FuseGI - "Cooperation for fusing skills on Cloud-based Open GeoInformatics: Innovative Environmental Management"

IO4

Training toolkit

Final Version 30/07/2022

AGREEMENT NUMBER: 2019-1-FR01-KA203-062767

Coordinator: UNIVERSITE D'AVIGNON

Leading Organisation of IO4: DIMOKREITIO PANEPISTIMIO THRAKIS (DPT)

Participating Organisations in IO4: DIMOKREITIO PANEPISTIMIO THRAKIS, EE4S, INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES, MAISON REGIONALE DE L' EAU, INTERNATIONAL HELLENIC UNIVERSITY, AVIGNON UNIVERSITY, HELLENIC FORESTS PARTNERSHIP (OLYMPOS PC)

INTELLECTUAL OUTPUT 4 FINAL REPORT CREATION

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SUMMARY

AVIGNON UNIVERSITE, in cooperation with DEMOCRITUS UNIVERSITY OF THRACE, EE4S, INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES, MAISON REGIONALE DE L' EAU, INTERNATIONAL HELLENIC UNIVERSITY and HELLENIC FORESTS (OLYMPOS PC), has undertaken the implementation of the project entitled "***FuseGI – Cooperation for fusing skills on Cloud-based Open GeoInformatics: Innovative Environmental management"*** under the Agreement n° 2019-1-FR01-KA203-062767 with Agence Erasmus + France, within the **"2019 Round 1 KA2 - Cooperation for innovation and the exchange of good practices KA203 - Strategic Partnerships for higher education"** Call.

More precisely, this intellectual output aims to address all call priorities described in the Application Form, meaning: Open education and innovative practices in a digital era (Horizontal) by creating a set of free novel courses in a public platform including hands on training and self-evaluation techniques, Tackling skills gaps and mismatches (HE) since it follows the assessment of market needs (IO1) and educational gaps (IO2) covering an important part of the draft curricula, and Supporting individuals in acquiring and developing basic skills and key competences (Horizontal) since it actually provides an environment for this though 9 courses and 4 specialized practical case studies that were created responding in actual market tasks.

This report presents the design and implementation of Intellectual Output 4 "Training toolkit" highlighting the innovative means adopted in methodological approach to create tangible and transferable results in the Geographic Information (GI) field.

This IO aims to deliver a pilot training program, covering basic theory required for geospatial data in order to introduce students to the practical part, freeware (software) training, providing extra (free) training material, tests, self-evaluation, course and project evaluation forms, including also hands on practice, podcasts and practical case studies among others. The training toolkit was formed trying to reach a variety of people, of different academic levels and fields.

The IO4 builds upon the findings of IO1 using field review to locate the gap between the actual and desired market skills, IO2 assessing the gap in GIS education in the participating countries and setting a draft curricula, and IO3 researching the available cloud-based platforms, VLE applicability and opportunities for building interactive novel courses, with complementarity and not overlapping.

The findings from the course creation, the course and platform testing and evaluation, of IO4 on diverse subfields of the environmental sciences were used as input data in the core of IO5 with the ability to upgrade and expand them.

ABBREVIATIONS

GI	Geoinformatics
GIS	Geographic Information Systems
IO	Intellectual Output
VLE	Virtual Learning Environment
ICT	Information communication Technology

1 Introduction

1.1 Overall objectives, implemented activities and results of the FuseGI Project

The FuseGI consortium had identified a gap between what the academic world provides towards its teachings and what the environmental labor market requires in terms of Geographic Information Systems (GIS) skills. Skills that are nevertheless essential for environmental and health risks management.

The goal of this consortium was to conduct an in-depth study (qualitative and quantitative) on the subject and then to design, develop and make available an adapted online tool to fill this GIS skills shortage to students and young professionals for the needs of the labor market.

The FuseGI consortium is composed of experts in the fields of water management, forestry and health (from both the academic world and the private sector) as well as computer scientists capable of setting up and sustaining online training tools. It was therefore relevant from the perspective of the project. ERASMUS+ through the projects "Cooperation in innovation and exchange of best practices" was the ideal and most relevant framework to achieve a project in this direction.

The overall objectives of the FuseGI project were:

1. Establishment of a transnational, interdisciplinary and open collaboration between academia and industry within the EU to address the training needs in GIS for better functionality and better environmental and health risks management.
2. Knowledge transfer and bridging of gaps in academic and professional experience of the partners in the use of GIS applications in different key environmental and health sectors.
3. Improved professional skills in the use of open GIS platforms for interdisciplinary collaborative data processing.
4. Development, implementation and validation of a virtual learning environment (VLE).
5. Design of the architecture of an adapted curriculum, corresponding to the needs of the market world, for master's degree courses.

Five transferable, innovative and tangible outputs:

IO1: Research and field review
IO2: Draft Curricula
IO3: Learning platform
IO4: Training toolkit
IO5: Final Curricula

1.2 Interrelations of project Intellectual Outputs

The concept and the methodological approach of the FuseGI project allowed strong interactions between all intellectual outputs. Each intellectual output represent an innovative, transferable and tangible result also as a necessary step for the project finalisation.

The following scheme (Fig. 1) represent the interrelations and connectivity of the FuseGI intellectual outputs.

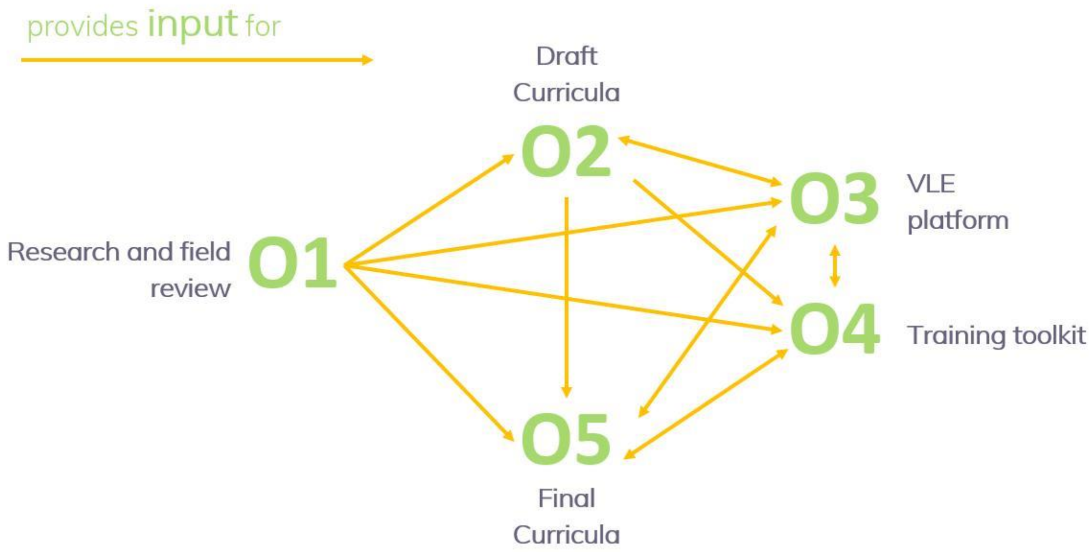

Figure 1 : Scheme of interrelations of FuseGI intellectual outputs

The IO4 builds upon the findings of IO1 using field review to locate the gap between the actual and desired market skills though GIS systems and curricula revision, questionnaires. It also incorporates IO2 assessing the gap in GIS education in the participating countries and setting draft curricula, lectures and courses. IO4 and IO3 co-development and creation provided the basis through researching the available cloud-based platforms, VLE applicability and opportunities for building interactive novel courses. All IOs are really important standalone procedures, necessary to map gaps, needs, tools and methods, in a market with advancing needs as they owed in a study-based project, and all are fused with complementarity and not overlapping points

1.3 Scope and Objectives of Intellectual Output 4

The scope of this Output is a multiple one since it actually creates a solid tool to be adopted by institutions, enterprises and individuals willing to learn or deepen their knowledge on GIS. FuseGI within this project wills to develop a program toolkit in order to present the program features, methodology, contents and delivery mechanisms.

The toolkit was designed to assist the user to articulate a clear understanding of the context of FuseGI and actively engage themselves to learning process and accomplish courses as well as enhance the operational capacity of FuseGI project to deliver successful GI and Environmental Management knowledge.

All training material/ references are uploaded at the project's platform and will be updated. Training coordinators, curriculum developers, and trainers can all use the Toolkit in preparing and presenting GI and Environmental Management training as was stated in the AF.

Though, through the solid findings of the previous IOs and the partnership's will to create something timeless as a basis for further development this toolkit was even developed to a complete set of courses, able to be included even in graduate and master programmes with an equivalence of 7 ECTS. What's more, the entire tool is based on freeware (QGIS) supporting openness in its entity using explicitly creative commons rights, open data, open courses and free books and manuals in the PowerPoints and in the supplementary material and operating through an open VLE platform.

The consortium's effort surpassed the foreseen working man-days but created more than a platform, but a self-tutoring tool for scholars and businesses, free from rights, easy and accessible.

1.4 Structure of Intellectual Output 4

The content of this report is organized as shown below.

1st section describes introductory elements for the IO4

2nd section delineates the methodological approach adopted for the IO4 production

3rd section details on each course separately

4th section details on each case study

5th section highlights the importance of the findings delineating innovation, tangibility and transferability

1.5 Intellectual Output 4 Sub tasks

Sub task
Strategic design to apply the FuseGI vision using open software
Consulting professionals on teaching methods and desired outcomes for building a curriculum
Revise existing available training and teaching material
Definition of access criteria, the participants profile, entry requirements and selection process
Setting courses' and case studies' criteria (format, duration, rights, training, testing, evaluation)
Testing VLE platforms compatibility and extensions
Determination of Desired Cognitive skills and course thematic structuring
Creation of the courses (ppts, podcasts, accompanying documents, training material, tests and evaluation forms)
Selection and formatting of real-life practical case studies

Testing of toolkit within the platform
Launching the training toolkit
Review period (internal and external)
Launching the revised final version of the toolkit

2 Methodological approach

In order to effectively train the users of the platform, 9 online courses are available on the platform as well as 4 case studies to put into practice the theoretical explanations.

The FuseGI VLE platform currently offers 9 courses to bridge the gap between the knowledge of graduating students and the expectations of professionals for the job. Classes may sometimes contain small exercises to help understand the lesson. In addition, a case study is available to implement all the functionalities of GIS and more particularly QGis.

The structure of each course is very similar: we first find an introduction, then a plan defining the different parts of the development, the development in question and then a conclusion and the associated sources. In addition, the language used for the courses is English, as it is universal, it facilitates access to all European users.

2.1 Preparatory phase

After having conceived the Strategic design how to apply the FuseGI vision and how to conform with the AF stating "The tool kit will be organized in several major units. Each unit will be made up of modules which themselves will contain smaller units covering an important component and learning objectives of GI and Environmental Management" we selected using open GIS software and the optimal selection was QGIS based on the availability of a range of add-ons and the compatibility with other software.

Given the recent covid period and the "activation" of distance learning techniques, we consulted professionals on teaching methods and desired outcomes for building a curriculum based on the IO2.

Then we revised the existing available training and teaching material from institution open courses, data providers, QGIS tutorials and tips, and existing exercises in order not to overlap with already accessible material (but to use it as supportive providing links and databases)

In close collaboration with the VLE platform, we defined the access criteria, the inclusivity (e.g. for people with impaired vision), the broad range of participants profile, entry requirements and selection process adopting the idea that the theory that is taught and the information given must be understood by both a graduate of an engineering school and philosophy.

The next step was setting courses' and case studies' criteria (format, duration, rights, training, testing, evaluation). So, for each course, we selected to provide a course summary, the cognitive skills, a podcast for the course presentation, the basic PowerPoint presentation, keywords, sources and literature used, a folder with additional data supplementary material (links, books, databases, exercises), create a short quiz (mostly for self-assessment reasons, not for grading) with multiple takes ability and both a course and project evaluation form.

Then we tested the selected open VLE platform Moodle for compatibility with embedded video and document players safeguarding also inclusion policy.

2.2 Creation of courses, case studies and testing

Based on the Outcomes of IO2 and IO3 and the recognized range of gaps both in market skills and GeoInformatics education we deemed that a set of 9 courses, 3 of them introductory and 6 practical (including also QGIS addons like GRASS) as described in the pictures below (Fig. 2, 3).

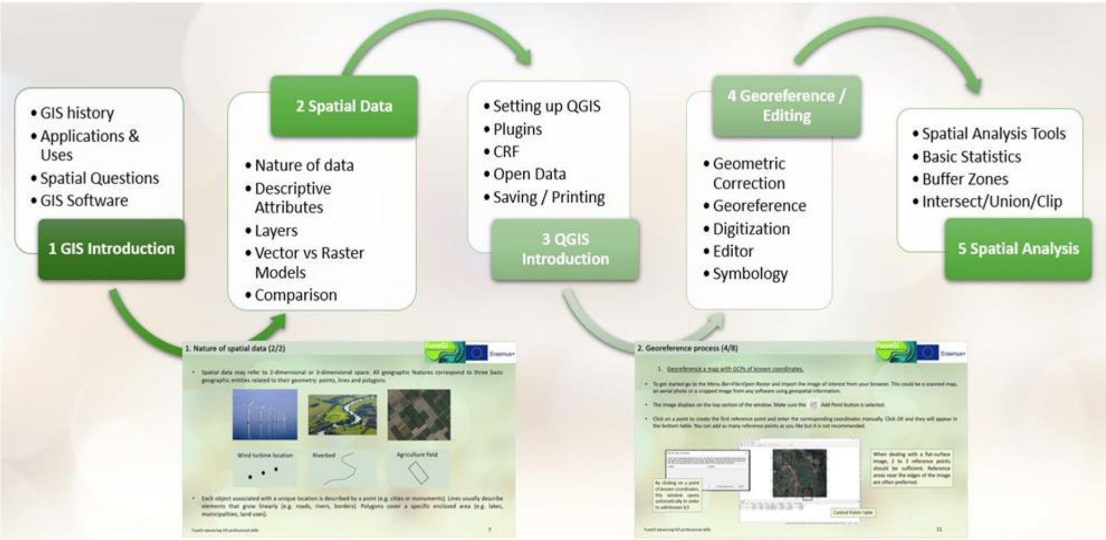

Figure 2. Lessons 1 to 5 flow chart with basic context presentation.

Figure 3. Lessons 6 to 9 flow chart with basic context presentation.

As the case study selection, we came in contact with experts and professionals in the fields of water, forests and health to meet their most usual tasks and needs through these case studies. Then we had to find the primary-raw data and select the proper articulation for describing the problem at hand and the solution we seek. Then we chose to “assist” the students by providing them optionally with a series of sub-tasks, as steps for the case study completion and where they could find each QGIS command to perform each action.

Then, before the official launch of the toolkit, we tested it with experts and then with students from participating universities (master and graduate) both individually and during C2 and C3 joint training event. Corrections were made according to indications.

2.3 Revising the toolkit

The first version was completed in time according to the Application Form. The final teaching material included in IO4 was produced by co-shaping the IO5 final Fuse GI curricula. This approach was selected in order to endorse the results from the validation phases that were held during the program, meaning the first edition of the platform tested by the consortium, focus groups, students and dissemination events as described in the Application Form. These gave important feedback that allowed us to evolve and adapt the material. These findings could be concluded in:

Augmented need for extra hands-on practice.

So, the second version of the toolkit had a clear aim: to ensure the competency-based approach promoted by IO5 finalized so as to fully master the newly acquired knowledge on QGIS tools and techniques.

The actual revised version of the toolkit had some adjustments for every level of the Finalcurricula design according to the competency-based approach.

Discovery level: The introductory courses were increased from 2 to 3 courses to distribute (equalize) the teaching duration and break it into more easily assimilable lectures.

Getting started level: There was the need for even more supplementary material related to the training for further self-engagement. The courses already included databases and practice exercises but in the final version, these were doubled in number.

Advanced use level: The revised version of the toolkit, trying to cope with the range of skills of the involved “students” of the program decided to raise the difficulty in two real-life case studies, naming Forestry and Hydrology ones along with the addition of Hydrology 2 case study related with biodiversity.

This series of adjustments in the first version advanced the training material (structure and content) and increased the overall quality of the toolkit ensuring competency-based approach which is the goal of IO5.

3 The courses

In order to effectively train the users of the platform, **9 online courses** are available on the platform as well as **4 case studies** to put into practice the theoretical explanations.

The FuseGI VLE platform currently offers 9 courses to bridge the gap between the knowledge of graduating students and the expectations of professionals for the job. Classes may sometimes contain small exercises to help understand the lesson. In addition, a case study is available to implement all the functionalities of GIS and more particularly QGis.

The structure of each course is very similar: we first find an introduction, then a plan defining the different parts of the development, the development in question and then a conclusion and the associated sources. In addition, the language used for the courses is English, as it is universal, it facilitates access to all European users.

3.1 Course 1: Introduction

The first course introduces the **basic concepts of GIS,** but also the definitions. We also find key figures and the history of GIS. We also learn more about the **possible applications of GIS** and its uses in certain areas. These courses allows to anyone know the **types of questions that can be solved thanks to GIS** and it also highlights the different software that can be used to make GIS. This course also illustrates the advantages and disadvantages of using GIS **(Figure 4).**

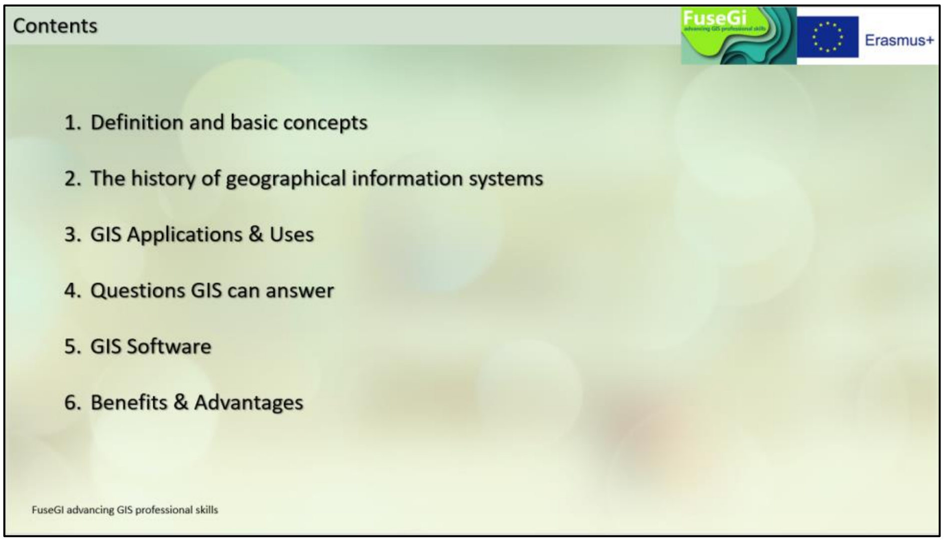

Figure 4 *: Slideshow map of course 1, available via the FuseGI VLE platform.*

The first part of this course defines the basic concepts of GIS, as well as the different reasons for using them to improve communication between different scientists **(Figure 5).**

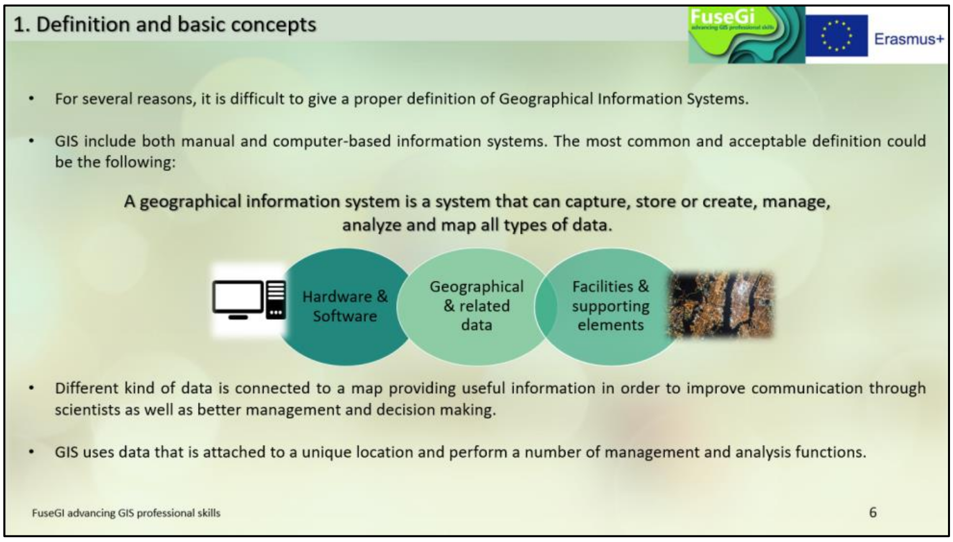

***Figure 5** : Slide 6 of course 1, available through the FuseGI VLE platform.*

The courses are quite simple to understand, a maximum of figures are added to the text to facilitate the understanding of it **(Figure 6).** For example, in order to explain the history of GIS, it is possible to use a timeline.

