
ICIMOD
Land Use and Land Cover Mapping and Image Classification Concepts
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Date: 11 March 2020

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

Example: Land use & land cover

1	**Land cover**	Forest
2	**Land use**	Commercial harvesting of *Populus sp.* for building

Source: Groninger, John. (2006). Forestry and Forestry Education in Afghanistan. *Journal of Forestry*. 104. 426-430.

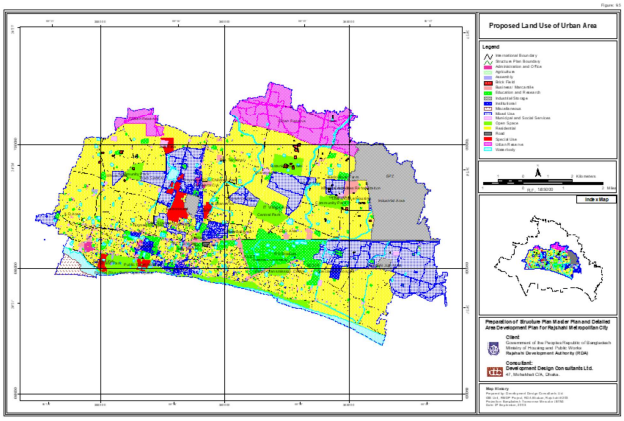
Figure 3. Three-year-old irrigated *Populus* plantation near Mazar-e-Sharif.

Figure 4. Small-diameter trees used in traditional roof construction.

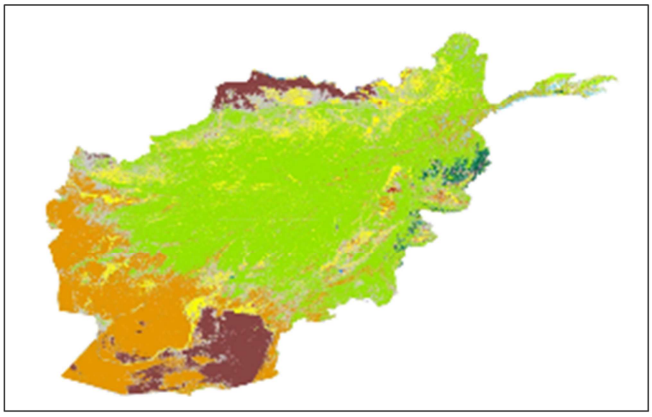
Populus plantations in Afghanistan are used to provide wood for building, like pictured in above figures. How would you define their land cover? Their land use?

Example: Land use & land cover

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

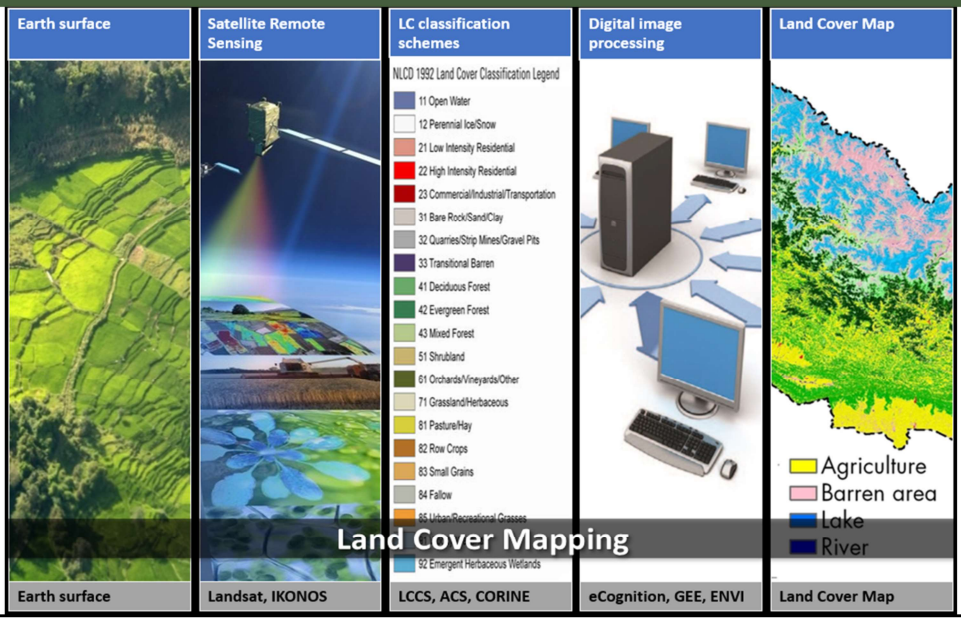


Preparation of structure plan, master plan and detailed area development plan for Rajshahi metropolitan city, Dhaka

