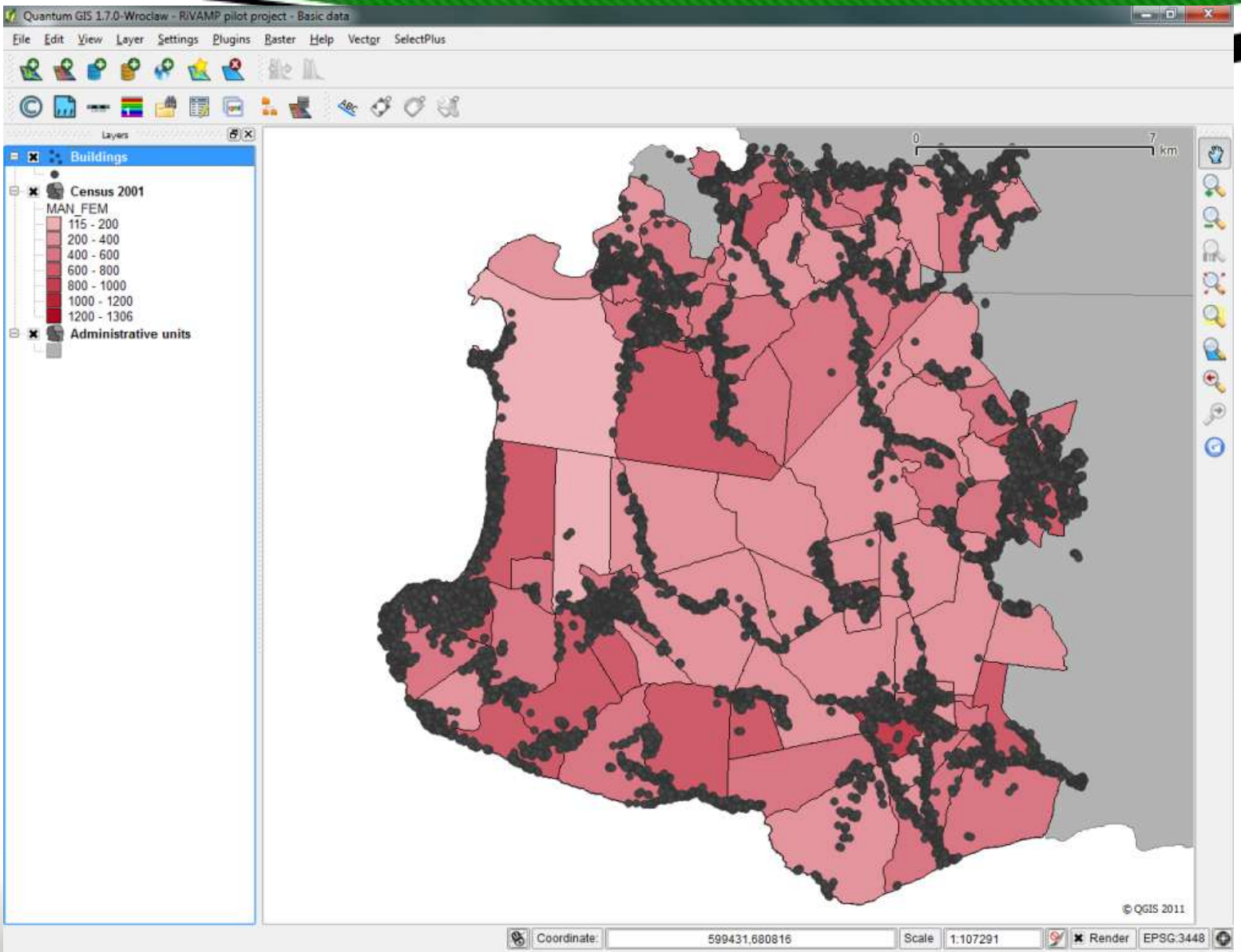
Urban Areas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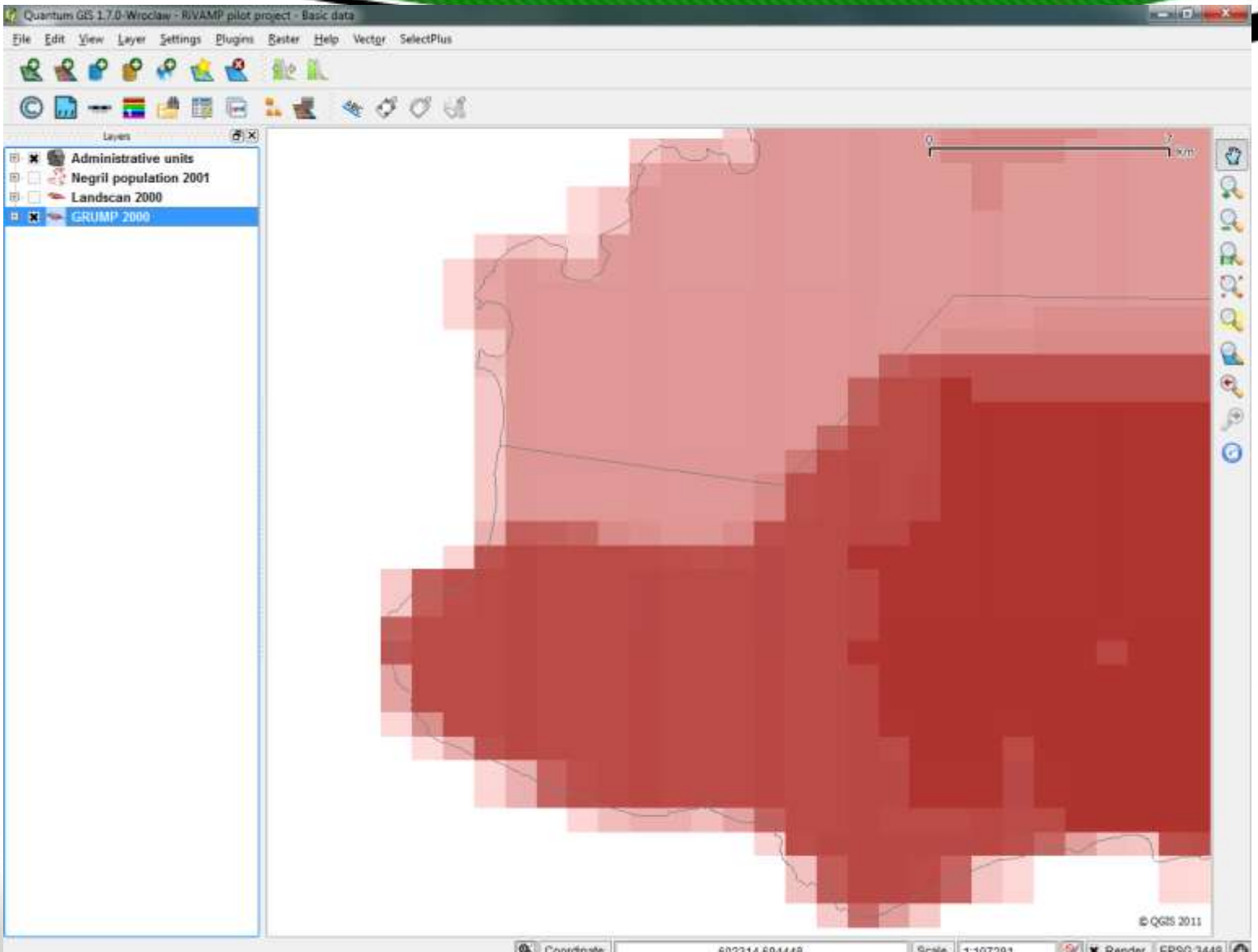
