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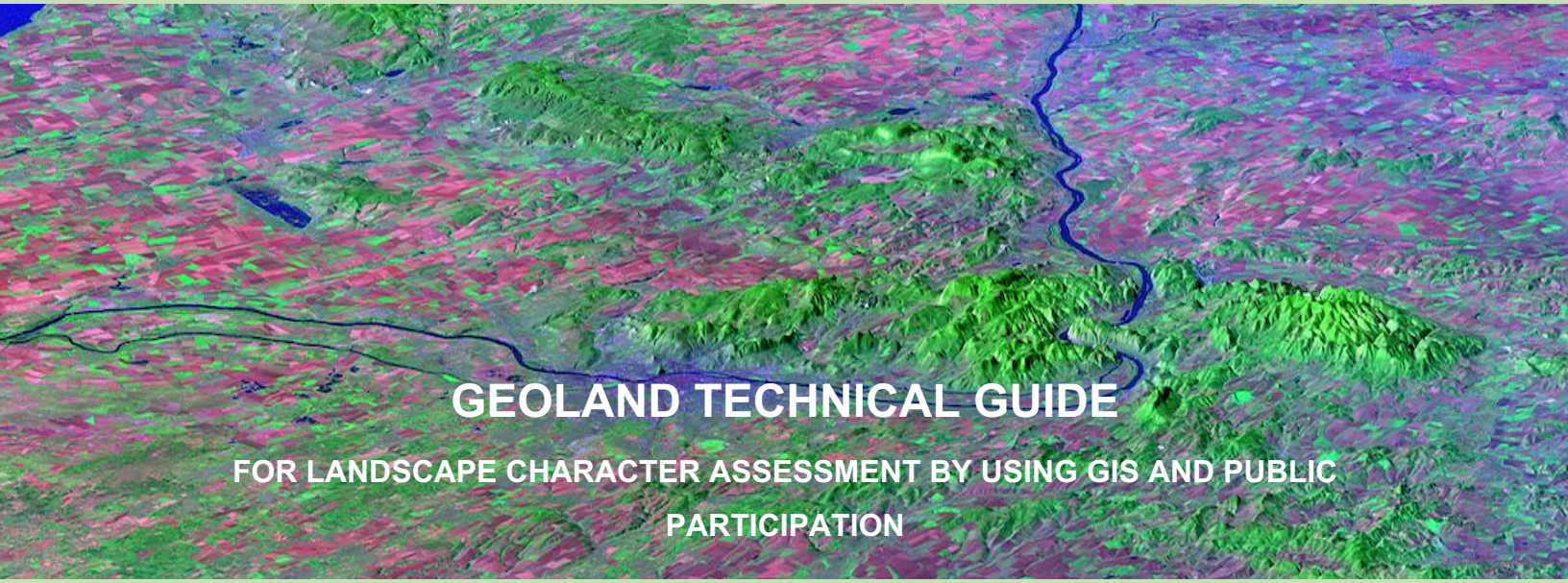
Digital Educational Geoinformatic Methodologies for Monitoring Landscape – GEOLAND

Annex of Intellectual Output 1



GEOLAND TECHNICAL GUIDE

FOR LANDSCAPE CHARACTER ASSESSMENT BY USING GIS AND PUBLIC PARTICIPATION

March 2022

ABOUT

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PROJECT BACKGROUND

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Under the new Green Deal, decision makers in the 21st century are faced with the responsibility of addressing increasingly complex environmental challenges to protect the ecology and, thus, the public health. This protection does not stop at country borders so it is inevitable that it has to be transnational. Considering also that efforts dealing with only one aspect may reveal or create other issues, the need for holistic and trans-disciplinary methodologies based on the integration of different scientific approaches and technological tools is considered to be crucial.

