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GOSTEAM Hands-on Activity Template *(Inquiry-based)*

Title:

Ecological Risk Assessment and Satellite observations

Short Description (Max 500 words):

During this scenario, students will become familiar with the use of satellite data to characterize the spatiotemporal distribution of anthropogenic disturbances to the physical environment and the ecosystems. The scope is to address different geospatial concepts that are mainly laying on the concepts of pattern recognition, spatial clustering or dispersion and spatial dependency and autocorrelation. These terms might seem complex or difficult, however, they consist of some fundamental pillars of the Geo-related fields.

Keywords (Up to 5):

Land-Use changes, Ecological sensitivity, Spatial patterns

Information about the Implementation

Age and language of the students:

	9-12	12-15	15-18	18+
Language: Greek — Age:	☐	☑	☐	☐

Number of Lessons – Duration (per lesson):

Number of Lessons: 1 Duration per Lesson: 45’

Subjects:

For which subject(s) the activity is usable, is it an interdisciplinary activity?

- Science ☑
  - Physics ☐ Chemistry ☐ Biology ☐ Geosciences ☑ Environmental ☑ Other ☐
- Technology ☑
- Engineering ☐
- Arts ☐
- Mathematics ☑

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Information about the Scenario

Curriculum and country:

Link of the current activity to the curriculum:

Country: Greece Class: Secondary Grade: 7 - 10

Topic: Land-Use/Landcover changes, Spatio-Temporal patterns

Objectives (Max 100 words):

Description of the learning objectives

Some of the key objectives to be addressed through this activity include:

1) The use of Geographic Information Systems to perform simplified spatio-temporal patterns recognition and assessment linked to landcover changes,
2) To explain these changes in terms of the measured impacts on the Earth ecosystems and overall, the natural environment.

Materials (Max 100 words):

Which resources and materials (software, hardware) are needed?

Material: Search Engines, Satellite Images

Software: QGIS

Spatial concepts, skills, and abilities:

Which spatial concepts and skills are covered by the activity?

Spatial concepts:

Primitives: Identity/Name ☐ Location ☐ Space/Time ☑

Simple: Distance ☐ Direction ☐ Connectivity ☐ Movement ☐ Boundary ☐ Shape/Area ☑ Adjacency ☐

Difficult: Overlay ☐ Buffer ☐ Topology ☐ Coordinate ☐ Map ☑ Scale ☐ Shortest Path ☐ Navigation ☐ Surface ☐ Slope/Gradient ☐ Aspect ☐ Contour ☐

Complex: Interpolation ☐ Map Projection ☐ Spatial Dependency ☑

Other:

Spatial skills:

- [ ] Map literacy
- [ ] Navigation/orientation
- [ ] Estimating distances and directions
- [x] Recognizing and understanding patterns/Understand and identify models of spatial organization
- [ ] Select an ideal location based on the given spatial features
- [ ] Visualization
- [x] Understand and identify spatial correlations/ dependencies
- [ ] Categorize spatial entities/ geographic features and identify hierarchies
- [x] Compare spatial entities and draw analogies among them
- [ ] Identify/determine connections/relations
- [ ] Understanding scale in space and time
- [x] Delineation of spatial regions/ zones based on given features/ properties

Short Description

Navigation/orientation: Finding one's way in unfamiliar environments, interpreting and giving walking and driving directions.
Estimating distances and directions: Measure paths, weighted distances, angles.
Map literacy: Using, interpreting/understanding, learning from, and communicating acquired spatial knowledge from maps, comprehension of geographic features represented as points, lines, or polygons.
Recognizing and understanding patterns/Understand and identify models of spatial organization. Delineation of spatial regions/zones based on given features/properties: Regionalization processes, pattern recognition and clustering identification in the 2d and/or the 3d world.
Select an ideal location based on the given spatial features: Single or multi-criteria siting and optimal areas identification.
Visualization: Visualizing spatial entities from written/oral verbal descriptions, from their 2d or graphical representations or through mental transformations; such as axis rotation or perspective taking.
Understand and identify spatial correlations/ dependencies: The ability to realize, identify and explain patterns, clusters and relevant spatial dependencies.
Categorize spatial entities/geographic features and identify hierarchies: Identify the hierarchical form of data and gradients between spatial entities.
Compare spatial entities and draw analogies among them: Calculate and compare different geometric objects' shapes, area and boundaries.
Identify/determine connections/relations: The ability to identify links and common characteristics among spatial entities and between humans and spatial entities.
Understanding scale in space and time: The understanding of changes/transitions through space and time for different spatio-temporal scales.

Geospatial concepts and spatial abilities documentation (see Section 3.2):
http://www.gosteam.eu/wp-content/uploads/2021/05/GOSTEAM_IO1_A1_final.pdf

Description of the activity in detail

Question Eliciting Activities

Provoke curiosity

Describe ways and materials that teachers will present to their students to attract their attention to the topic investigated.

- *Usually, the most effective way to provoke students' curiosity is by presenting an exciting video or a series of photos*

You can start the activity by asking students:
How much does the broader area around your school has changed the last 30 years?
Or maybe your city boundaries?
How do you think these changes affect the natural environment and our lives?
Explanatory videos for landcover changes monitoring:
https://www.youtube.com/watch?v=-5BTOCZY8qg (Climate variables: Landcover)
https://www.youtube.com/watch?v=957LUMNrzmg (Spotting changes)

Propose preliminary explanations or hypotheses

Formulate the scientifically oriented questions that teachers will present to the students to trigger their engagement in thinking about the topic investigated based on their existing knowledge. Make these questions digitally available and easily usable, e.g., by integrating them in the materials described in the previous step.

It is best to ask these questions in the context of a relative discussion.

Can you imagine how can we quantify and evaluate these changes?
What data we need?

Active Investigation

Plan and conduct simple investigation

Provide the teachers with a specific plan of the investigation that will take place. Offer instructions about the activities they students will need to perform and what kind of materials they may need. Describe ways that the teachers can use to facilitate the students to focus on evidence.

This is the phase in which students are being prepared for the subsequent phase of evidence gathering during observation.

During this step, students may collect evidence regarding the data they need, where to find these data and how they can "translate" these data to valuable spatial information.

What is the difference between land-use and land cover change:
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/land-cover-change
https://oceanservice.noaa.gov/facts/lclu.html

Land-use and land cover change definition, impact and trends:
https://nca2014.globalchange.gov/report/sectors/land-use-and-land-cover-change

The first step is to understand how we monitor these changes!

Land cover datasets are typically based on observations from satellite-mounted sensors. These sensors record the intensity of reflectance of different wavelengths of the electromagnetic spectrum from the surface of the Earth. The raw data are then processed into analysis ready intermediate datasets.

(Source: OECD-Monitoring Landcover changes)

How are these changes categorized?