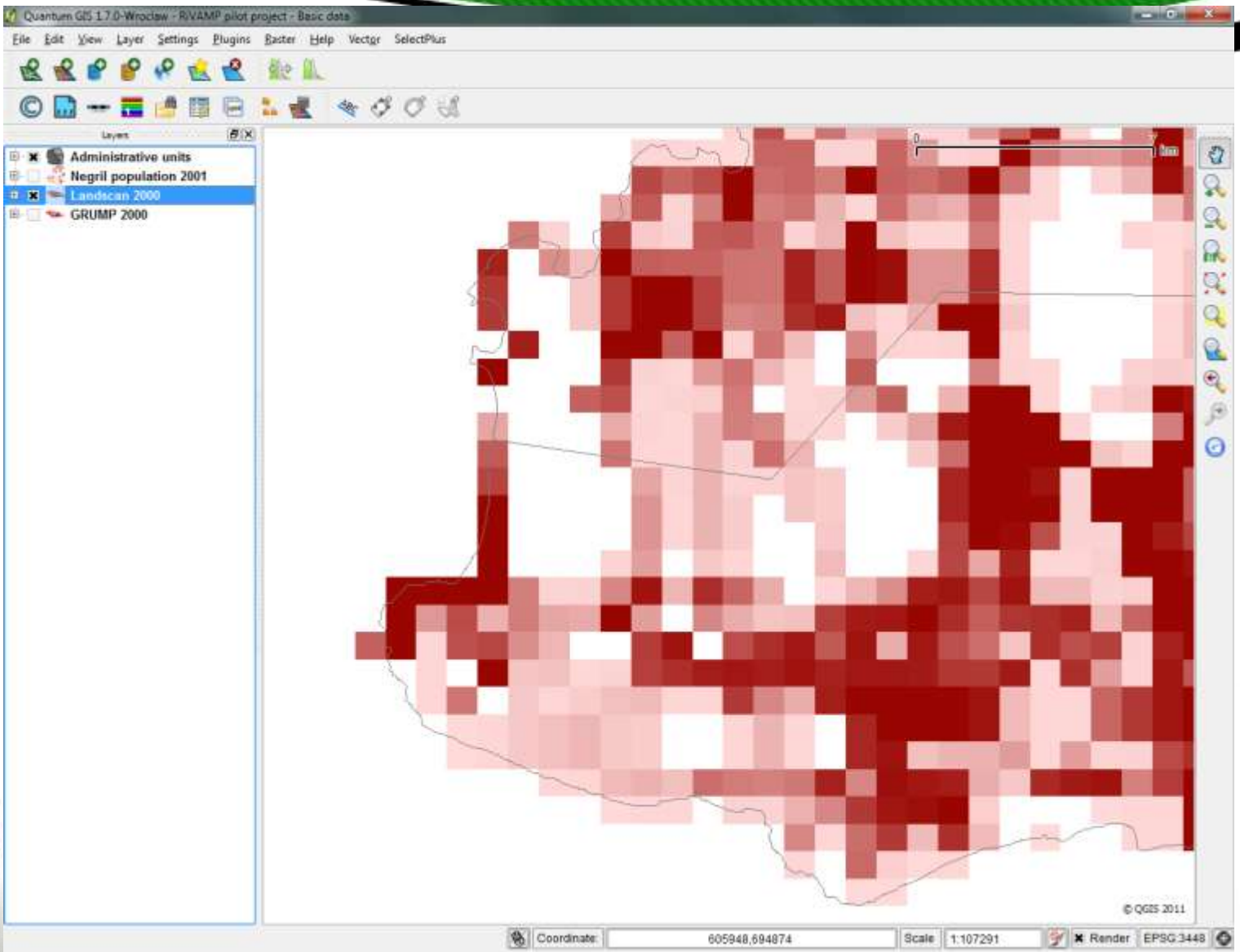
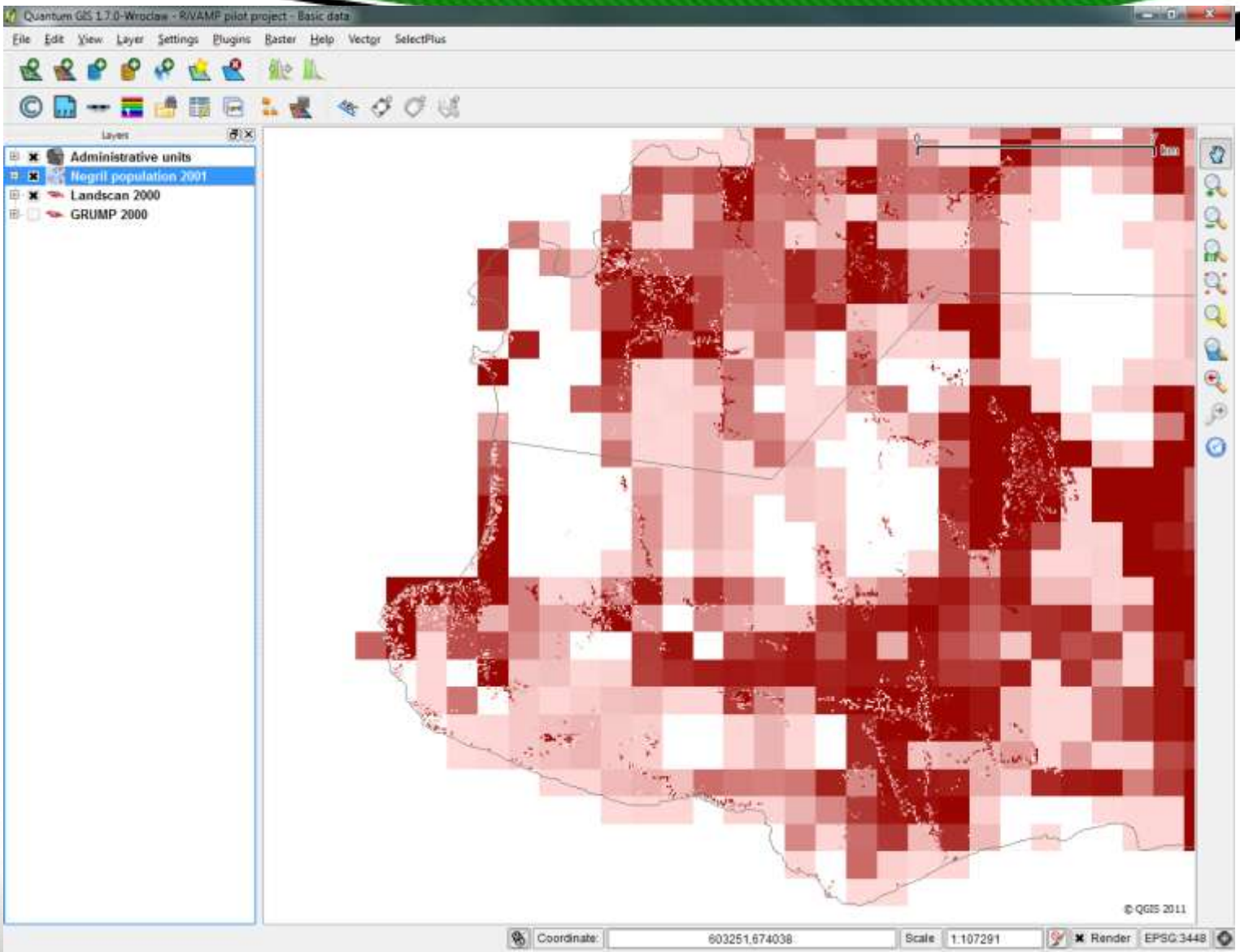
Population distribution