In the above context, the vision of the GEOLAND project is to establish and promote the effective participation of Higher Education (HE) institutions in monitoring actions leading to influencing decision-making for the implementation of the European Landscape Convention (ELC). Ultimately, the GEOLAND project seeks to develop a learning path for HE students and their professors so that they are able to exploit their (existing or new) knowledge for the assessment, management and protection of European landscapes with significant environmental and socio-economic value. Specifically, this relates to the use of Landscape Character Assessment (LCA) for given “NATURA 2000” sites across Europe, highlighting the capabilities of state-of-the-art geoinformatic technologies (Earth Observation – EO and Geographic Information Systems – GIS) and innovative scientific approaches like citizen science, employed in pedagogies. Through the “remoteness” characteristic of the specific technologies and tools, the GEOLAND project also addresses the digital skills and readiness of HE students in the (post-)COVID-19 pandemic era.

Some of the main objectives of GEOLAND project can be listed as follows:

- Introduce HE students in environmental science, and particularly regarding the implementation of ELC.
- Support the teaching and learning about landscapes as a multidisciplinary subject area in HE institutions.
- Empower HE students and professors in the principles of citizen science (mainly the public participation) for decision-making and employing environmental policies.

- Promote in academic society the benefits of using state-of-the-art geoinformatic technologies (EO and GIS) and geospatial freely distributed / open access data (e.g. Copernicus satellite imagery data) in landscape-related studies.
- Highlight the integration of EO, GIS and public participation approaches in relevant studies.
- Help HE students to recognize “NATURA 2000” landscapes as an essential component of people’s surrounding environment.
- Synthesize and integrate readily communicable findings suitable for awareness raising and policy negotiations in terms of landscape management and protection.
- Assist students and professors to assess, compare and evaluate the different methodologies that each country uses in the implementation of ELC.

The expected results of GEOLAND project are the following:

- General guidelines for LCA based on the combination of public participation (experts’ and/or students' opinions by questionnaires, personal interviews and new people-centric applications) with geoinformatic technologies.
- A web-based GIS platform sharing multi-temporal geospatial data (derived from GIS and EO-based monitoring techniques) for pilot European “NATURA 2000” landscapes.
- Environmental policy suggestions emphasizing the importance of the assessment, management and protection of landscapes.
- An “Online Gallery” presenting the HE students’ work their findings and relevant cartographic visualizations (maps).
- Communication and digital educational strategies aiming to support the transfer of subject-related knowledge to students and broader educational communities (Article 6 of the ELC).

The GEOLAND project will reinforce European Policy in landscape conservation as well as national and local actions regarding the implementation of the ELC. In particular, its transnational perspective is going to help students and professors to comprehend the problems that arise from heterogeneous applications of ELC and suggest solutions to these problems. The outcomes of the project will provide essential recommendations for

policy makers and maintain a dialogue with relevant stakeholders, open for future development. Citizens will also gain a voice on local issues and tailored advice on important issues regarding landscape assessment, management and protection. The overall methodology of the project is eventually expected to constitute a road map for relevant studies not only in Europe but also worldwide.

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1. General

As the Handbook *("Educational Handbook for Monitoring European Landscape")* – which this Technical Guide provides support to – mentions, there are five methodological stages Fig.1) for Landscape Character Assessment (LCA) by using GIS and public participation:

(a) Purpose definition
(b) Desk-based data collection
(c) Field-based data collection
(d) Classification
(e) Overall evaluation