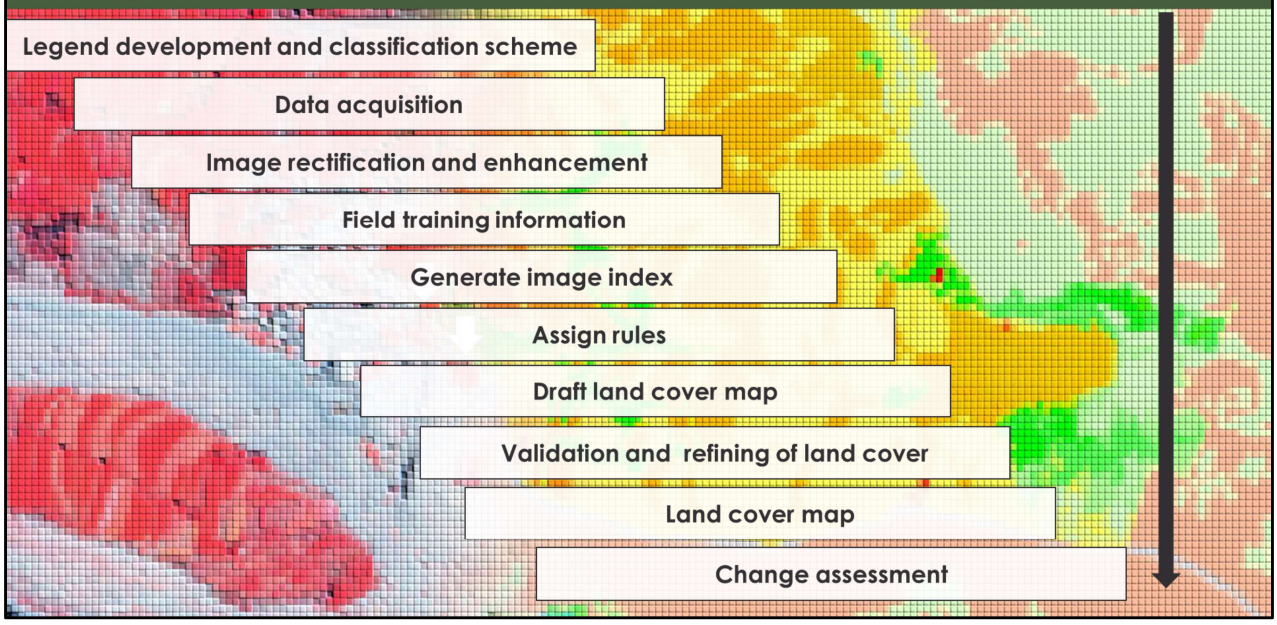


LULC map of Afghanistan

Procedure of land cover mapping



Steps of land cover mapping



Visual interpretation

Traditional method: User outlines classes manually such as digitization

True color, Landsat 8, 2018 mosaic, Kabul, Afghanistan

What can we do to classify land instead?

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

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

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.

1	1	1	1	1	2	2	2	2	4	4	4	4	4	4	4	4	4	4
1	1	1	1	1	2	2	2	2	4	4	4	4	4	4	4	4	4	4
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1	1	1	1	1	2	2	2	2	5	5	5	5	5	2	2	2	2	2
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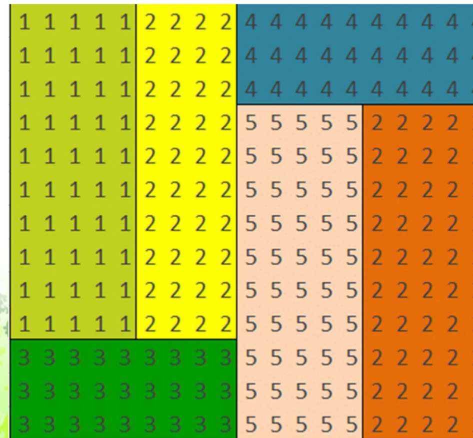
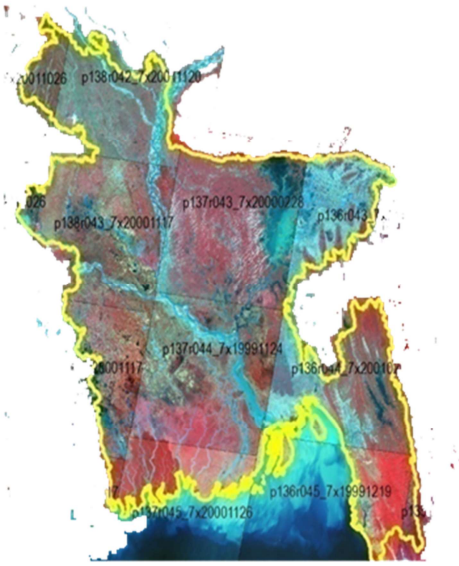


Image classification



Example of sorting image pixels into information classes

Legend (Land use/land cover 2017)