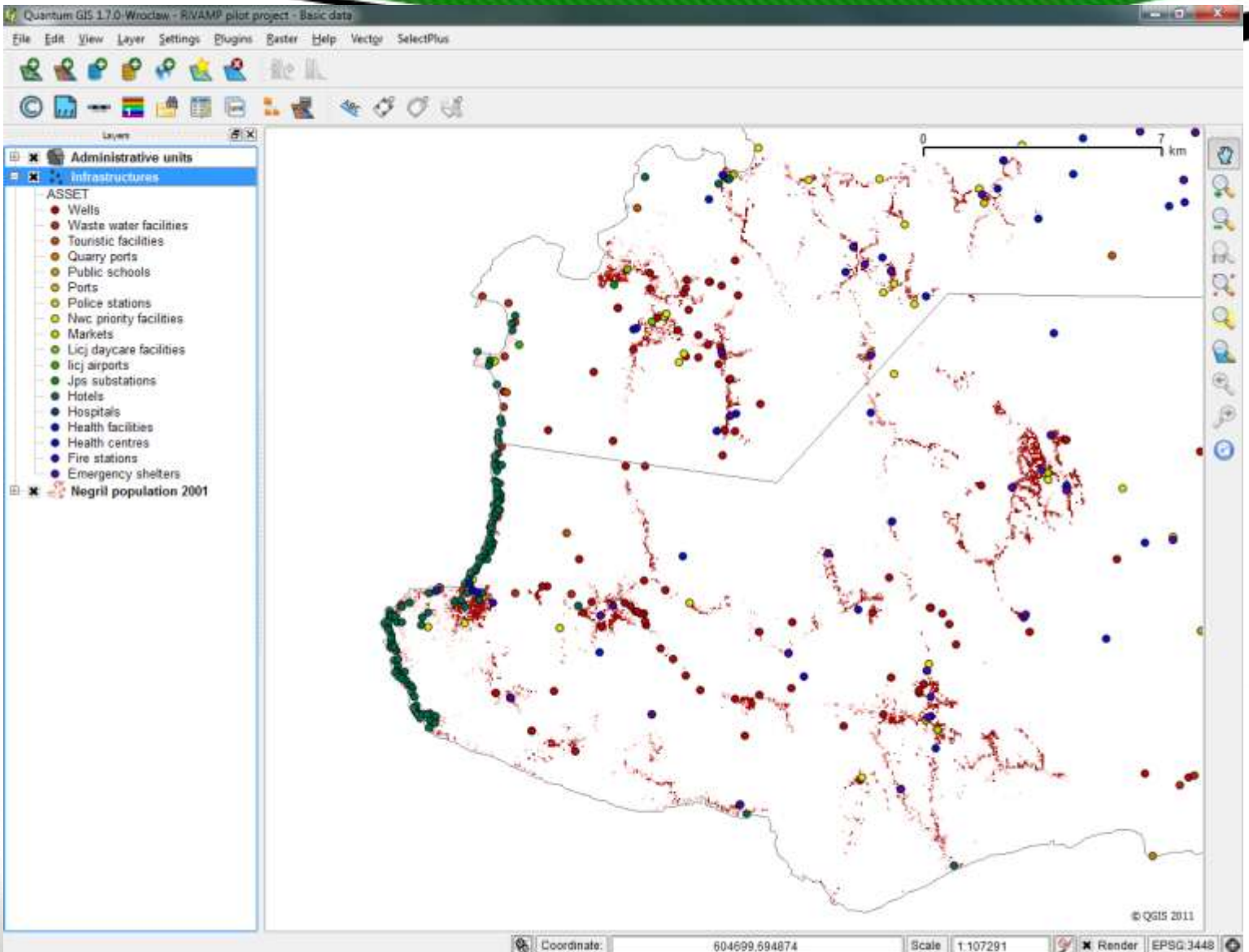
Population distribution



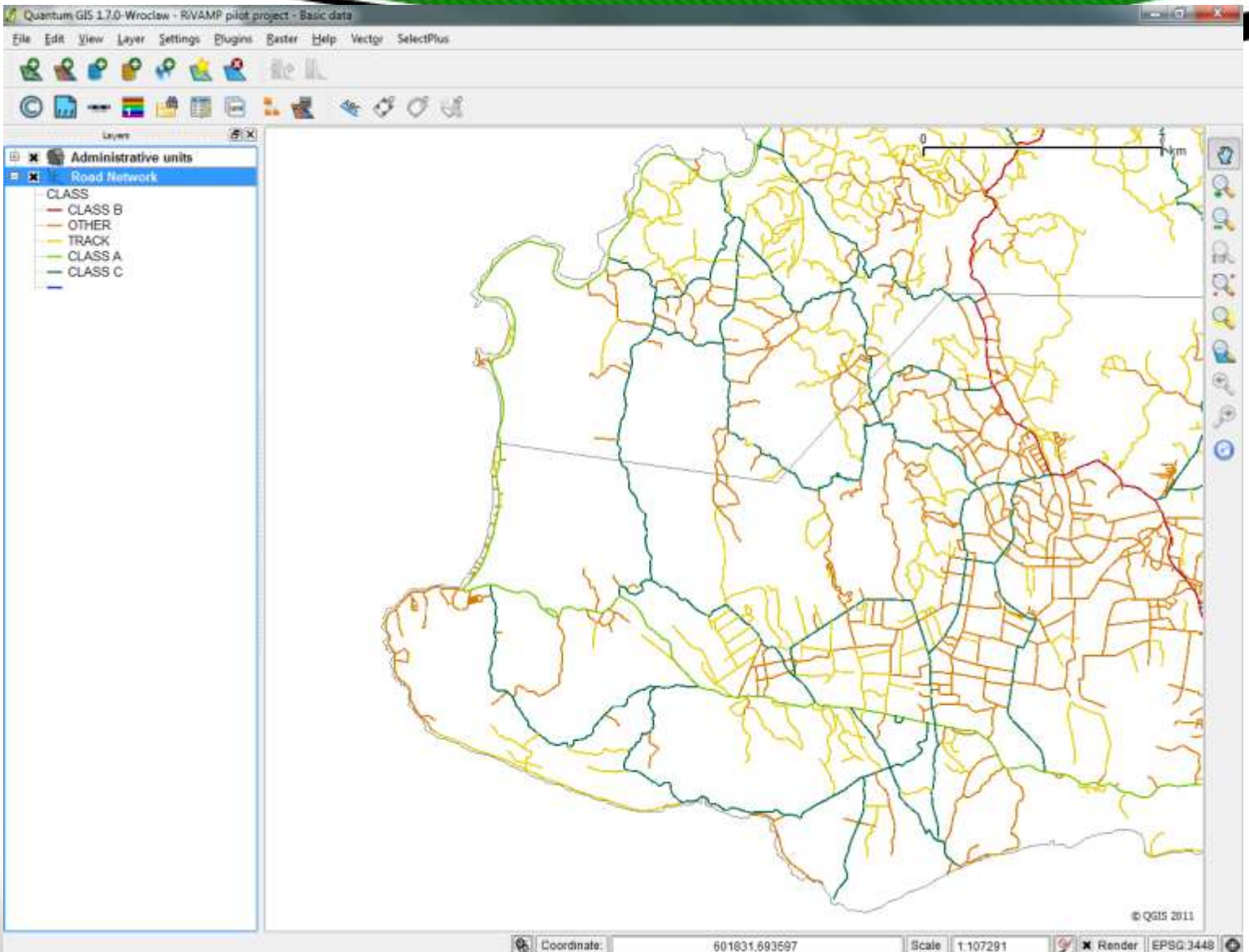
Population distribution



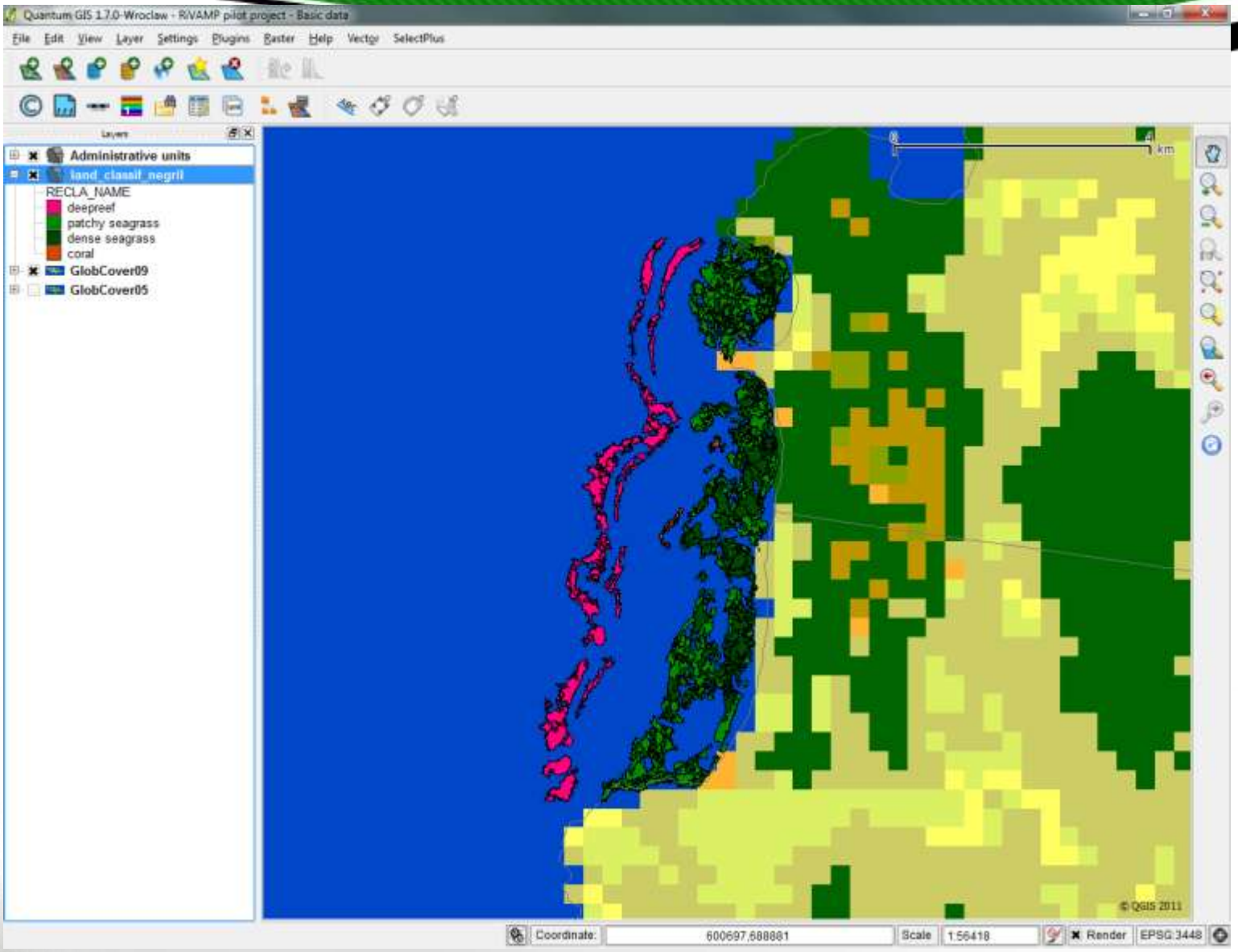
Assets (buildings, infrastructure)