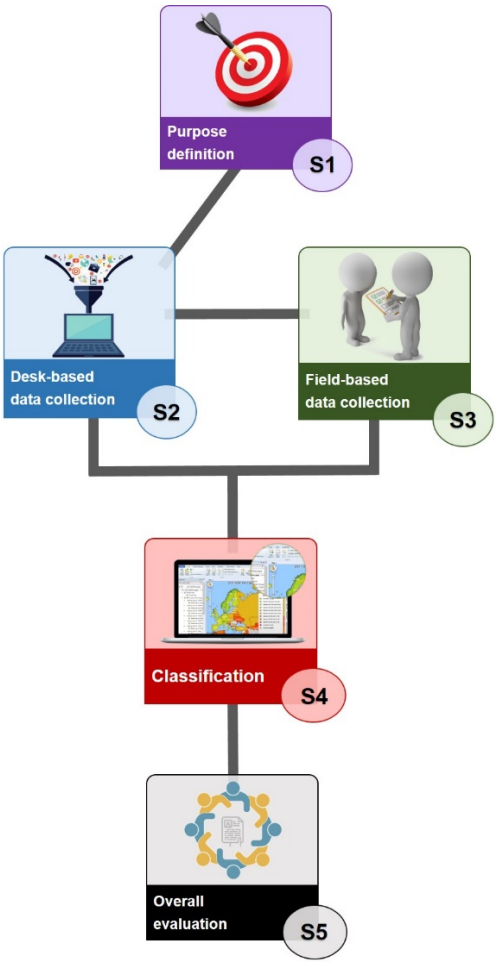


Figure 1: Methodological stages of Landscape Character Assessment framework.

2. Technical guidelines

In the context of GEOLAND project, the above methodological stages are recommended to include the following steps in practice:

(a) Purpose definition

- Professors *select* an existing[1] "NATURA 2000" site to be used as landscape under investigation (Fig. 2).

Figure 2: Example of "NATURA 2000" site in the Mediterranean island of Crete (Greece).

** The "NATURA 2000" site investigated for each country (Belgium, Spain, etc.) under GEOLAND project has already been selected by the relevant project partner.*

(b) Desk-based data collection

- Students *collect* and *manage* geospatial datasets within a GIS environment for generating and representing the natural and socio-cultural landscape indicators

[1] The boundaries of the "NATURA 2000" sites across Europe have been defined by the European Union (EU) Member States in collaboration with the European Environment Agency (EEA).

(Fig.3). Indicatively it is recommended to generate the following four common indicators:

- Land use: *Download* the CORINE Land Cover XXXX (the latest version) dataset from the "Copernicus" Land Monitoring Service (https://land.copernicus. eu/pan-european/corine-land-cover). It is in vector format (shapefile) including polygon features. Then, *clip* the dataset to the appropriate extent based on the selected landscape.

- Landforms: *Download* the appropriate EU-DEM vX.X (the latest version) dataset tile from the "Copernicus" Land Monitoring Service (https://land.copernicus. eu/imagery-in-situ/eu-dem). It is in raster format (grid) with spatial resolution of 25 m. Then, *clip* the tile to the appropriate extent based on the selected landscape. Finally, based on the resultant DEM (Digital Elevation Model), *generate* the dataset of landforms presenting the relevant classes/categories.

  ** There are open-source GIS softwares programs (such as SAGA GIS) providing algorithm-based tools for the automatic generation of landforms; otherwise a manual generation can be achieved in any GIS software by using mathematical expressions and classifications (such as those proposed by A.D. Weiss in http://www.jennessent. com/downloads/tpi-poster-tnc_18x22.pdf).*

