Introduction to GPS and GIS Workshop

Institute for Social and Environmental Research – Nepal

October 13 – October 15, 2011

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SAN DIEGO STATE UNIVERSITY

Introduction

- Instructor:
  Alex Zvoleff, Doctoral Candidate
  San Diego State University, USA
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  Website: http://rohan.sdsu.edu/~zvoleff

- My background:
  – BS in Earth Science, University of California, San Diego, USA
  – MA in Climate and Society, Columbia University, New York, USA
  – Ph.D. in Geography, San Diego State University (in progress)

- My interests:
  – Climate change
  – Habitat change
  – Population dynamics

What We Will Cover

- GIS
  – What is GIS
  – Key GIS concepts
  – Types of GIS Data
  – How to use GIS software
- GPS
  – How to use GPS data
  – How to gather GPS data with a handheld GPS
  – How to import GPS data into GIS software
- How to make a finished map

Schedule

- Day 1 – Introduction to GIS and GPS
  – October 13, 12:00PM – 4:00PM

- Day 2 – Data collection with GPS
  – October 14, 12:00PM – 4:00PM

- Day 3 – Making Maps with Quantum GIS
  – October 15, 12:00PM – 4:00PM

Day 1 Outline

1. What is GIS
2. Types of GIS Data
3. Coordinate Systems
4. GIS Software
5. The GPS System
6. Tips on Collecting GPS Data

What is GIS?

What are Paper Maps?

- Paper maps store information on a single sheet of paper

- One map = one layer of information

- Paper maps have a single scale and coordinate system

vegetation

soil

rivers

Unsuitable

Buildings

Advantages / Disadvantages – Paper Maps

- Advantages of paper maps
  - Easy to use
  - Cheap (inexpensive, to use)
  - Already available for many areas

- Disadvantages of paper maps
  - Hard to compare two different maps to each other
  - Paper maps are generally limited to a single purpose
  - Hard to measure areas and distance from paper maps
  - Hard to update a paper map

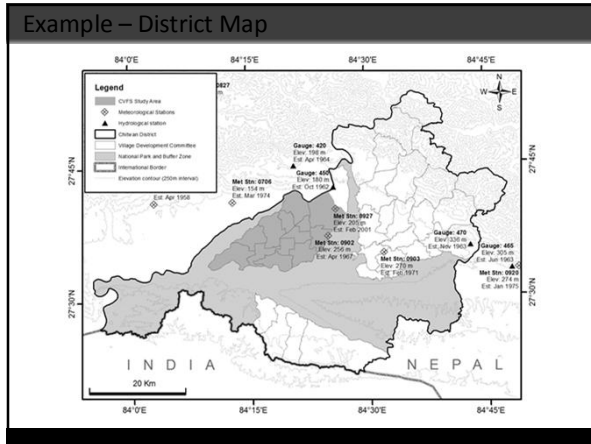## Geographic Information Systems (GIS)

Geographic information systems (GIS) are:
computerized systems for storing, retrieving, and analyzing geographic data

What does a GIS look like?

- A GIS stores maps on a computer in a digital format

- GIS allows spatial data to be easily:
  - Visualized
  - Analyzed
  - Combined
  - Manipulated
  - Updated

Topographic base

Parcels

Zoning

Floodplains

Wetlands

Land cover

Soils

Survey control

Composite overlay of all data layers

Example – National Map

C H I N A

Chitwan District

Kathmandu

I N D I A

Example – District Map

Populated Area

Buffer Zone

Buffer Zone

Chitwan National Park

Buffer Zone

Example – District Map

Types of GIS Data

Definitions: Features versus Attributes

- **Feature:** anything with geographic coordinates
  - Examples: a house, a building, canal, a road, an intersection, a VDC, a district

- **Attribute:** something that describes a feature

- Example: a road is a *feature*
  - A road has attributes: a name, a length, a width, the type of material the road is made out of, the color of the road

Example: Road Feature

- **Feature:** Road 1
  - **Attributes:**
    - Length: 10km
    - Width: 5m
    - Name: Alex's Road
    - Material: dirt
    - Color: brown
- **Feature:** Road 2
  - **Attributes:**
    - Length: 20km
    - Width: 8m
    - Name: Krishna's Road
    - Material: concrete
    - Color: gray

Types of Data: Vector and Raster

- There are two main types of data in a GIS:
  - Vector
  - Raster

- Rasters map continuous features

- Vectors map points, lines, or polygons

Raster Data

- **Raster**: an image. Maps continuous features.