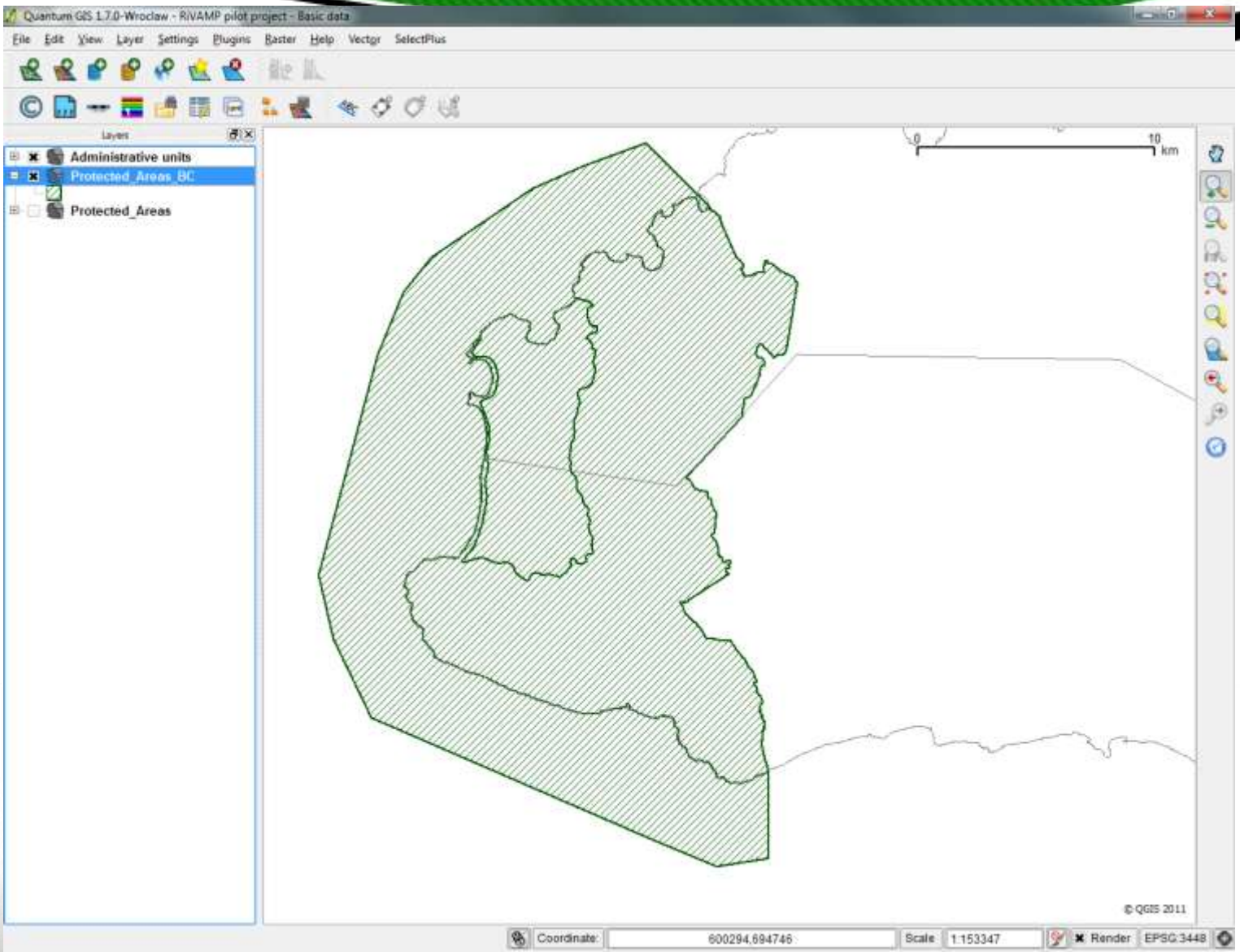
Transportation



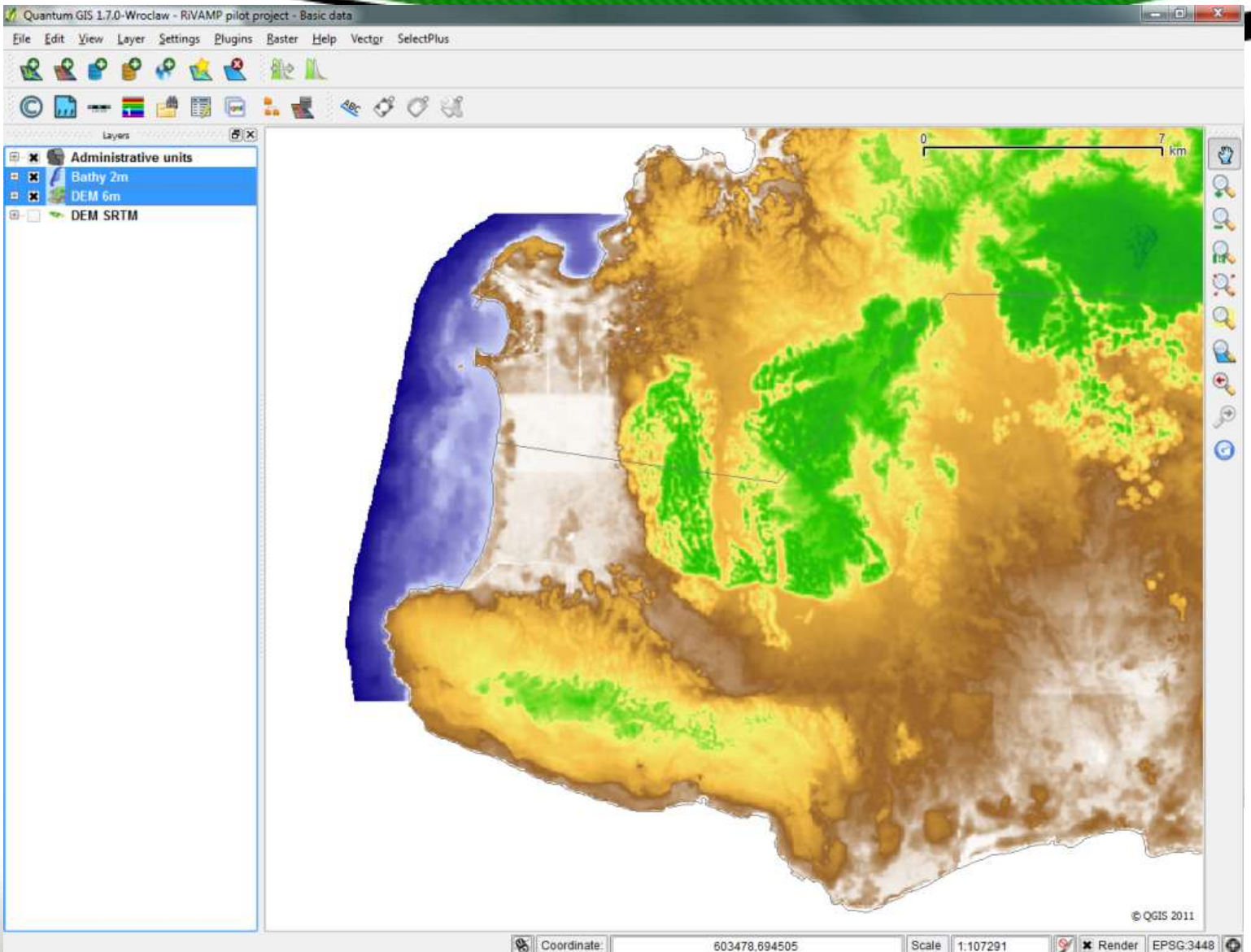
Land cover, land use and specific vegetation



