The Use of Geographic Information Systems in Risk Assessment

With Specific Focus on the RiVAMP Methodology

Presented by Nadine Brown
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Climate Studies Group Mona
Climate Change Workshop
• 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.
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

- Skilled Persons
- Hardware
- Data
- Software
- Procedures
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

APPENDIX 4A: NUMBER OF AUTOMATED BANKING MACHINES BY PARISH, 1997 & 2001 & 2005

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

<table>
<thead>
<tr>
<th>Parish</th>
<th>1997</th>
<th>2001</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Andrew</td>
<td>37</td>
<td>30</td>
<td>140</td>
</tr>
<tr>
<td>St. Catherine</td>
<td>13</td>
<td>25</td>
<td>61</td>
</tr>
<tr>
<td>St. James</td>
<td>8</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td>St. Ann</td>
<td>8</td>
<td>13</td>
<td>31</td>
</tr>
<tr>
<td>Westmoreland</td>
<td>5</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Manchester</td>
<td>6</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>Kingston</td>
<td>5</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Clarendon</td>
<td>4</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>St. Elizabeth</td>
<td>2</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>St. Mary</td>
<td>2</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Hanover</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Portland</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Trelawny</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>St. Thomas</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>87</td>
<td>199</td>
<td>400</td>
</tr>
</tbody>
</table>

Prepared by the Planning Institute of Jamaica
March, 2006
Source: JETS Limited
Map Densities
Find What’s Inside

Proposed Sites - Life Centre (Surrounding Communities)
Poverty 2002 (Consumption-Based Approach)

Legend:
- Proposed Site
- 5 km
- 10 km

Persons below the Poverty Line (%):
- 0.00 - 11.49
- 11.50 - 21.79
- 21.80 - 32.90
- 32.91 - 45.20
- 45.21 - 68.30

0 0.5 1 2 3 4 Kilometers
Find What’s Nearby

Schools within 1km of the Proposed Highway 2000 Alignment

<table>
<thead>
<tr>
<th>FID</th>
<th>Shape</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Point</td>
<td>Seaview Gardens Primary</td>
</tr>
<tr>
<td>69</td>
<td>Point</td>
<td>Denbigh High</td>
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<tr>
<td>88</td>
<td>Point</td>
<td>Anchovy High</td>
</tr>
<tr>
<td>99</td>
<td>Point</td>
<td>Tydeyn All Age</td>
</tr>
<tr>
<td>103</td>
<td>Point</td>
<td>Waterford High School</td>
</tr>
<tr>
<td>107</td>
<td>Point</td>
<td>Portsmouth Primary School</td>
</tr>
<tr>
<td>108</td>
<td>Point</td>
<td>Gregory Park Primary School</td>
</tr>
<tr>
<td>108</td>
<td>Point</td>
<td>Waterford Primary School</td>
</tr>
<tr>
<td>108</td>
<td>Point</td>
<td>Haile Selassie High School</td>
</tr>
<tr>
<td>153</td>
<td>Point</td>
<td>Dupont Primary and Infant School</td>
</tr>
<tr>
<td>154</td>
<td>Point</td>
<td>Cockburn Gardens Primary School</td>
</tr>
<tr>
<td>157</td>
<td>Point</td>
<td>McIntosh Memorial School</td>
</tr>
<tr>
<td>162</td>
<td>Point</td>
<td>Comfort Hall All Area School</td>
</tr>
</tbody>
</table>

(78 out of 1629 Selected)
Map Change

Violence Related Injuries in the Kingston Metropolitan Area 2005

Legend:
- Low: Green
- Moderate: Yellow
- High: Red

Violence Related Injuries in the Kingston Metropolitan Area 2006
January - September

Legend:
- Low: Green
- Moderate: Yellow
- High: Red
A GIS stores information about the world as a collection of thematic layers that can be linked by geography.
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

<table>
<thead>
<tr>
<th>Parish Name</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Thomas</td>
<td>Morant Bay</td>
</tr>
<tr>
<td>St. James</td>
<td>Montego Bay</td>
</tr>
</tbody>
</table>
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
• 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).
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 Maps and analysis output

- **Spatial data**
  - Location
  - [Map]

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

ArcGIS
ArcMap™ 10

ILWIS 3.8 Open

G2 North

GeoMedia

MapInfo Professional

IGiS
Geomatics Revealed

SGL
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

User friendly (GUI) but powerful (plugins, connection with GRASS)

Easy to install through QGIS, excellent for process automation

The unique real open source solution able to perform segmentation
Administrative Units - Parishes
Urban Areas
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
URISA's 2012
Sixth Caribbean GIS Conference
November 12-16, 2012
Hilton Rose Hall
Montego Bay, Jamaica

http://www.urisa.org/carib2012
NOW FOR A LITTLE GIS EXERCISE

“What makes you say our graphics hardware is out of date?”