Spatial data applications using GIS

Module 4, Lecture 10
Spatial (or geospatial) data

- Location is everything
- Geographic information
- GIS
- Spatial analysis and maps

- Data acquisition:
  - GPS
  - Remote sensing (satellite images; ortophotos; LiDAR)

Geospatial data exists anywhere and anytime; it is a matter of recognizing it and put it to use to provide useful and relevant geographic information.
Spatial (or geospatial) data

- GPS
- Digitised maps
- Remote sensing
- LiDAR
- Aerial photography
- Unmanned aerial vehicles

http://www.interworldrsa.com/images/gtco/gtco-accollt.jpg
GIS

- Integration and analysis of geospatial data to produce geographic information (purpose of the application)
- It needs different components acting together to make it work (hardware, software, people, procedures, data)
- Data model organizes and stores geospatial data: set of layers that represent each real world feature (vector or raster)
GIS applications

- GIS is fundamentally about solving real world problems
- Decision making has a geographic dimension
- GIS supports mapping, measurement, management, monitoring and modelling

(Longley, Goodchild, Maguire & Rhind, 2011)
GIS applications

- **Rational, effective and efficient** allocation of resources in accordance with clearly stated criteria
- **Monitoring and understanding** observed spatial distributions of attributes
- Understanding the difference that place makes – identifying which characteristics are inherently similar between places and what is distinctive and possibly unique about them.
- **Understanding** of processes in the natural and human environments
- **Prescription** of strategies for environmental maintenance and conservation, as in national park management.

Longley, Goodchild, Maguire & Rhind (2005)
GIS applications

- Complexity & Urgency
- Creativity
- Technology
- Budget

Complexity & Urgency / Creativity
- Research & development of modelling algorithms to incorporate in the GIS software

Technology
- Data acquisition
- Software & Hardware

Improvement / Validation
- Feedback from the users to validate and improve the output
GIS applications

- **Ubiquitous geographic information (UBGI)**
- Geographic information that exists anywhere and anytime and this implies that services become available to help the general public utilize it without much a priori knowledge of GIS

Examples GIS applications

- Spatial planning
- Movement analysis
- Marine GIS
- Agriculture
- Defense
- Transportation
- Energy developments – Mining
- Health and Human services
Spatial planning

- Integration of different spatial data (demographics, environmental quality data, transportation networks, development scenarios (at the national, regional and local level), natural resources data and climate scenarios.
- Better decision-making; increased public participation (web-GIS)
- Up-to-date maps
A GIS-based spatial decision support system for tourists of Great Smoky Mountains National Park

The wide range of potential activities available in the park also present a major challenge for park visitors to plan activities that will better meet their preferences and constraints. GIS-based spatial decision support system (SDSS) application that integrates GIS functions and SDSS designs with easy-to-use graphic user interfaces to help visitors of GSMNP choose and plan their activities more effectively to match their personal preferences and constraints.

Movement analysis

- Recent advances in tracking technologies result in geographic information representing the movement of individuals accurately in space-time
- New insights into dynamic geographic processes
- Behavioural ecology (hot-spots identification; social interactions; seasonal or permanent migration behaviour)
- Geospatial Modelling Environment: http://www.spatialecology.com/gme/
Wildlife tracking data management: a new vision

Large, continuous, high-frequency datasets of wildlife behavioural data available derived from GPS and other animal-attached sensor devices.

These data can be further complemented by a wide range of other information about the animals' environment.
Marine GIS

- Climate change (sea level rise); maritime transport; renewable energy production; natural catastrophes (tsunamis, hurricanes); pollution
- Space-time marine database (highly complex, three-dimensional, multitemporal data aggregation of spatial information with different data formats)
- Combination of different information levels
A GIS modelling framework to evaluate marine spatial planning scenarios: Co-location of offshore wind farms and aquaculture in the German EEZ

Different spatial co-location scenarios for the coupling of offshore aquacultures and wind farms are evaluated in order to support efficient and sustainable marine spatial management strategies.