Protected areas



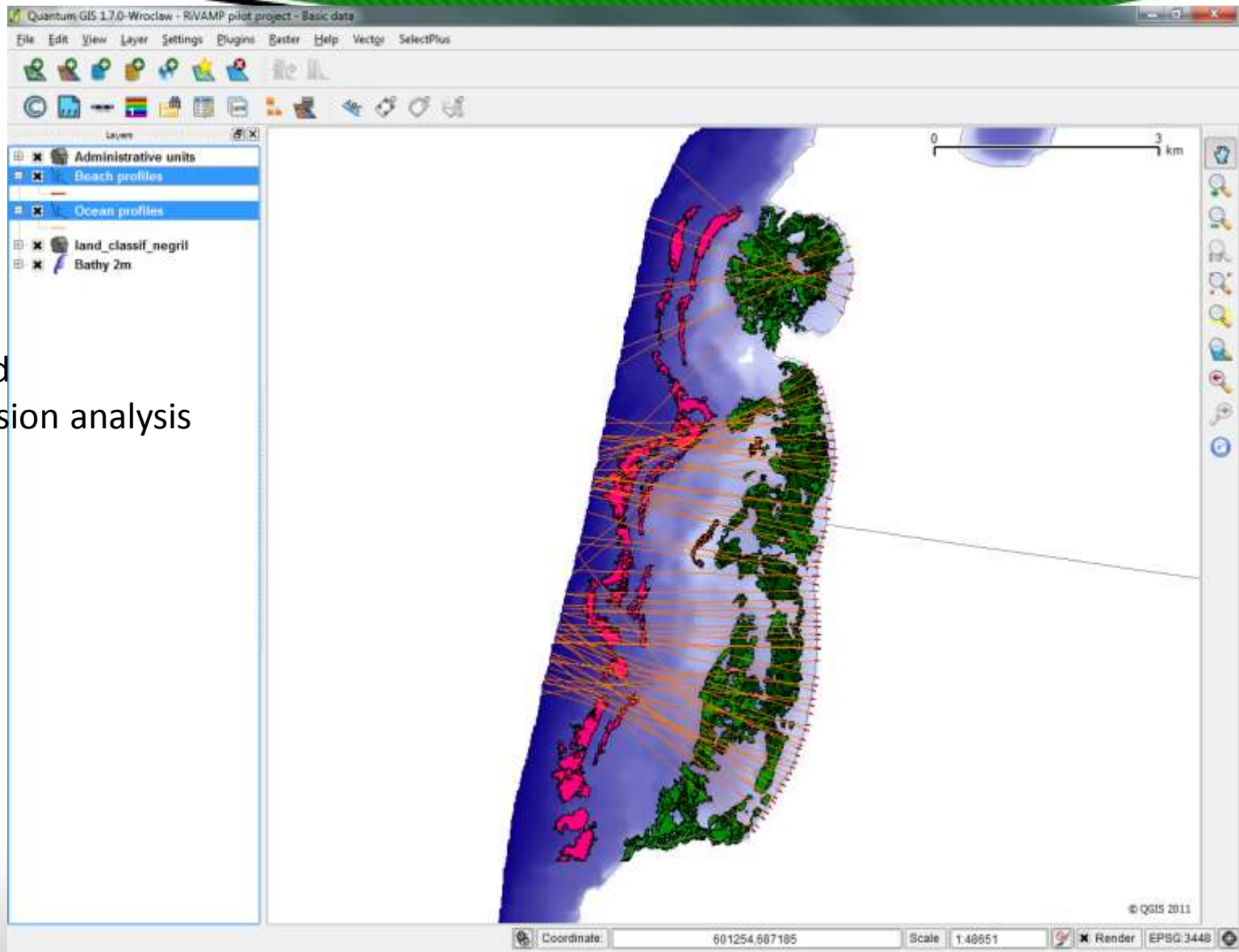
Digital Elevation Model DEM



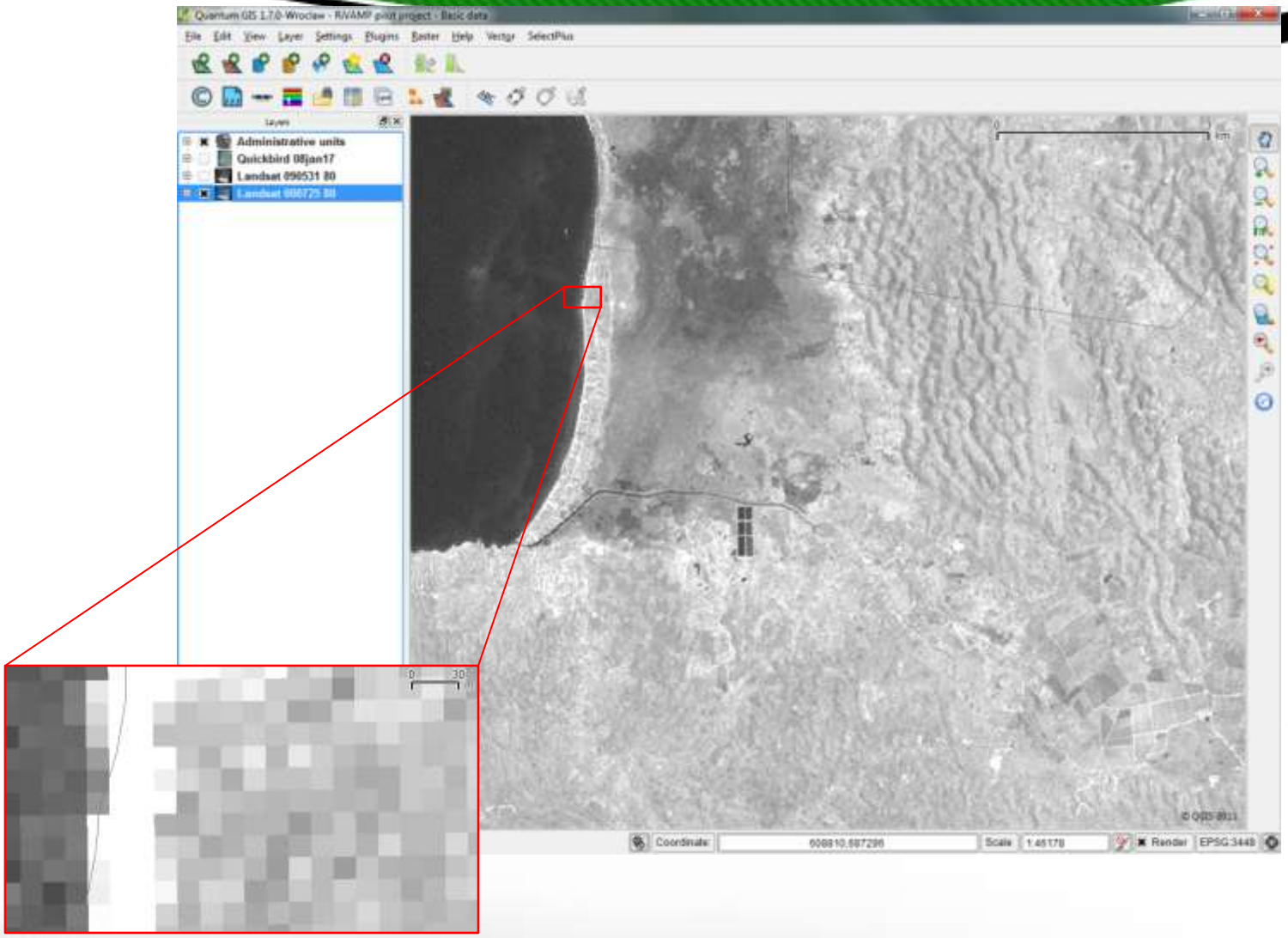
Beach Profiles, Nearshore Bathymetry, Distribution of coastal ecosystem

Quickbird
Satellite Imagery
(16 January, 2008)