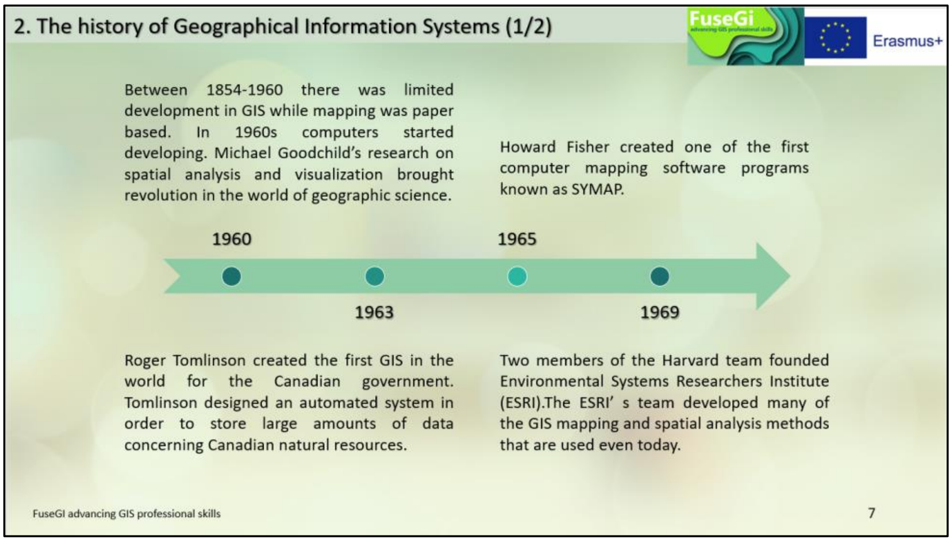

***Figure 6** : Slide 7 of course 1, available via the FuseGI VLE platform.*

The second part of this module traces the history and improvements of GIS over time, from its inception in 1960 to the present **day (Figure 7).**

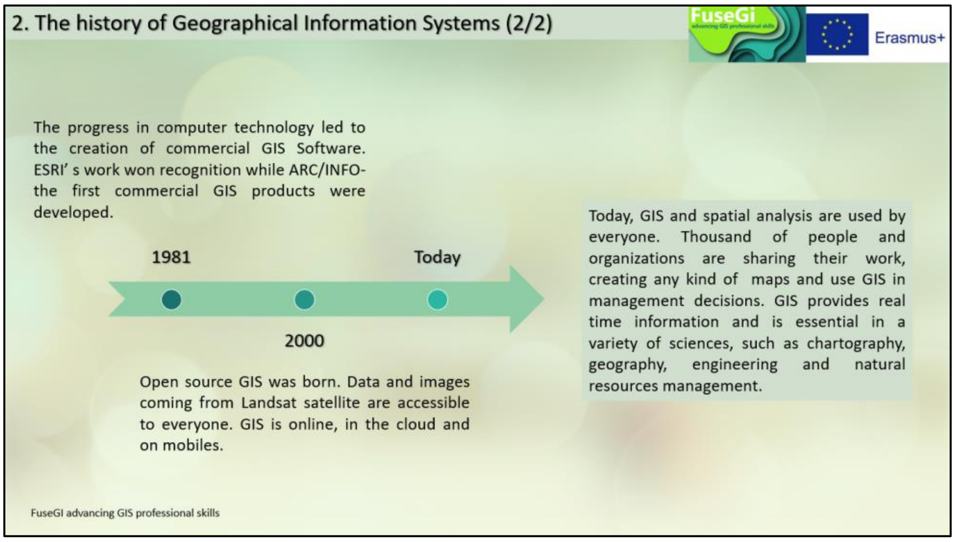

***Figure 7** : Slide 8 of course 1, available via the FuseGI VLE platform.*

The third part lists all the fields that can use GIS **(Figure 5-2),** such as tourism, geology, health or politics.

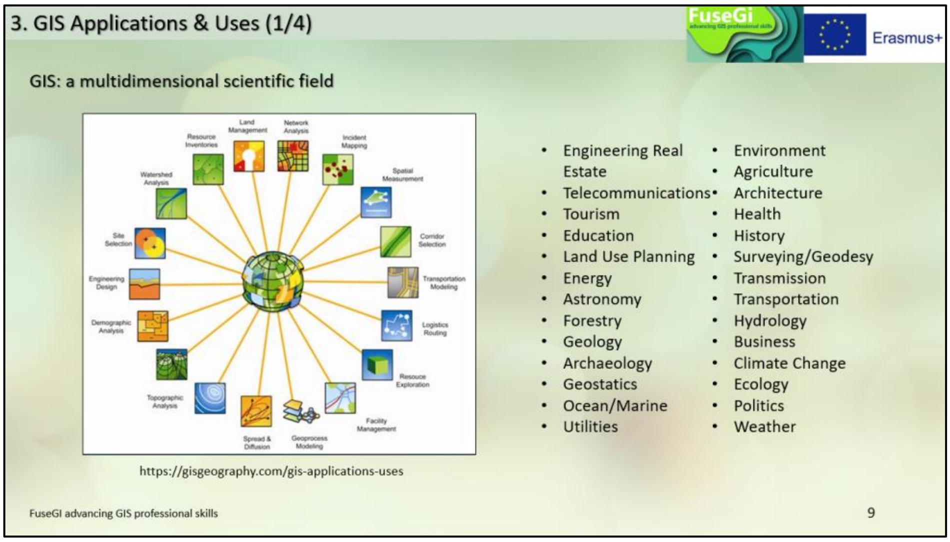

***Figure 8** : Slide 9 of course 1, available via the FuseGI VLE platform.*

This part also shows the possible use of GIS in different fields such as climate change, ecology, hydrology or forestry **(Figure 9).**

***Figure 9** : Slides 10, 12 and 13 of course 1, available via the FuseGI VLE platform.*

The fourth part provides a better understanding of the use of GIS. Indeed, this part explains what types of problems can be solved using GIS, such as defining a forest area sensitive to climate change **(Figure 10).**

***Figure 10** : Slides 13, 14, 15 of course 1, available via the FuseGI VLE platform.*

In the fifth part, users of the platform become aware of all types of software using GIS, whether paid software, such as ArcGIS, or the QGIS suite of free and open-source software **(Figure 11).**

Figure 11 *: Slides 16 and 17 of course 1, available via the FuseGI VLE platform.*

The sixth and final part of this first GIS course is a list of advantages and benefits of using GIS in the different areas listed above **(Figure 12).**

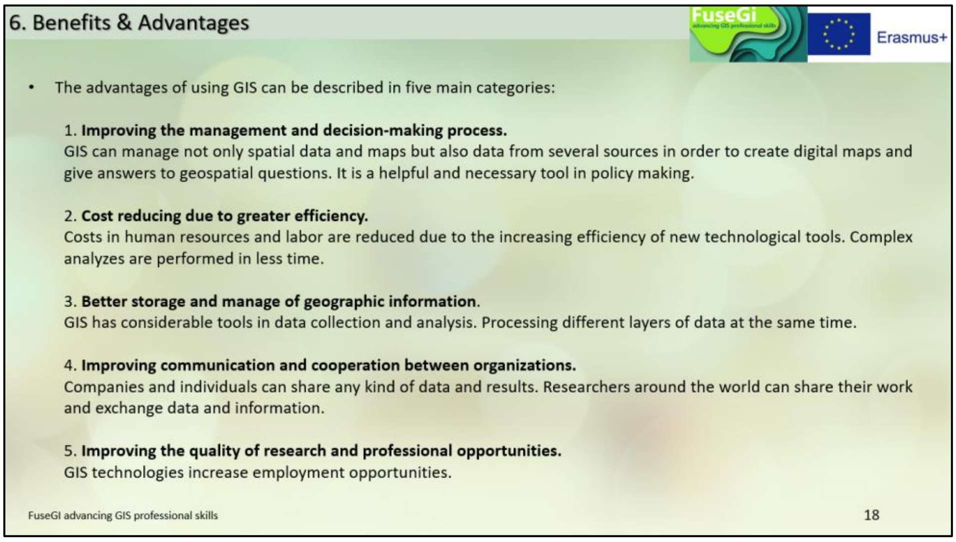

Figure 12 *: Slide 18 of course 1, available via the FuseGI VLE platform.*

This first course teaches the basics of GIS as well as when to use GIS to process information and communicate with other scientists and professionals

3.2 Course 2: Spatial Data

The second course **defines raster and vector models.** These concepts are very important for using GIS. It also includes criteria for selecting raster and vector models and a comparison between the two models. This course also introduces the **concepts of layers and objects**, **descriptive attributes**, the **nature of** spatial data, and **spatial data models (Figure 13).**

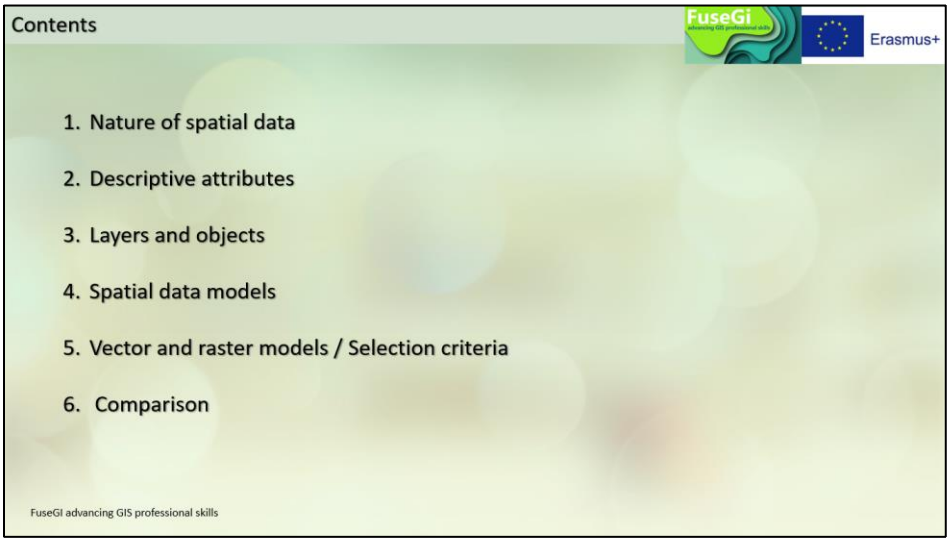

Figure 13 *: Course outline 2, available via the FuseGI VLE platform.*

First, the course defines the concepts of data collection as well as the characteristics of spatial or geographical data **(Figure 14).**

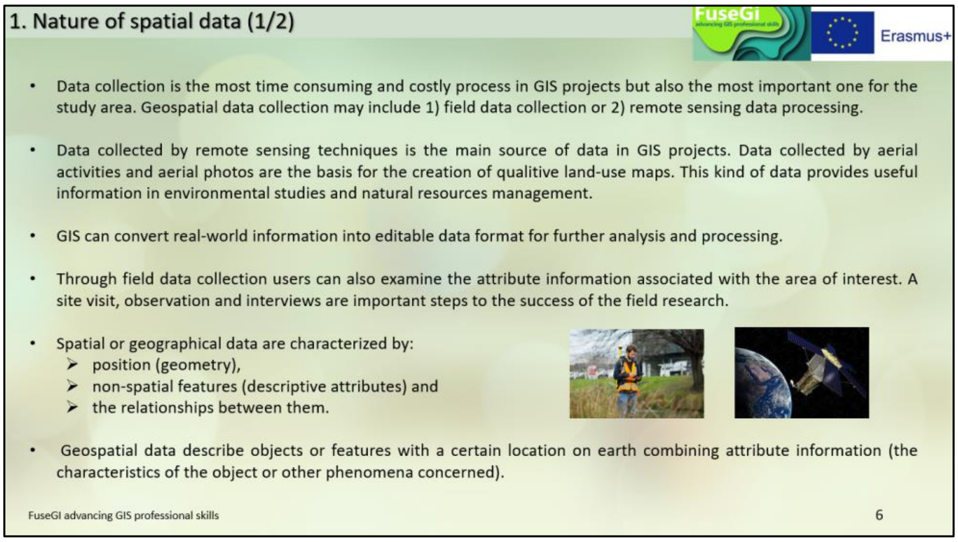

Figure 14 *: Slide 6 of course 2, available via the FuseGI VLE platform.*

Next, the course develops the three geographical features that can be connected with geometric elements: points corresponding to an object with a precise location, lines that can represent linear elements such as a river, and polygons representing specific areas **(Figure 15).**

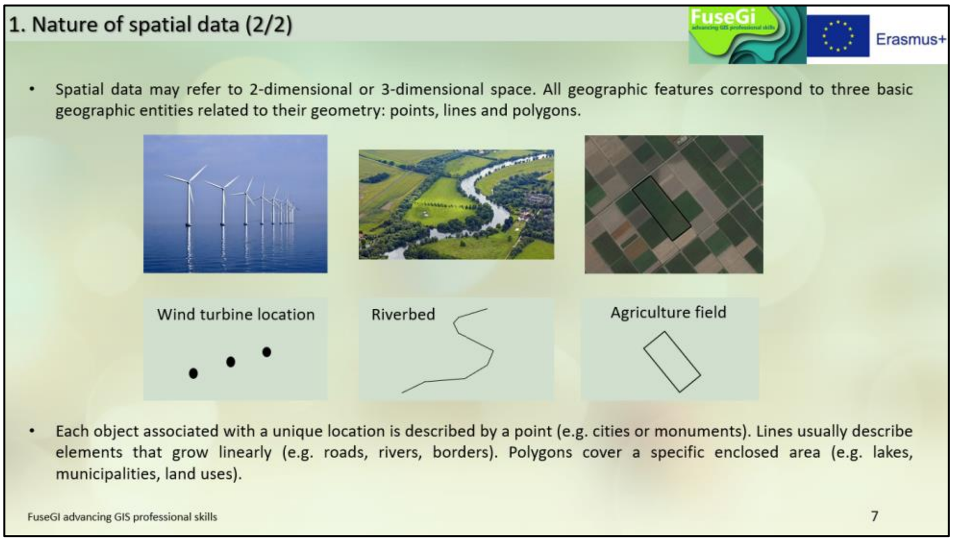

Figure 15 *: Slide 7 of course 2, available via the FuseGI VLE platform.*

Slide 8 allows platform users to better understand attributes and their usefulness in a GIS project **(Figure 16).**

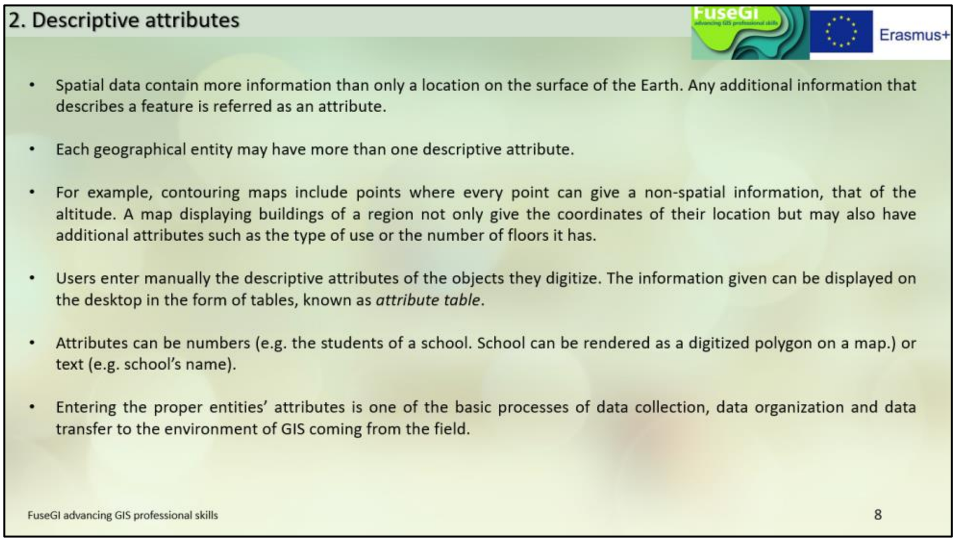

Figure 16 *: Slide 8 of course 2, available via the FuseGI VLE platform.*

This course is widely used to define the basics for beginners or to make reminders to more experienced users, with for example the slide "Layers and objects (1/2)" which defines what a layer is (**Figure 17).**

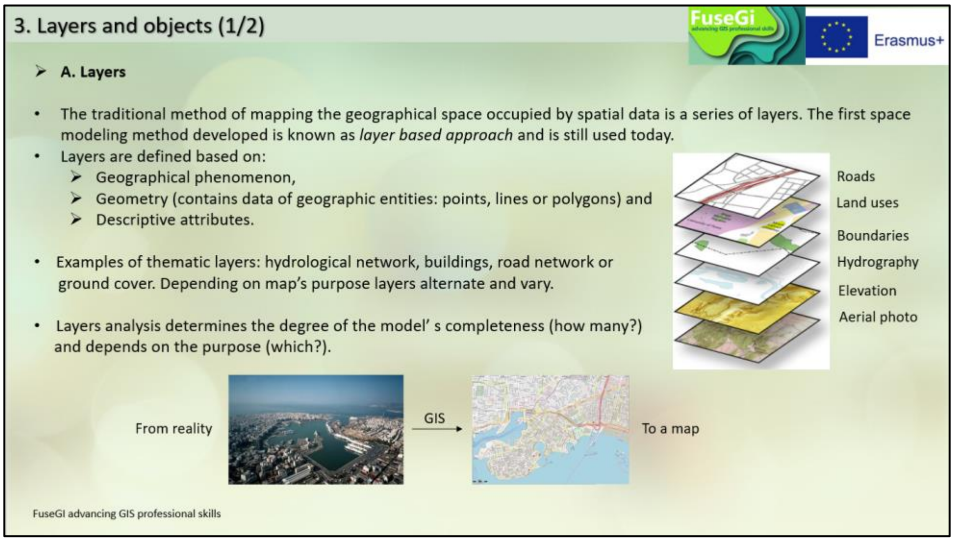

Figure 17 *: Slide 9 of course 2, available via the FuseGI VLE platform.*

Like the previous slide, this one is intended to define another concept that is very important for the use of GIS, the notion of object. It therefore defines objects and helps to understand their uses **(Figure 18).**

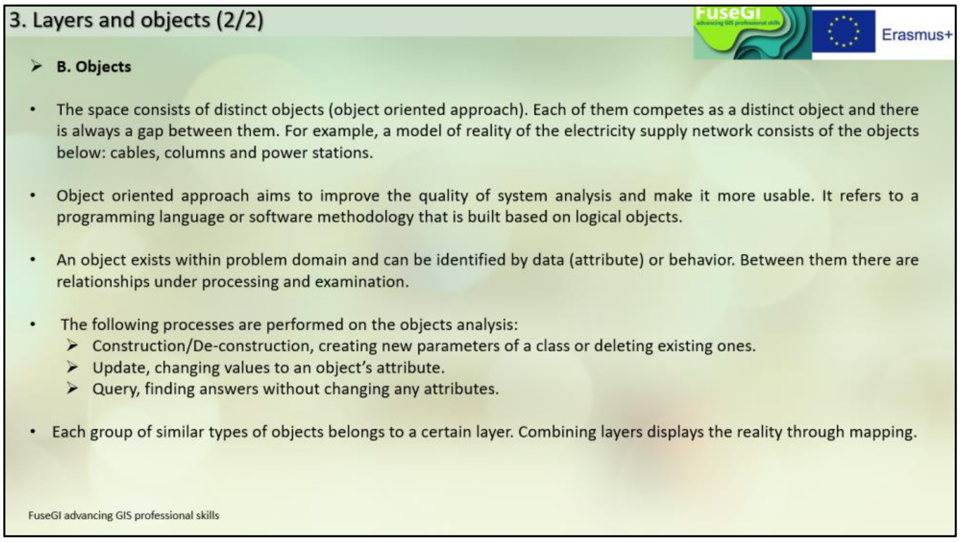

Figure 18 *: Slide 10 of course 2, available via the FuseGI VLE platform.*

Then, the course again defines very important concepts to understand such as the difference between a raster model and a raster model. In addition, it defines and informs on the particularities of each of these types of models **(Figure 19).**