- A raster is a grid of cells laid over the landscape, with one value in each cell

- Rasters can be used to map:
  - Satellite imagery
 - Elevation
  - Temperature, wind speed, etc.

## Example – District Map
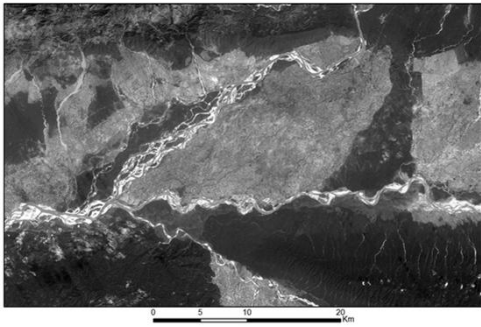
Vector Data

- Vector data models discrete features
- Each vector has coordinates
- Different types of vector data:
  - Point data (house, well, tree)
  - Line data (road, river, canal)
  - Polygon data (VDC boundary, community forest, national park)
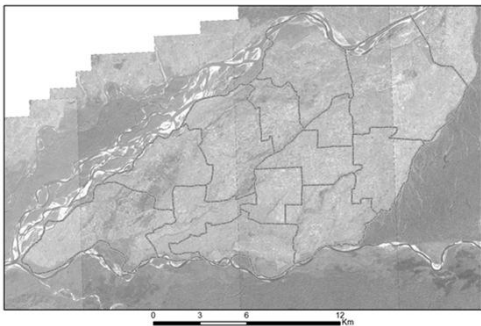- Lines have a length, but no area
- Polygons have a perimeter and an area

Vector Data – Point Data – Healthposts
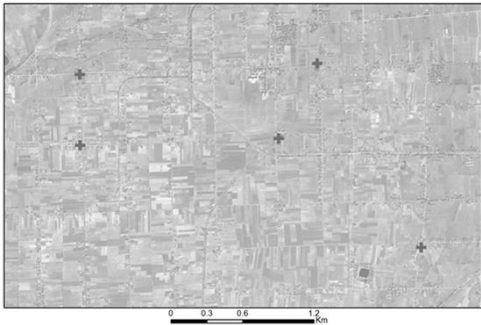
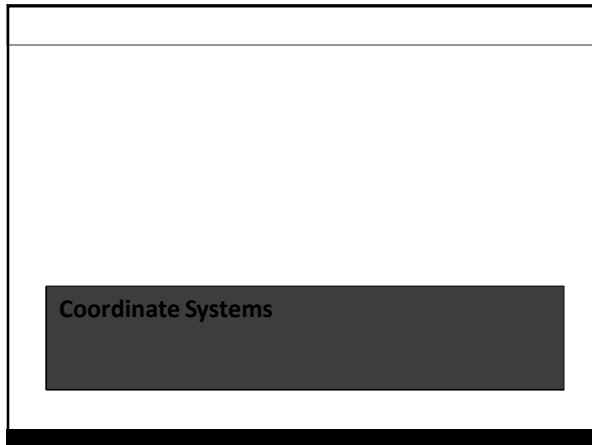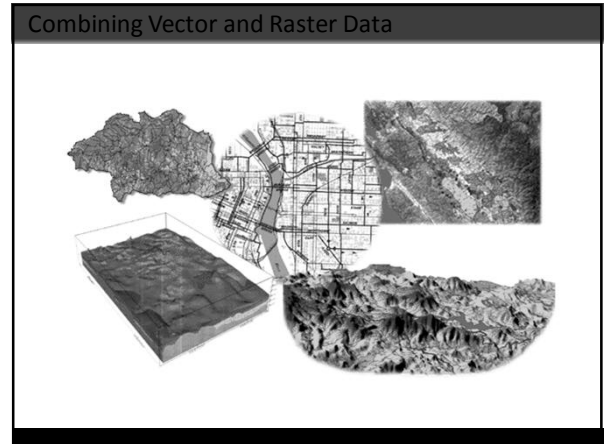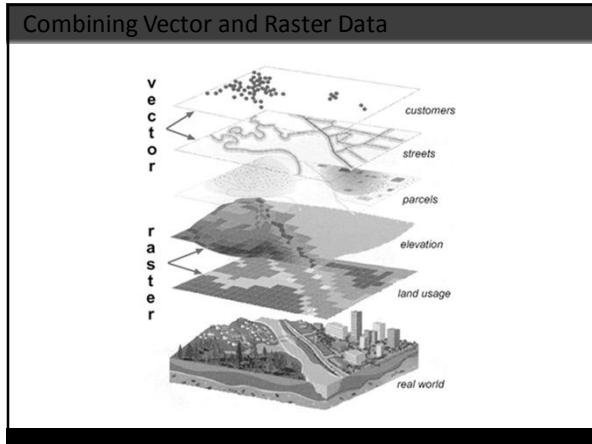## Vector Data – Line Data – Roads
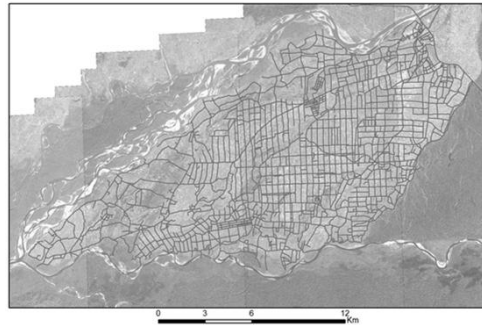
Vector Data – Polygon Data – VDC Boundaries