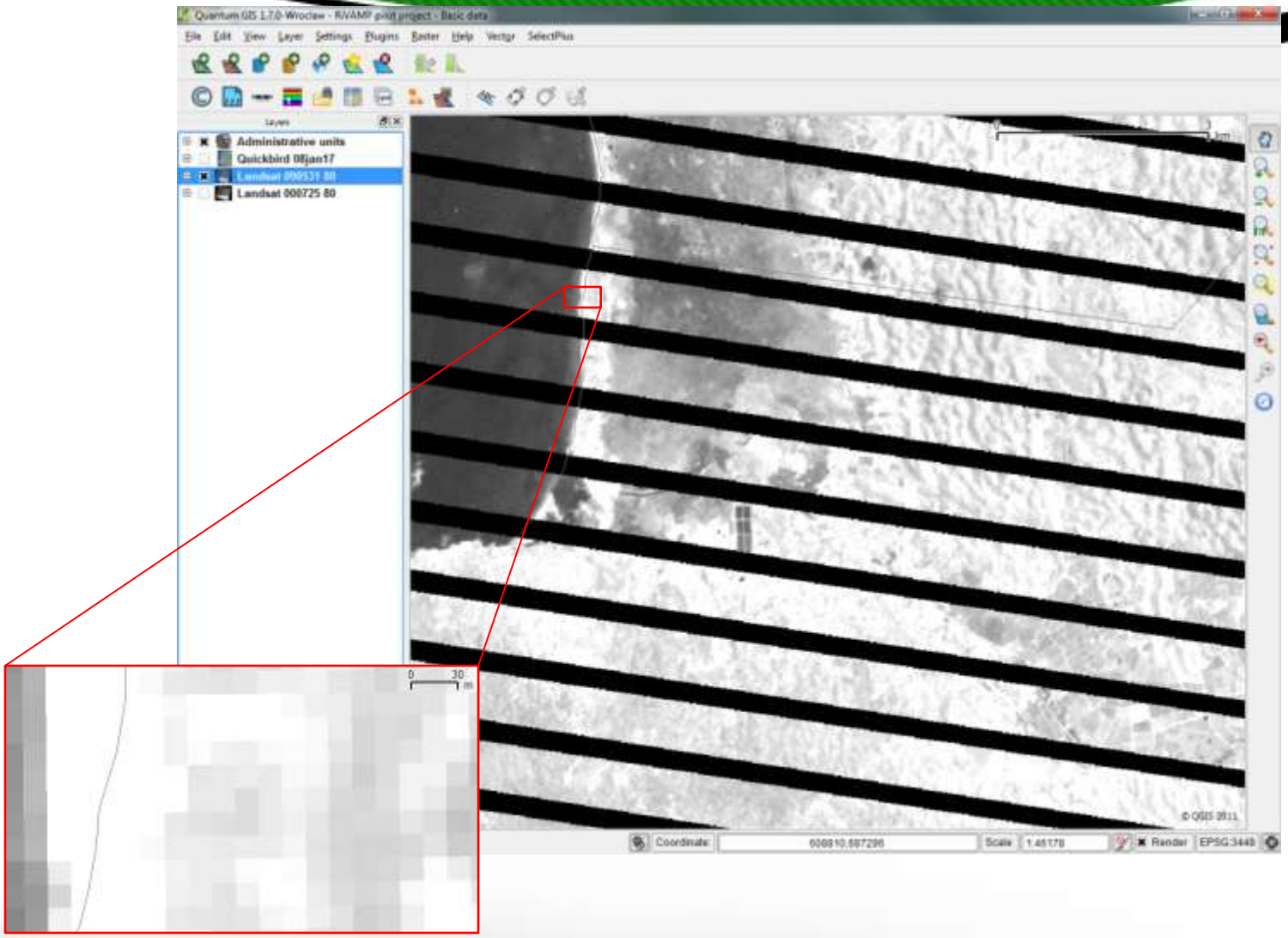
Beach profiles used
for multiple regression analysis