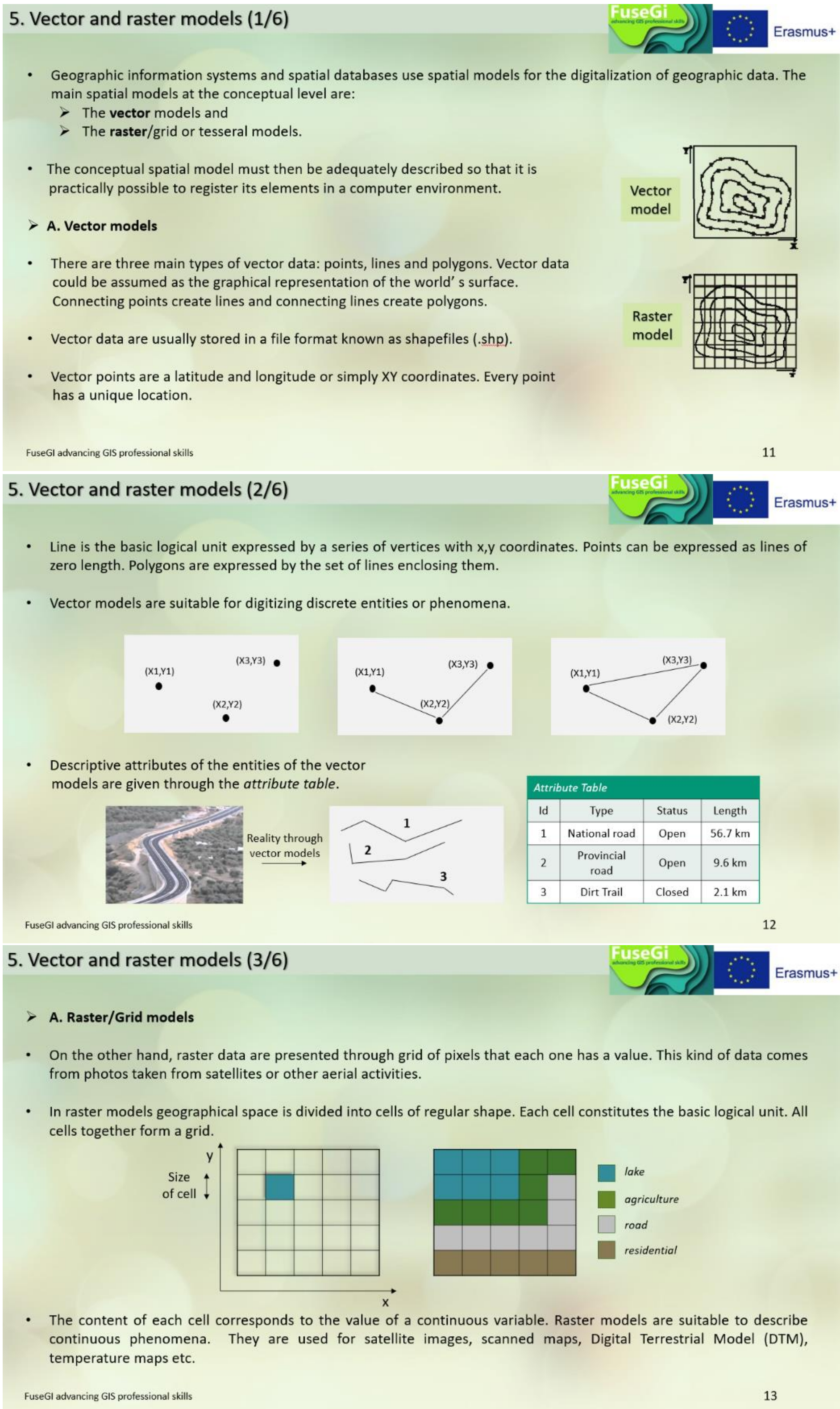

***Figure 19** : Slides 11, 12, 13 of course 2, available via the FuseGI VLE platform.*

The course also helps to understand the geometric difference between vector and raster type representations of points, lines and polygons **(Figure 20).**

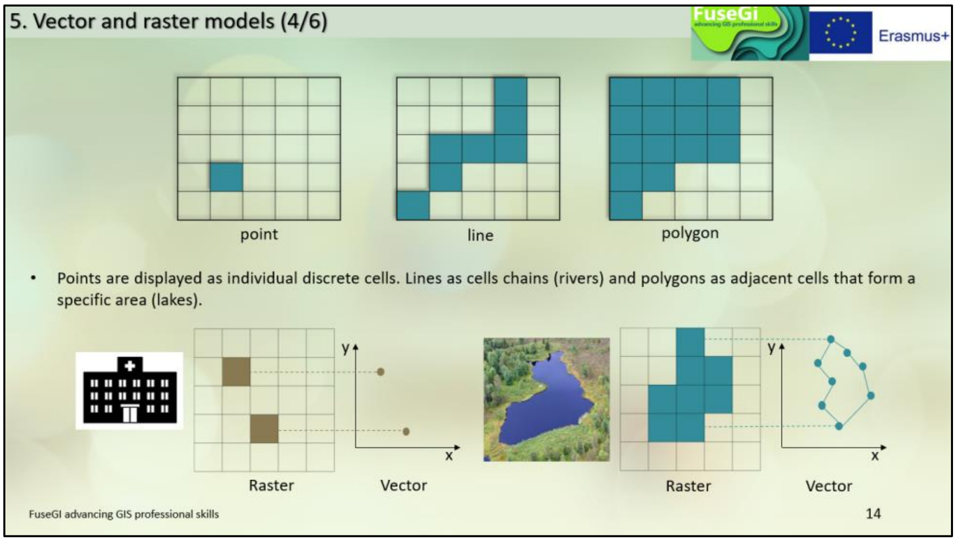

***Figure 20** : Slide 14 of course 2, available via the FuseGI VLE platform.*

Thanks to this course, it will be possible for users of the platform to choose the appropriate type of model based on the data they want to analyze **(Figure 21).**

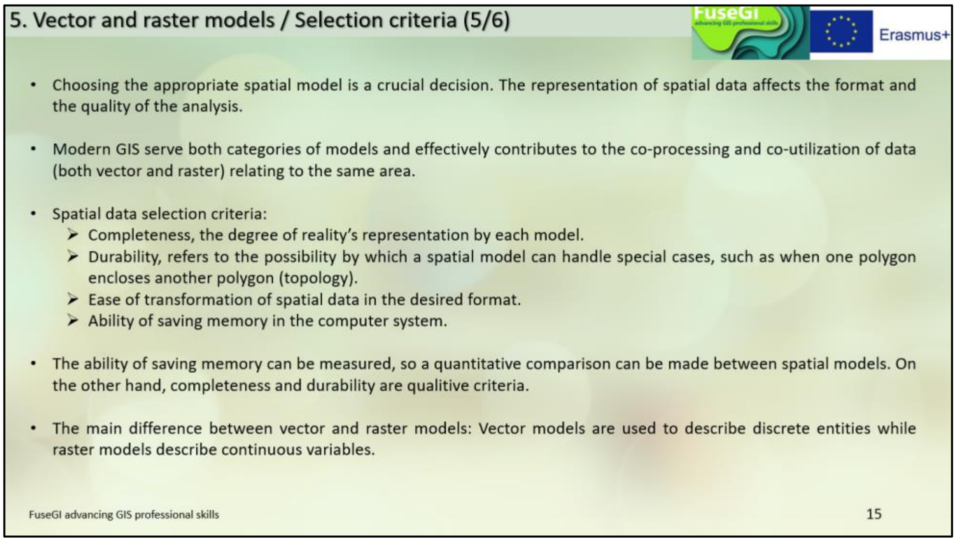

***Figure 21** : Slide 15 of course 2, available via the FuseGI VLE platform.*

Then, the course makes the connection between the type of data and the format used in GIS software like QGIS. For example, Shapefile files are used in vector format while GeoTiff files are used in raster format **(Figure 22).**

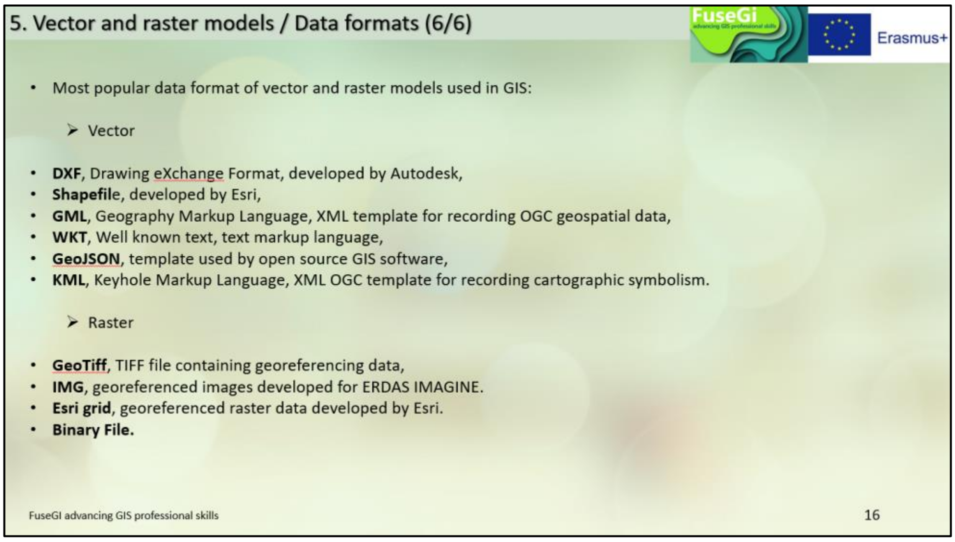

***Figure 22** : Slide 16 of course 2, available via the FuseGI VLE platform.*

Finally, this course concludes with a comparison of the two types of model by listing the advantages and disadvantages of each **(Figure 23).**

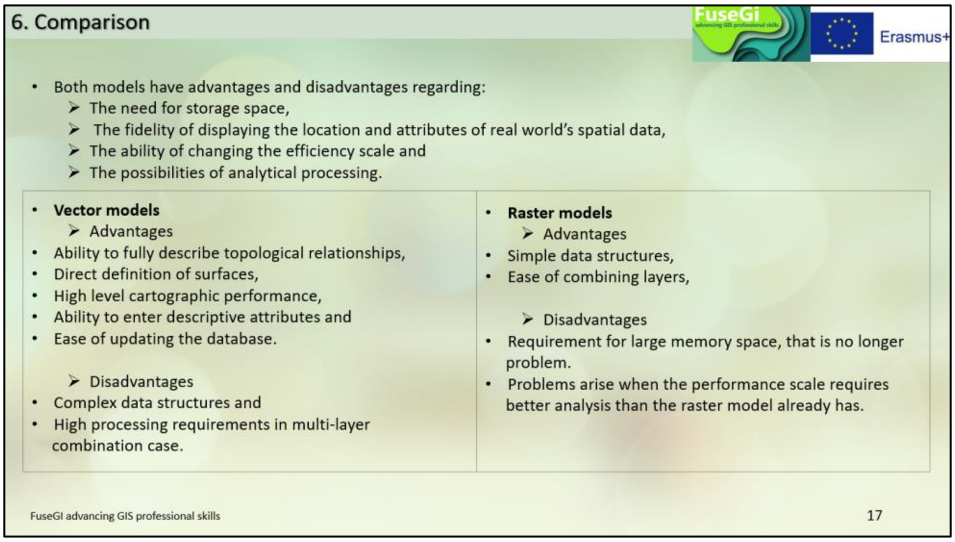

***Figure 23** : Slide 17 of course 2, available via the FuseGI VLE platform.*

3.3 Course 3: Introduction to QGIS Software

The third course **introduces QGIS software.** This software is free and open access. The course consists of an introduction to QGIS software. Part of this course explains how to **download** the latest version of this software to users' personal computers, as well as the **steps to install the software**. The rest of the course **presents the different menu bars of the software**, but also how to install the **extensions** in it. In addition, this course provides an understanding of **the use of different coordinate systems**, open data, but also how to **add data and create layers**. It also helps us to properly save files and export the different projects **(Figure 24).**

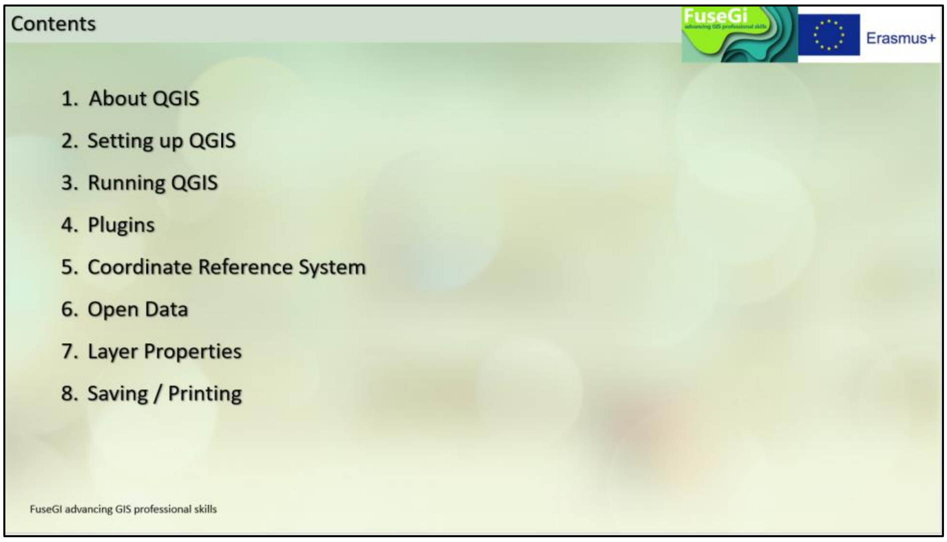

Figure 24 *: Course outline 3, available via the FuseGI VLE platform.*

First, the course begins with an introduction defining the QGIS software suite **(Figure 25).**

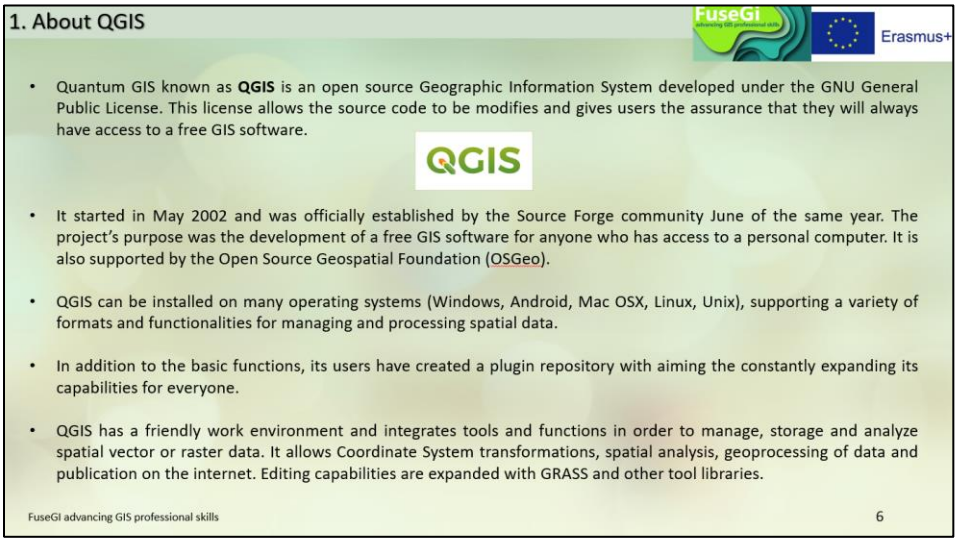

Figure 25 *: Slide 6 of course 3, available through the FuseGI VLE platform.*

In this course is explained the path to follow in order to successfully install QGIS **(Figure 26).** It is important to know that this software is downloaded with other GIS software, such as GRASS GIS and SAGA.

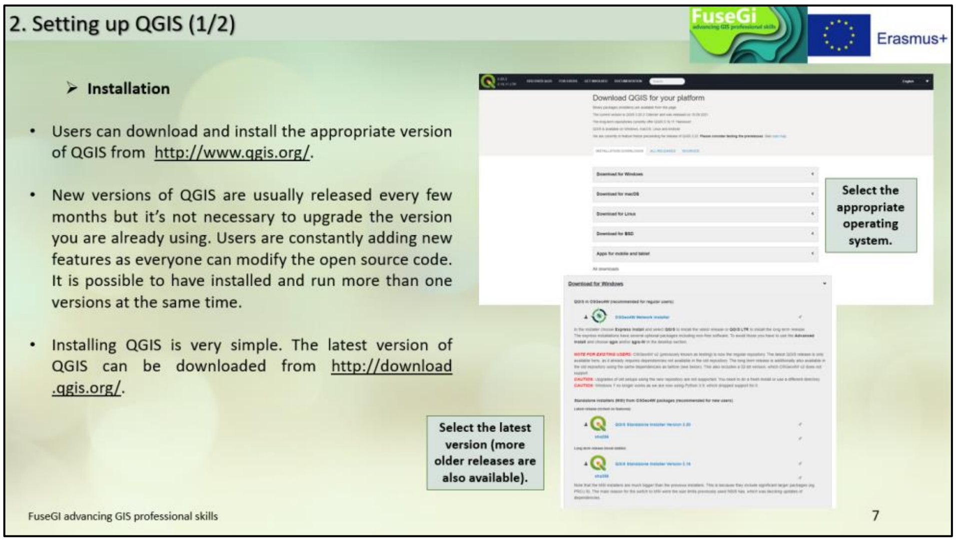

***Figure 26** : Slide 7 of course 3, available through the FuseGI VLE platform.*

The third course is useful for learning the features of QGIS software for beginners and also serves as a reminder for more experienced users. Indeed, the menu bar is detailed to help the use of the software **(Figure 27).**

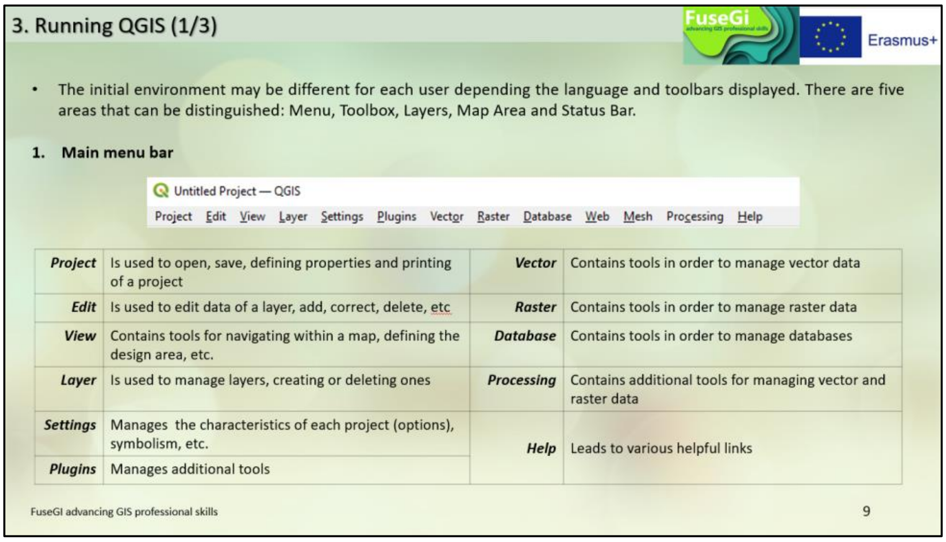

***Figure 27** : Slide 9 of course 3, available through the FuseGI VLE platform.*

This third course also describes the working environment of the QGIS software, such as the toolbar, the location of the list of layers created or added, the visualization area of the map as well as the status bar where we find the scale or the type of coordinates used for the project **(Figure 28).**

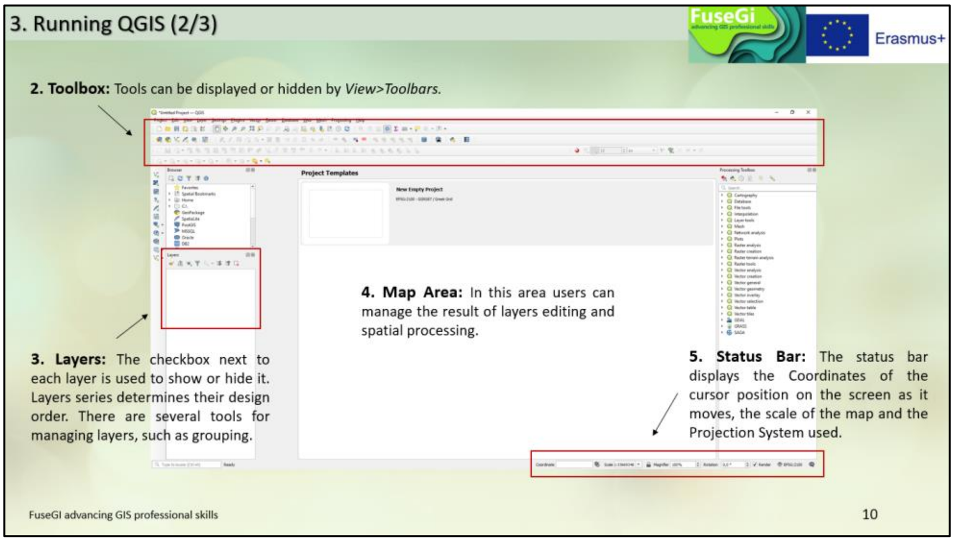

***Figure 28** : Slide 10 of course 3, available through the FuseGI VLE platform.*

As QGIS software is open-source software, it is possible to add extensions (plugins) in order to extend the functionality of the software. This course shows users how to install extensions in QGIS **(Figure 29).**

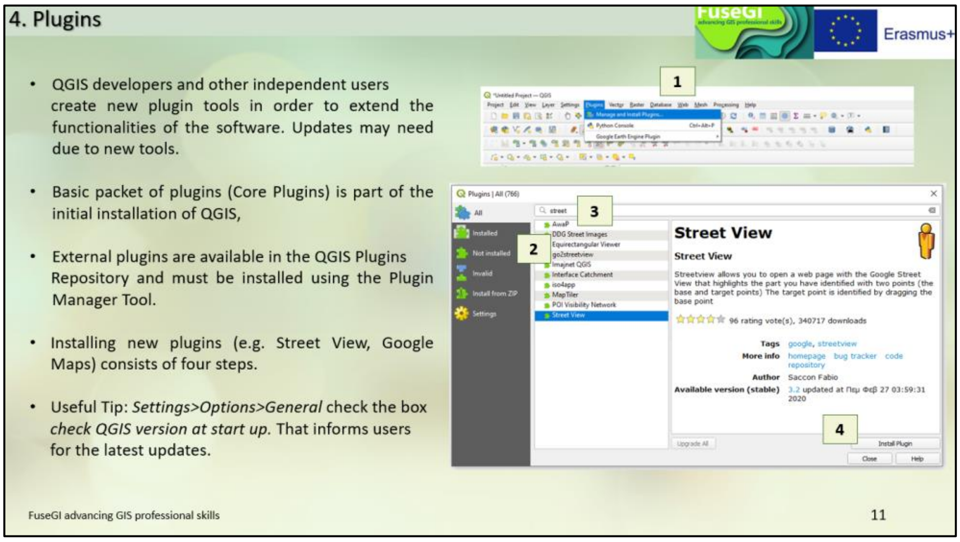

***Figure 29** : Slide 11 of course 3, available via the FuseGI VLE platform.*

Another essential point for the proper use of QGIS software is the reference coordinate system used for the project. Indeed, it must be adapted to the area studied and is specific to it. First, the course defines what a reference coordinate system is **(Figure 30).**