- Cropland
- Built-up area
- Barren area
- Waterbodies
- Grassland
- Rural settlement and homestead orchard
- Hill forest
- Mangrove forest
- Madhupur forest

Landsat image of Bangladesh Classified image of Bangladesh

Classification

1 Supervised

2 Unsupervised

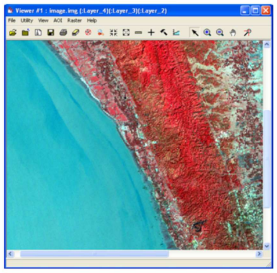
Definitions

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

Definition: https://mapasyst.extension.org/whats-the-difference-between-a-supervised-and-unsupervised-image-classification/

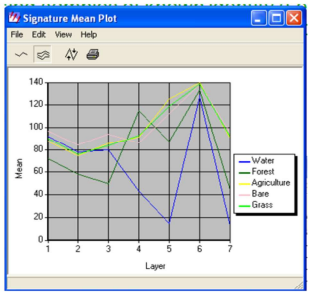
Which classification method?



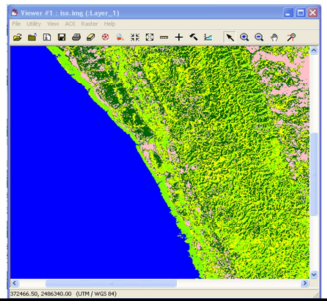
STEP 1: **User creates training dataset**

Supervised!

STEP 2: **Create signature file**



STEP 3: **Label pixels**



https://gisgeography.com/image-classification-techniques-remote-sensing/

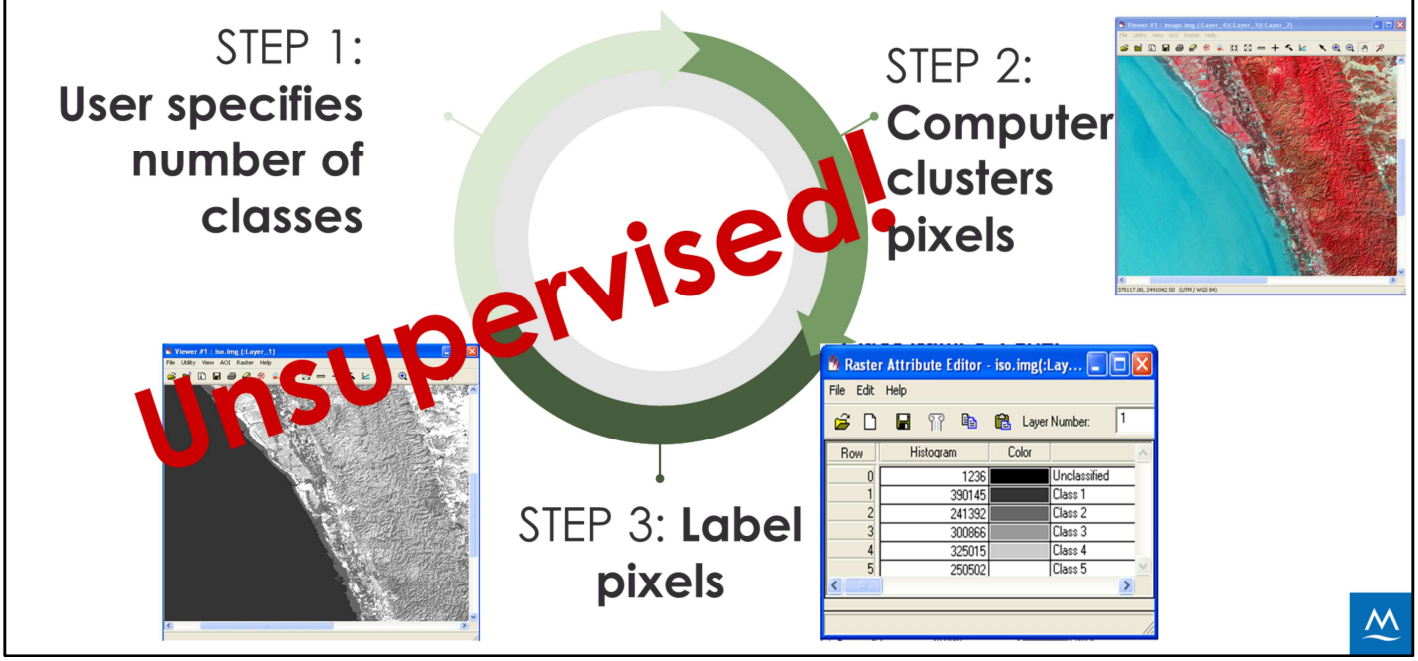
Supervised classification: The process of using samples of known identity (i.e., pixels already assigned to information classes) to classify pixels of unknown identity (i.e., all the other pixels in the image)