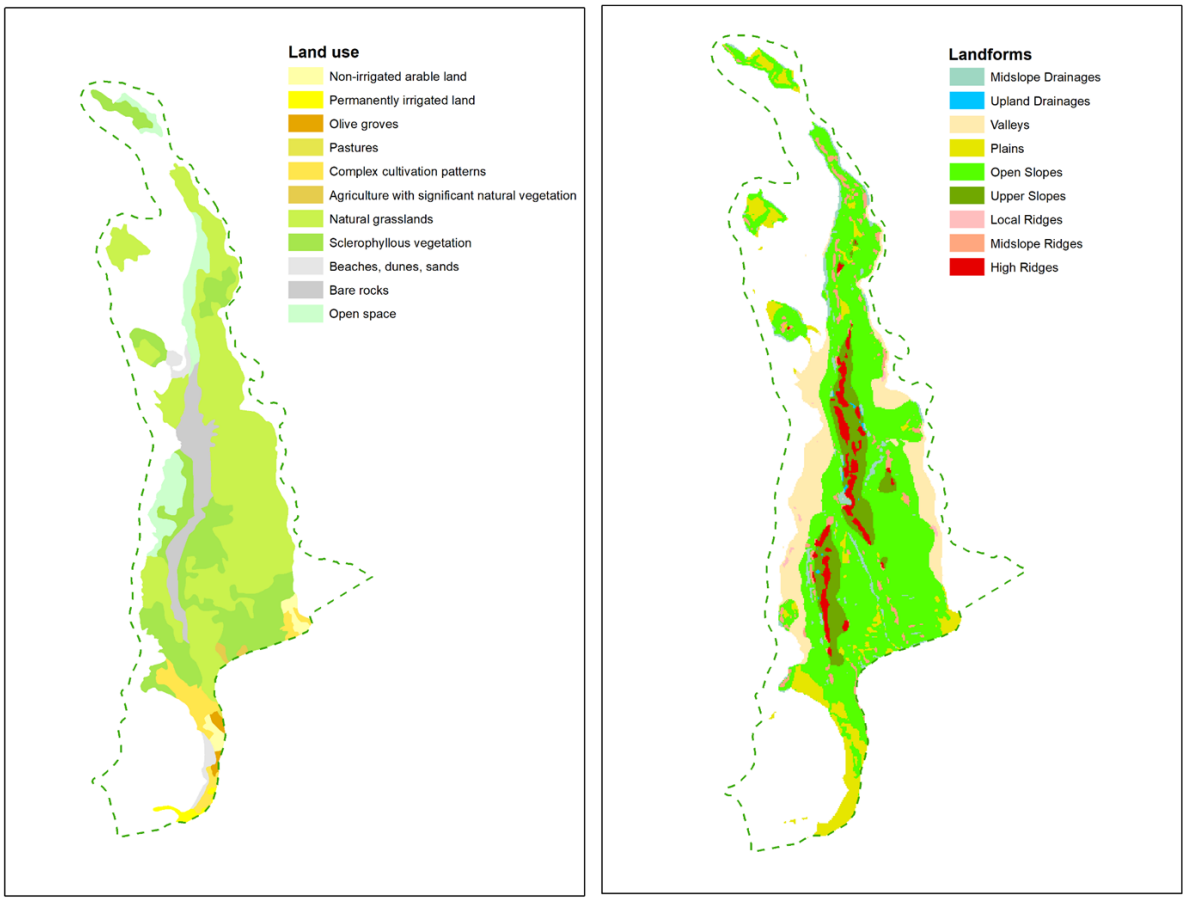
  ** Any Digital Elevation Model (DEM) of better accuracy (i.e., lower spatial resolution) provided by other regional/central administration data source can be used instead of the aforementioned.*

- Vegetation density: *Download* the appropriate Landsat-5/7/8 and/or Sentinel-2 satellite images from the United States Geological Survey (USGS) (https://earthexplorer.usgs.gov/) and/or "Copernicus" program (https://scihub. copernicus.eu/), respectively. They are in raster format with spatial resolution of 30 and/or 10 m, respectively. Then, *if it is necessary*, *correct* them atmospherically and radiometrically, as well as *unify* them in order to build a full image mosaic covering the total extent of the landscape. Finally, *estimate* the normalized difference vegetation index (NDVI) by using the near-infrared (NIR)

and red visible bands of satellite imagery data. The output ought to be a grid with values ranging between −1 and 1 to indicate lack of or dense vegetation, respectively. By *classifying* this output, the relevant vegetation density classes can be presented.

** There are various Remote Sensing software programs (such as SNAP, ERDAS, ENVI, etc.) providing tools for automatic estimation of NDVI; otherwise a manual estimation can be achieved in any GIS software by using the relevant equation (for instance among others, presented in the study of Polykretis et al. 2020, https://doi.org/ 10.3390/rs12020319).*

- Hydrology: Datasets representing the main rivers and streams of a country *are usually provided* (free, in most of cases) by the relevant national/regional/central administration offices and/or geo-portals. They are in vector format including line features.