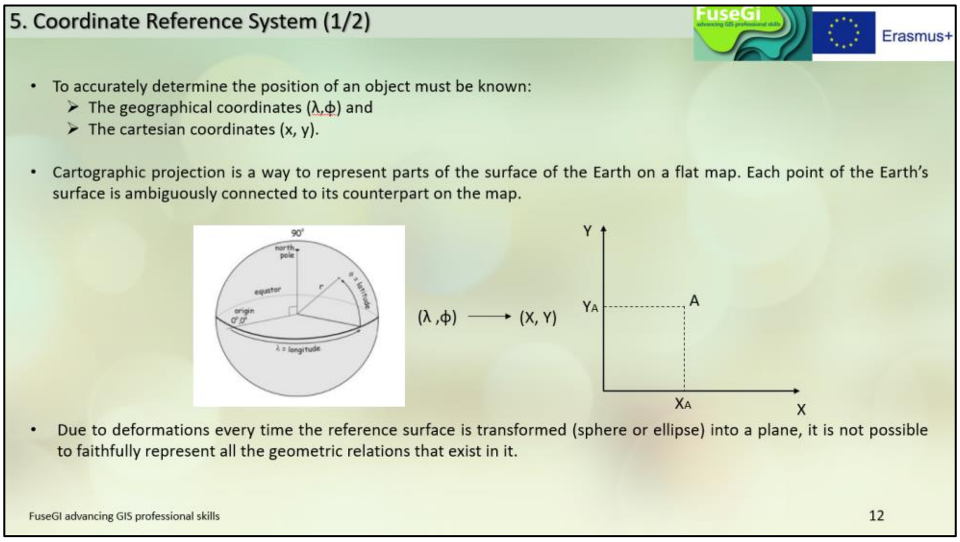

Figure 30 *: Slide 12 of course 3, available via the FuseGI VLE platform.*

Then, it shows the path to follow in order to define the coordinate system for each of the layers of the project **(Figure 31).**

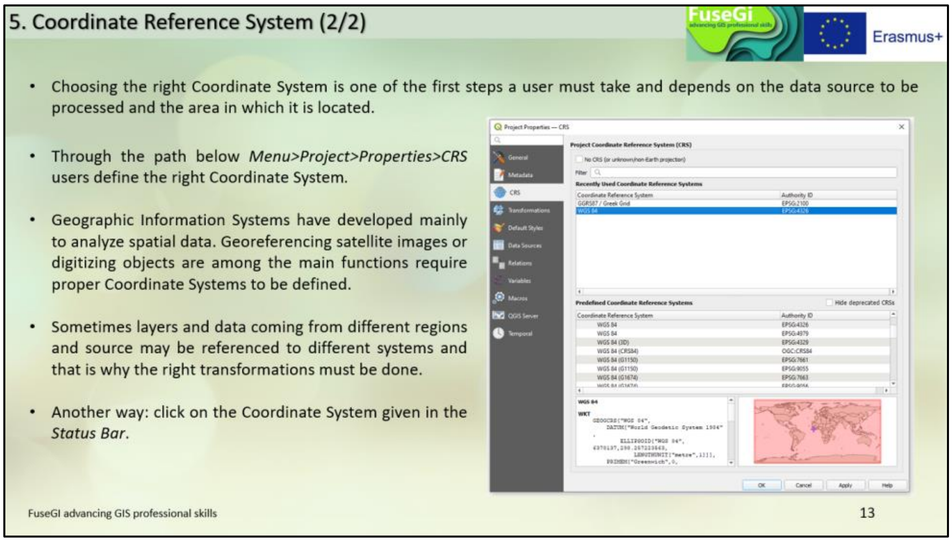

Figure 31 *: Slide 13 of course 3, available via the FuseGI VLE platform.*

Open data is data that is freely accessible, reusable and redistributable by everyone. These data may be provided by public or private sources. In the sixth part of the third course, open data is defined and some sites where it is possible to download data for free are cited **(Figure 32).**

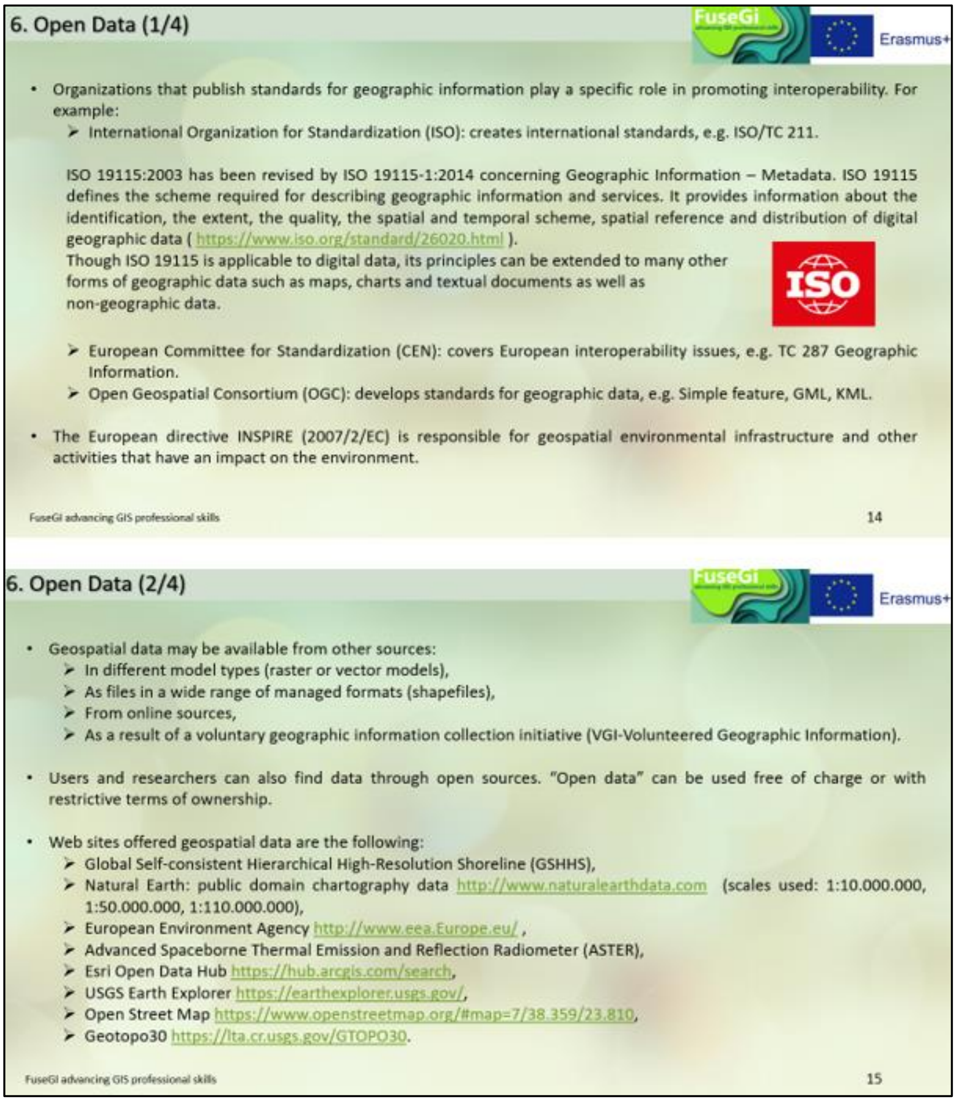

***Figure 32** : Slides 14 and 15 of course 3, available via the FuseGI VLE platform.*

Next, the course shows how to integrate the downloaded data into the QGIS software **(Figure 33).**

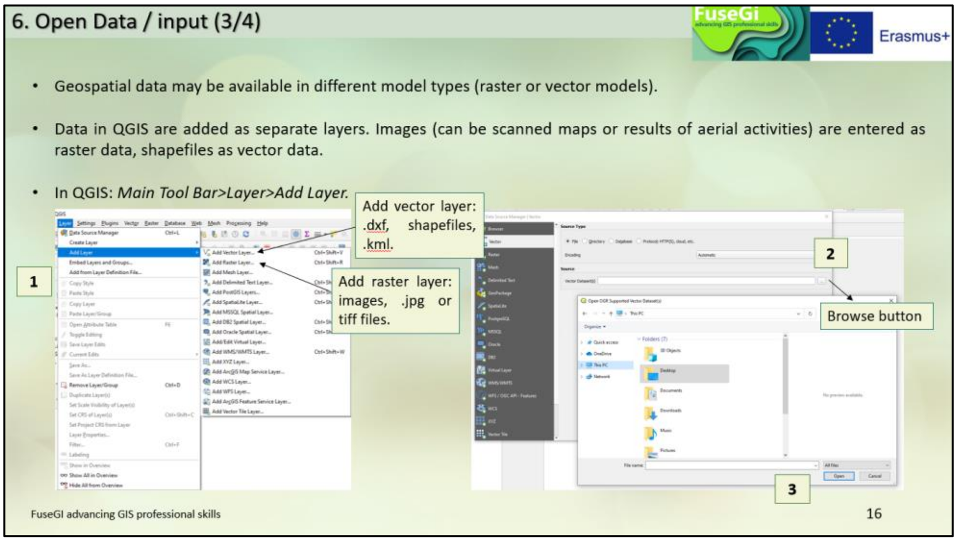

Figure 33 : Slide 16 of course 3, available via the FuseGI VLE platform.

This course also allows you to understand and use the browser and layer panels available in QGIS **(Figure 34).**

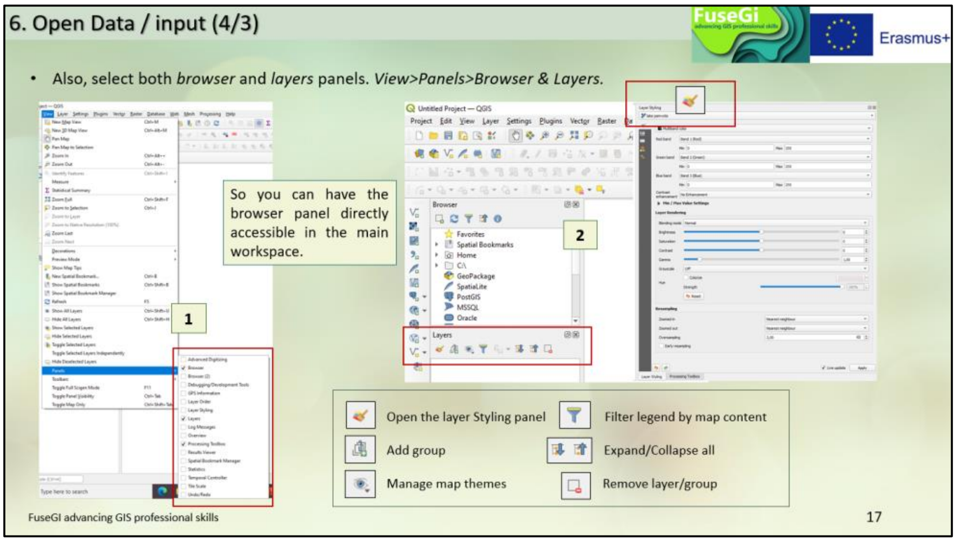

Figure 34 : Slide 17 of course 3, available via the FuseGI VLE platform.

This third course is also useful for learning the basics of using QGIS, such as creating layers, whether for drawing lines, points, or polygons **(Figure 35).**

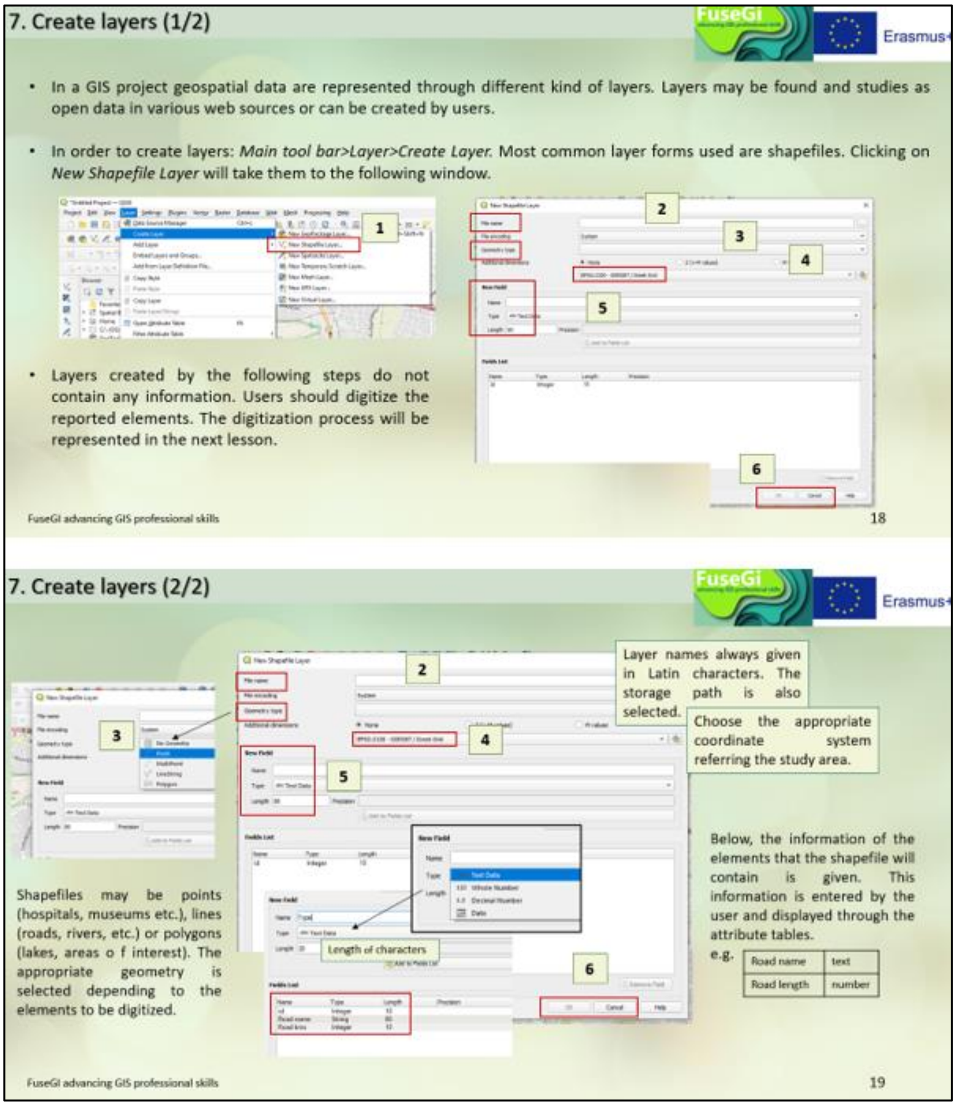

Figure 35 *: Slides 18 and 19 of course 3, available via the FuseGI VLE platform.*

Finally, the last slide of this third course shows how to save and save the project **(Figure 36).**

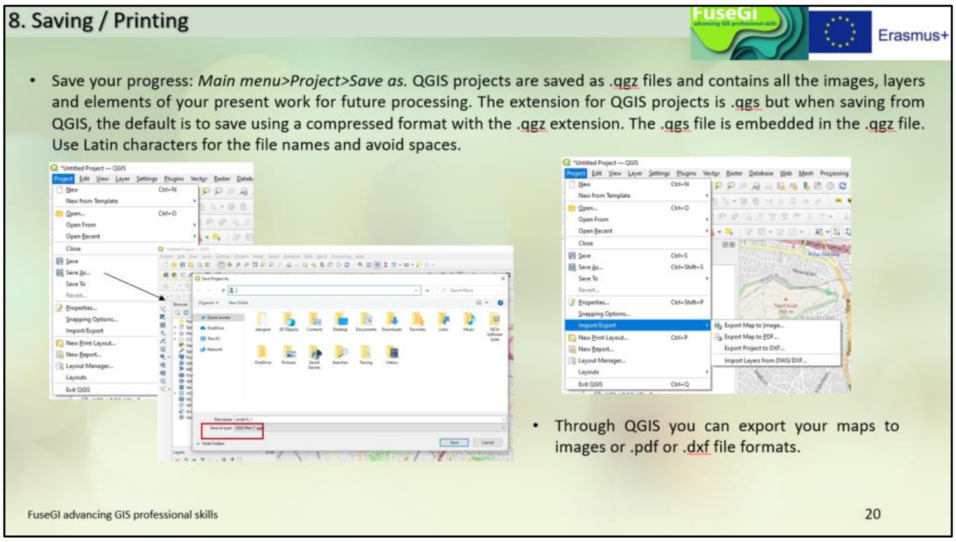

Figure 36 *: Slide 20 of course 3, available via the FuseGI VLE platform.*

3.4 Course 4: Georeferencing, Scanning and Editing Tools

This fourth course allows to continue **deepen the mastery of QGIS software**. Indeed, we can find in it the different steps to follow to carry out the **georeferencing process, the creation of layers** or those of correcting **the geometry of** a layer **(Figure 37).**

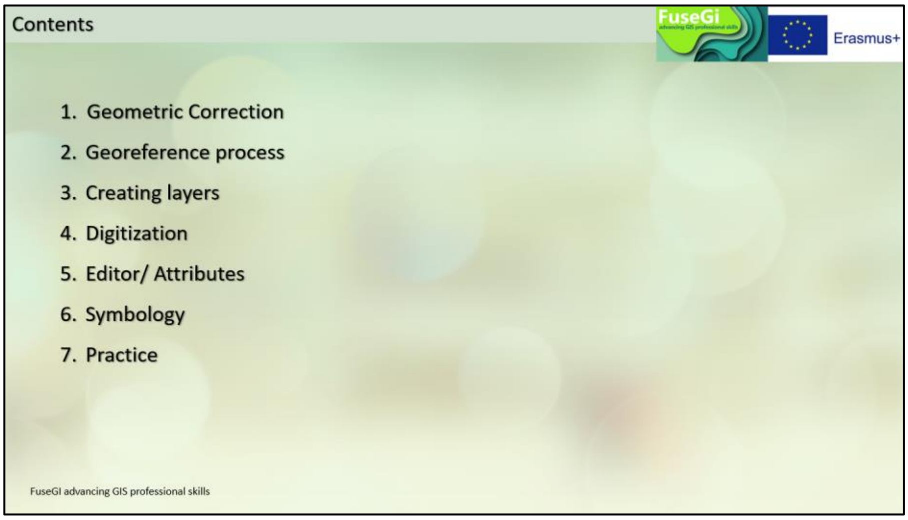

Figure 37 *: Course outline 4, available via the FuseGI VLE platform.*

After learning in the previous course how to create layers, it is important to know the editing tools, georeferencing as well as scanning. This is why the course begins by defining the usefulness and purpose of the geometric correction of photographic data made in QGIS **(Figure 38).**

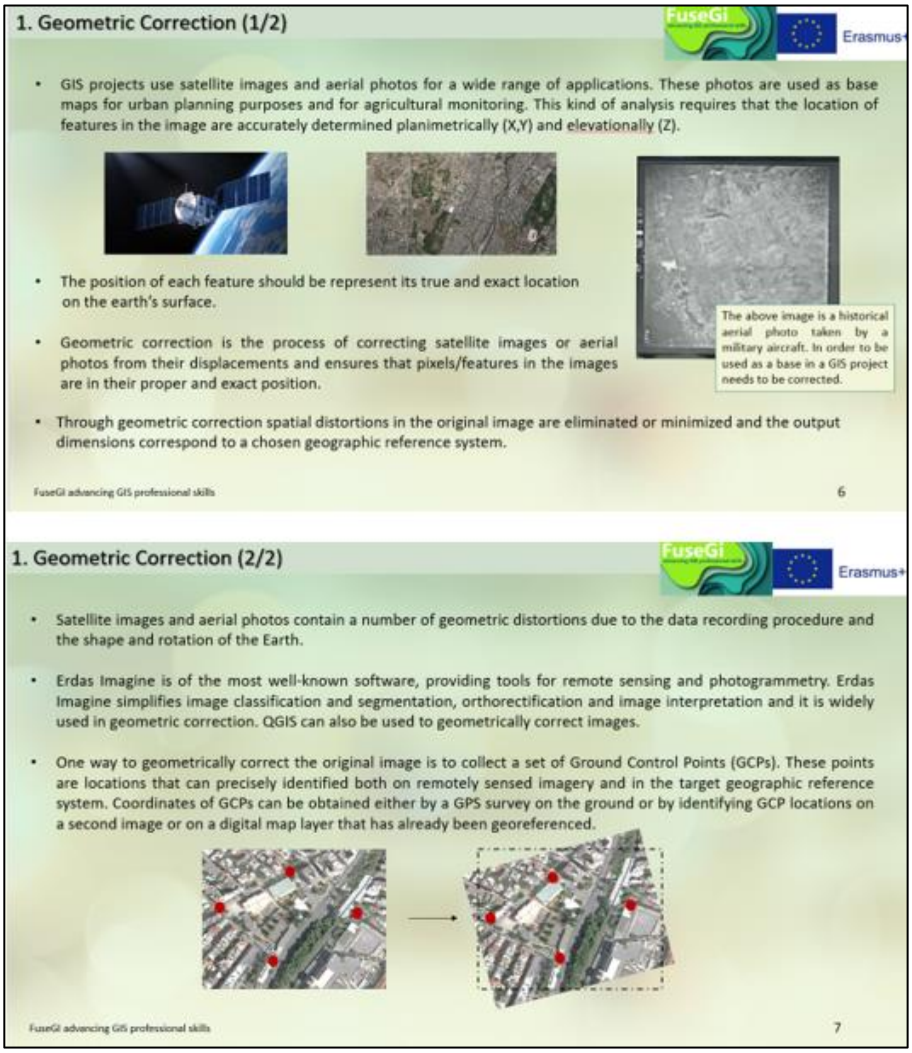

Figure 38 *: Slides 6 and 7 of course 4, available via the FuseGI VLE platform.*

The georeferencing process is an indispensable process for adding photographs to GIS projects **(Figure 39).**