Review: Supervised

Disadvantages	Advantages
• Time and effort to collect training samples • Quality of classification depends on quality of training samples	• Can be more accurate than unsupervised method • Classes are informative

If input training sample data is inaccurate, than the output classification will be inaccurate

Which classification method?



http://gsp.humboldt.edu/OLM/Courses/GSP_216_Online/lesson6-1/unsupervised.html

- 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

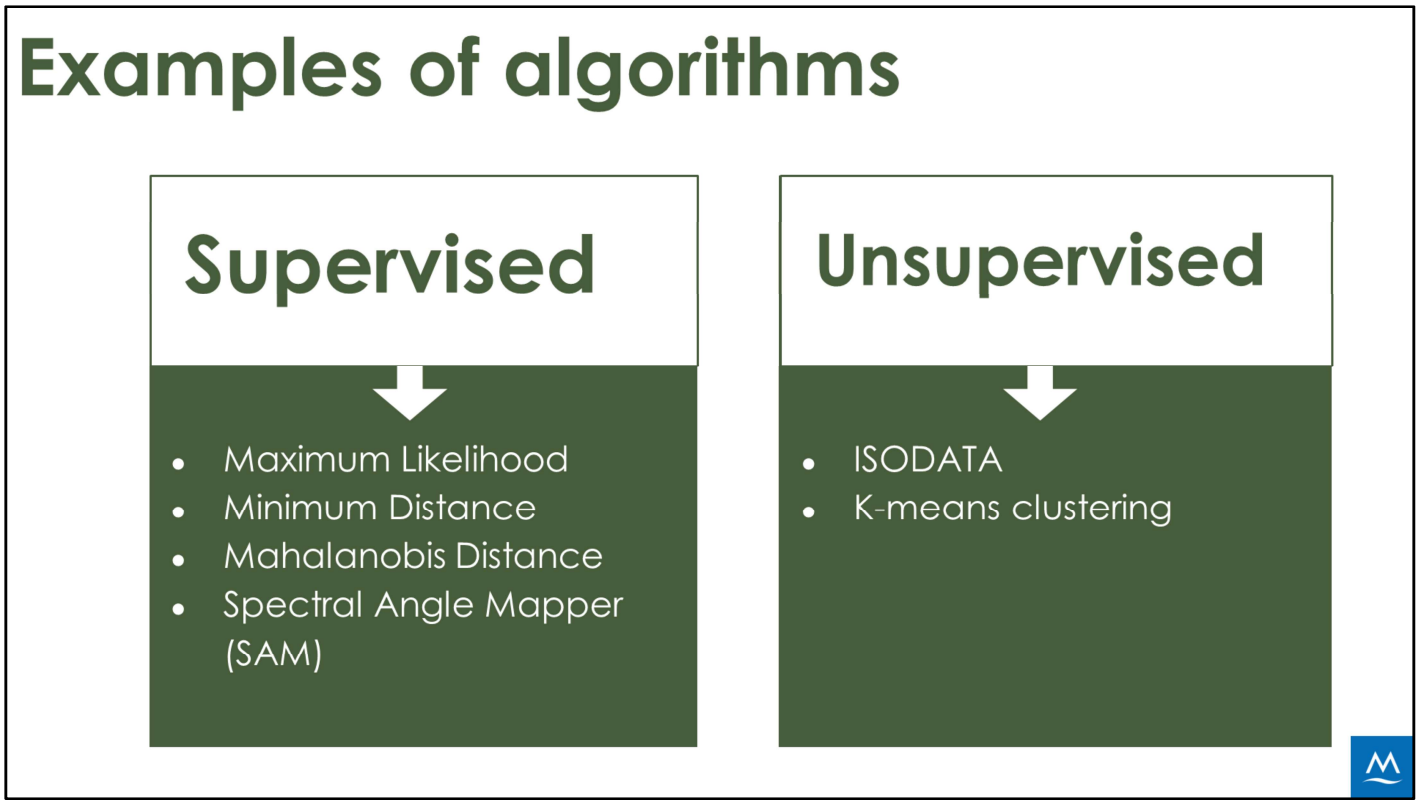
Review: Unsupervised

Disadvantages

- Classes may not correspond to useful land cover definitions
- Spectral characteristics may differ for the same class in different images

Advantages

- Objective, based on spectral information
- Quick and easy
- No labeled data necessary



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.

Options for classification

1 Object-based image analysis (OBIA)

2 Pixel-based

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/
https://pro.arcgis.com/en/pro-app/help/analysis/image-analyst/overview-of-image-classification.htm
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.