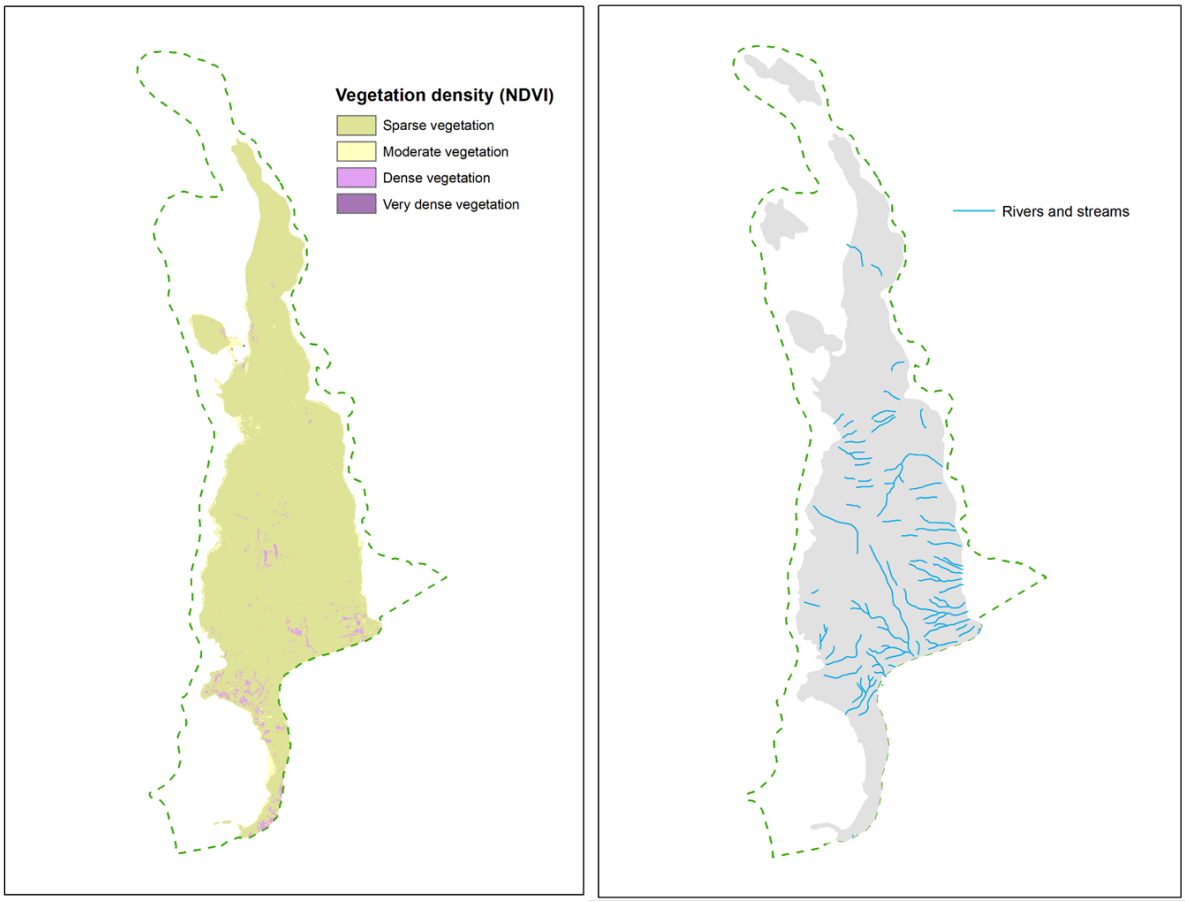


Figure 3: Examples of desk-based collected datasets for the four common landscape indicators.

** Different from and/or more than the above four desk-based landscape indicators can be generated and examined by the students. They can also include natural and socio-cultural indicators of soils, population density, pollution (e.g., noise, air), protection, etc. The amount and type of indicators selected is highly dependent on the availability of the relevant geospatial datasets.*

(c) Field-based data collection

- Professors and/or students *visit* the landscape under investigation (field study) to have a first "contact" with and glance at it; then, back to the University for discussion.
- Professors and/or students *discuss* their visit, back at their educational base.

