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Land cover classification using QGIS Template

Section 1: Introduction to the learning unit

Title	Land cover classification using QGIS
Duration	Four hours (4h)
Introduction	The application of QGIS (Quantum Geographic Information System) for land cover classification represents a pivotal advancement in the realm of geospatial analysis. This approach leverages the versatile capabilities of QGIS software to meticulously categorize land cover types, providing indispensable insights for an array of critical domains, including environmental monitoring, urban planning, natural resource management, and land-use policy formulation. In this tutorial, we delve into the multifaceted utility and unique advantages of QGIS in land cover classification, shedding light on its instrumental role in elevating spatial data analysis and facilitating informed decision-making processes.
Learning outcomes	After completing this tutorial, the learners will be able to: 1. Recall key terminology and concepts related to land cover classification. 2. Explain the fundamental principles of land cover classification and its importance in various fields. 3. Utilize classification techniques to categorize land cover types within a specific geographic area. 4. Analyze the results of land cover classification to identify potential errors.

	5. Evaluate the accuracy and reliability of land cover classification results generated using QGIS. 6. Develop an informative land cover classification map that effectively communicates findings to diverse audiences.
Material	Here is a list of course materials • QGIS software • Geospatial data • Computer or Laptop • Internet connection
Literature	Here are some of the basic literature on Land cover classification • QGIS project., 2023. A Gentle Introduction to GIS —QGIS documentation.https://docs.qgis.org/3.28/en/docs/gentle_gis_introduction/index.html • USDA Forest Service. (2017). Module 3: Introduction to QGIS and Land Cover Classification, 68. https://servirglobal.net/Portals/0/Documents/Articles/ChangeDetection Training/Module3_LC_Classification_Accuracy_Assessment.pdf • Luca Condego. (2014). Land Cover Classification of Cropland: A Tutorial Using the Semi-Automatic Classification Plugin for QGIS. Www.directionsmag.com. Retrieved September 8, 2023, from https://www.directionsmag.com/article/1428. • Zaki, A., Buchori, I., Sejati, A. W., & Liu, Y. (2022). An object-based image analysis in QGIS for image classification and assessment of coastal spatial planning. The Egyptian Journal of Remote Sensing and

	Space Science, 25(2), 349-359 https://doi.org/10.1016/j.ejrs.2022.03.002. • Gómez, C., White, J. C., & Wulder, M. A. (2016). Optical remotely sensed time series data for land cover classification: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 116, 55-72.https://doi.org/10.1016/j.isprsjprs.2016.03.008.
Metadata	Name: Land cover classification using QGIS Learning Resource Type: Video Tutorial Description: The video tutorial, "Land Cover Classification with QGIS," is a comprehensive instruction appropriate for both beginners to Geographic Information Systems (GIS) and experienced users wanting to improve their skills. The lesson goes into QGIS's advanced tools for image processing, remote sensing, and vector analysis, covering each step of land cover classification, from data preparation to exact map production. The video, guided by an expert educator, covers fundamental principles, practical demonstrations, and helpful hints, finally providing viewers with the expertise and confidence to correctly categorize land cover using QGIS. This resource is intended for students, GIS professionals, and anybody interested in geospatial analysis, and it provides an opportunity to improve GIS skills and fully utilize QGIS's land cover classification capabilities. Subscribe now to get started on your path to QGIS expertise. Keyword(s): Land cover classification, QGIS, Image Classification, confusion matrix Author(s): Orou-Seko C. Abdou, Alemu Kefale Ejigu, Nzapa Nzeouango Sephora, Getachew Kebede Aragaw, Upile Pulaizi Language: English

Section 2: Input

Let's get started!!!!!!!

Key terminology and concepts

In understanding and working with land cover classification in the context of remote sensing and GIS applications some key terminology and concepts related to land cover classification is essential for anyone working in this field such as:

- ➢ **Image classification** is the process of categorizing pixels or groups of pixels within a digital image into predefined classes or categories based on their spectral characteristics, allowing for the identification of distinct features or land cover types.
- ➢ **Land Cover** refers to the physical material at the Earth's surface, such as vegetation, water, urban areas, and bare soil. It describes the observed physical state of the land.
- ➢ **Spectral Bands:** Different regions of the electromagnetic spectrum used for remote sensing, often represented as different colors in an image. Common bands include red, green, blue, and infrared.
- ➢ **Pixel:** Short for "picture element," it is the smallest unit of a digital image. In remote sensing, each pixel represents a small area on the Earth's surface and has associated spectral values.
- ➢ **Supervised Classification:** A classification method where the algorithm is trained on a set of known reference samples (training data) to assign pixels in an image to specific land cover classes.