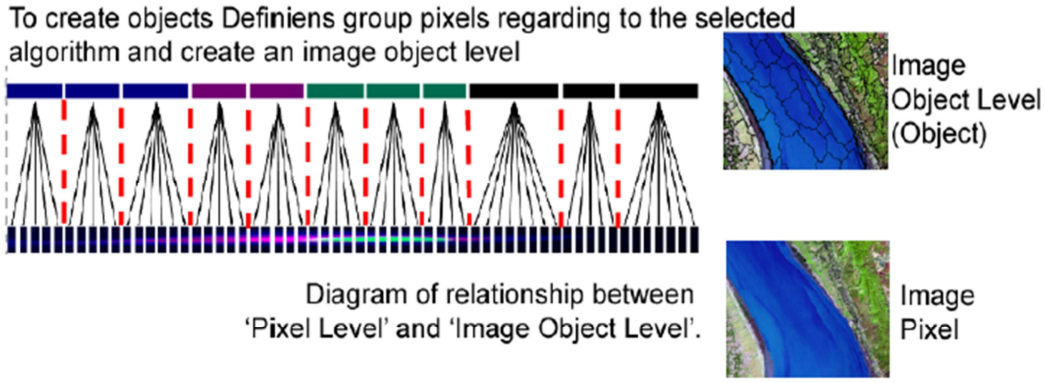


Diagram of relationship between 'Pixel Level' and 'Image Object Level'.

https://gisgeography.com/image-classification-techniques-remote-sensing/
https://pro.arcgis.com/en/pro-app/help/analysis/image-analyst/overview-of-image-classification.htm
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

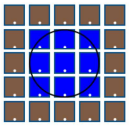
Object-based image analysis

Before knowing more details about object based image analysis lets use relatively simple example

Object-based image analysis

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



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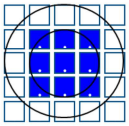
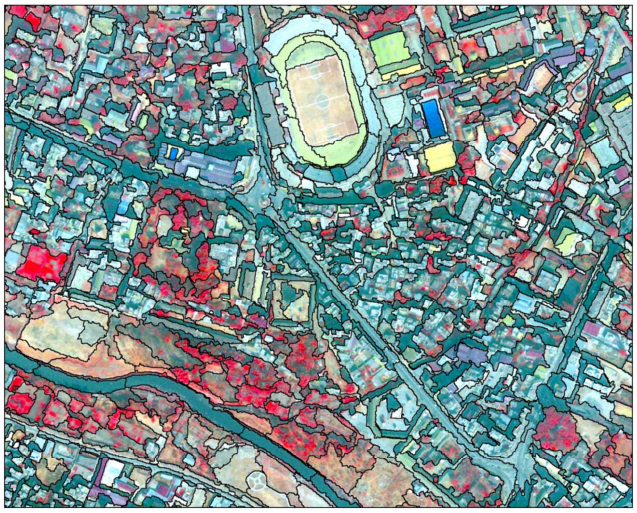
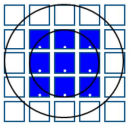