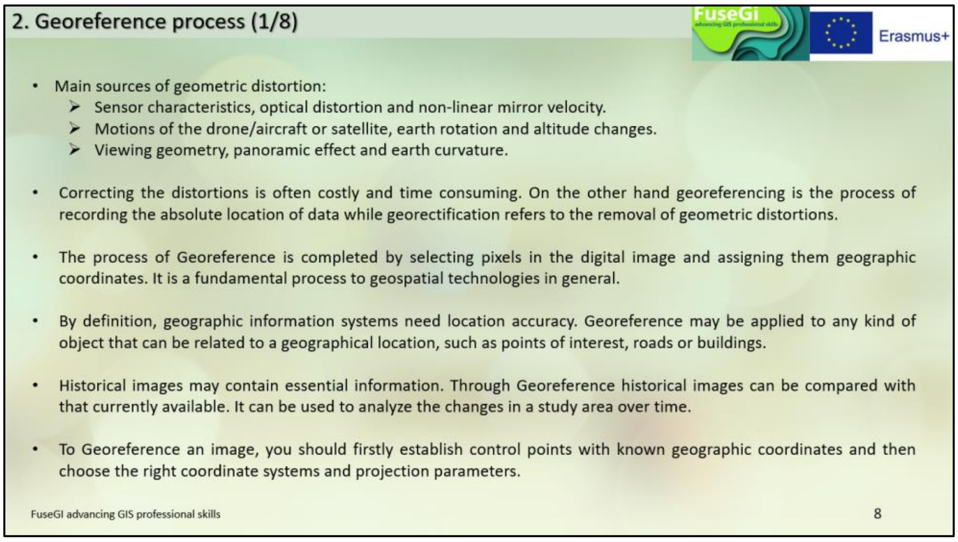

Figure 39 *: Slide 8 of course 4, available through the FuseGI VLE platform.*

This process uses files in GeoPDF or GeoTiff formats, the tool used to perform georeferencing is already included in QGIS **(Figure 40).**

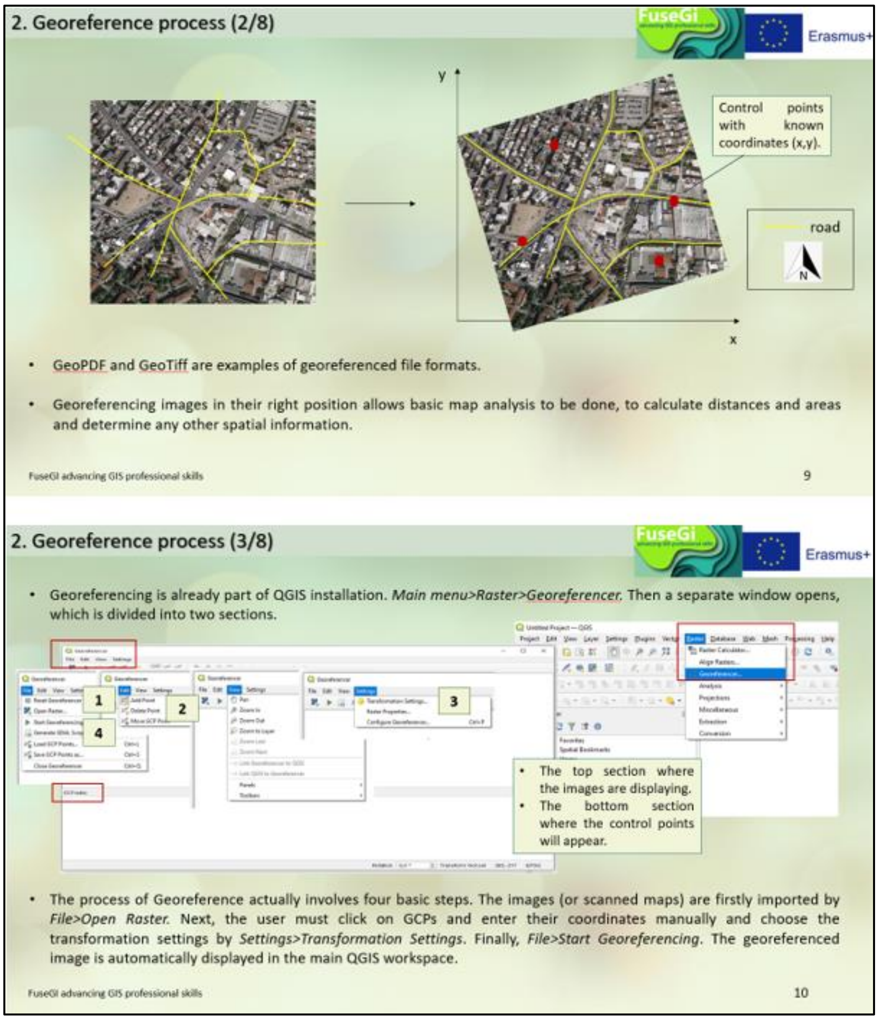

***Figure 40** : Slides 9 and 10 of course 4, available via the FuseGI VLE platform.*

Then, instructions on how to use the "georeferencing" tool are given in the slides "Georeference process 4/8" and "Georeference process 5/8". The first case of georeferencing a photograph is when a map and known coordinates are used. It is important to choose the type of transformation algorithm to georeference the image **(Figure 41).**

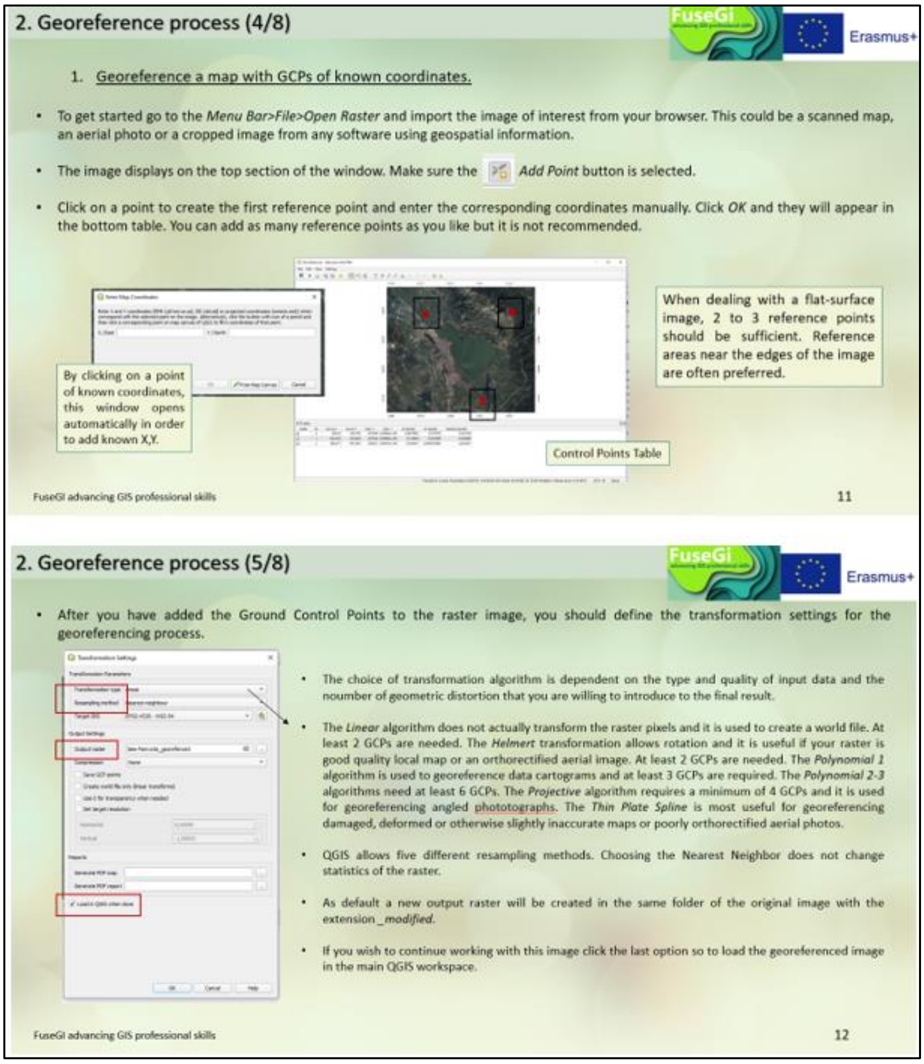

Figure 41 *: Slides 11 and 12 of course 4, available via the FuseGI VLE platform.*

In case the coordinates of the photo to be georeferenced are known from Google Earth, the process is a little different **(Figure 42).**

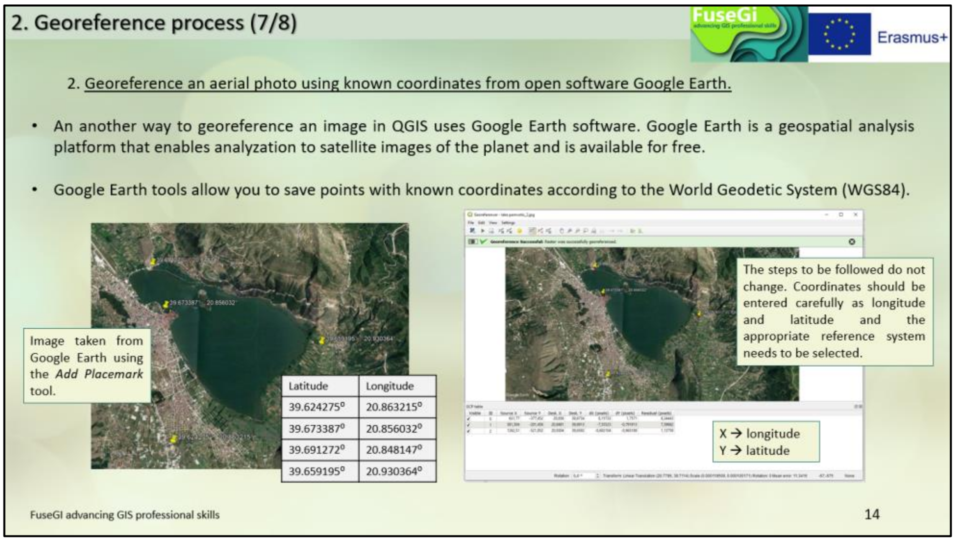

Figure 42 *: Slide 14 of course 4, available via the FuseGI VLE platform.*

In the latter case, the photo to be georeferenced is based on the use of an additional map such as Google Street View. The purpose of these steps is to place points on the image to be georeferenced as well as on the map at the samepoints chosen at the samepoints. The more points there are, the more accurate the georeferencing is **(Figure 43).**

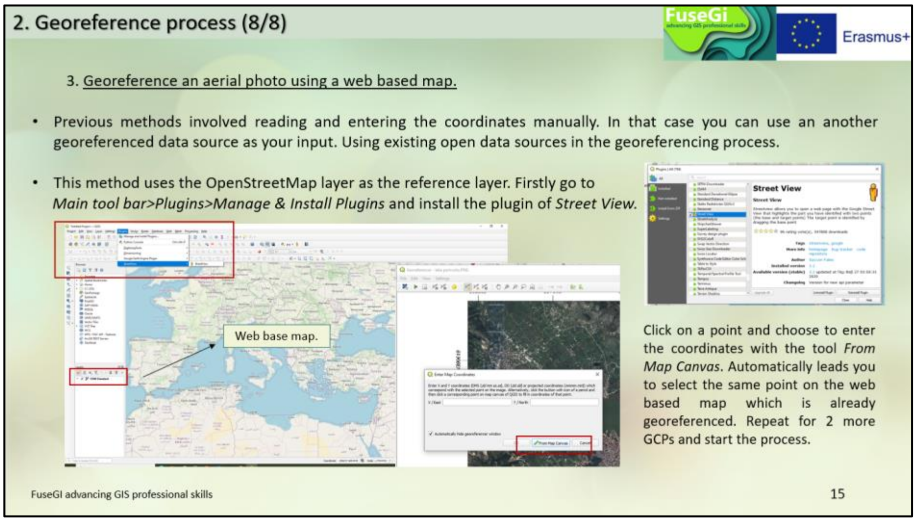

Figure 43 *: Slide 15 of course 4, available via the FuseGI VLE platform.*

Next, the course provides a reminder of how to use the layer creation tool **(Figure 44).**

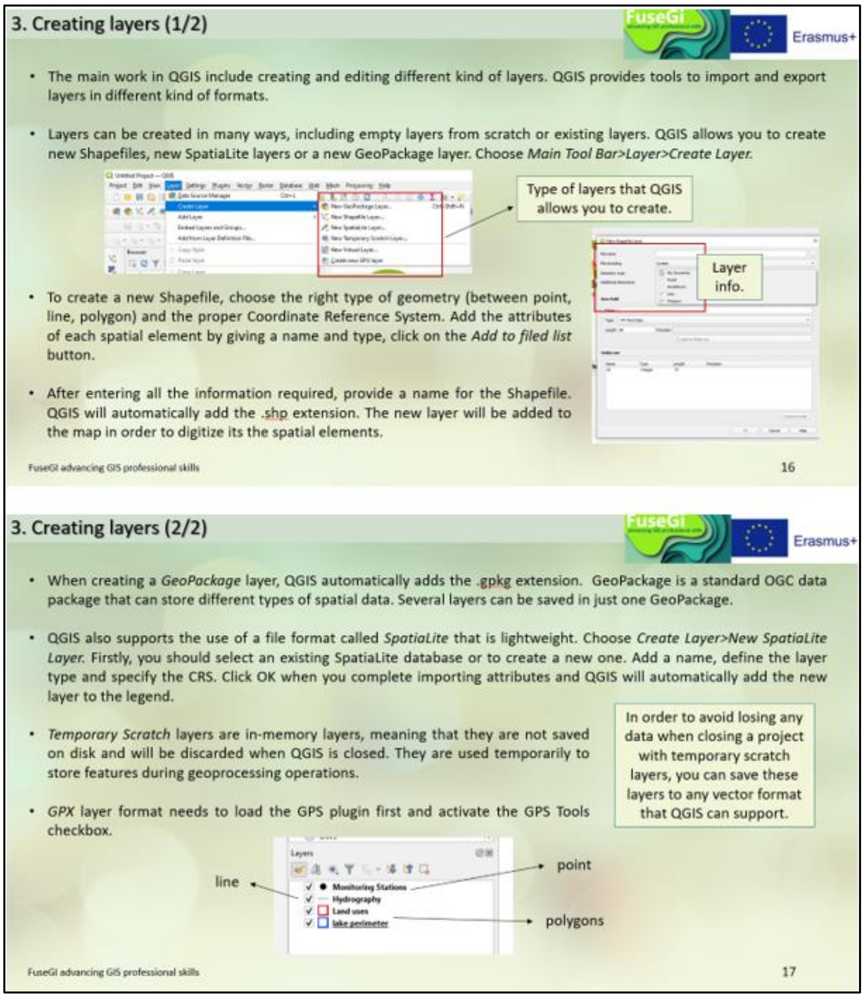

***Figure 44** : Slides 16 and 17 of course 4, available via the FuseGI VLE platform.*

These processes are essential for a good use of the software and a mastery of GIS. This course also teaches how to scan, symbology, edit and use attributes. In addition, an exercise to apply the concepts learned is available at the end of this course. This course gives us many examples and explanations of the tools that can be used with the QGIS software **(Figure 45).**

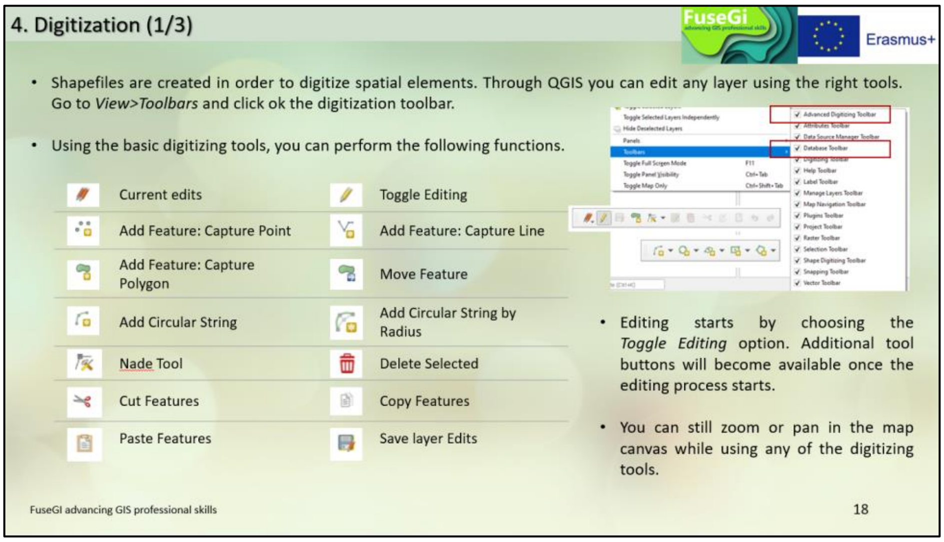

***Figure 45** : Slide 18 of course 4, available via the FuseGI VLE platform.*

Then, the course defines and allows the use of tools allowing the digitization of data and new characteristics useful to the GIS project **(Figure 46).**

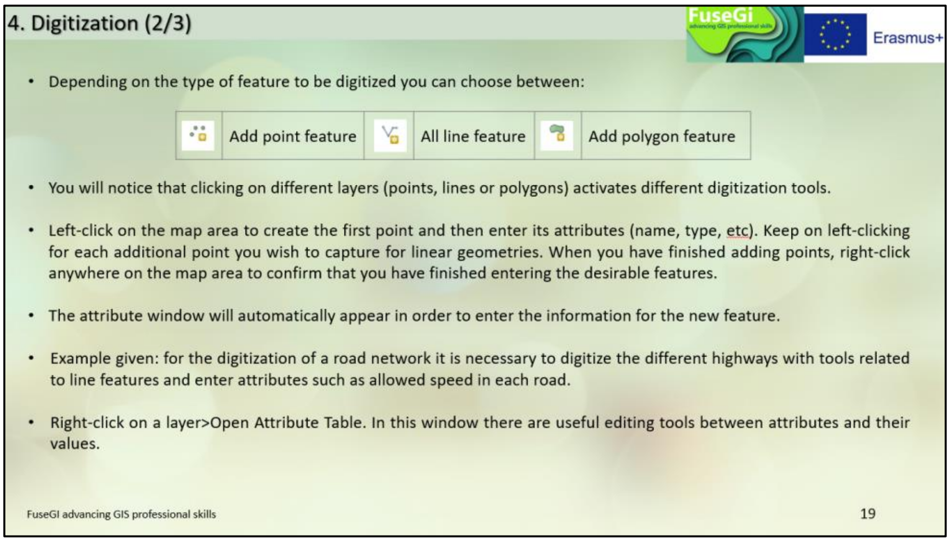

***Figure 46** : Slide 19 of course 4, available via the FuseGI VLE platform.*

Then, two videos are available in the slideshow to illustrate the digitization of the data and facilitate the understanding of the manipulations to be carried out **(Figure 47).**

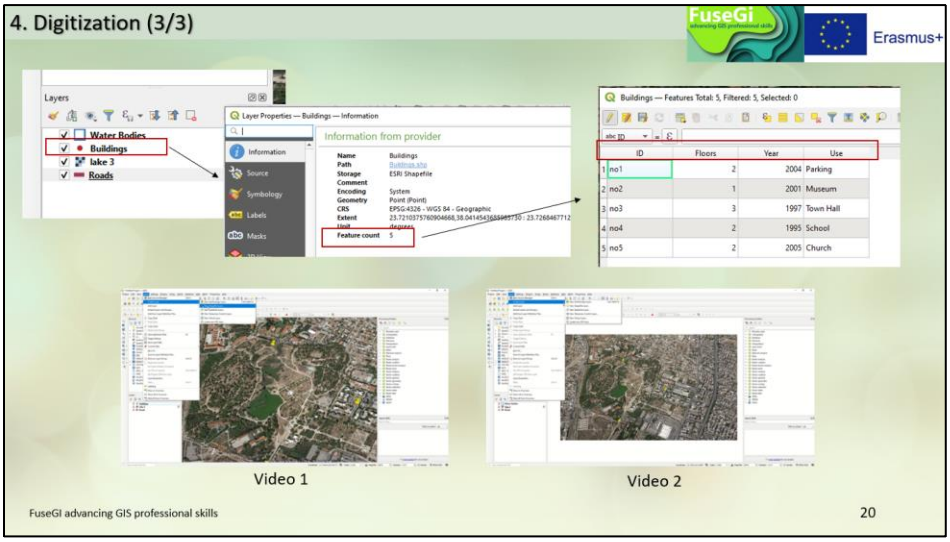

***Figure 47** : Slide 20 of course 4, available via the FuseGI VLE platform.*

Each of the data that is added to the project or created for it has visible data in the layer parameters or in the attribute table. In addition, it is possible to modify, add or remove this data **(Figure 48).**