- ➢ **Unsupervised Classification:** A classification method where the algorithm groups pixels in an image based on statistical similarities without prior knowledge of the land cover types.

- ➢ **Training Data:** A set of samples or data points with known land cover labels used to teach a classification algorithm.

- ➢ **Accuracy Assessment**: The process of evaluating the reliability and correctness of land cover classification results by comparing them to ground truth data.

- ➢ **Confusion Matrix:** A table used in accuracy assessment that shows the number of correctly and incorrectly classified pixels for each land cover class.

- ➢ **Overall Accuracy:** A measure of classification accuracy that calculates the percentage of correctly classified pixels out of the total.

- ➢ **Training Polygons:** are specific areas or regions of interest within remote sensing imagery that are manually delineated and labeled with their corresponding land cover classes. They are used in supervised classification algorithms to train the algorithm to recognize and classify similar features across the entire image.

- ➢ **Sentinel:** is a family of Earth-observing satellites developed by the European Space Agency (ESA) as part of the Copernicus program. These satellites provide free, high-resolution imagery and data for various applications, including environmental monitoring, disaster management, and land cover classification. The Sentinel program includes multiple missions (e.g., Sentinel-1 for radar imaging, Sentinel-2 for optical imaging) that offer a wealth of Earth observation data.

- ➢ **Raster Data:** is a type of spatial data representation where the Earth's surface is divided into a grid of regularly spaced cells or pixels. Each pixel in a raster dataset has a value that represents a specific attribute (e.g., color, elevation, temperature) at a particular location. Raster data is commonly used in remote sensing and GIS to store and analyze continuous spatial information, such as satellite imagery, digital elevation models, and land cover maps.

- ➢ **Accuracy vs. Precision**: Accuracy refers to how close the classification results are to the true values, while precision relates to the consistency of results when repeated.

Fundamental principles

To be able to accurately classify the land cover, a number of principles need to be met such as:

Unicity of the spectral signatures of the data: Land cover types have unique spectral characteristics in remote sensing data, which are based on how they reflect or emit electromagnetic radiation at different wavelengths, **Training Data need to be labeled:** Classification algorithms require labeled training data, which are examples of known land cover types used to teach the algorithm how to differentiate between classes, **Type of the classifier algorithms:** Various machine learning and statistical algorithms are employed to analyze the spectral information of pixels and assign them to specific land cover classes, **Take into account the spatial and temporal context:** Incorporating information about neighboring pixels and temporal changes can improve the accuracy of land cover classification by considering the surroundings and changes over time.

Fields of application: Land cover classification provides valuable insights into the Earth's surface, making it a fundamental tool in various fields for informed decision-making, environmental conservation, and sustainable development. For instance in the field of :

➤ Environmental Monitoring: Land cover classification is crucial for monitoring changes in ecosystems, such as deforestation, urbanization, and wetland loss. It helps assess the impact of human activities and climate change on the environment.

➤ Agriculture: Land cover classification aids in crop monitoring, yield prediction, and precision agriculture. It enables farmers to make informed decisions regarding crop management, pest control, and resource allocation.

➤ Urban Planning: Urban areas are characterized by complex land cover patterns. Classification helps urban planners manage land use and infrastructure development, and assess the effectiveness of zoning regulations.

➤ Natural Resource Management: Land cover classification is essential for managing natural resources like forests, water bodies, and wildlife habitats. It supports sustainable resource utilization and conservation efforts.

➤ Disaster Management: Rapid land cover classification after natural disasters (e.g., hurricanes, wildfires) assists in assessing damage, planning rescue operations, and prioritizing recovery efforts.