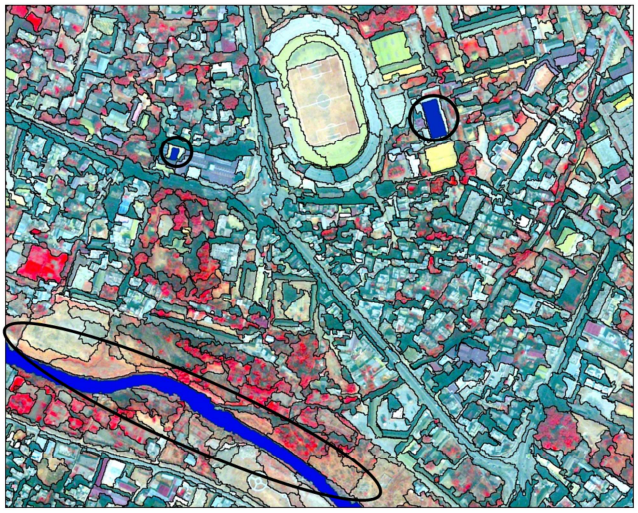
Object-based image analysis

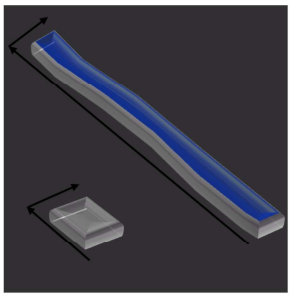


Segmentation of objects

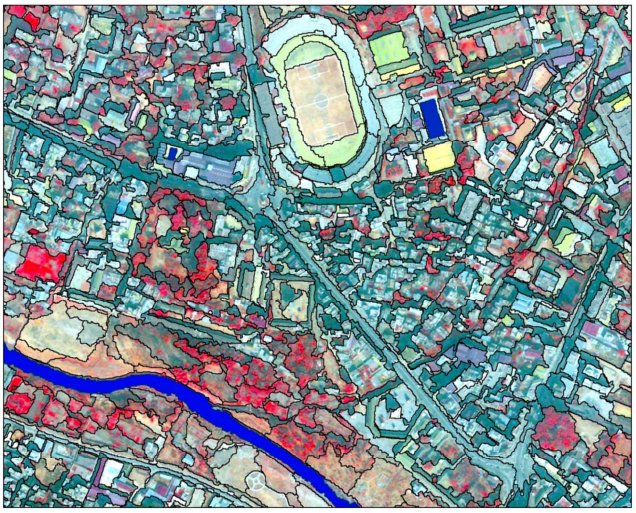


Object-based image analysis



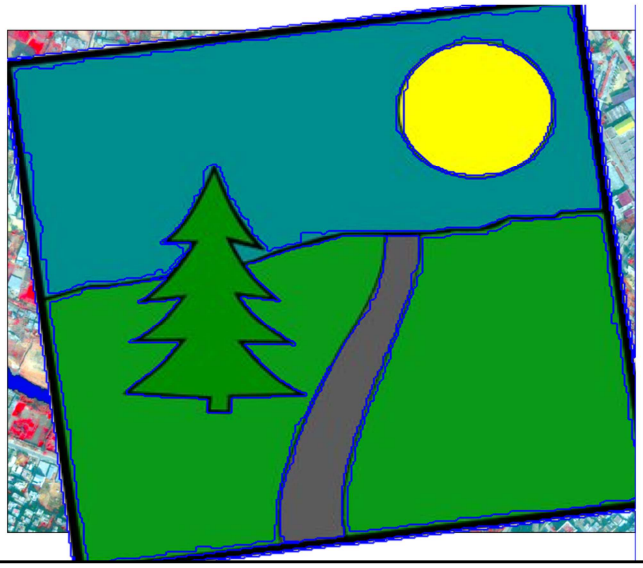


Object-based image analysis



- 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