Vector Data – Polygon Data – Land Parcels

Combining Vector and Raster Data

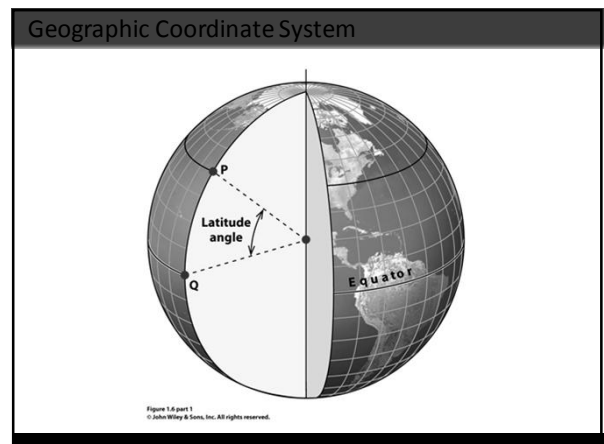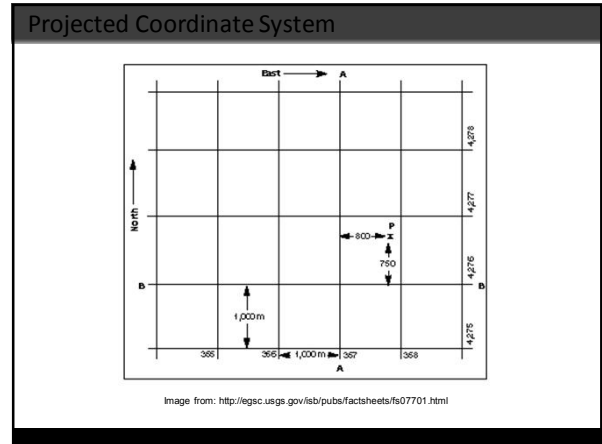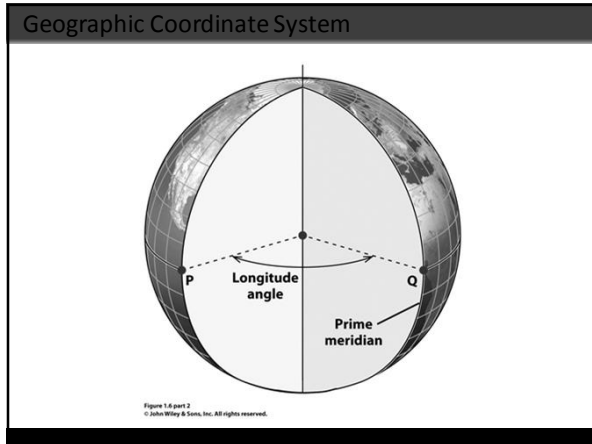## Combining Vector and Raster Data

Coordinate Systems

What is a coordinate system?