Agriculture

- Satellite positioning technologies locating agricultural machinery in the field; increasing availability of geographic information in digital form
- GIS enables farmers to measure the spatial and temporal variability in soil, vegetation, relief, etc. within a field and to modify their operations to react to this
- Analysis of site-specific conditions and the reaction of crops and animals to these may assist the farmer in more efficient agriculture
- GIS for agriculture: http://www.esri.com/industries/agriculture
Using GIS to map impacts upon agriculture from extreme floods in Vietnam

GIS technology to map the extent of 1-in 10, 20 and 100 year flooding. An overlay algorithm used the flood inundation map and land use map to estimate the potential impact of floods on agricultural land. The study demonstrates the value of GIS modelling, particularly when meteorological and hydrological data are limited, and remote sensing images taken during flood events are unavailable.
Defense

- Driving factor for the development of GIS
- Defense mapping brings the data as fast as possible to the commander or soldier in an operation
- Integration of huge amounts of data necessary for building operation scenarios, assist decision-making and prepare responses.
- NATO Core GIS: spatial data infrastructure for classified – “Who maps wins” :

http://www.act.nato.int/article-2013-1-17
Transportation

- Collecting, storing, retrieving, and operating spatial/aspatial data for planning and administering transportation facilities and systems

- Solve new challenges from collection and processing of various sensor data, distributing and presenting information to vehicle operators and city professionals, and provision of computation for algorithms required for traffic evaluation
User oriented planning of bus rapid transit corridor in GIS environment

Demographic, transit trip and land use characteristics of the city to identify the high ridership oriented BRT corridor.

The model generates graphical GIS based maps as output for the better understanding of the transit demand pattern and policy making, for the urban planners.
Energy developments - Mining

- Understand geographic, infrastructure, business conditions, and environmental factors about the region proposed for development
- Mining: GIS modelling to integrate complicated technical, business, risk, environmental, and economic factors
- Definition of optimal pattern for a reserve, selection of locations, selection of best routes
GIS-based environmental database for assessing the mine pollution: A case study of an abandoned mine site in Morocco

Acid Mine Drainage pollution from abandoned mines is responsible for soil and water contamination, land resources degradation, changes in landscapes, habitat destruction and human health hazards. The impact of the old mining activity is assessed by the design and elaboration of an environmental database supported by GIS.

The major geographical features of the earth’s surface (physical, biological, and cultural) mesh well with the determinants of health (human biology, lifestyle, environment, and health care organization).

Mapping and spatial analysis are essential to study world’s greatest health problems (HIV/AIDS pandemic, malaria, tuberculosis, maternal and child mortality).

Response to natural disasters such as floods, earthquakes, wildfires, and hurricanes.

Preparedness and response depend on location-based information.
Containing the Ebola Outbreak – the Potential and Challenge of Mobile Network Data

Understanding human mobility in the context of the Ebola

Mobility patterns and connectivity in West Africa

Using mobile data & location

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SPAN (Spatial Data Analysis Networks) - GIS applications for research projects within the University
Dark Skies Initiative
To discover the best observation points (darkest skies) within national parks

Geospatial data:

- Polygons representing national parks
- Points representing administrative centres and points of interest
- Raster representing the skyglow calculated using Walkers Law formula where 100% means that the sky glow is double the natural background
Effects of urban encroachment on the use of hollow bearing trees by squirrel gliders

Geospatial data:

- GPS locations of trees that had cameras with sensors to detect squirrel glider presence
- Raster basemap (Google Earth image)
The effects of land use and water regime on the ecological character and sediment phosphorus dynamics of the ephemeral Lake Cowal ecosystem in inland Australia

Geospatial data:
- GPS locations of water sampling points
- Raster representing the interpolated mean total phosphorous
Herbivory of common Brushtail Possum (home ranges of possums radio tracked during field work overlaying roads in the Strathbogie region of Victoria)

Geospatial data:

- GPS locations
- Polygons representing habitat range
Socio-economic outcomes of community forestry in Nepal: Lessons from three diverse rural communities (a study area map)

Geospatial data:
- Polygons representing countries and administrative regions
- Points representing administrative centres
- Lines representing major rivers