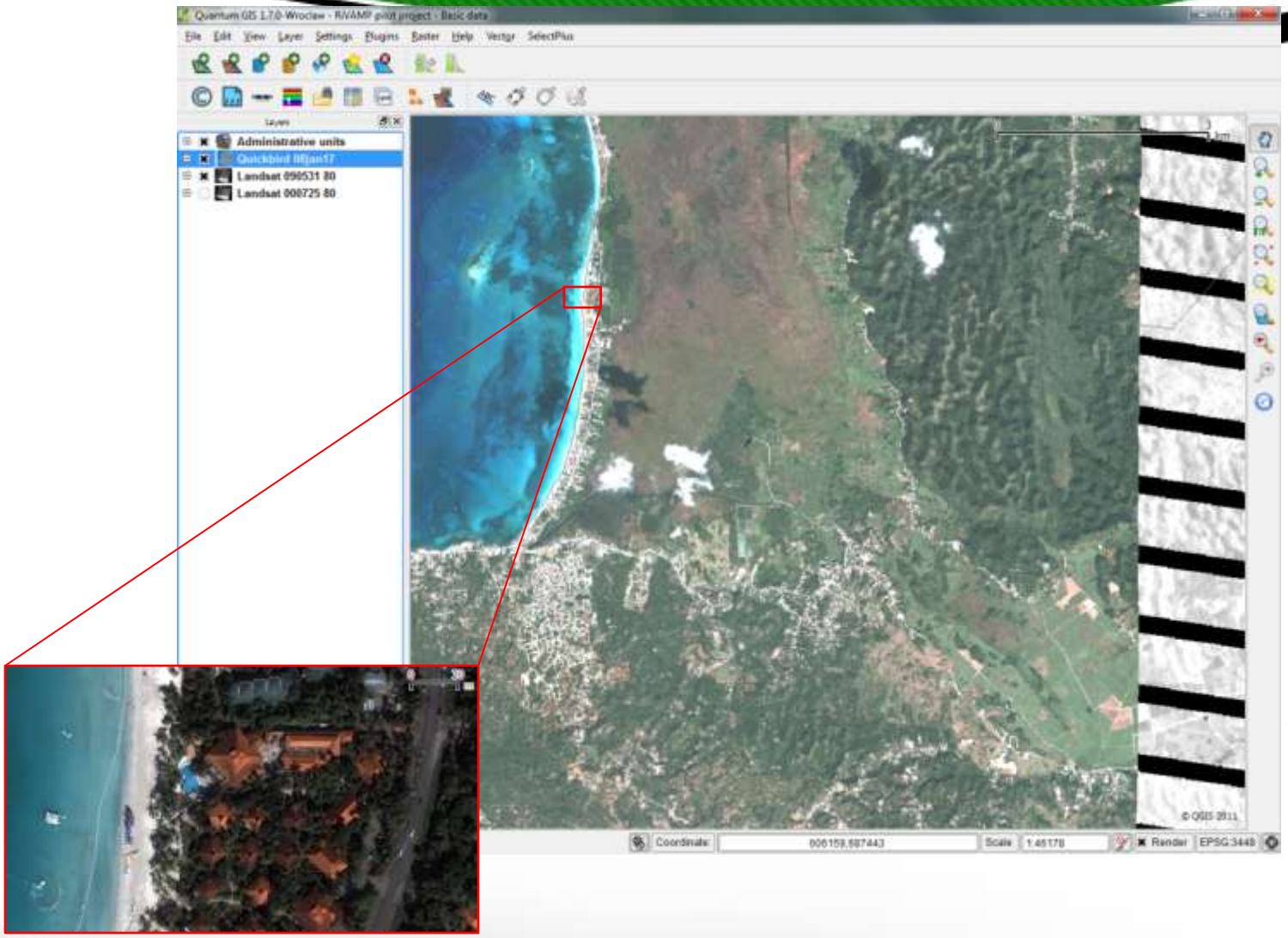
Satellite Imagery



Satellite imagery



Satellite imagery



Flooded Area Exposure

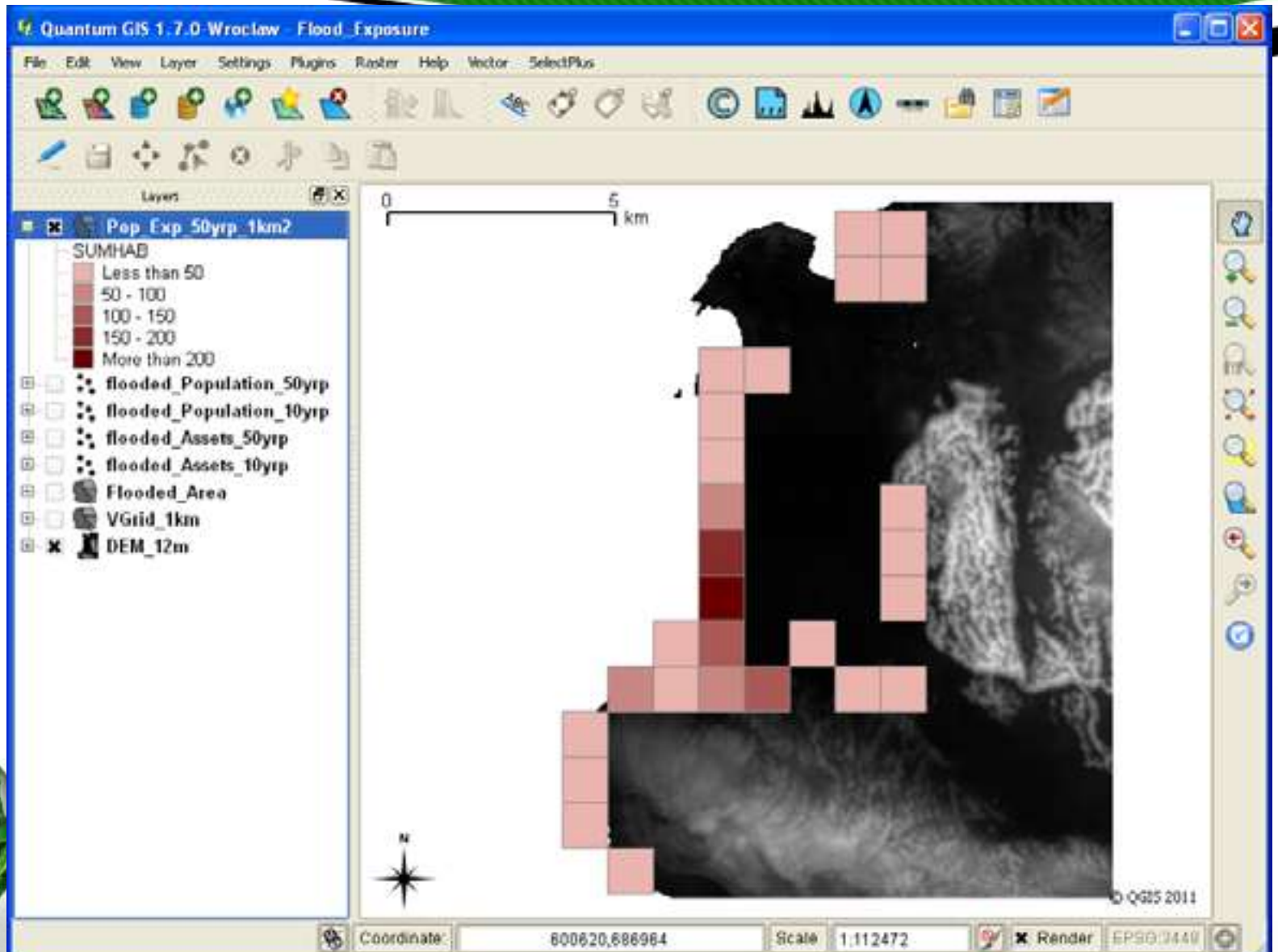
Aim:

- To define the land areas potentially exposed to floods due to tropical cyclones
- To estimate the population and assets that will be affected