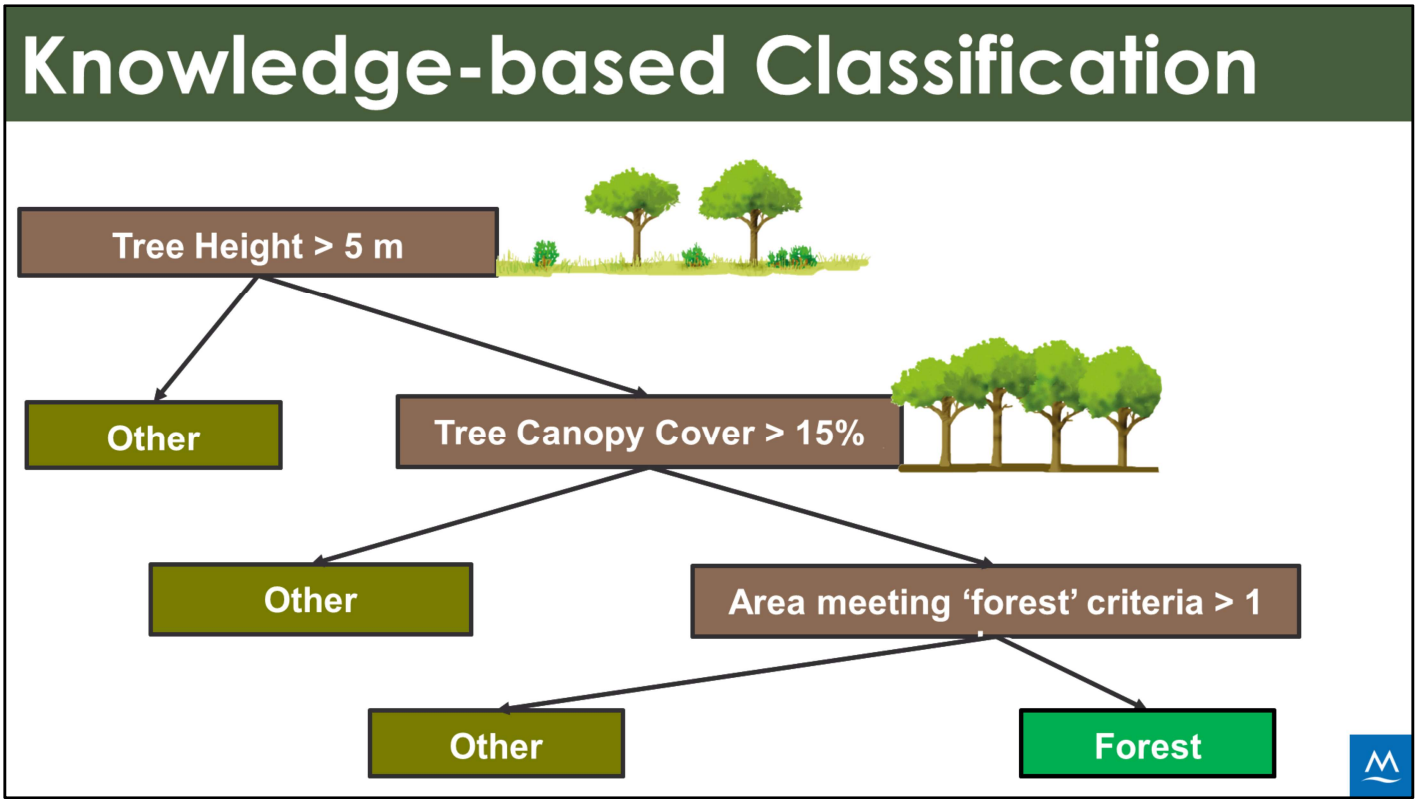
IDRISI

ERDAS Imagine

ENVI

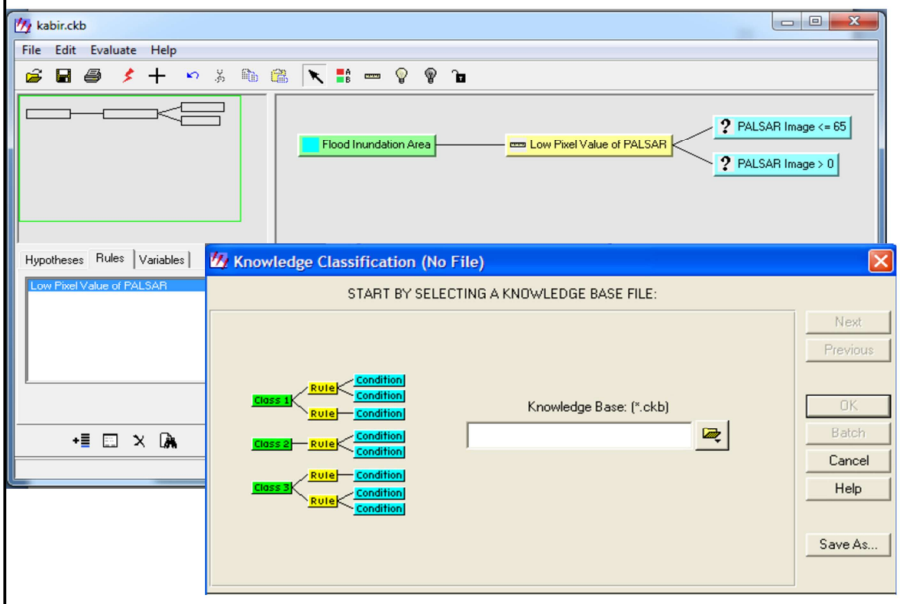
MADCAT

Knowledge-based Classification



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.

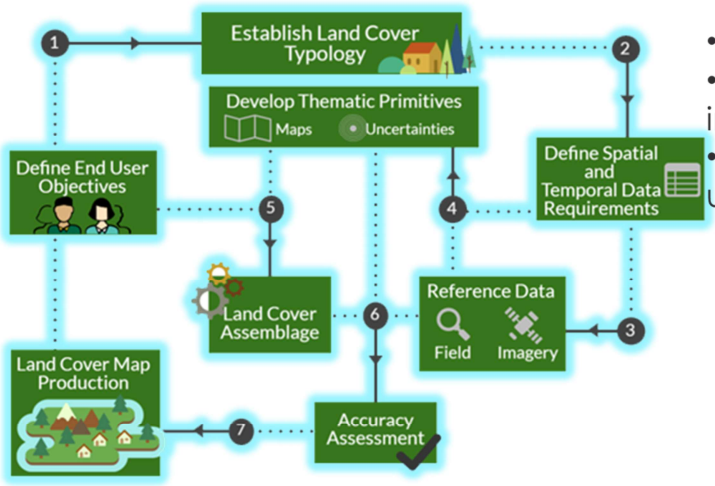
Knowledge-based Classification



- **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**"