> ➢ Climate Change Analysis: Tracking changes in land cover over time is critical for understanding climate change impacts. It helps scientists study carbon dynamics, albedo changes, and land-atmosphere interactions.
>
> In categorizing land cover of the Earth's surface into distinct classes several classification techniques are employed to achieve this task, each with its strengths and applications. Those techniques include Supervised classification**,** unsupervised classification, object-based classification, machine learning and deep learning, and hybrid approaches, and in this tutorial, we will focus on supervised classification to analyze land cover classification to identify potential errors, evaluate the accuracy and reliability of land cover classification results generated using QGIS, and develop an informative land cover classification map that effectively communicates findings to diverse audiences.
>
> **Hungry Minds:** For additional learning, please follow the two documents here 1, here 2.

Section 3: Application

> **Hands-On Experience: Land Cover Classification Using QGIS and OTB**
>
> In this exercise, you will learn how to perform supervised classification using QGIS. You will use the Fogo Island dataset and apply a classification algorithm to classify land cover types. You will also have all the necessary document to be able to work effectively including: the videos tutorials, step by step note. By the end of this exercise, you should be familiar with the basic steps of supervised classification in QGIS.
>
> The objective exercise is to perform land cover classification using QGIS with the Orfeo Toolbox (OTB) for pixel-based image classification and assess classification accuracy.
>
> **Software Requirement**: QGIS (install it if not already installed)
> (OTB) plugin for QGIS (install it if not already installed)

Step 1: Adding and Creating Layers

- Open QGIS and create a new project.
- Add your remote sensing imagery as a raster layer.
- Add any vector layers (e.g., shapefiles) for reference or ground truth data.

Step 2: Using OTB Pixel-based Image Classification

2.1. Polygon Statistics

- Use the QGIS Processing Toolbox to access the OTB tools.
- Find and run the "Polygon statistics" tool from the OTB category.
- Select your reference vector layer as the input polygon layer and the remote sensing image as the input raster.
- Calculate statistics for each class within the polygons.

2.2. Sample Pixel Selection

- Use the "Sample selection" tool in the OTB category.
- Choose your input raster and the training polygons (ROIs) from the reference vector layer.
- Specify the number of samples per class.
- Generate a sample file.

2.3. Train Image Model and Accuracy Assessment

- Access the "TrainImageClassifier" tool from the OTB category.
- Provide your input image, training samples file, and specify a classifier (e.g., Random Forest).
- Train the image classifier model.
- Use the "ImageClassifier" tool to classify the entire image.
- Compare the classified image with the reference vector layer to assess accuracy.

2.4. Image Classification

- Run the "ImageClassifier" tool from the OTB category.
- Input the trained model and the image you want to classify.
- Generate a classified image.

2.5. Classified Image Labeling and Calculate Accuracy Assessment

- Add the classified image as a new layer in QGIS.
- Label the classes using the Layer Styling panel.
- Perform an accuracy assessment using the "Confusion Matrix" tool in QGIS.
- Calculate metrics such as overall accuracy, kappa coefficient, and producer's/user's accuracy.

Here is the result of what we did this is an example that you can use to compare with your own results here

If you are not able to follow all the steps described above please, we have prepared a tutorial for you here

Section 4: Assessment and Wrap up

To be able to evaluate your progress in land cover classification use the following task.

Self-Assessment Tasks

d explain at least five key terminology and concepts of land cover classification.

the fundamental principles of land cover classification and its importance in various fields.

classification techniques in QGIS to categorize land cover types within a specific geographic

e the results of your own land cover classification to identify potential errors and compare it with

see if you are in the right track.

e the accuracy and reliability of your land cover classification results generated using QGIS to

is in an acceptable range or not.

Develop an informative land classification map that shows land cover classification findings to audiences.

Rate your overall proficiency in land cover classification using QGIS based on your responses above as Intermediate

Section 5: Appendix

Here are some of the basic literature on Land cover classification

- Jansen, L. J. M., & Di Gregorio, A. (2004). Land Cover Classification System: Basic concepts, main software functions and overview of the ''land system''approach. *Developments in strategic landscape monitoring for the Nordic countries. Nordic Council of Ministers of Environment. ANP*, *705*, 64-73.
- Di Gregorio, A. (2005). Land cover classification system: classification concepts and user manual: LCCS (Vol. 2). Food & Agriculture Org...
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- https://www.directionsmag.com/article/1428.
- https://doi.org/10.1016/j.ejrs.2022.03.002.
- https://doi.org/10.1016/j.isprsjprs.2016.03.008.