- A GIS needs to know the position on the earth's surface of each feature on a map

- But: the earth's surface is a complex shape, with mountains, valleys, oceans, deltas

- A coordinate system is a mathematical formula a GIS uses to represent the position of a feature

Two Main Kinds of Coordinate System

- Geographic Coordinate System
  - Can be used to define position anywhere on the globe
  - Defines position using latitude and longitude
    Example: ISER-N is at: 84°22'20.265"E 27°38'59.079"N

- Projected Coordinate System
  - Defines position as an (x, y) coordinate
    Example: ISER-N is at: 832,748m, 3,062,951m (UTM45N)
  - Represents the **curved** surface of the earth on a **flat** map
  - Distance and area can be easily calculated

Geographic Coordinate System

Figure 1.6 part 1
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Geographic Coordinate System

Figure 1.6 part 2
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Projected Coordinate System

Image from: http://egsc.usgs.gov/isb/pubs/factsheets/fs07701.html

Coordinate Systems in GIS

- Why are coordinate systems important?
  - If you use the wrong coordinate system for a dataset, the positions will all be **wrong**
- GIS software will try to set the coordinate system for data automatically
  - When you use GPS data with a GIS program, you need to set the coordinate system of the GPS
- If you want to combine datasets in a map, they should all have the same coordinate system

Common Coordinate Systems Used in Nepal

| Name	Abbreviation	Type	Where Used
World Geodetic System 1984	WGS84	Geographic	GPS Data, Google Earth
Everest 1830 (Nepal)	Everest 1830	Projected	Nepal Survey Department
Everest 1937 (Nepal)	Everest 1937	Projected	Nepal Survey Department
Universal Transverse Mercator 44 North	UTM44N	Projected	US Geological Survey
Universal Transverse Mercator 44 South	UTM45N	Projected	US Geological Survey

Summary

- **Feature** versus **attribute**
- **Raster** versus **vector**
- Three kinds of vectors:
  - Point
  - Line
  - Polygon
- Two kinds of coordinate systems
  - Geographic
  - Projected

GIS Software

Main GIS Software Choices

| Name of Software	Price	Comments
ArcView/Editor/Info (ESRI)	$2000+	Many features but very expensive
Quantum GIS	Free	Many features, some better than ArcGIS, and FREE
GRASS	Free	Full featured and free, but difficult to use
Google Earth	Free - $150	Good for viewing free satellite maps, has few GIS features

Quantum GIS

- Quantum GIS is free software

- Can be used to:
  - View GIS data
  - Process GIS data (calculate areas or distances)
  - Make maps from existing data
 - Make maps from GPS data

- Download from: http://www.qgis.org

Quantum GIS
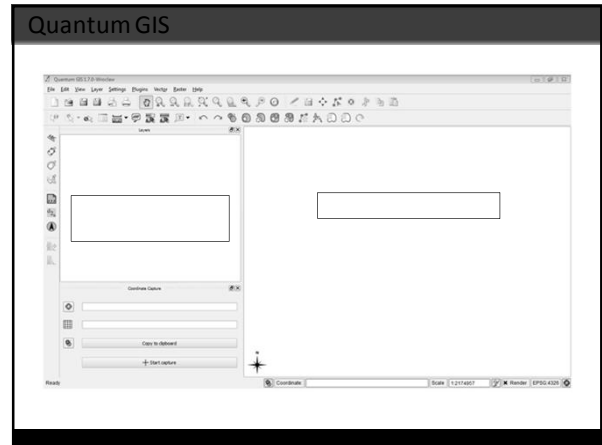
Two Kinds of GIS Files

- Data File
  - A data file stores raw GIS data
  - A data file is not a map – it is just a list of coordinates and attributes
- Map File
  - A map file does not contain any data
  - It saves the layout of a map (including the title and legend, etc.)
  - A map file also stores a list of data files that are included in the map.
  - **NOTE:** Without data files the map file is useless