- Professors and/or students *determine* a vector grid consisting of polygons/squares with certain dimensions (Fig. 4).

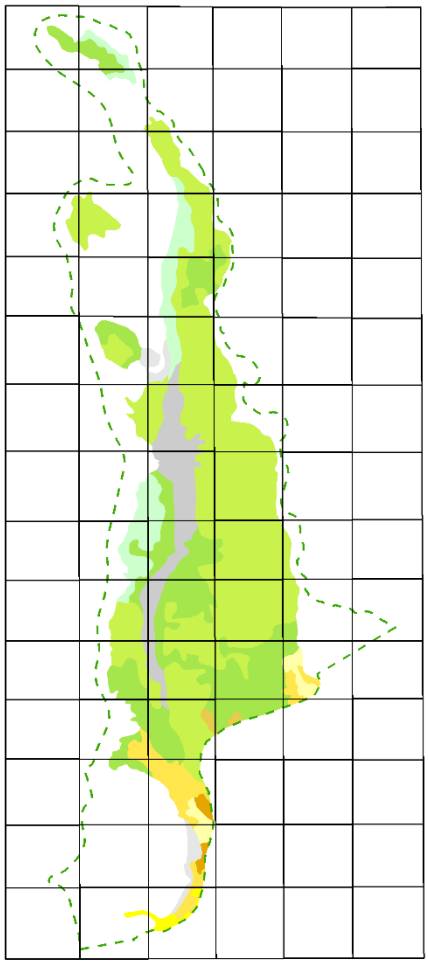


Figure 4: Example of vector grid determined for a landscape under investigation.

- Students *go back* to the landscape area in order to *implement* the main field work study by using the GEOLAND Survey app.

  The app enables:

  - recording (automatically) of the user's location
  - providing different types of questions to be responded
  - taking and uploading pictures of a place
  - using the widely known basemap of Google Maps®

- incorporating the determined vector grid

The following questions are suggested; they can be categorized into two different types:

(a) Rating questions of the following form:

- By choosing a score mark (e.g., from 1 to 5, indicating from negative to positive meaning), rate the specific landscape site/spot according to each of the below:
  1. **Naturalness**
  2. **Smell regime**
  3. **Sound regime**
  4. **Memories**

(b) Open questions of the following form:

- Personal background *(all the information collected will be kept strictly confidential and will be used only for statistical reasons)*
  1. Gender?
  2. Age?
  3. Residence place?
  4. Property (student/surveyor or resident/visitor)?
  5. E-mail (optional)?
- Related to landscape
  1. Why do you like (or not) this landscape?
  2. Do you think it is important/acceptable/understandable that this is a "Natura 2000" protected landscape?
  3. What are the current land use activities in the area?
  4. Are there any animals? Which and how much?
  5. Vegetation regime (bare, grass, herbs, cultivated in %)
  6. What would you do with this landscape?

** Given that the responses to the open questions are not rated, they will be just exploited for qualitative analysis, data collection and general discussion.*

** Students are free to add more questions.*

Students *respond* to the questions and the other requirements of app. Then, they *offer the ability* to the common public (including residents, visitors/tourists, and people passing by) *to respond* as well.

** In general, all the respondents ought to add rating value marks on base map about specific landscape sits/spots (ideally, within the polygons of determined vector grid) and clarify their selections via the open questions. In order to typify all these, pictures presenting the sites/spots also ought to be added and uploaded.*

(d) Classification

** In the GIS environment, the datasets collected under the desk-based work ought to contain two vector layers (land use and hydrology) and two raster layers (landforms and vegetation density).*

- Students *consider* the land use as the basic layer for spatially determining (delimiting) the different landscape character areas.
- Students *overlay* manually on the land use layer the remaining three layers, and…

  ** The manual overlay can be achieved by adjusting with the visual properties (mainly, the transparency) of the raster layers of landforms and vegetation density, and by placing the linear vector layer of hydrology on the top.*
- and…they should *recognize* the different landscape character types (Fig. 5).