Single changes or multiple changes events:

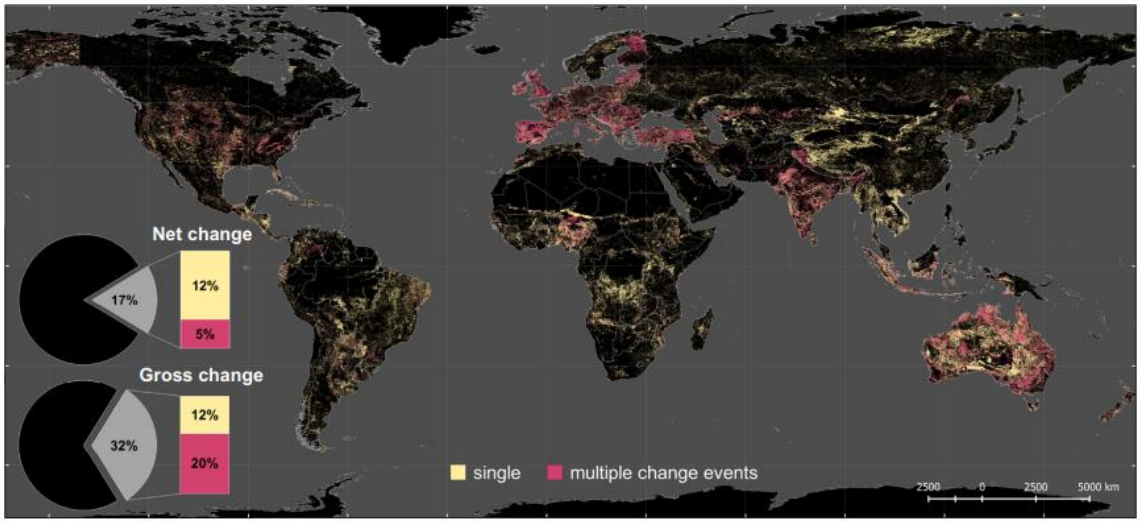


Figure 1: Global extent of single and multiple land-use/cover changes

What does it mean? For one specific area we can simply have a transition of the landcover from forest area to burnt area/bare ground (single change) or a multiple change event if on this area additional changes occurred (i.e. urban expansion etc.)

Changes that are focusing on specific landcover types, for example, forests, cropland and pastures or urban areas!

For example, **Figure 2** presents all forest areas globally and potential loss or gain of forest areas from 1960-2019.

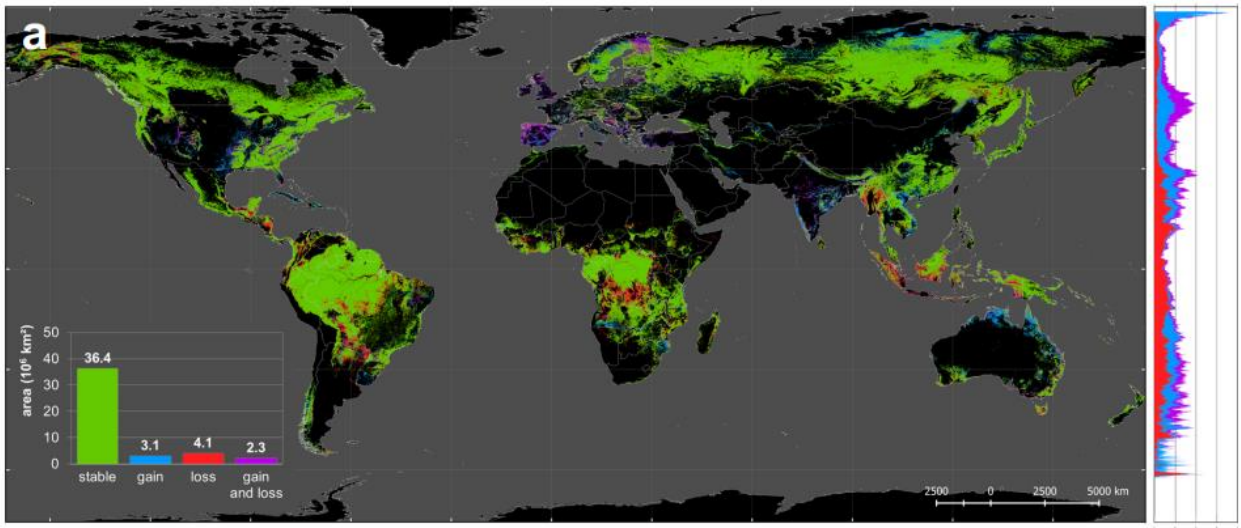


Figure 2: Global forest areas (**green**: stable, **red**: loss, **blue**: gain, **purple**: gain & loss)
Source: https://www.nature.com/articles/s41467-021-22702-2.pdf

Similarly, **Figure 3** presents all pasture/rangeland areas globally and potential loss or gain of this land-use type from 1960-2019.

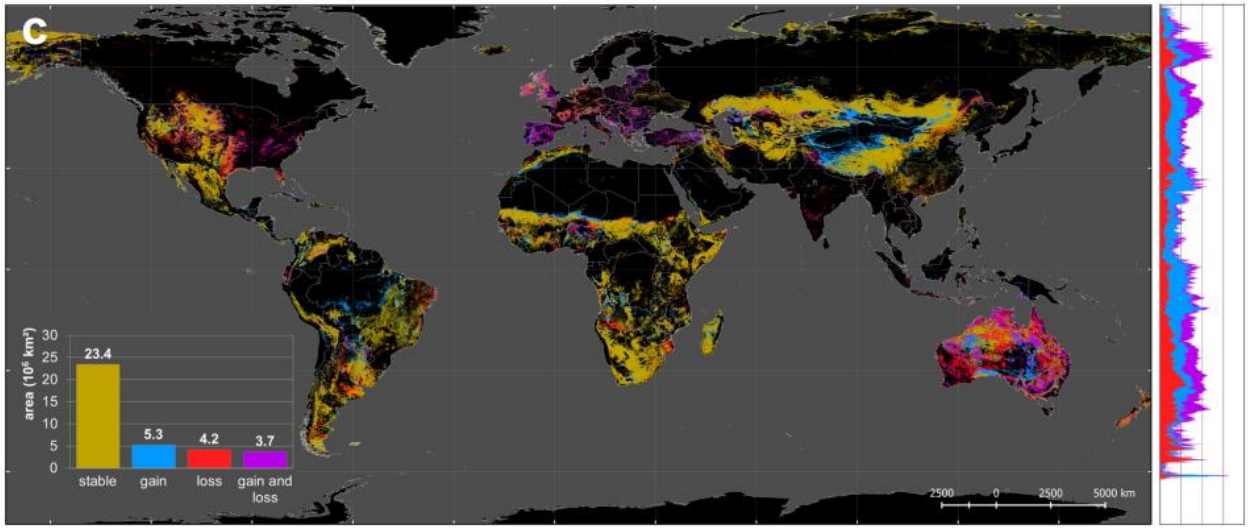


Figure 3: Global pasture/rangeland areas (**yellow**: stable, **red**: loss, **blue**: gain, **purple**: gain & loss)
Source: https://www.nature.com/articles/s41467-021-22702-2.pdf

Observing these Figures (2 and 3), can you identify any specific patterns and trends? Can you explain these trend, potential causes etc.?

Furthermore, we are discussing about loss and gain of specific landcover types. How do we know about these changes?

Keep always in mind that we are analyzing satellite images! And this is "translated" to pixels' values!

Explanation about raster data and satellite images:

https://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/what-is-raster-data.htm

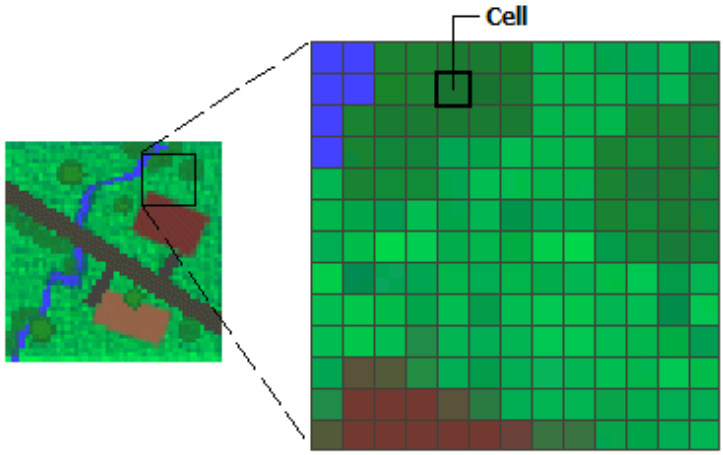


Figure 4: Indicative example of a raster dataset (i.e satellite image) expressed as a grid of multiple cells with different (or the same) pixel/cell values, for example, landcover types

How do we manage and process this type of data?