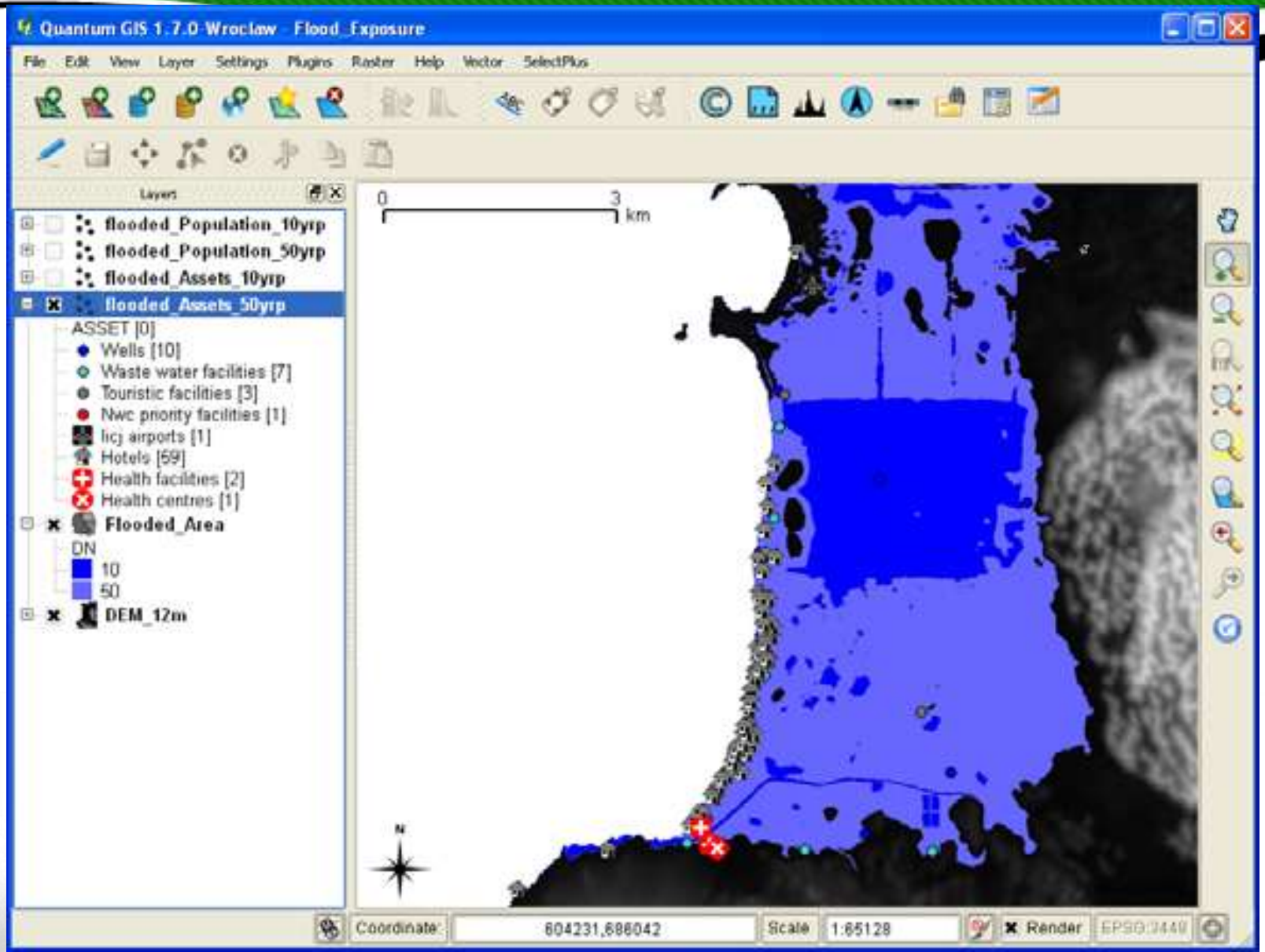
Data Used:

- Digital Elevation Model
- Maximum elevation of wave height
- Population Distribution Raster
- Assets Location Layer

Exposed Population



Exposed Assets



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