Common Types of Vector GIS Data Files

- Shapefile
  - A shapefile is a set of files that stores a single type of GIS data (line, polygon, or point)
- Coverage
  - A coverage is a directory of files containing GIS data
- KML/KMZ file
  - KML and KMZ files store GIS data for use in Google Earth

Shapefile – An Example

Coverage – An Example

Coverage – An Example
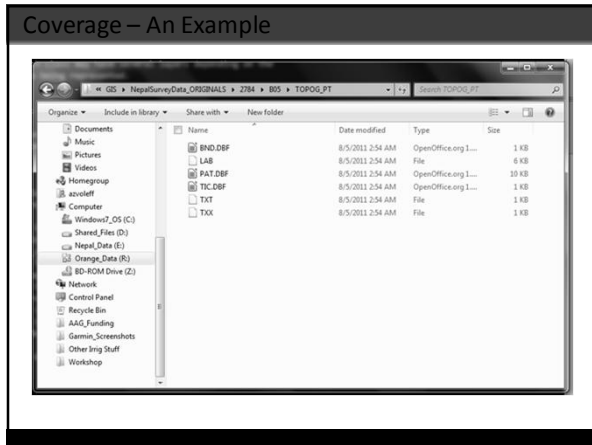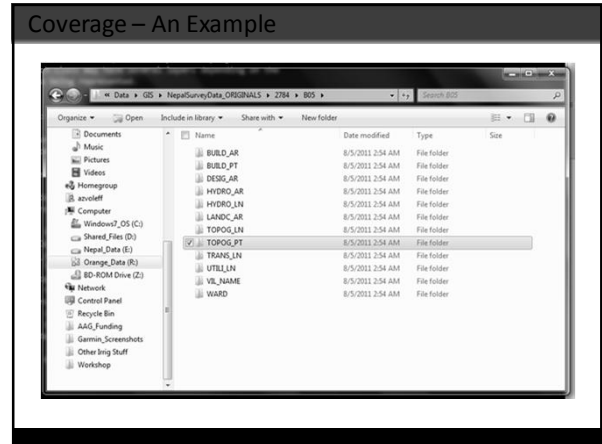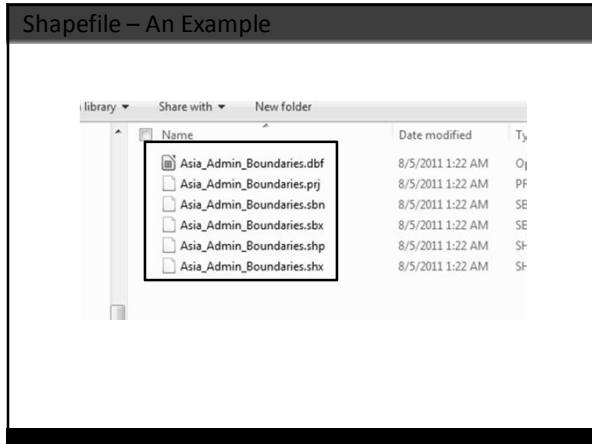
Common Types of Raster GIS Data Files

- GeoTIFF – a raster image for use in GIS system

- A GeoTIFF is a set of 2-4 files with:
  - ".tif"
  - ".tfw"
  - ".aux"
  - ".rrd"

GeoTiff Raster File

GeoTiff Raster File
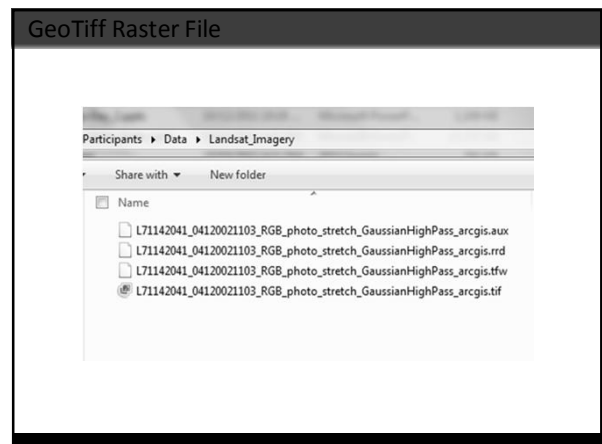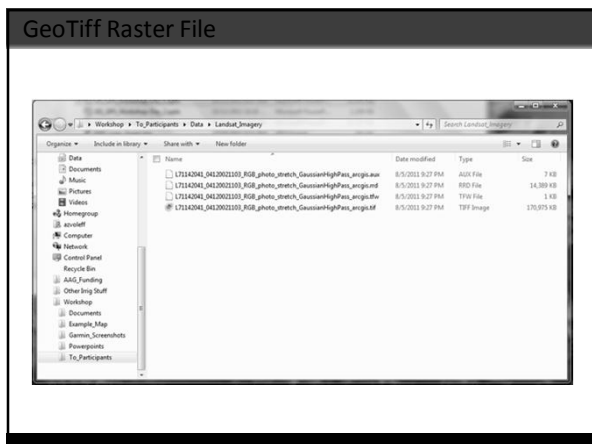
Types of GPS Map Files