Using Geographic Information Systems (GIS) and specific GIS-based applications and platforms!

GIS definitions: https://www.esri.com/en-us/what-is-gis/overview

GIS software and platforms (see QGIS):
https://en.wikipedia.org/wiki/List_of_geographic_information_systems_software

Finally, why do we monitor landcover changes and what is the impact on the natural environment and ecosystems?

Land cover change is the best measure available to monitor pressures on terrestrial ecosystems and biodiversity. These changes generally occur slowly, but they are associated with declines in species diversity and populations and can have a major impact on ecosystems and climate (see Figure 5).

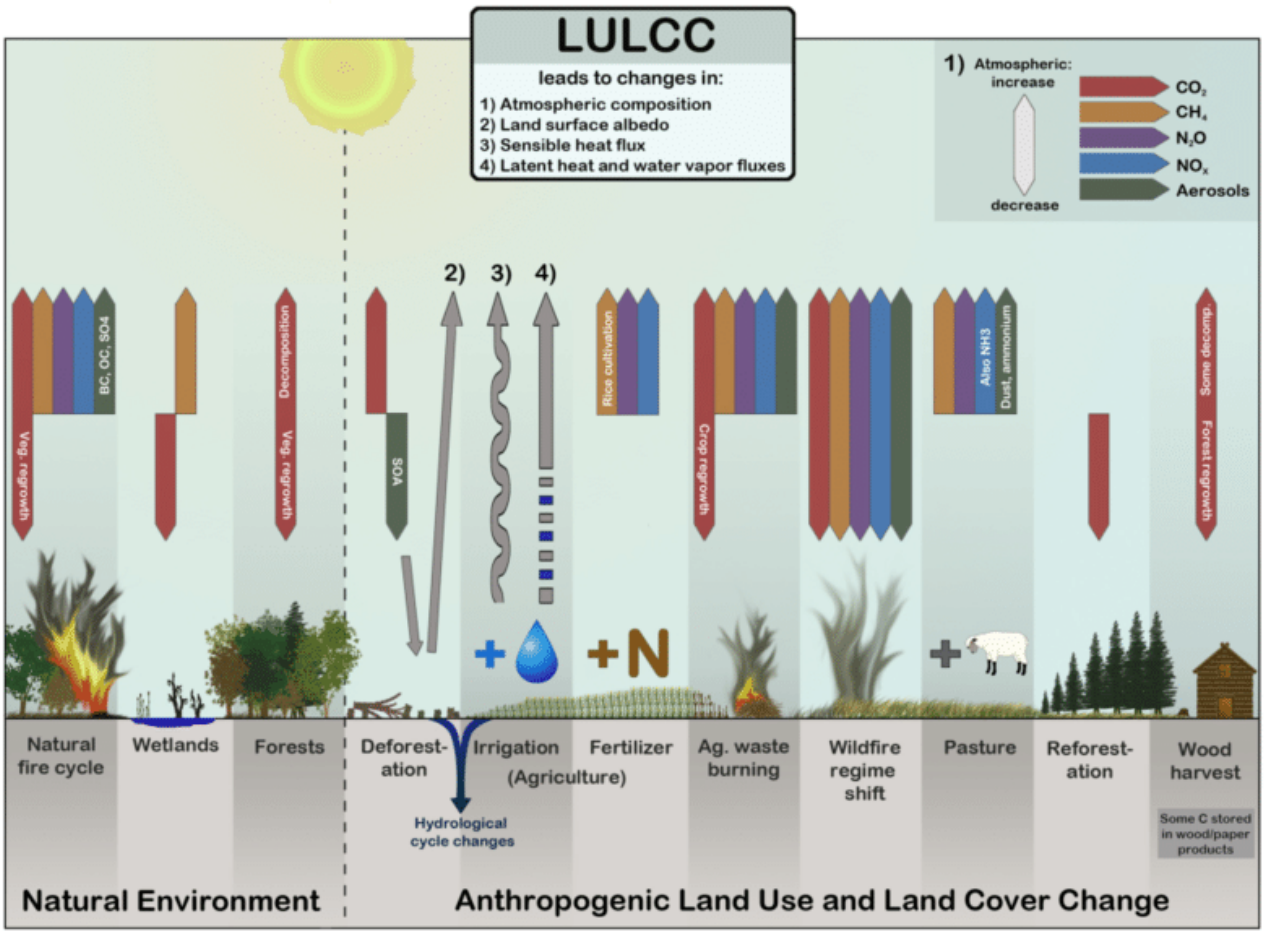


Figure 5: A schematic illustration of the climate impacts of land use and land cover change
Source: https://www.researchgate.net/figure/A-schematic-illustration-of-the-climate-impacts-of-land-use-and-land-cover-change-See_fig4_307841349

Creation

Gather evidence from observation

Students can work in groups of two where each member of the group is responsible for:

1) Data collection (maps, spatial data etc.) and reporting
2) Data interpretation and analysis

Before we begin, students have to download and install QGIS platform!

QGIS Platform Download (version 3.18.1)

https://qgis.org/downloads/

Download landcover data (CORINE 1990 and 2018)

https://land.copernicus.eu/pan-european/corine-land-cover

The selected resource (e.g., a simulation, an experiment, an animation, a graph, or other exhibit of similar nature) must provide students with an opportunity to collect evidence addressing the scientific questions presented in previous stages through direct or indirect observation.

It is recommended to introduce group work at this stage. Guide the teachers to divide students in groups, each of which will be facilitated by the teacher to formulate and to evaluate explanations to the scientific questions based on the collected evidence.

Preparative steps

1. Download CORINE data

Visit the following website and Register (top right corner)

https://land.copernicus.eu/pan-european/corine-land-cover

Figure 6: Copernicus hub webpage for Corine landcover data

After you finish your registration, by activating your account you can download any Corine dataset you want!

When you click on a specific Corine dataset, you can visually inspect the data as also, you can download the Corine data (in .tif format) and load them on QGIS for further processing.

You can also zoom-in to your data and inspect the color differences based on the different landcover types (see Figure 7)! But how these colors are translated???

Click on the legend button and see the different colorized landcover categories!