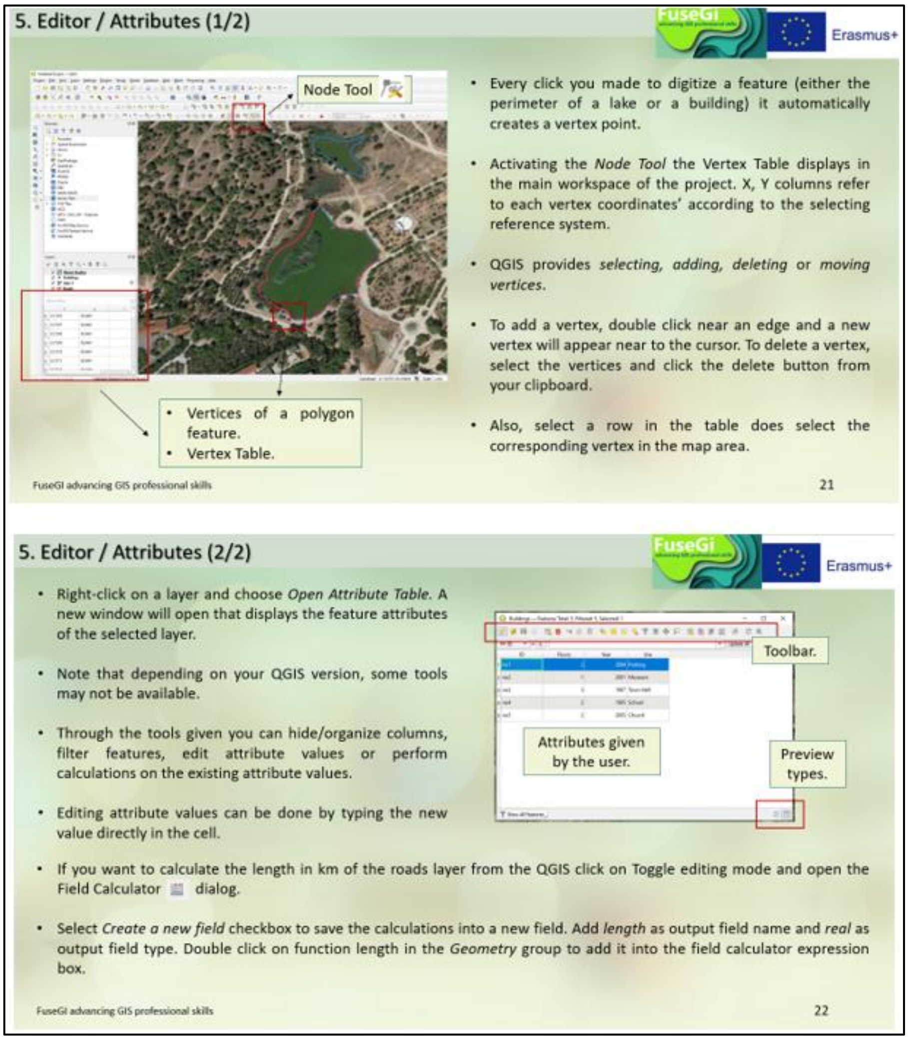

Figure 48 *: Slides 21 and 22 of course 4, available via the FuseGI VLE platform.*

It is also possible to customize the layers and the style of these, whether they are points, lines or polygons **(Figure 49).**

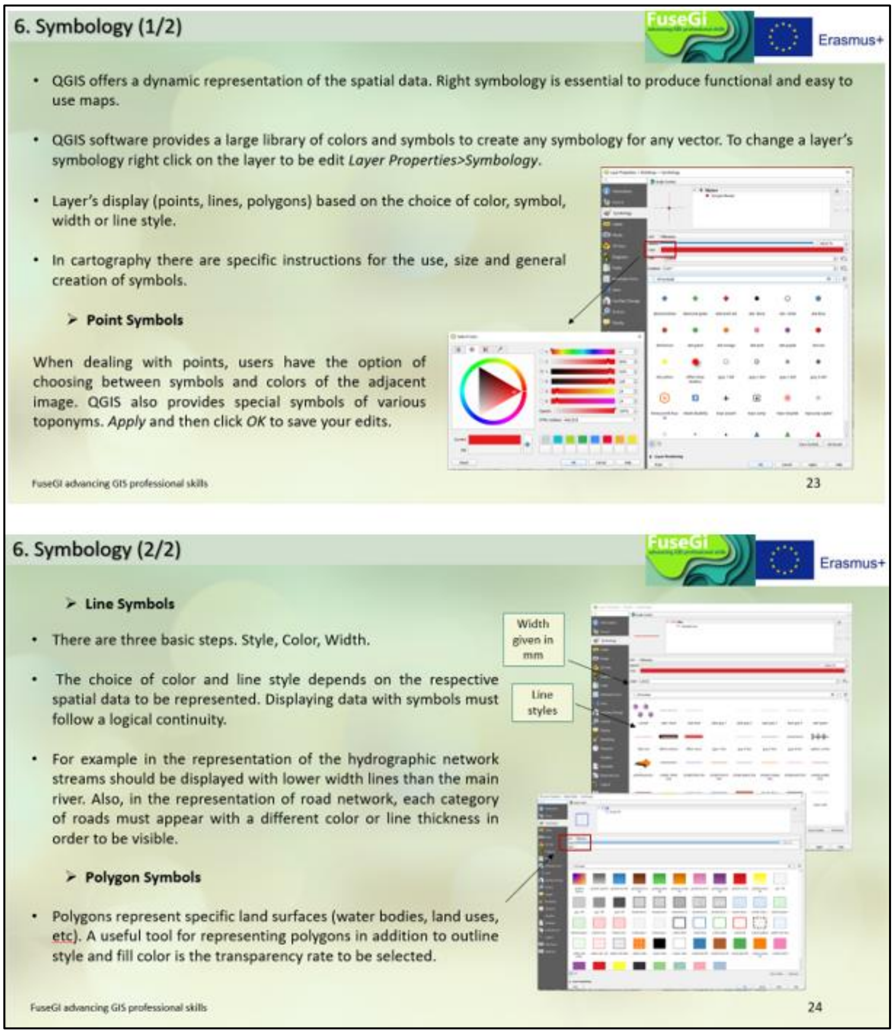

***Figure 49** : Slides 23 and 24 of course 4, available via the FuseGI VLE platform.*

In order to better understand all the tools described in the course, an exercise is available **(Figure 50).**

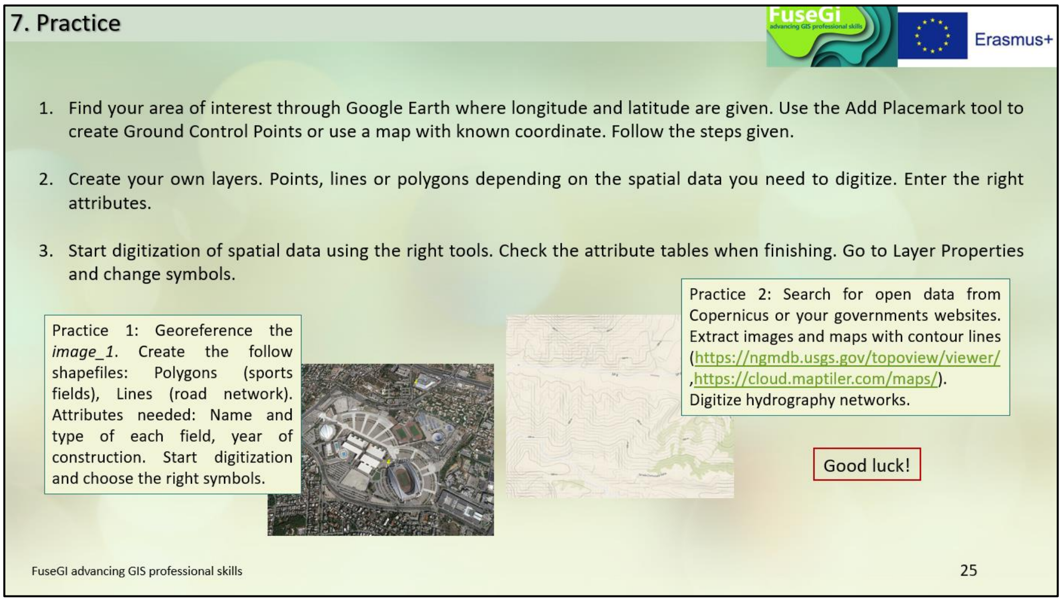

***Figure 50** : Slide 25 of course 4, available via the FuseGI VLE platform.*

3.5 Course 5: Spatial Analysis

This fifth course aims to **explain spatial analysis tools** as well as **spatial queries with location selection** and **basic statistics (Figure 51).** It allows you to learn more about buffer zones as well as to master other layer processing tools such as union, clip, intersection tools for example.

***Figure 51** : Course outline 5, available via the FuseGI VLE platform.*

First, we find in the course a definition of spatial analyses as well as an overview of the type of domain that can use these analyses **(Figure 52).**

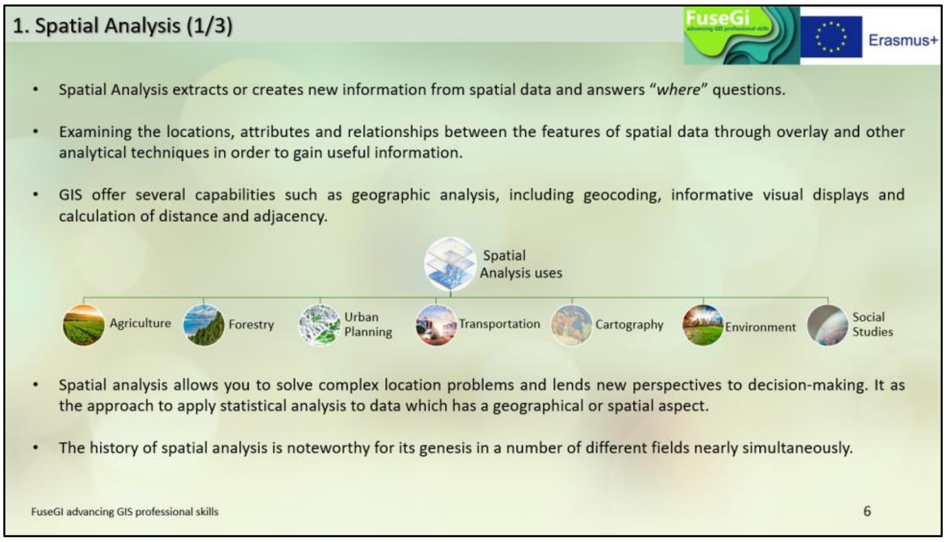

***Figure 52** : Slide 6 of course 5, available via the FuseGI VLE platform.*

The course provides an understanding of the conditions under which spatial analyses are carried out **(Figure 53).**

Figure 53 *: Slides 7 and 8 of course 5, available via the FuseGI VLE platform.*

The next slide defines spatial analysis tools and explains what thesetools can do, such as analyzing patterns or modeling spatial relationships **(Figure 54).**

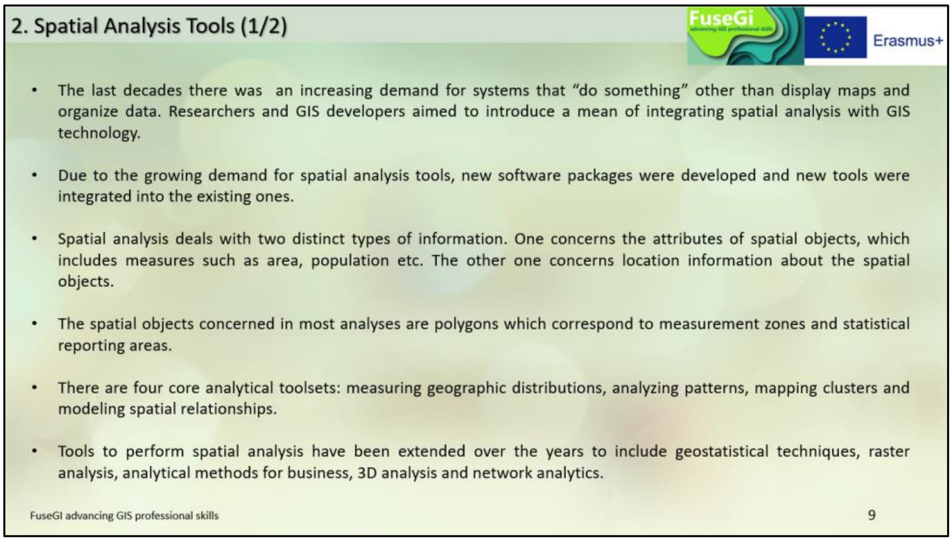

Figure 54 *: Slide 9 of course 5, available via the FuseGI VLE platform.*

In the course, 6 spatial analysis tools are mentioned such as QGIS, GRASS GIS or Google Earth **(Figure 55).**

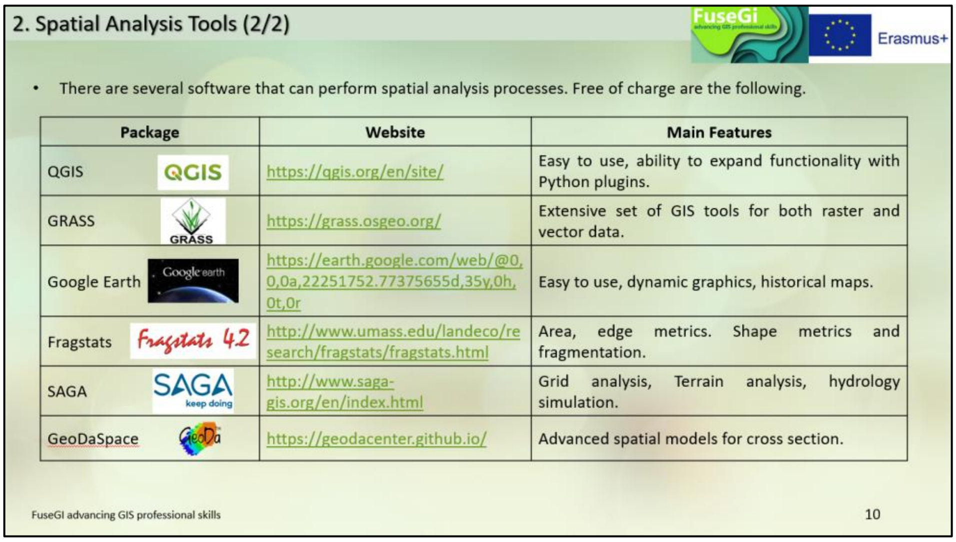

Figure 55 *: Slide 10 of course 5, available via the FuseGI VLE platform.*

Basic statistics are a method defined in the course since it is very often used to carry out research concerning scale, geostatistics or classifications **(Figure 56).**

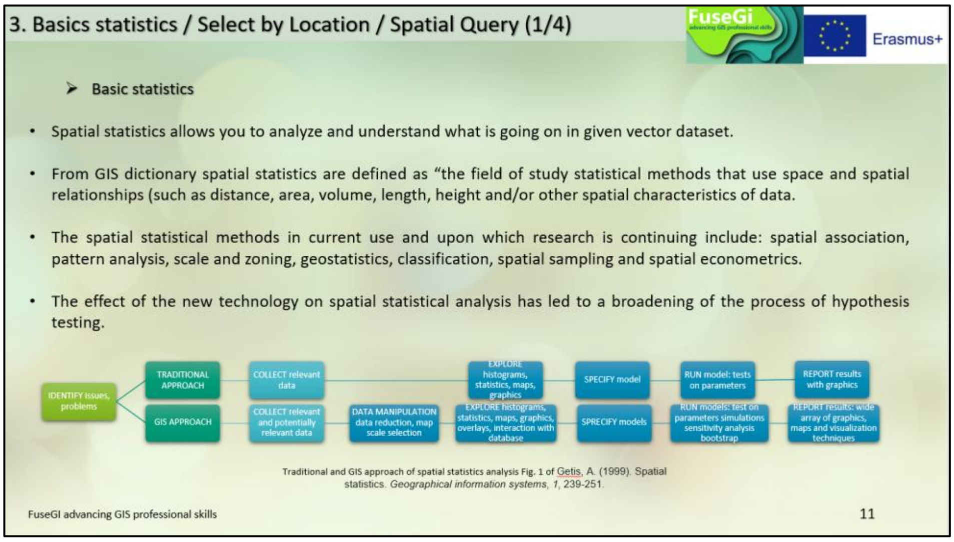

Figure 56 *: Slide 11 of course 5, available through the FuseGI VLE platform.*

The course allows to know the path to the basic statistical analysis tool, available in the QGIS software **(Figure 57).**

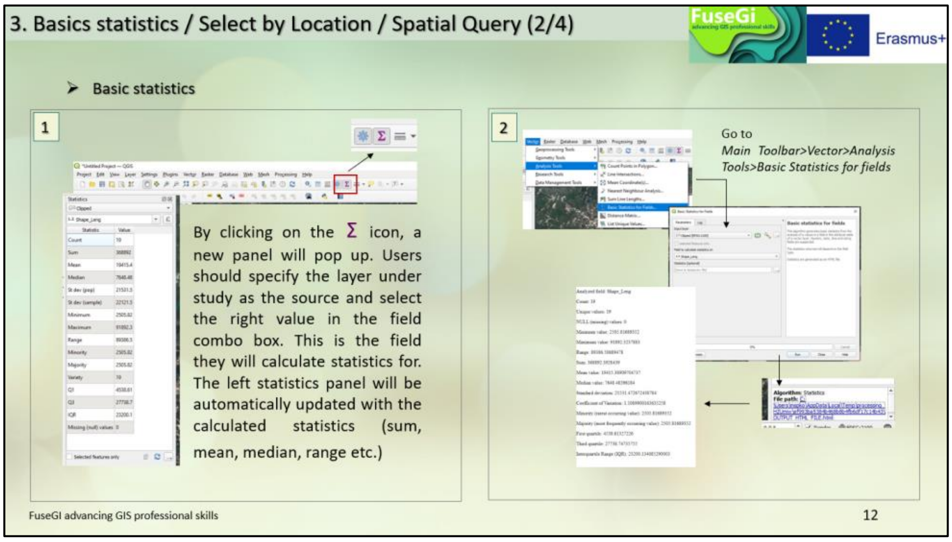

***Figure 57** : Slide 12 of course 5, available via the FuseGI VLE platform.*

The course defines and shows the path of the "select by location" tool. In addition, an example of use illustrates the slide which facilitates understanding **(Figure 58).**

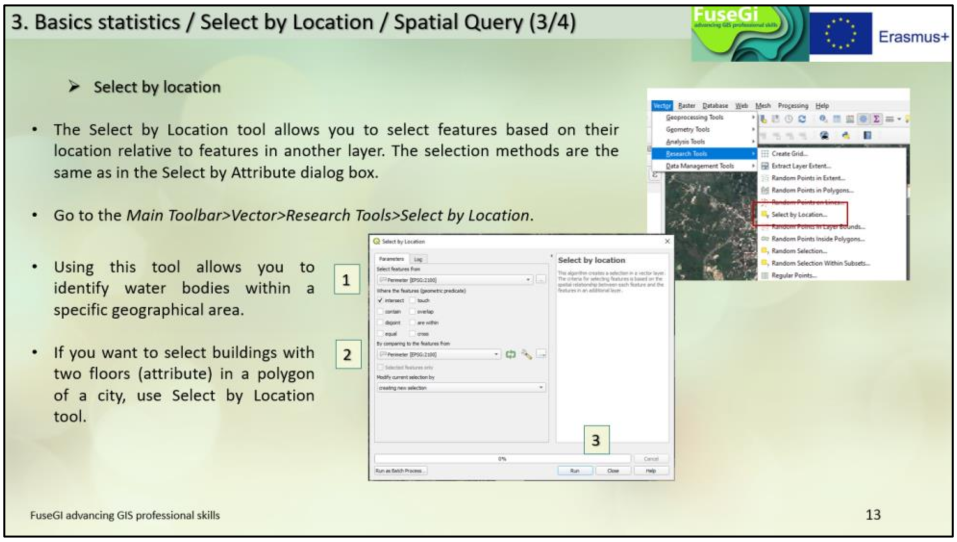

***Figure 58** : Slide 13 of course 5, available via the FuseGI VLE platform.*

Finally, a final spatial analysis tool is presented, the "spatial query" tool **(Figure 59).**