- Map files – store information on the layout of a map

- ".mxd" file
  - A .mxd file stores a map made using ArcGIS software

- ".qgs" file
  - A .qgs file stores a map made using Quantum GIS software
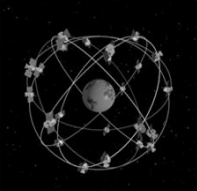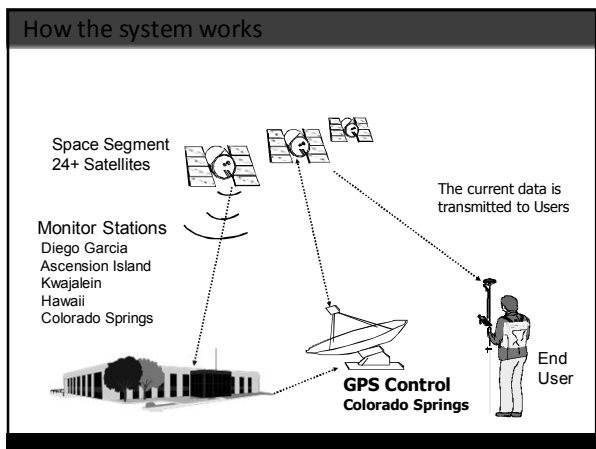
Summary

- **Data file** versus **map file**

- Most common vector data file: shapefile

- Most common raster data file: GeoTIFF

GPS – The Global Positioning System

What is GPS?

- The Global Positioning System (GPS)

- A set of Earth-Orbiting Satellites maintained by the United States Government

- GPS used to calculate geographic positions on and above the surface of the Earth

How the system works

Space Segment
24+ Satellites

The current data is transmitted to Users

Monitor Stations
Diego Garcia
Ascension Island
Kwajalein
Hawaii
Colorado Springs

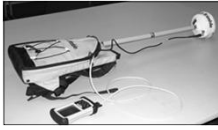**GPS Control**
Colorado Springs

End User

GPS Applications

- GPS can be used to map:
  - Roads
  - Canals
  - Households
  - Buildings
  - Anything on the ground…

- GPS can also be used to locate features from a GIS

Examples of Handheld GPS Receivers

Trimble ProXRT with Nomad Field Computer

Trimble GeoXM

Trimble Juno ST

Garmin eTrex

Tips on Collecting GPS Data

- A GPS receiver has to have a good view of the sky to work properly
- A GPS will not work well:
  - Indoors
  - Under a roof
  - Very close to buildings
  - Under dense trees
  - When it is very cloudy
  - Under high voltage power lines
- GPS usually is accurate to within 5-10 meters

When Collecting Data with GPS

- Follow the instructions for your type of GPS

- Stand **directly on top of** the point you want to record data for

- Unless you are recording a line or a polygon, **do not move while the GPS is recording**

When Collecting Data with GPS

- Follow the instructions for your type of GPS

- Stand **directly on top of** the point you want to record data for

- Unless you are recording a line or a polygon, **do not move while the GPS is recording**

Types of GPS Data Files

- GPX File
  - A "GPX" file ends in ".gpx" and stores GPS data from a GPS device

- SSF File
  - An "SSF" file ends in ".ssf" and stores GPS data form a Trimble brand GPS device

Summary

- Main type of GPS file: GPX file

- GPS needs a good view of the sky to operate

- GPS accurate to within 5-10m