Land Use and Land Cover Mapping and Image Classification Concepts
Definitions

1. Land cover
2. Land use
Definitions

1 Land cover - Physical characteristics

2 Land use - Purpose served to people

NOAA definition of the difference between land cover and land use:
https://oceanservice.noaa.gov/facts/lclu.html

Michigan State U. definition:
https://www.canr.msu.edu/news/the_difference_between_land_use_and_land_cover
Populus plantations in Afghanistan are used to provide wood for building, like pictured in above figures. How would you define their land cover? Their land use?

<table>
<thead>
<tr>
<th></th>
<th>Land cover</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Land use</td>
<td>Commercial harvesting of <em>Populus</em> sp. for building</td>
</tr>
</tbody>
</table>

Example: Land use & land cover

What are some of the examples of land cover vs. land use?

Preparation of structure plan, master plan and detailed area development plan for Rajshahi metropolitan city, Dhaka

LULC map of Afghanistan
### Procedure of land cover mapping

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Earth surface</td>
</tr>
<tr>
<td>2</td>
<td>Satellite Remote Sensing</td>
</tr>
<tr>
<td>3</td>
<td>LC classification schemes</td>
</tr>
<tr>
<td>4</td>
<td>Digital image processing</td>
</tr>
<tr>
<td>5</td>
<td>Land Cover Map</td>
</tr>
</tbody>
</table>

#### LC classification schemes

1. Open Water
2. Perennial ice/Snow
3. Low Intensity Residential
4. High Intensity Residential
5. Commercial/Industrial/Transportation
6. Bar-Roof/Forest/Coral
7. Quarried/Strip Mine/Gravel Pit
8. Transformed Barrier
9. Woodland
10. Forest/Plantation/Lined/Windbreak
11. Grassland/Wetland
12. Bareland
13. Rangeland
14. Forest/Plantation/Lined/Windbreak
15. Snow
16. Bar-Roof/Forest/Coral
17. Rock
18. Water
19. Fossil
20. Emergent Herbaceous Wetlands
21. Bar-Roof/Forest/Coral
22. Agriculture
23. Barren area
24. Lake
25. River

#### Land Cover Mapping Systems

- Earth surface
- Landsat, IKONOS
- LCCS, ACS, CORINE
- eCognition, GEE, ENVI
- Land Cover Map
Steps of land cover mapping

Legend development and classification scheme
Data acquisition
Image rectification and enhancement
Field training information
Generate image index
Assign rules
Draft land cover map
Validation and refining of land cover
Land cover map
Change assessment
Visual interpretation of remote sensing imagery is extremely time consuming (example buildings and vegetation in Kabul, Afghanistan), and so we often use other methods for classifying land cover/land use.
## Traditional vs. automated mapping

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>Automated</td>
</tr>
<tr>
<td>• More reliable information extraction based on visual interpretation</td>
<td>• Time consuming &amp; costly</td>
</tr>
<tr>
<td>• Interpreter’s expertise supports the quality input</td>
<td>• Information can be interpreted only from the 3 bands at a time</td>
</tr>
<tr>
<td>• Can be automated for large area mapping</td>
<td>• Requires experience &amp; training for quality input</td>
</tr>
<tr>
<td>• Better consistency</td>
<td>• Large number of computations, particularly many spectral bands are involved</td>
</tr>
<tr>
<td>• Can process as many images with as many bands as necessary</td>
<td>• Overlapping of classes</td>
</tr>
</tbody>
</table>
Image classification

- The process of sorting pixels into a number of data categories based on their data file values.

- The process of reducing images to information classes i.e. forest, water, urban etc.
Image classification

Example of sorting image pixels into information classes

Landsat image of Bangladesh  Classified image of Bangladesh
Classification

1. Supervised

2. Unsupervised
1 **Supervised** - Computer clusters pixels based on the common characteristics without user-provided classes

2 **Unsupervised** - User selects pixels representative of specific classes and then the computer uses these training sites as references to group other pixels

Supervised classification: The process of using samples of known identity (i.e., pixels already assigned to information classes) to classify pixels of unknown identity (i.e., all the other pixels in the image)
If input training sample data is inaccurate, than the output classification will be inaccurate.
The process of automatically segmenting an image into spectral classes based on natural groupings found in the data

The process of identifying land cover classes and naming them

www.gsp.humboldt.edu/OLM/Courses/GSP_216_Online/lesson6-1/unsupervised.html
## Review: Unsupervised

<table>
<thead>
<tr>
<th>Disadvantages</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Classes may not correspond to useful land cover definitions</td>
<td></td>
</tr>
<tr>
<td>- Spectral characteristics may differ for the same class in different images</td>
<td></td>
</tr>
<tr>
<td>- Objective, based on spectral information</td>
<td></td>
</tr>
<tr>
<td>- Quick and easy</td>
<td></td>
</tr>
<tr>
<td>- No labeled data necessary</td>
<td></td>
</tr>
</tbody>
</table>
Examples of algorithms for supervised classification in ENVI:

**Maximum Likelihood:** Assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Each pixel is assigned to the class that has the highest probability (that is, the maximum likelihood). This is the default.

**Minimum Distance:** Uses the mean vectors for each class and calculates the Euclidean distance from each unknown pixel to the mean vector for each class. The pixels are classified to the nearest class.

Mahalanobis Distance: A direction-sensitive distance classifier that uses statistics for each class. It is similar to maximum likelihood classification, but it assumes all class covariances are equal, and therefore is a faster method. All pixels are classified to the closest training data.