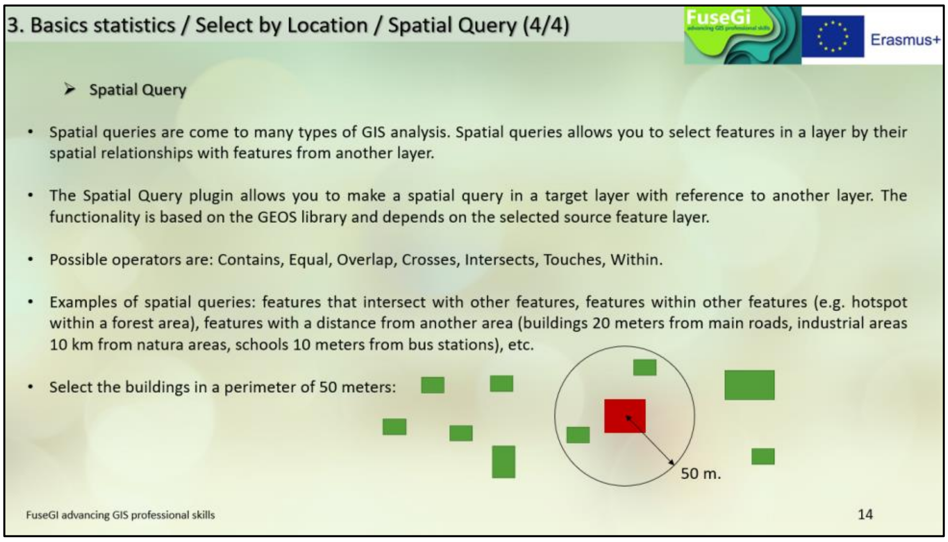

***Figure 59** : Slide 14 of course 5, available via the FuseGI VLE platform.*

The following slides are devoted to the definition and use of the "buffer" tool **(Figure 60).**

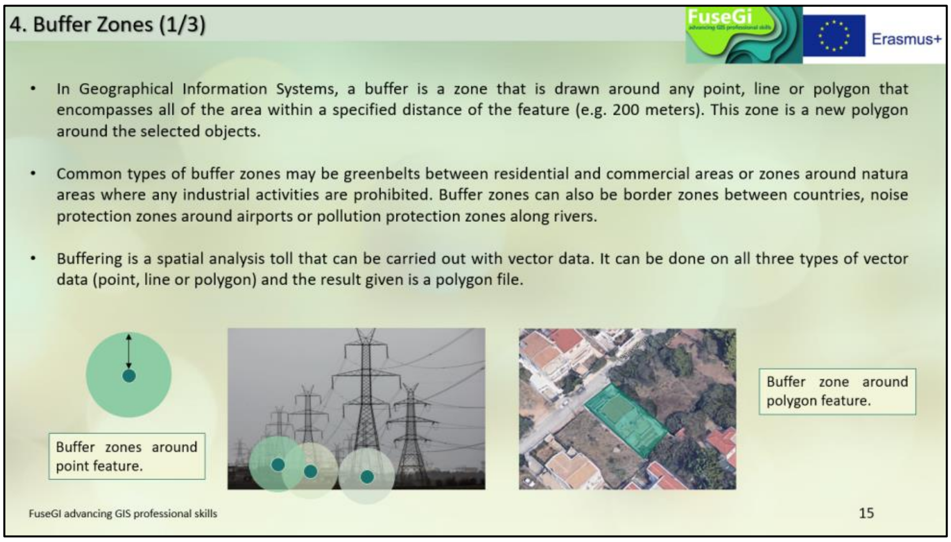

***Figure 60** : Slide 15 of course 5, available through the FuseGI VLE platform.*

It is possible to create buffer zones of different diameters **(Figure 61).**

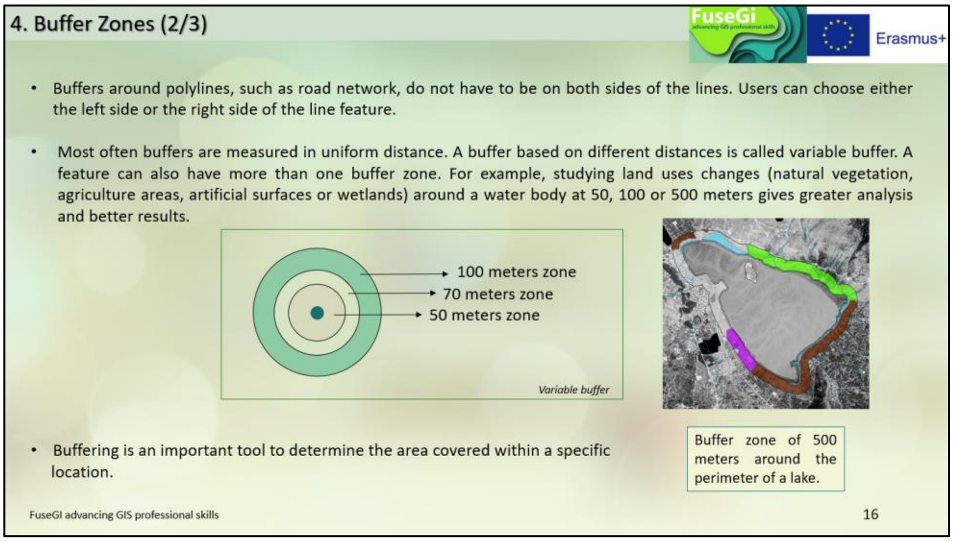

Figure 61 *: Slide 16 of course 5, available through the FuseGI VLE platform.*

The path to the "buffer" tool is described in the fifth course. An example of the use of the tool is also available and provides a better understanding of the use of this tool **(Figure 62).**

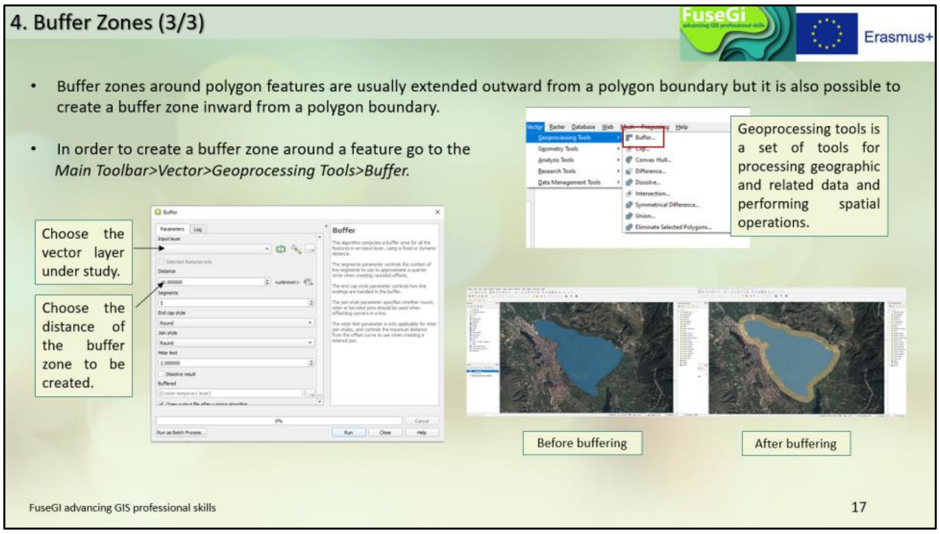

Figure 62 *: Slide 17 of course 5, available through the FuseGI VLE platform.*

Other tools described in this course include the "intersection", "union" and "cut" tools. The "intersection" tool is used to extract the features superimposedbytwo layers **(Figure 63).**

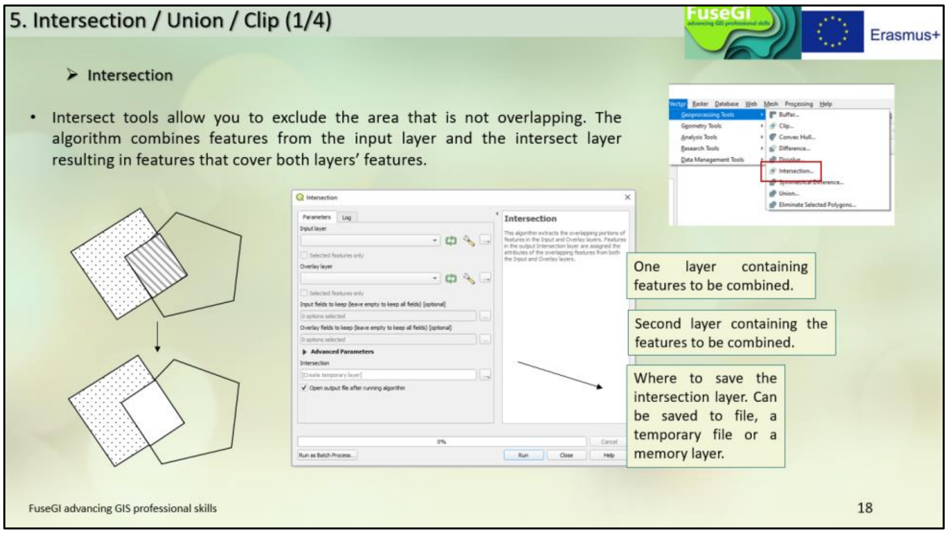

***Figure 63** : Slide 18 of course 5, available via the FuseGI VLE platform.*

The "union" tool verifies overlaps between two-layer entities and creates separate entities for overlapping and non-overlapping parts **(Figure 64).**

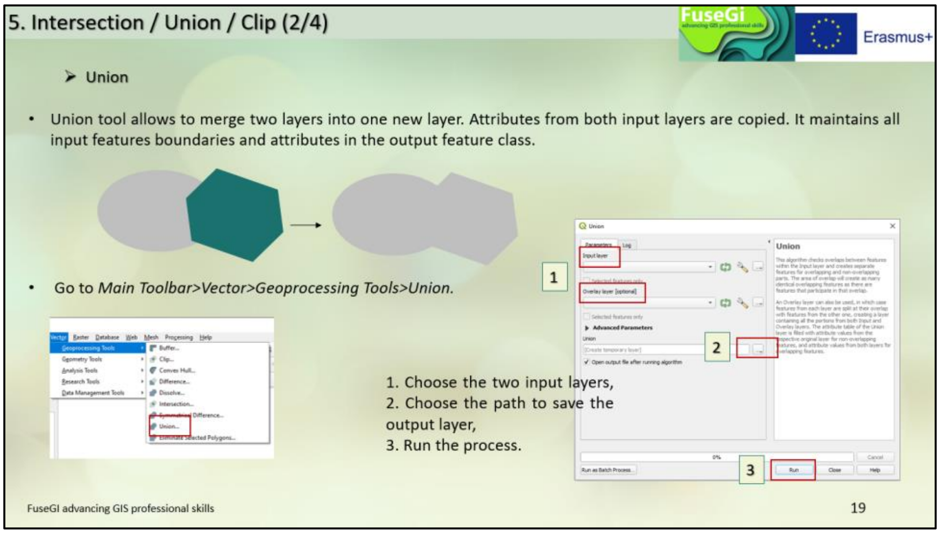

***Figure 64** : Slide 19 of course 5, available via the FuseGI VLE platform.*

The "cut" tool extracts the common parts between two layers by creating a new vector layer **(Figure 65).**

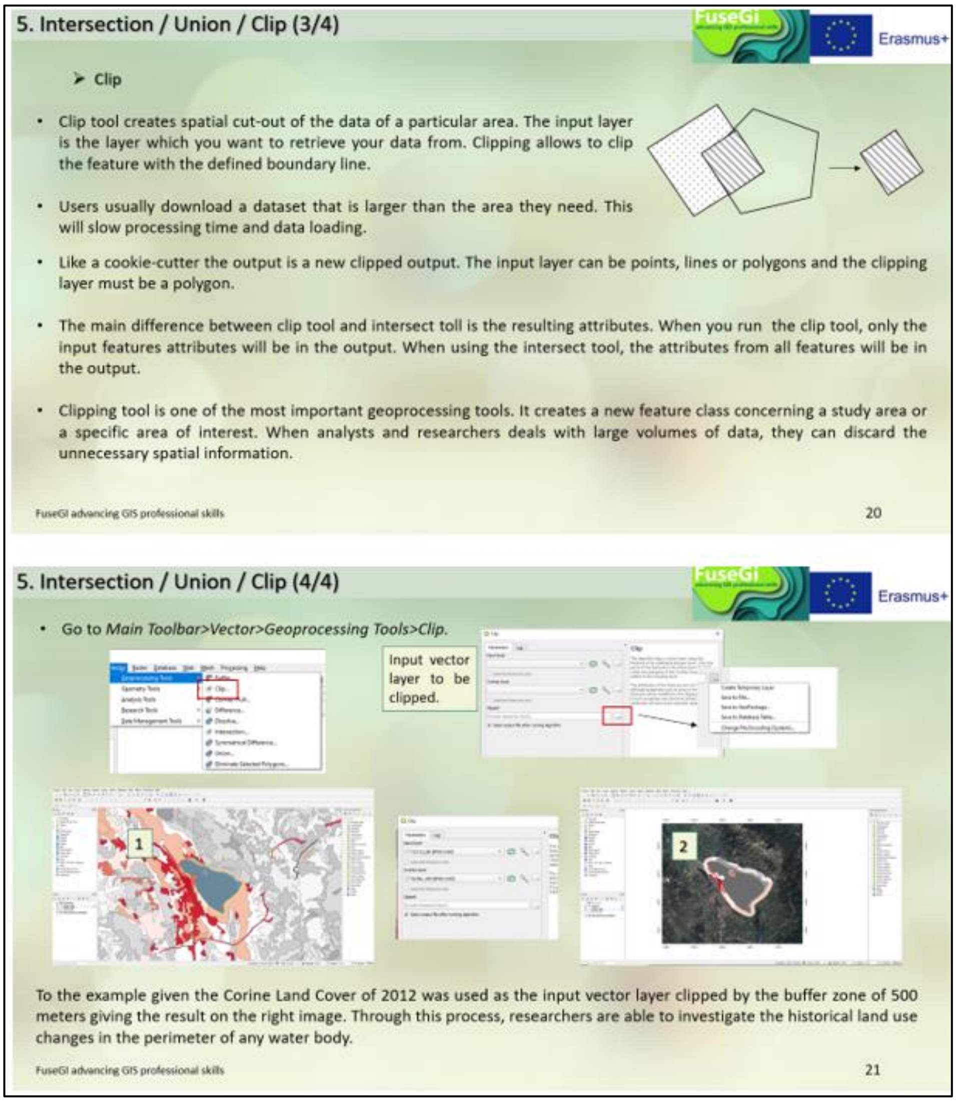

Figure 65 *: Slides 20 and 21 of course 5, available via the FuseGI VLE platform.*

3.6 Course 6: Cartography

The sixth course teaches us the **principle of cartography**, but also how to **create our own maps using the QGIS software (Figure 66).** The mapping tool allows you to export the layers present in the project into data that can feed a map. This course teaches us how to change the symbols and colors of the map, create the legends and how to export the document.

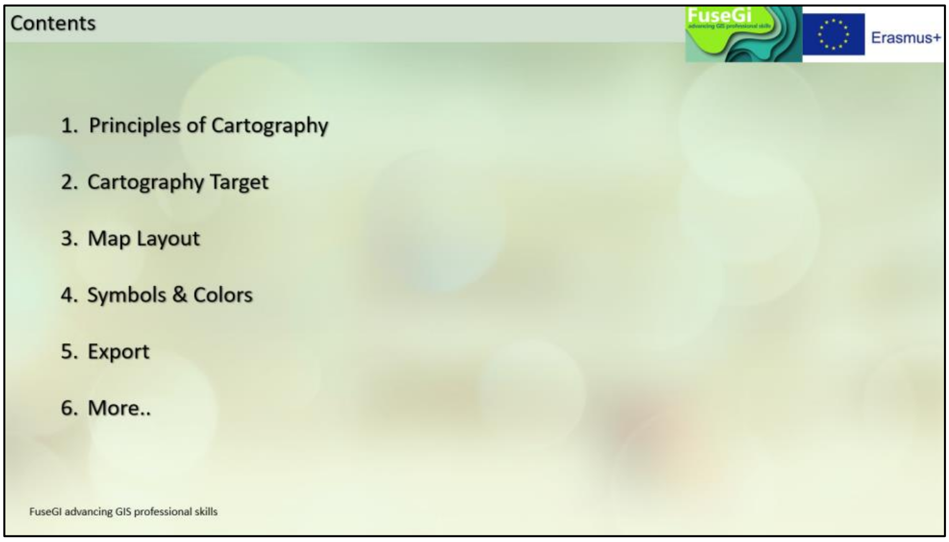

Figure 66 *: Course outline 6, available via the FuseGI VLE platform.*

This course begins with the basics and principles of cartography **(Figure 67).**

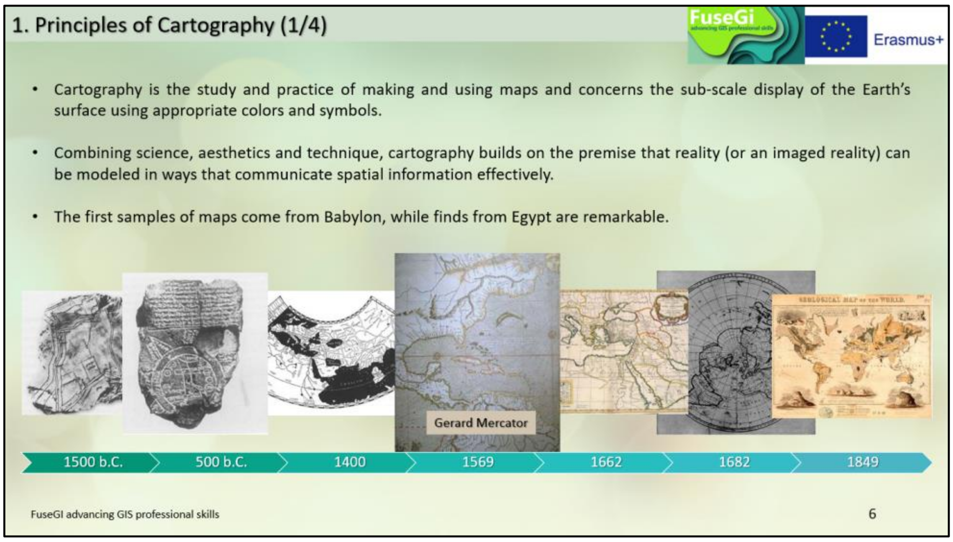

Figure 67 *: Slide 6 of course 6, available via the FuseGI VLE platform.*

The following slides are slow reminders and define the principles of mapping **(Figure 68).**

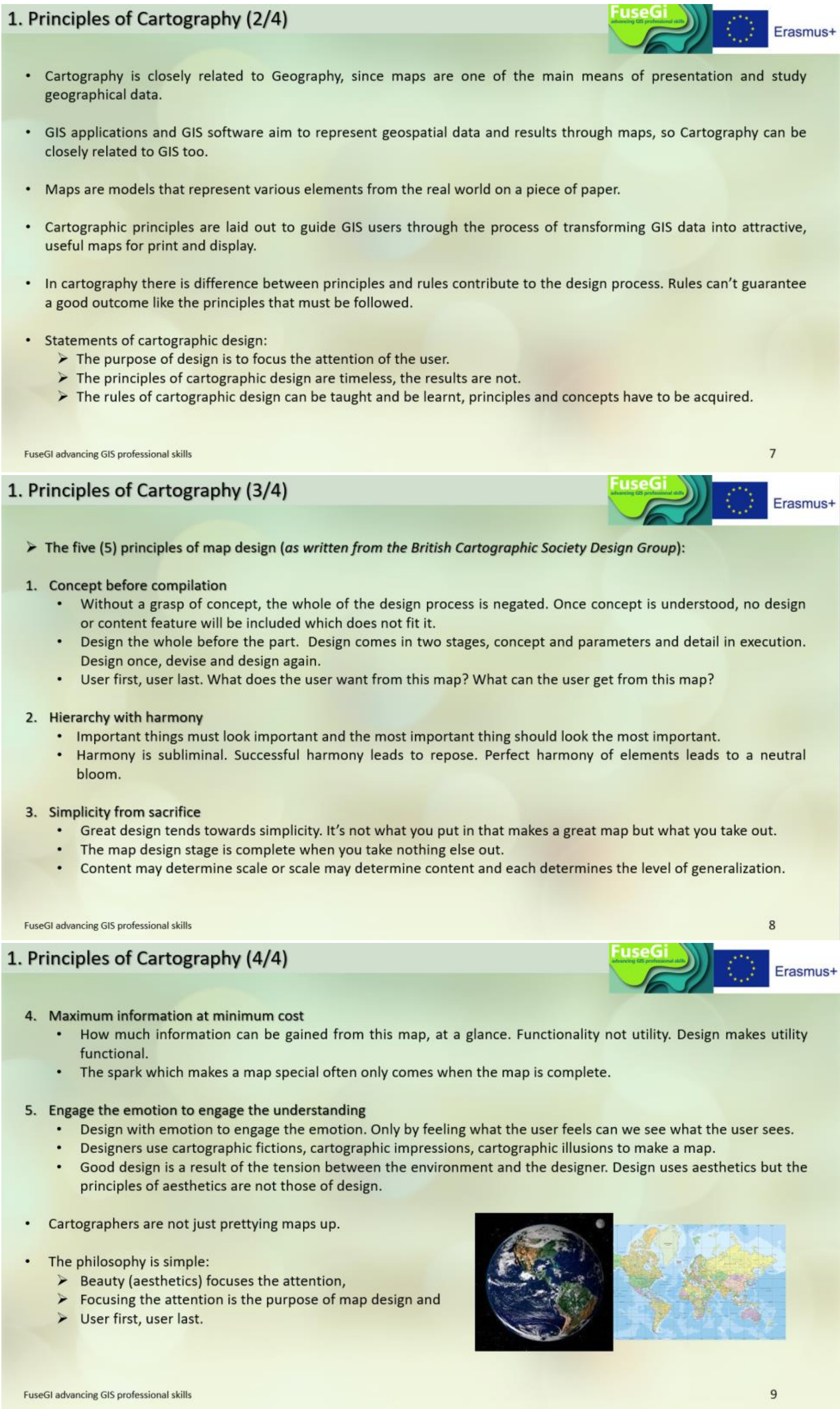

***Figure 68** : Slides 7, 8 and 9 of course 6, available via the FuseGI VLE platform.*

Next, the course shows us the basic functions of a map and what types of information can be found in a map **(Figure 69).**