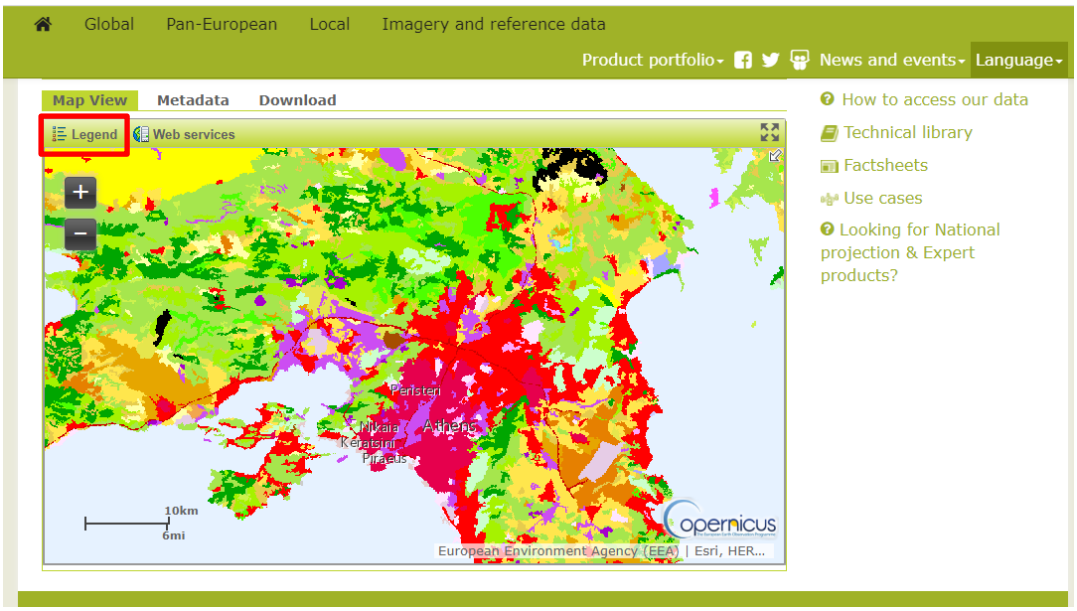


Figure 7: Map view (zoom-in) of the Corine 2018 to the broader Attica region

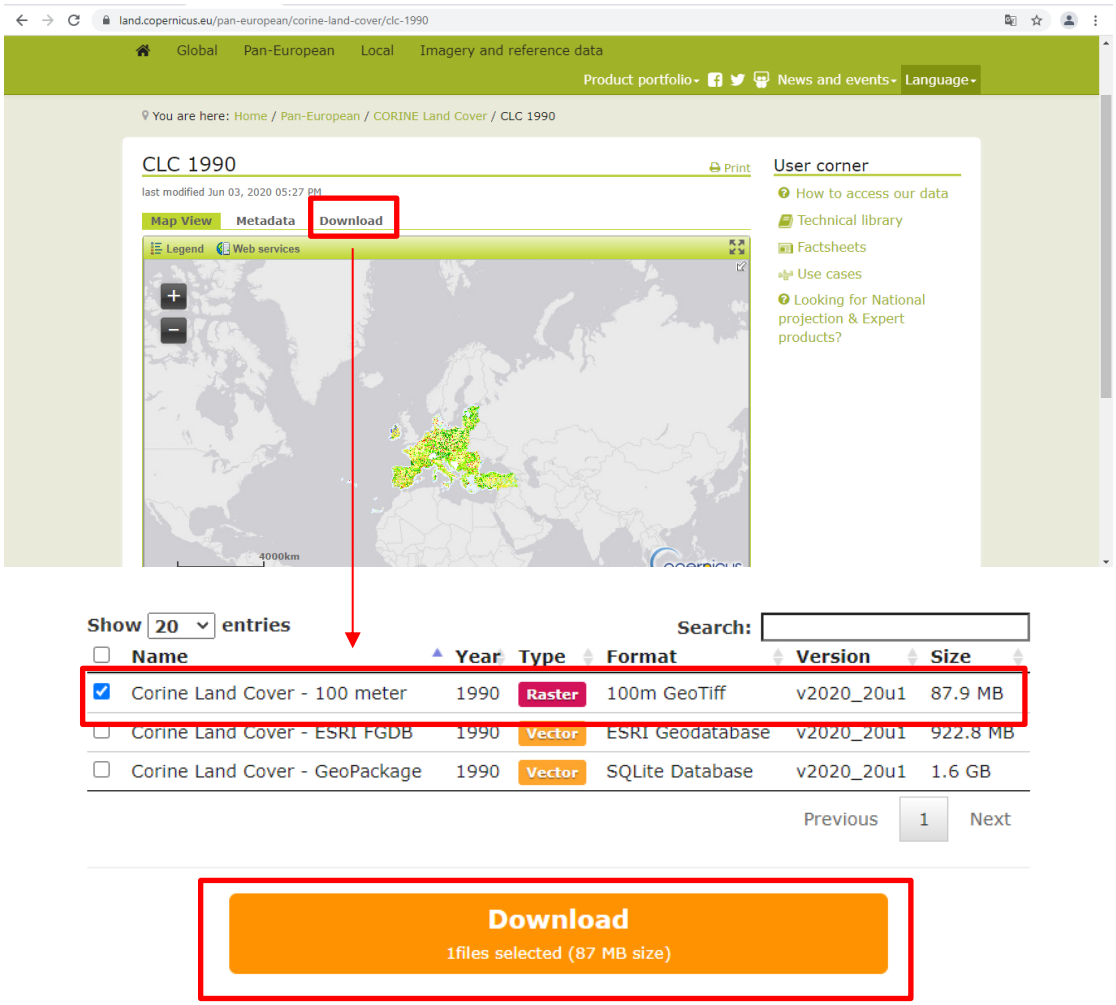


Figure 8: Corine data visualization and download button

2. Download and install QGIS 3.18.1 version: https://qgis.org/downloads/

Some technical guidelines considering the tools (QGIS Platform) we will use during this Activity!

Load data: In general, data can be loaded in four ways. The first way (Figure 5-selection 2) is to use the Layer > Add Layer menu and select the appropriate type of data you wish to load. The second way (Figure 5-selection 1) is to open the Browser panel, navigate to the data you wish to load, and then drag the data on to the map display, or on to the Layers panel. The third way (Figure 5-selection 6) to load data is to enable the Manage Layers toolbar and click on the button representing the data type you wish to load. The fourth way is to locate the data in QGIS Browser, drag to the data, and drop it onto the QGIS Desktop Map Display or Layers panel (Source: https://www.gislounge.com/loading-data-mastering-qgis/).

QGIS Interface

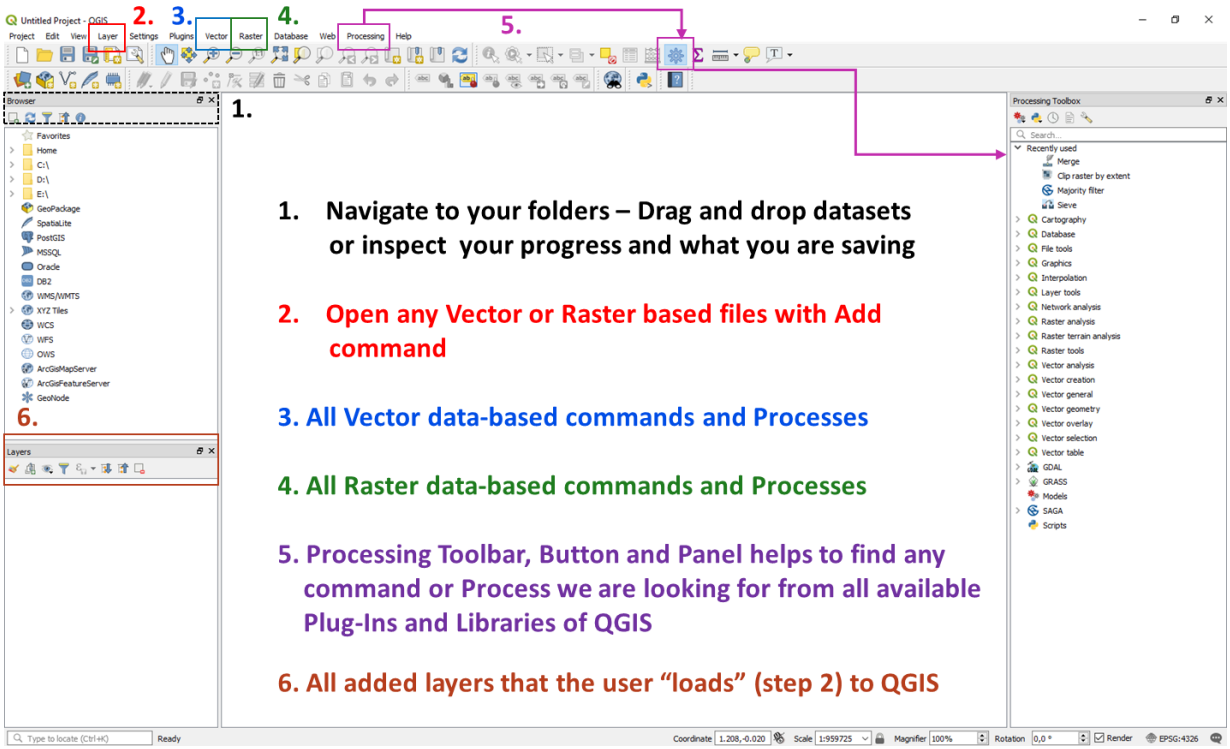


Figure 9: QGIS interface and key functionalities

Step 1 - Based on the above-mentioned instruction you can start with:

1. *During the first step of the Activity, un-compress the Corine compressed file and load Corine 1990 and 2018 data in the QGIS platform (DATA Folder > **U2018_CLC2018_V2020_20u1.tif** and **U2000_CLC1990_V2020_20u1.tif** files).*
2. *Use the Main toolbar (top of the screen) -> Layers -> Raster Layer -> Navigate to your folder and load **U2018_CLC2018_V2020_20u1.tif** and **U2000_CLC1990_V2020_20u1.tif** files.*
3. *Change layout colors using the instructions on the Document folder (**How use ESRI CLC raster files in QGIS**).*

4. *Zoom in to the area of your interest (See Figure 10)*

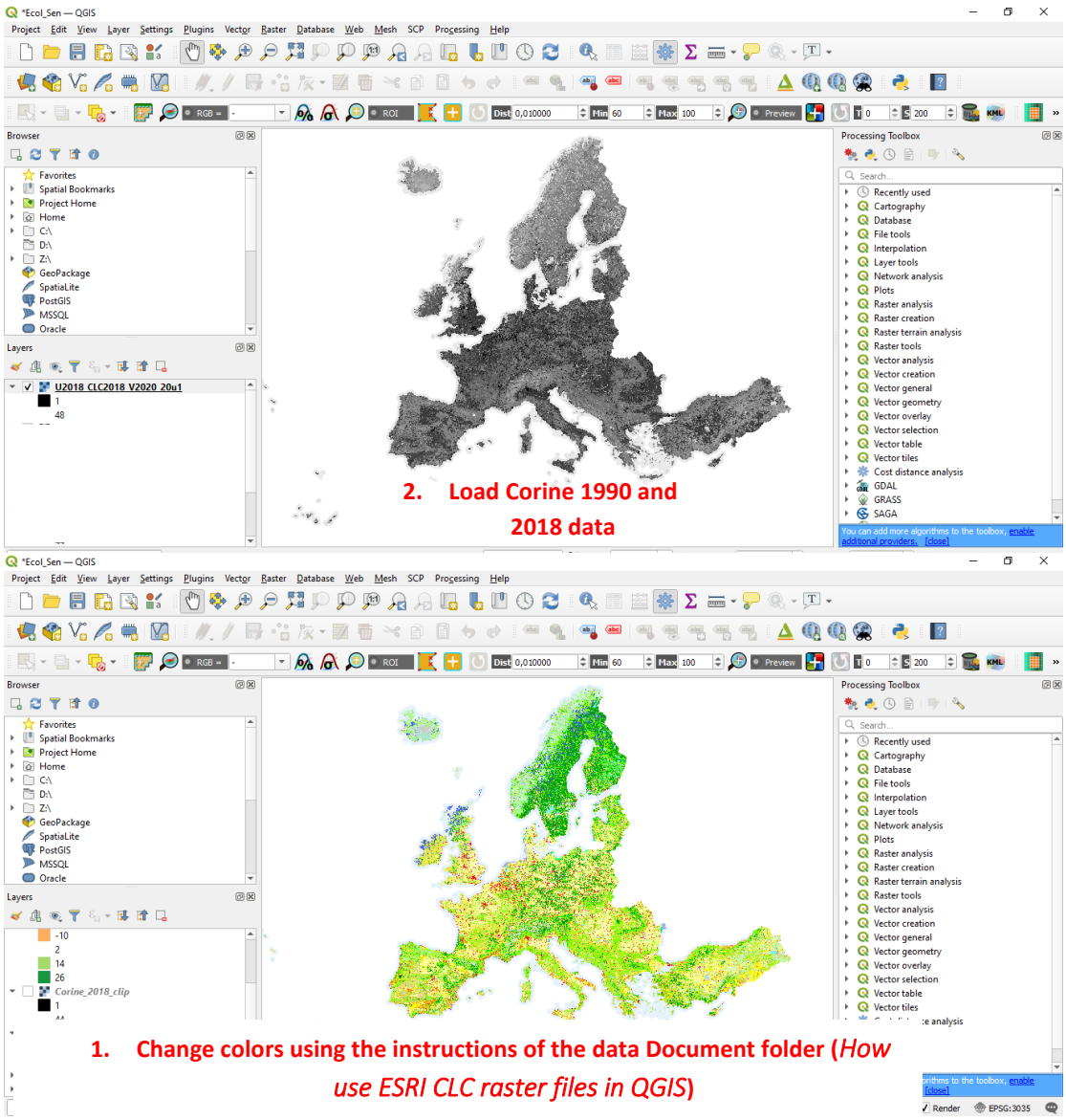


Figure 10: Load Corine data and change Symbology colors

After you zoom-in to a specific area (e.g. Attica region in Greece), you have to clip your files (Corine 1990 and 2018) to this specific extent (we clip our data in order to have a better visual inspection of the landcover changes as also, to reduce the computational effort needed due to the files' size!).

For clipping our data, we need a specific raster clipping tool. On the main toolbar on the top of QGIS platform use ***Raster > Extraction > Clip Raster by Extent.***

Follow the Steps described in **Figure 11**!

Important note: *"Clip Raster by Extent" means to clip our image (raster) to the boundaries that are visible on our screen when we zoomed-in to our area of interest!*