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.719.7072&rep=rep1&type=pdf

Regional land cover monitoring system

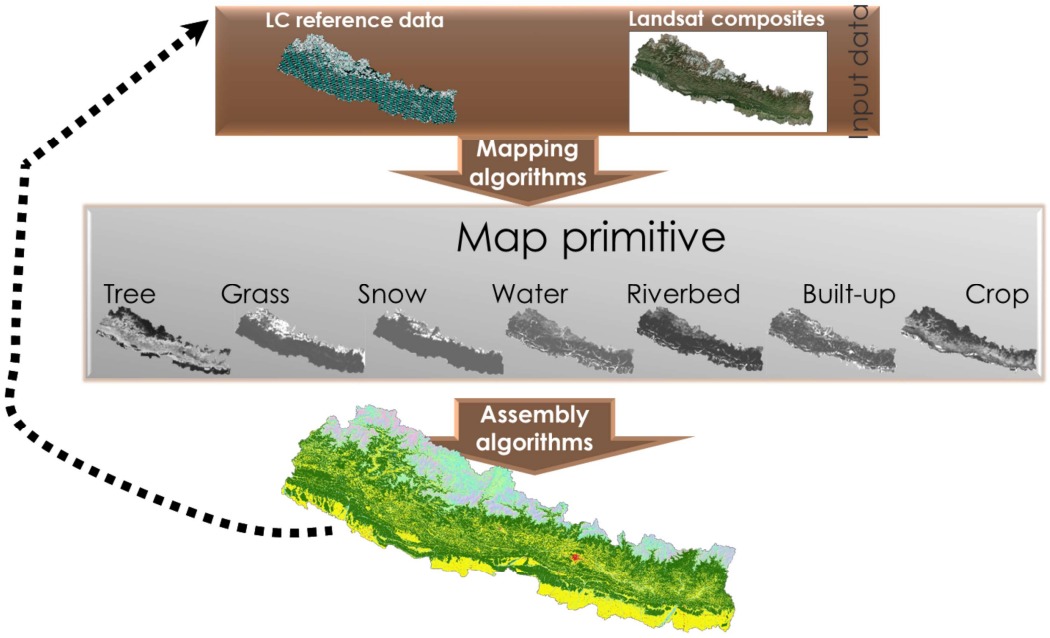


•A robust system developed collaboratively
•Produces consistent products at regular intervals
•Serves the expressed needs of multiple users in the region

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

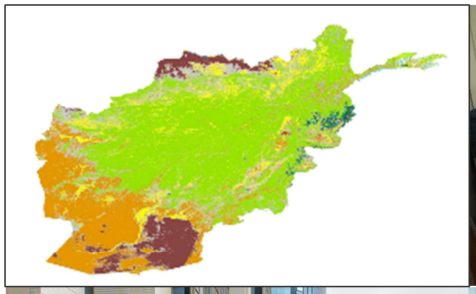
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.719.7072&rep=rep1&type=pdf

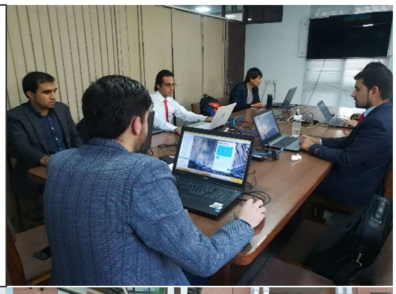
Regional land cover monitoring system



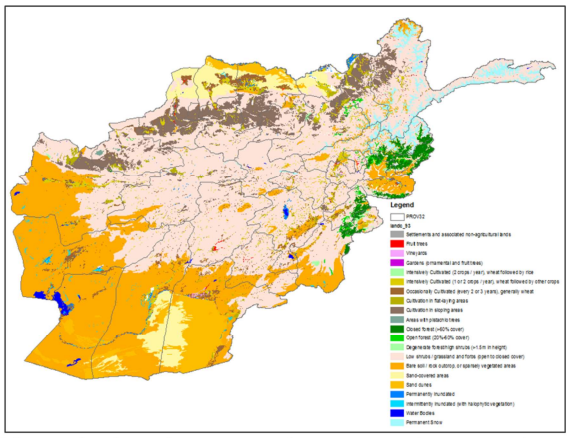
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.719.7072&rep=rep1&type=pdf

Where we stand in Afghanistan





Where we stand in Afghanistan



11 main land cover classes and a number of mixed classes were recognized, with special emphasis on Agricultural Lands, Orchards and Forests

- 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

Where we stand in Afghanistan

Sl no	Land Cover 1972	Land Cover 1993	Land Cover 2010
1.		Natural Forests, with sub-classes 6A, B	Forest and Shrubs
2.		Pistachio Forests	
3.		Pistachio Forests	
4.		Natural Forests, with sub-classes 6A, B	Vineyards
5.	Orchards/Gardens	Orchards/Fruit Trees, with sub-classes 2A, B, C	Fruit Trees
6.	Rainfed Agricultural Land (Grades VI, VII	Rangeland, with sub-classes 7A, B	Rangeland
7.	Intensively Cultivated Land (Grades I, II	Rain Fed Agricultural Lands, with sub-classes 4A, B	Rainfed Agricultural Land
8.	Intermittently Cultivated Land (Grades IV	Irrigated Agricultural land, with sub-classes 3A, B, C	Irrigated Agricultural Land
9.		Barren lands, with sub-classes 8A, B, C	Barren Land
10.		Marsh/Swamp Areas, with sub-classes 9A, B	Sand Cover
11.		Water Bodies	Water body and marshland (seasonal and permanent)
12.		Permanent Snow	Permanent Snow
13.		Urban Areas	Built-up
14.	Unclassified		

Use one slide from three options to end your presentation