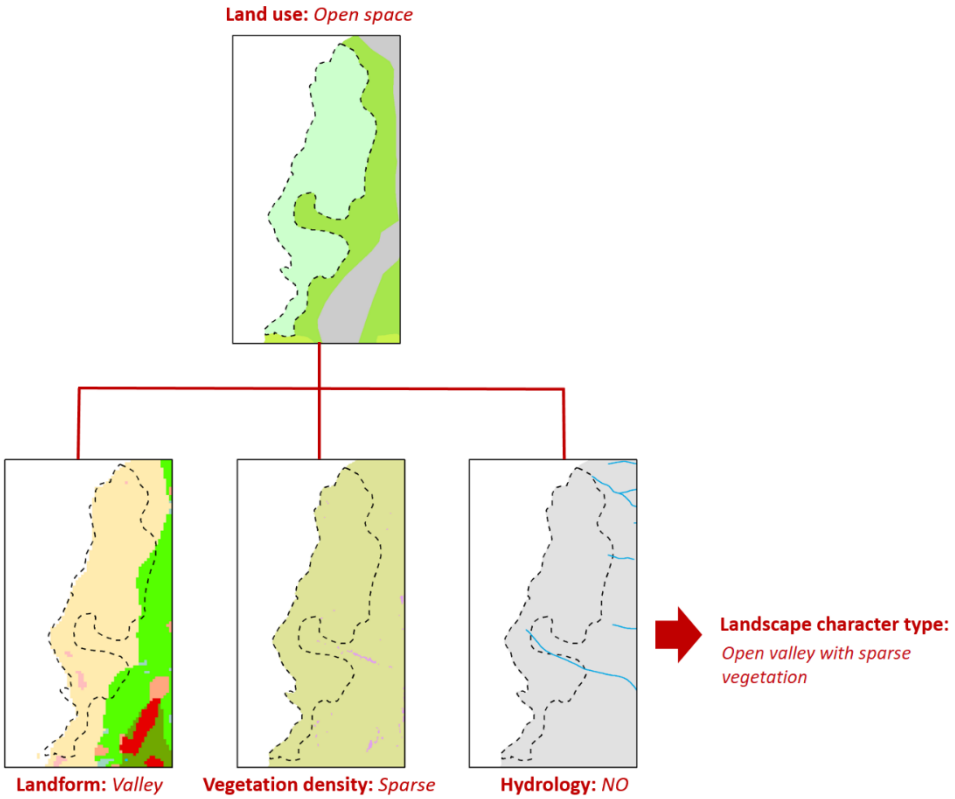


Figure 5: Example of recognition of the landscape character type for a specific landscape character area (land use feature).

- Students *assign* the recognized landscape character types, in either alphabetical format (e.g., "Open valley with sparse vegetation", etc.) or numerical (e.g., code "1", etc.) format, to the landscape character areas (land use features). Therefore…
- …students *create* the vector layer of landscape character types (i.e., the land use layer presenting the new descriptions/codes from its new attribute table field of character types).

(e) Overall evaluation

- Students *assign* a certain score (e.g., from 1 to 5, indicating from negative to positive meaning) to each landscape character type according to their knowledge for the landscape under investigation, their beliefs, their initial discussion with the professors, etc. *("expert" evaluation)*.

- Students *download* the data collected under the field-based work (recorded points are added as a vector layer in the GIS environment) and *start processing*. The processing includes the following:

    1. If they have more than two responses in a vector grid cell (polygon/square) for a specific rating question, they *calculate* the mean value (sum of rating scores divided by the amount of respondents).
    2. They *calculate* the total field-based score for each grid cell (polygon/square) by summing all the individual mean values from the different rating questions *("public" evaluation)* and normalize (Field based result = ([Total field based score] * 5) / 20**) the final results to the value of five (5) so results are in accordance with the desk-based results.