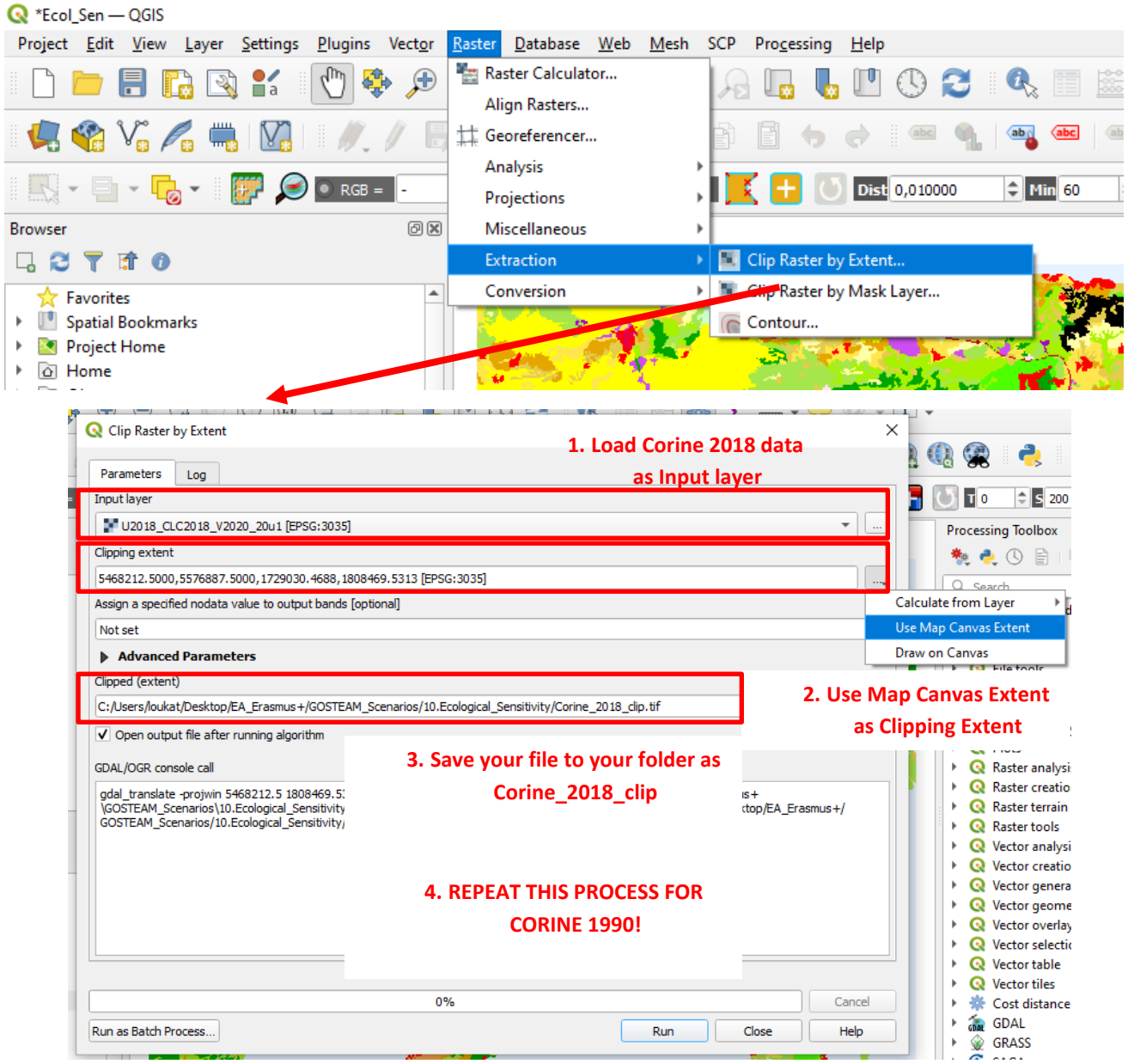


Figure 11: Clip your Corine 1990 and 2018 data to a specific area of interest

After you clip your data follow the instructions *on the Document folder (**How use ESRI CLC raster files in QGIS**)* in order to adjust the colors of your clipped image. *See Figure 12!*

Overlay the Corine 1990 and Corine 2018 images. Do you see any differences????

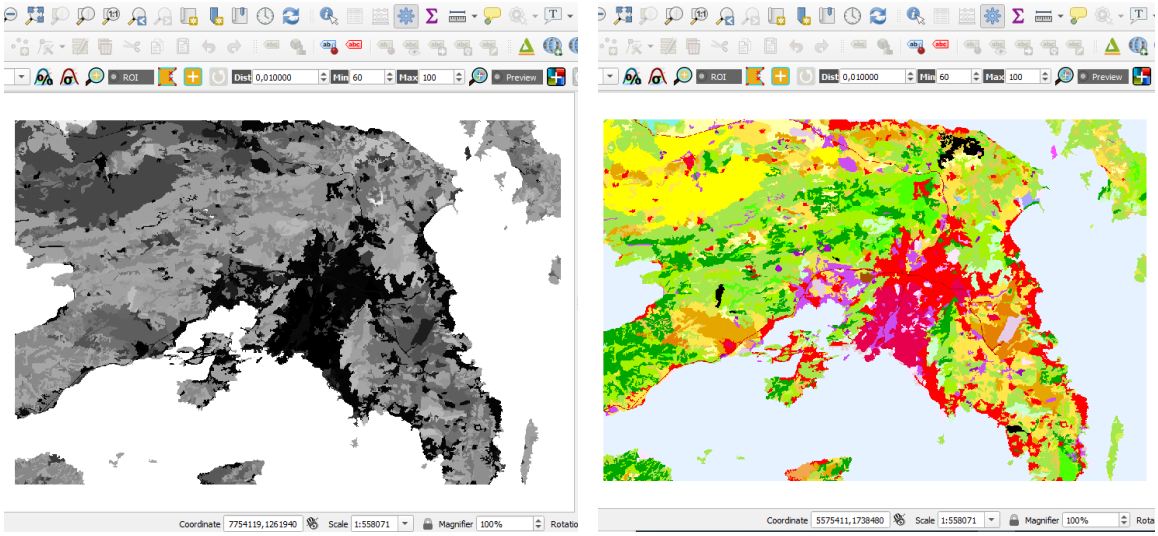


Figure 12: Clipped Corine image to a specific region extent, grey scale colors (left) and colorized (right)

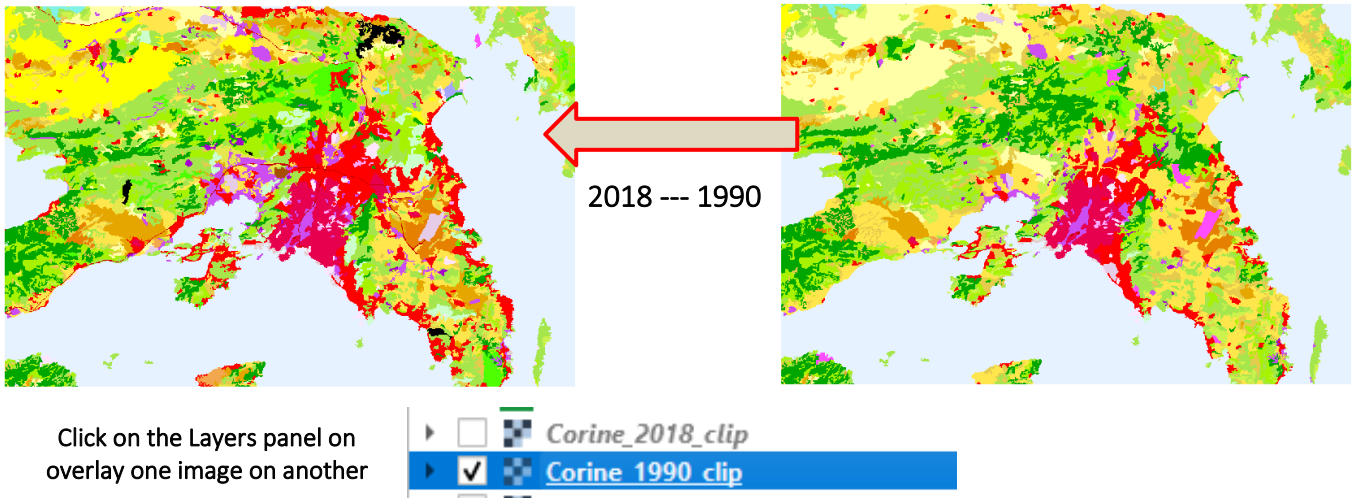


Figure 12: Corine differences between 1990 (right image) and 2018 (left Image)

BUT HOW WE QUANTIFY THE DIFFERENCES AND THE TRANSITION FROM ONE LAND-USE TYPE TO ANOTHER???

We have to simply compare each pixel's value from Corine 1990 and 2018 and we have to do this for all pixels! To succeed that, we need a specific tool called ***"Raster Calculator".*** Using this tools we can run through different math operations and conditional statements between different rasters (images).

A simplified measure to compare pixels' values is by subtracting the pixel values of Corine 1990 from Corine 2018!