Spectral Angle Mapper: (SAM) is a physically-based spectral classification that uses an n-Dimension angle to match pixels to training data. This method determines the spectral similarity between two spectra by calculating the angle between the spectra and treating them as vectors in a space with dimensionality equal to the number of bands. This technique, when used on calibrated reflectance data, is relatively insensitive to illumination and albedo effects.
Resources describing pixel based and object based. Pixel-based is always described as being either a supervised or unsupervised technique. OBIA often is as well, but sometimes the literature describes it separately.

https://gisgeography.com/image-classification-techniques-remote-sensing/
http://www.fis.uni-bonn.de/en/recherchetools/infobox/professionals/image-analysis/classification
Object-based or pixel-based?

1. Categorizes based on spatial relationship of pixel with the surroundings — Object-based

2. Categorizes solely based on information in that pixel — Pixel-based
Object-based image analysis

1. The first step of an object-based image analysis is to cut the image into pieces, which serve as building blocks for further analysis – this step is called **segmentation** and there is a choice of several algorithms to do this.

2. The next step is to label these objects according to their attributes, such as shape, color and relative position to other objects.

https://gisgeography.com/image-classification-techniques-remote-sensing/
http://gsp.humboldt.edu/olm_2016/courses/GSP_216_Online/lesson6-1/object.html
https://www.researchgate.net/publication/312172775_Object-based_and_Knowledge-based_classification_techniques_in_urban_areas_using_Hyperspectral_imagery_and_LiDAR_data
Object-based image analysis

Before knowing more details about object-based image analysis, let's use a relatively simple example.
Part of the application of GEOBIA lets extract water from the high resolution image.

When visually inspecting data sets searches all the blue pixel that should be water.
Object-based image analysis

Part of the application of GEOBIA lets extract water from the high resolution image.

When visually inspecting data sets looks all the blue pixel should be water.
Object-based image analysis

Segmentation of objects
Object-based image analysis
Object-based image analysis

- Color Statistics
- Shape
- Texture
- Hierarchy
- Relations to...
  - neighbor objects
  - super-objects
  - sub-objects
Object-based image analysis

- Color Statistics
- Shape
- Texture
- Hierarchy
- Relations to...
  - neighbor objects
  - super-objects
  - sub-objects
Object Based Classification (Software)

- eCognition/ Definiens
- IDRISI
- ERDAS Imagine
- ENVI
- MADCAT
Knowledge based classification -> criteria incorporated into an assembly algorithm such as this one on how to define forest versus other land cover type, based on physical characteristics.
Knowledge-based classification is a pixel level approach in which the classification is done through a defined set of hypothesis, rules and variables. These can be represented in a "Knowledge base".

Regional land cover monitoring system

- A robust system developed collaboratively
- Produces consistent products at regular intervals
- Serves the expressed needs of multiple users in the region

- Uses transparent, well-documented, open source approach
- Includes quality control/quality assurance methods that integrates information from multiple sources

Where we stand in Afghanistan
Where we stand in Afghanistan

- Land cover maps were generated using 1990-93 Landsat TM images adopting state-of-the-art technique of visual interpretation, table-digitization and manual interpretation
- Land cover classes were finally compiled as digital database using ARC/INFO GIS software
- Provincial Land Cover Atlas, comprising provincial land cover maps and statistics for the 1972 and 1990-93 datasets, together with a review of the agricultural land cover changes from 1972 to 1993

11 main land cover classes and a number of mixed classes were recognized, with special emphasis on Agricultural Lands, Orchards and Forests.
<table>
<thead>
<tr>
<th>Sl no</th>
<th>Land Cover 1972</th>
<th>Land Cover 1993</th>
<th>Land Cover 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Natural Forests, with sub-classes 8A, B</td>
<td>Forest and Shrubs</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Pistachio Forests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Pistachio Forests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Natural Forests, with sub-classes 6A, B</td>
<td>Vineyards</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Orchards/Gardens</td>
<td>Orchards/Fruit Trees, with sub-classes 2A, B, C</td>
<td>Fruit Trees</td>
</tr>
<tr>
<td>6.</td>
<td>Rainfed Agricultural Land (Grades VI, VII)</td>
<td>Rangeland, with sub-classes 7A, B</td>
<td>Rangeland</td>
</tr>
<tr>
<td>7.</td>
<td>Intensively Cultivated Land (Grades I, II)</td>
<td>Rain Fed Agricultural Lands, with sub-classes 4A, B</td>
<td>Rainfed Agricultural Land</td>
</tr>
<tr>
<td>8.</td>
<td>Intermittently Cultivated Land (Grades IV)</td>
<td>Irrigated Agricultural land, with sub-classes 3A, B, C</td>
<td>Irrigated Agricultural Land</td>
</tr>
<tr>
<td>9.</td>
<td>Barren lands, with sub-classes 8A, B, C</td>
<td>Barren Land</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Marsh/Swamp Areas, with sub-classes 9A, B</td>
<td>Sand Cover</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Water Bodies</td>
<td></td>
<td>Water body and marshland</td>
</tr>
<tr>
<td>12.</td>
<td>Permanent Snow</td>
<td></td>
<td>Permanent Snow</td>
</tr>
<tr>
<td>13.</td>
<td>Urban Areas</td>
<td></td>
<td>Bulk-up</td>
</tr>
<tr>
<td>14.</td>
<td>Unclassified</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Use one slide from three options to end your presentation