    ** Each cell of the vector grid (polygon) ought to have as many attribute table fields as the rating questions are, plus the total score.*

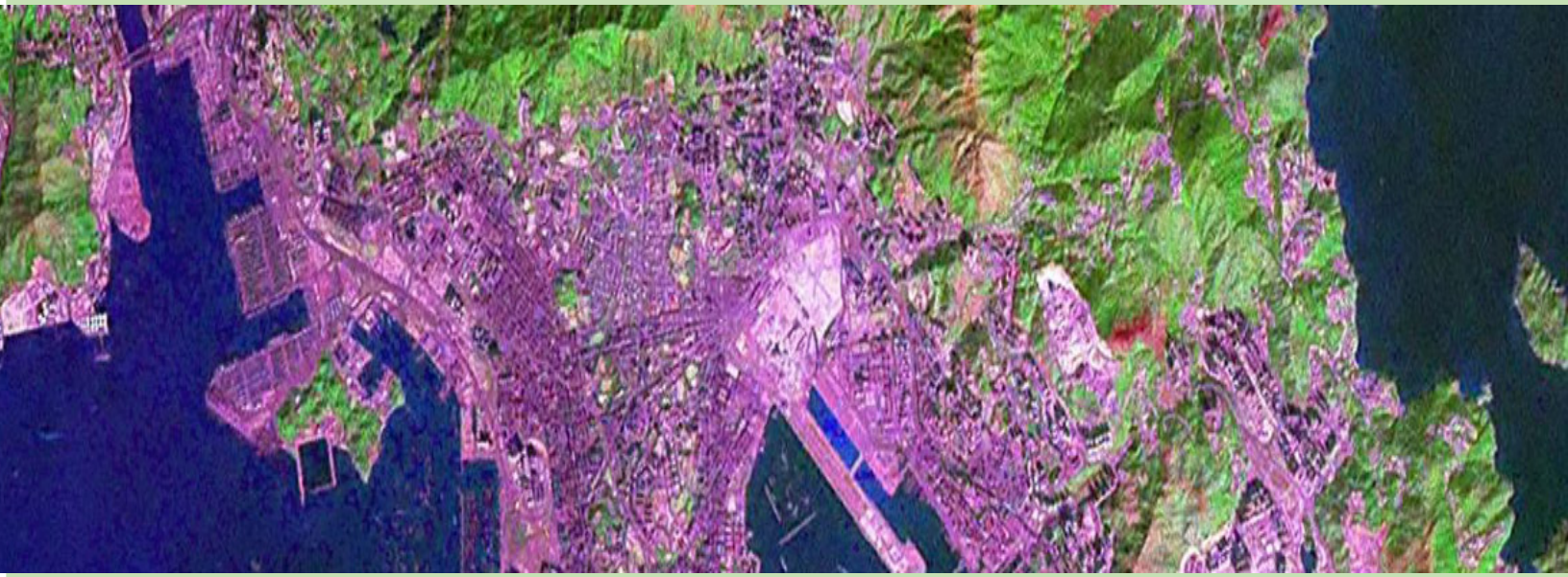
    *** The value of 20 is assigned only in case of the analysis of four (4) field based analysis factors with maximum ranking score, for each factor, the value five (5).*

- Students *convert* the two resultant layers of evaluations ("expert" and "public") from vector (shapefiles) to raster format (grids).
- Students *calculate* the overall evaluation score by using the mathematical expression:

    *Overall evaluation score = ["expert" evaluation result] * [weight1] + ["public" evaluation result] * [weight2]*

    ** Professors / Students are free to assign the values of the weights.*

    ** The values of the weightings can be between the range 0-1, aiming to result in a total weighting of 1; the assignment of a higher value for the weight of "expert" evaluation is recommended (e.g., 0.6 for weight1, and 0.4 for weight2).*



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