Hence, open Raster Calculator via the main toolbar > Raster > Raster Calculator and type:

```
"Corine_1990_clip@1" - "Corine_2018_clip@1"
```

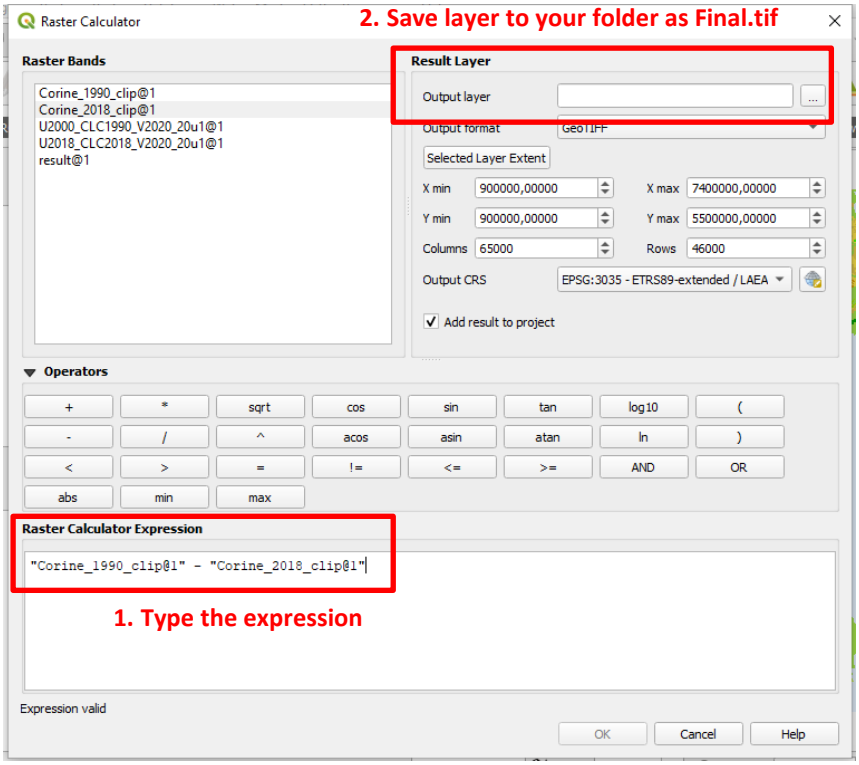


Figure 13: Raster calculator tool for Images processing

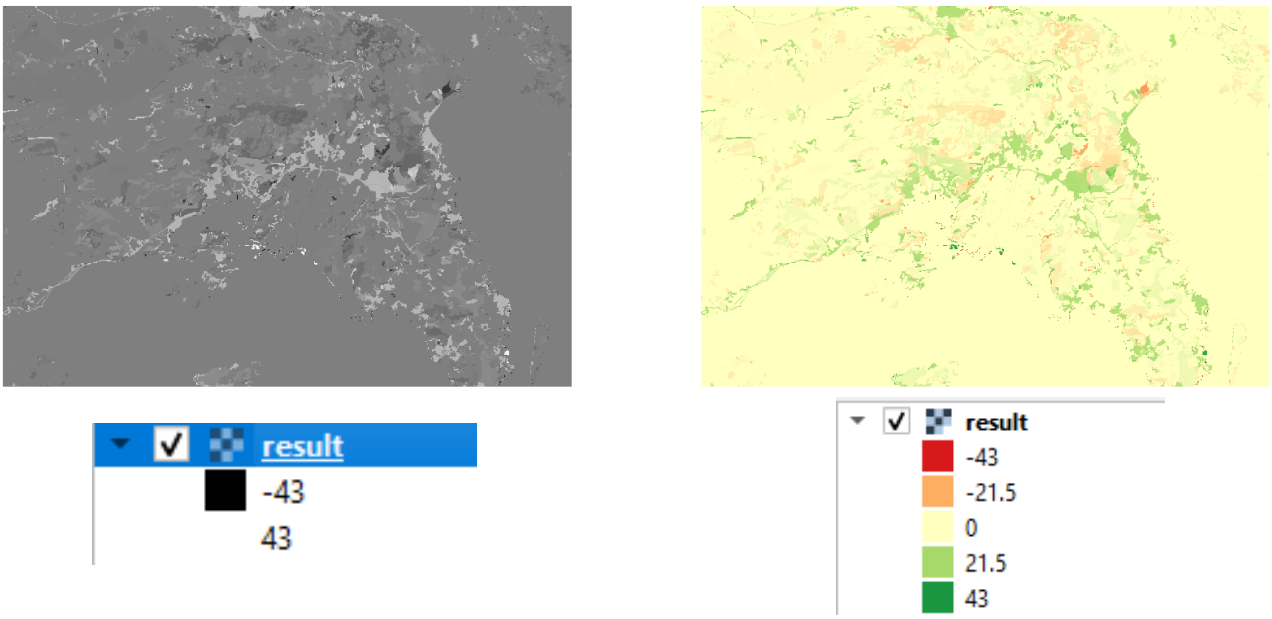


Figure 14: Final results in grey scale (left) and colorized (right)

In order to change the Final.tif colors you can double-click on the Image name on the Layers panel > Symbology > Render type: Singleband Pseudocolor > Classify > OK (Figure 15).

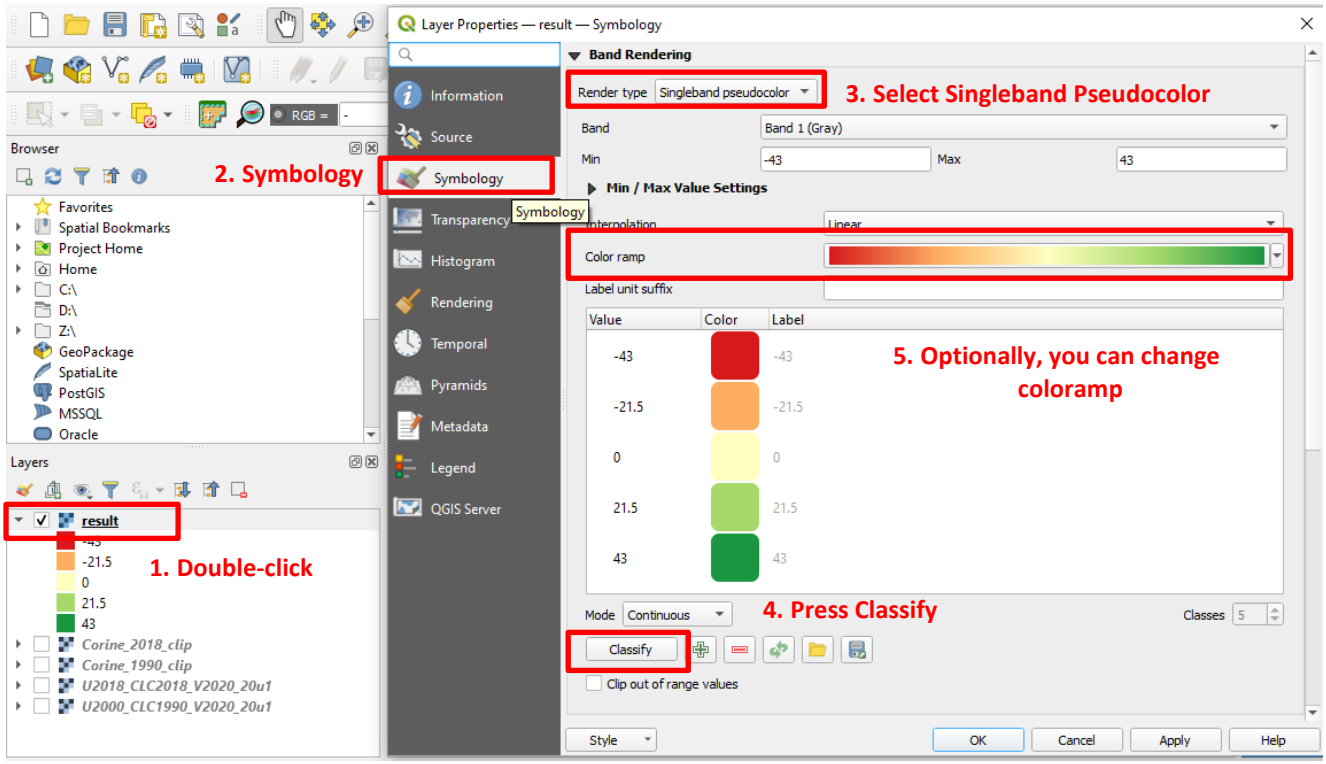


Figure 15: Change colors on your resulted Image

Inspect your results, the colors and the min-max values!

Discussion

Explanation based on evidence

Encourage your students to provide correct explanations for the topic(s) investigated.

Describe ways and they can use to this end and give them directions how to discover them.

You can start a conversation related to the results explanation by asking:

What do you think that the minimum and maximum values indicate?

Increased minimum values point out a potential landcover transition from urban areas to forest areas or water surfaces!

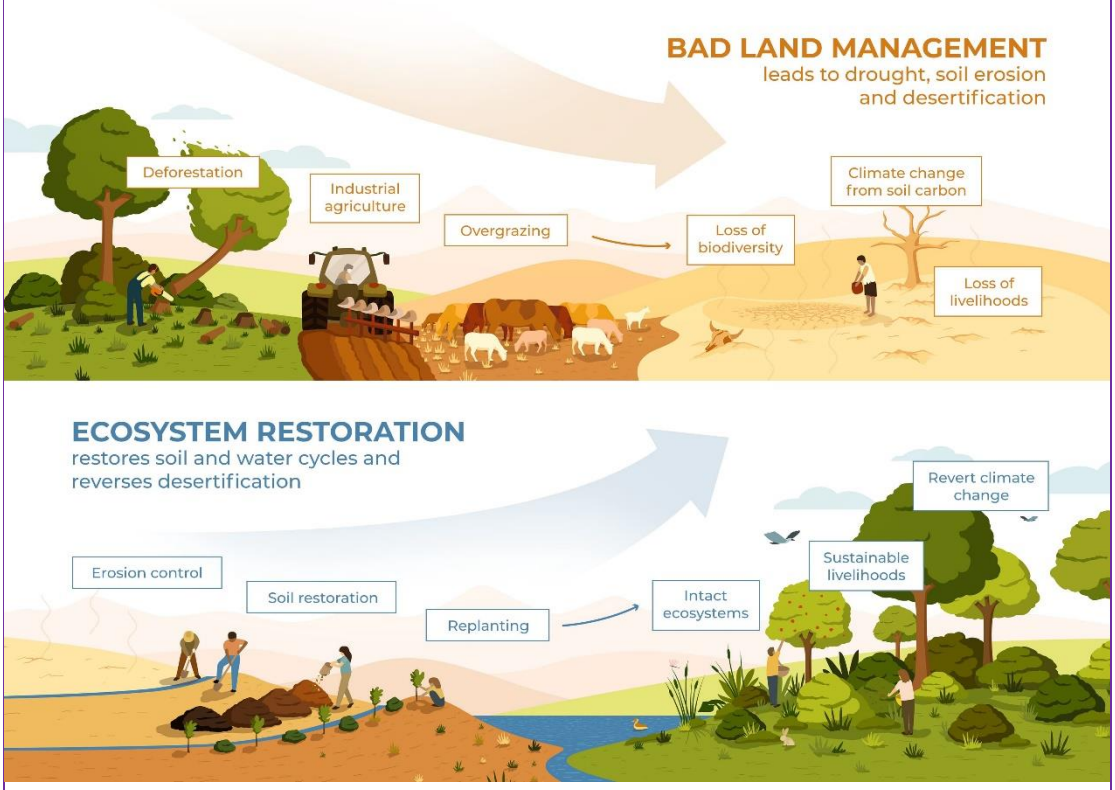
On the contrary, increased positive values highlight transition patterns from forest areas or water surfaces to urban areas!

Ask students if they can identify the broader area that their home is located! What changes do they see? Can they remember any specific examples of green areas near their homes that changed to urban areas?

Consider other explanations

Direct teachers to facilitate the student groups to evaluate their own explanations in the light of alternative explanations, particularly those reflecting scientific understanding. Illustrate examples they can use and give them instructions how to locate them.

On the area they studied how the ecosystems are affected and what measures do they propose to protect them?



Source: https://medium.com/age-of-awareness/making-the-most-of-the-un-decade-on-ecosystems-restoration-bioregional-regenerative-development-484119e763ee

Support material (Table 2 and 4):

https://onlinelibrary.wiley.com/doi/full/10.1111/rec.13035

Support material - Sparing or sharing:
https://community.rspb.org.uk/ourwork/b/science/posts/sparing-or-sharing?CommentId=7df3451c-3880-4025-bec8-9a8424e158a1

Finally, you can ask students “What if we want to monitor landcover changes before 1990? What could we do and is it possible?”

The answer is that yes, we can! But, it is a difficult task because we have to search for satellite images that are not processed at all! Hence, we do not know about the landcover types, only band combinations of the satellites' sensors wave spectrums. This means that we have to process these images in order to extract landcover types and remember, for a limited spatial coverage (and not the entire Europe)!

Reflection

Communicate explanation

Guide teachers to facilitate each student group to reflect on the previous experiences and to produce a report with its findings, presenting and justifying the proposed explanations to the other groups and the teacher.

Provide content which the teacher can use to help the students to get familiarized and to become efficient in scientific writing.

Ask from students to write a short report by incorporating the scope of this Activity (the objective?), the data and the tools they used, what methodology (QGIS tools) and to present their results in the form of maps (images) by reporting the differences on the landcover types from 1990 to 2018.

They can also report all potential adjustments they made (clipping areas) or any future research they want to consider (add landcover data for year 2000, 2011 etc.).

The report outline could be in the form of:

i) Introduction,
ii) Relevant information about monitoring landcover changes and how they affect the ecosystems,
iii) Study area and Data used,
iv) Methodology,
v) Results and Discussion and finally,
vi) Conclusions and Future work

Follow-up activities and materials

Describe and direct the user to any follow-up activities or materials that can be used to wrap-up the hands-on activity.

These could include appropriate learning assessment and/or reminder materials (e.g., quizzes, games, other user-friendly tests), hints for further activities etc.

Land-use and water management game:

https://games.bwdh2o.org/home/selectyourgames

Earth observation Poster:

https://ckan.ssec.wisc.edu/dataset/2016-earth-observation-day-poster

EO Browser Change detection examples:

https://apps.sentinel-hub.com/eo-browser/?zoom=10&lat=30.6338&lng=30.2879&themeId=HISTORICAL-NORMAL-MODE&visualizationUrl=https%3A%2F%2Fservices.sentinel-hub.com%2Fogc%2Fwms%2Fa2b6e4cb-6aa9-4a6e-a38f-b24ea4e2a1f4&datasetId=AWS_LOTL1&fromTime=2019-08-11T00%3A00%3A00.000Z&toTime=2019-08-11T23%3A59%3A59.999Z&layerId=4-NDVI

(Select add to compare both images from different years and go to compare tab)

Sustainable contact

Loukas Katikas (lkatikas@ea.gr)

References (if any):

OECD (2018): Report on "Monitoring Landcover changes"

Ward D. and Mahowald N. (2014): Potential climate forcing of land use and land cover change, Atmospheric Chemistry and Physics;14(8), DOI:10.5194/acpd-14-12167-2014

Winkler et al. (2021): Global land use changes are four times greater than previously estimated, Nature Communications;12:2501, https://doi.org/10.1038/s41467-021-22702-2

ESRI Overview: What is GIS

Assessment (if any):