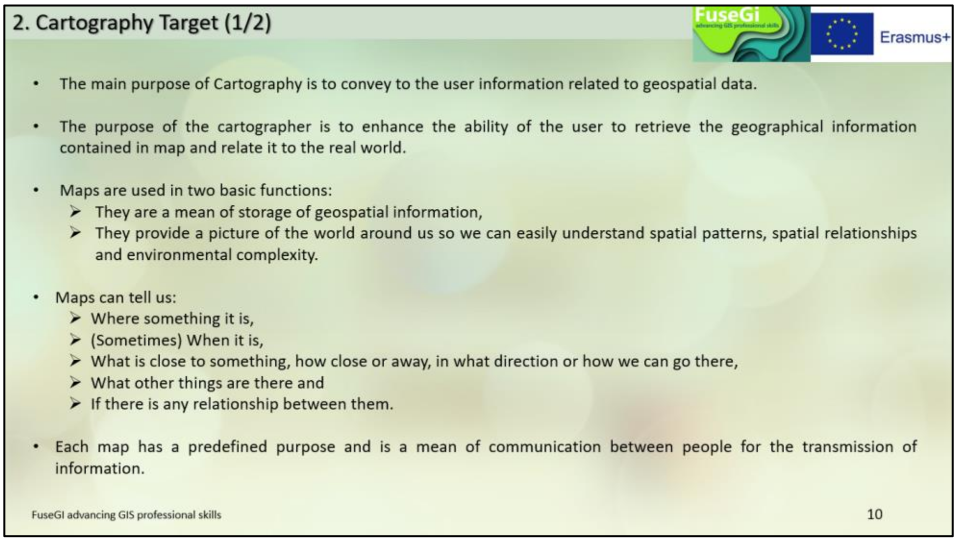

***Figure 69** : Slide 10 of course 6, available through the FuseGI VLE platform.*

In addition, the course indicates what types of maps can be represented using GIS **(Figure 70).**

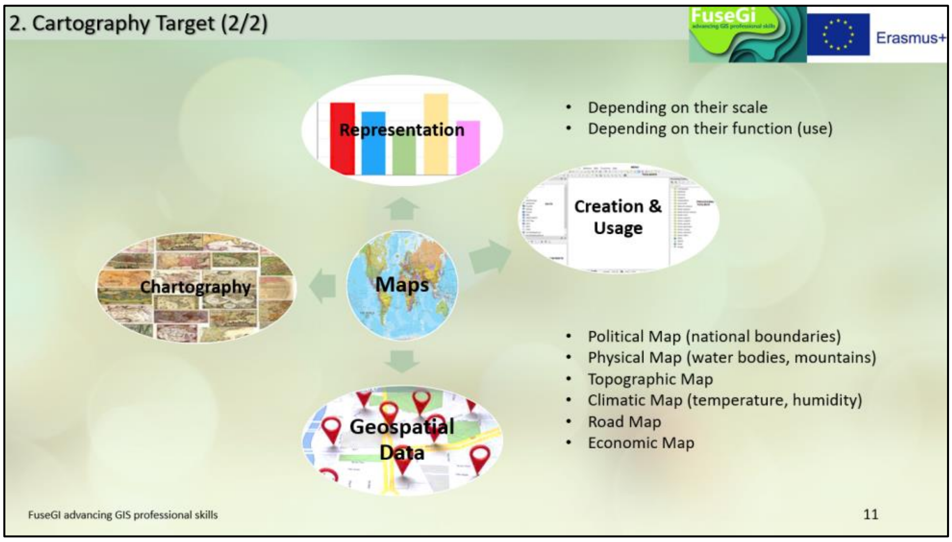

***Figure 70** : Slide 11 of course 6, available via the FuseGI VLE platform.*

After processing the data and the different layers, it is possible thanks to the QGIS software to create cartographic representations. These map representations follow 5 design principles presented in the next slide **(Figure 71).**

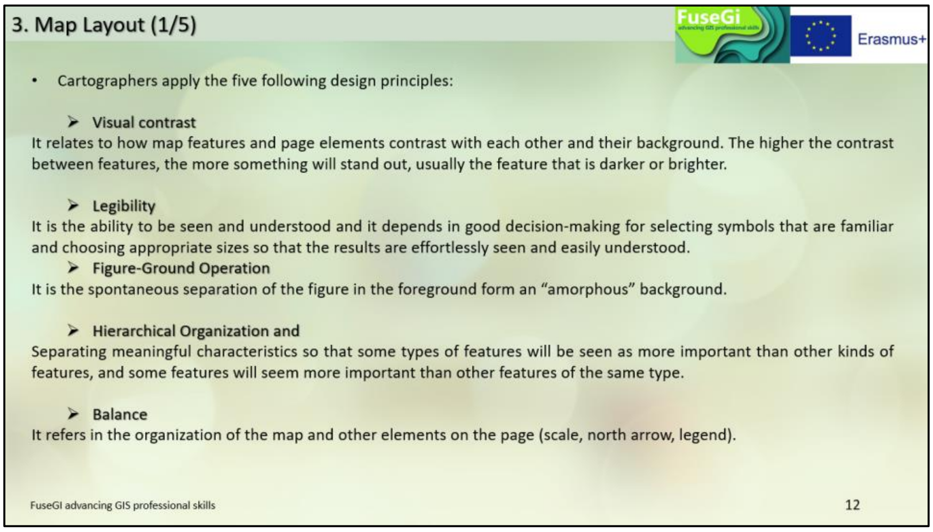

***Figure 71** : Slide 12 of course 6, available via the FuseGI VLE platform.*

It is possible to add all the basic elements of a map such as the title, the arrow indicating north, the scale bar, the legend and the map itself **(Figure 72).**

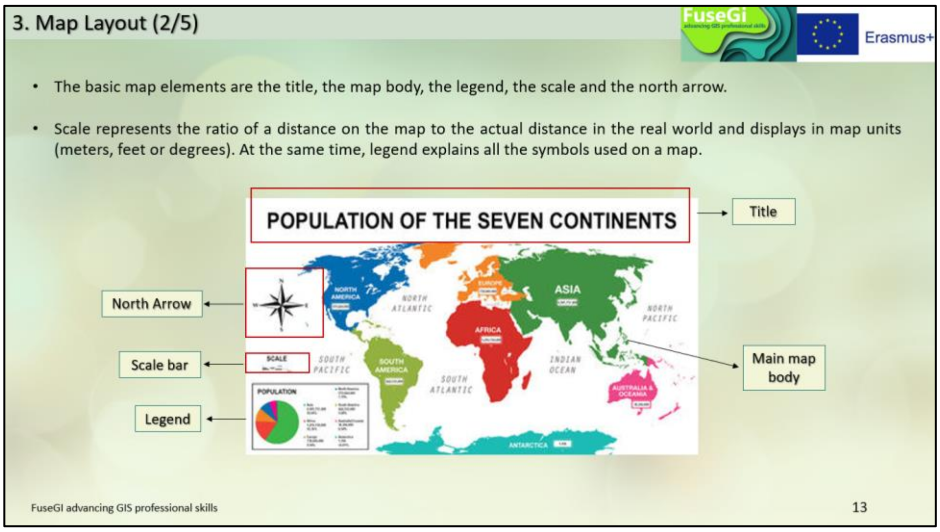

***Figure 72** : Slide 13 of course 6, available via the FuseGI VLE platform.*

All of these items listed above are available in the QGIS mapping workspace **(Figure 73).**

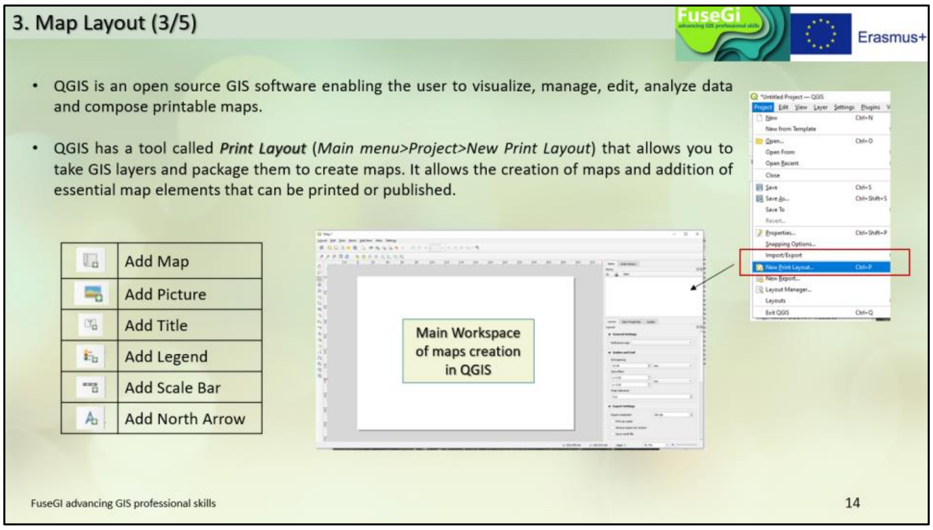

Figure 73 : *Slide 14 of course 6, available via the FuseGI VLE platform.*

It is possible to change the titles of the legend and the color and appearance of the symbols **(Figure 74).**

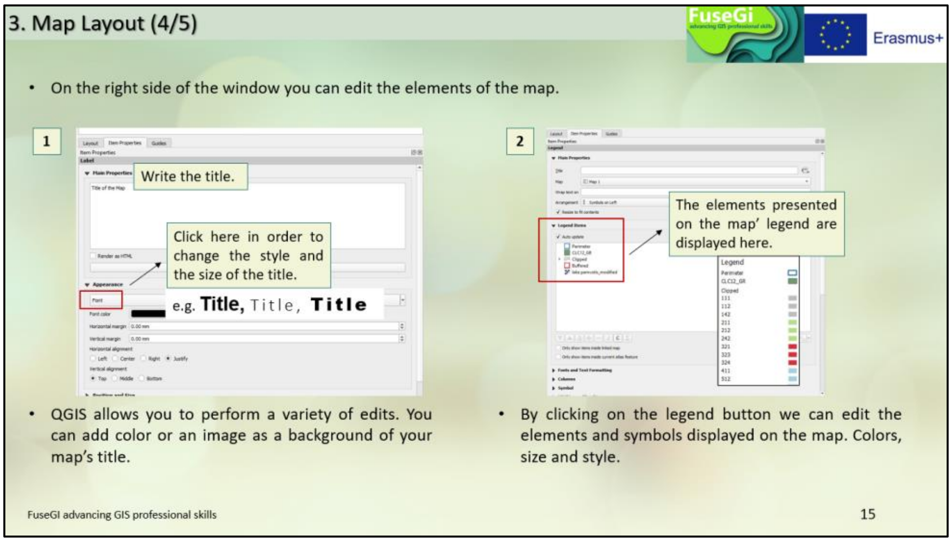

Figure 74 : *Slide 15 of course 6, available via the FuseGI VLE platform.*

In addition, elements such as the arrow indicating north or the scale bar are customizable **(Figure 75).**

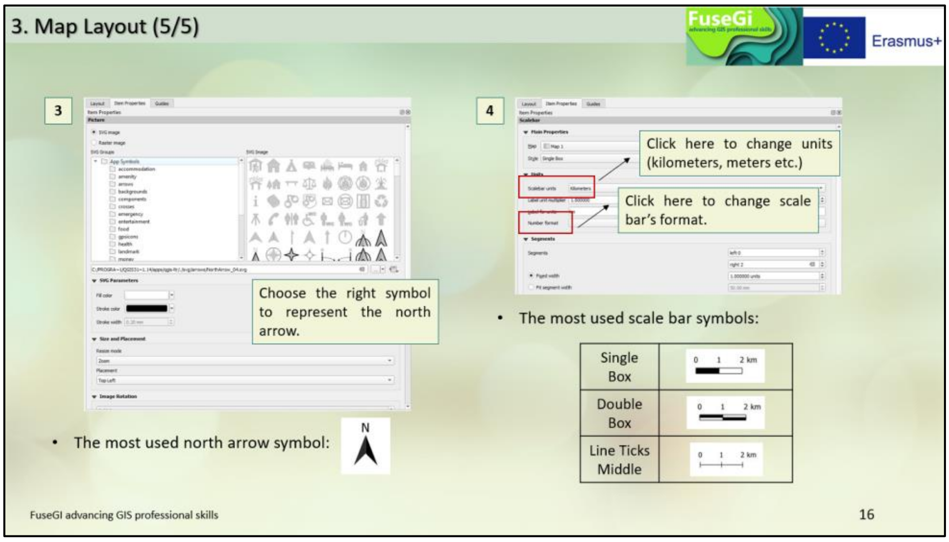

Figure 75 *: Slide 16 of course 6, available via the FuseGI VLE platform.*

In order to have a better visibility of the information on the map, it is possible to customize the symbols used. To do this, go to the "settings" of the layer to modify and open the "symbology" tab **(Figure 76).**

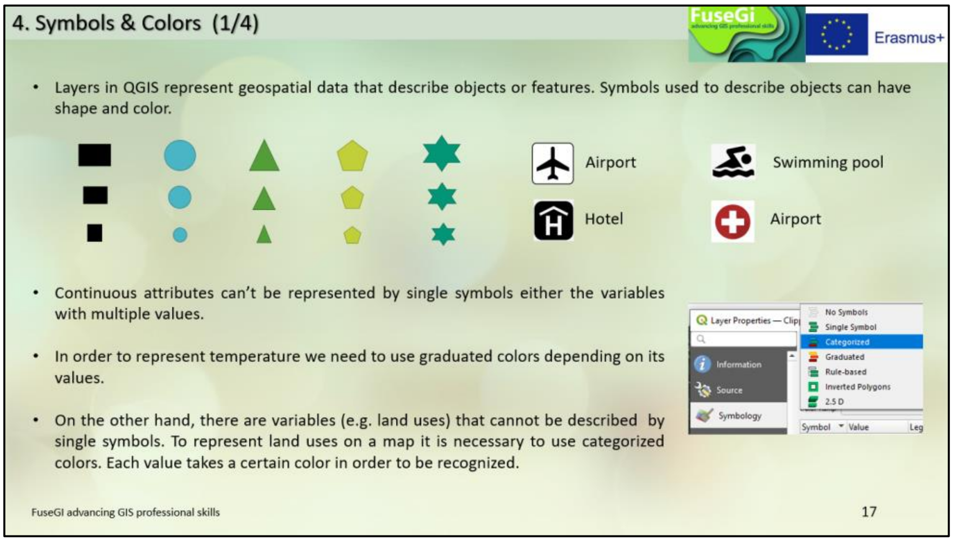

Figure 76 *: Slide 17 of course 6, available through the FuseGI VLE platform.*

In addition, it is possible to categorize information, add information, or remove information **(Figure 77).**

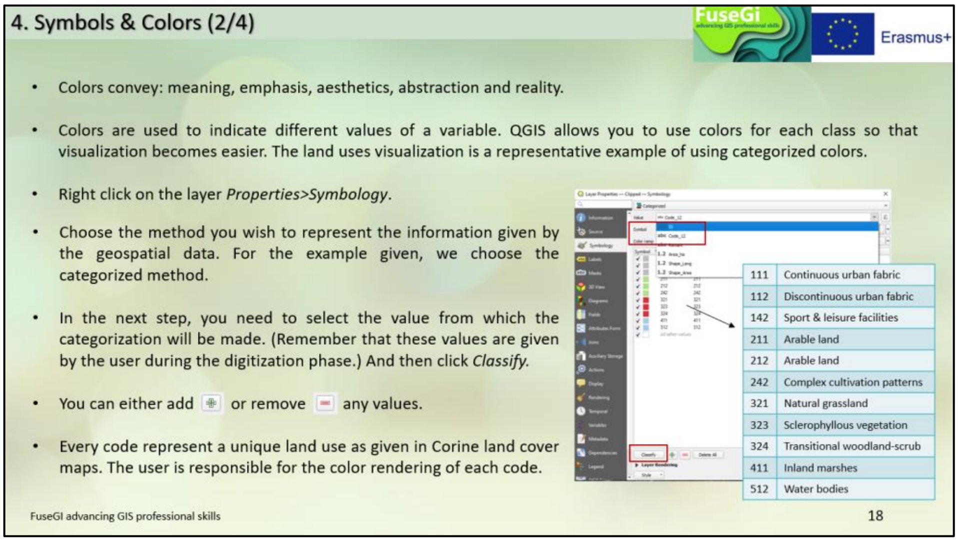

***Figure 77** : Slide 18 of course 6, available via the FuseGI VLE platform.*

In the course, there are examples of card personalization. Each of the colours represents a different environment such as agricultural land or artificial surfaces **(Figure 78).**

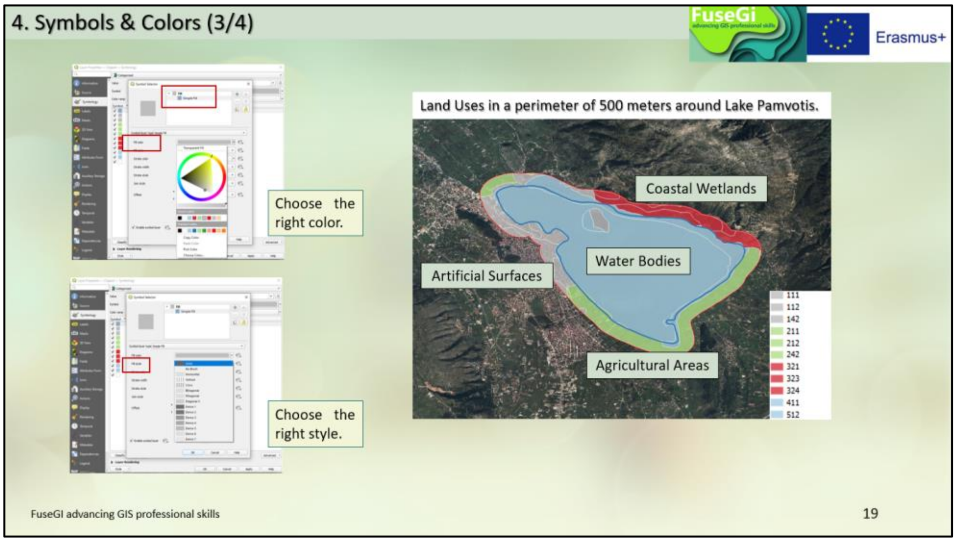

***Figure 78** : Slide 19 of course 6, available via the FuseGI VLE platform.*

Another example of map customization is available. This time, it is the customization of layers thanks to the "graduated" option in the "symbology" section of the layer parameters that is presented **(Figure 79).**

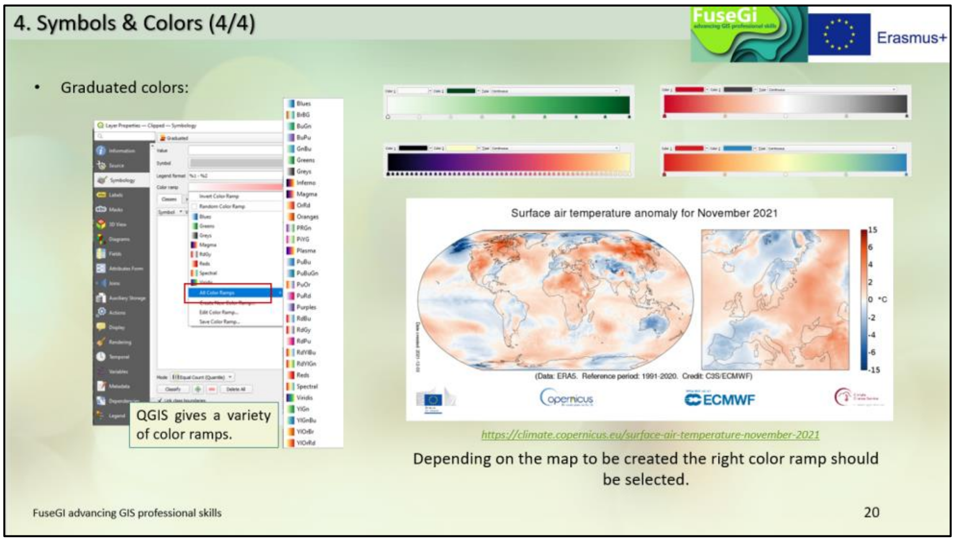

***Figure 79** : Slide 20 of course 6, available through the FuseGI VLE platform.*

Finally, all cartographic representations can be exported and saved in PDF for example **(Figure 80).**

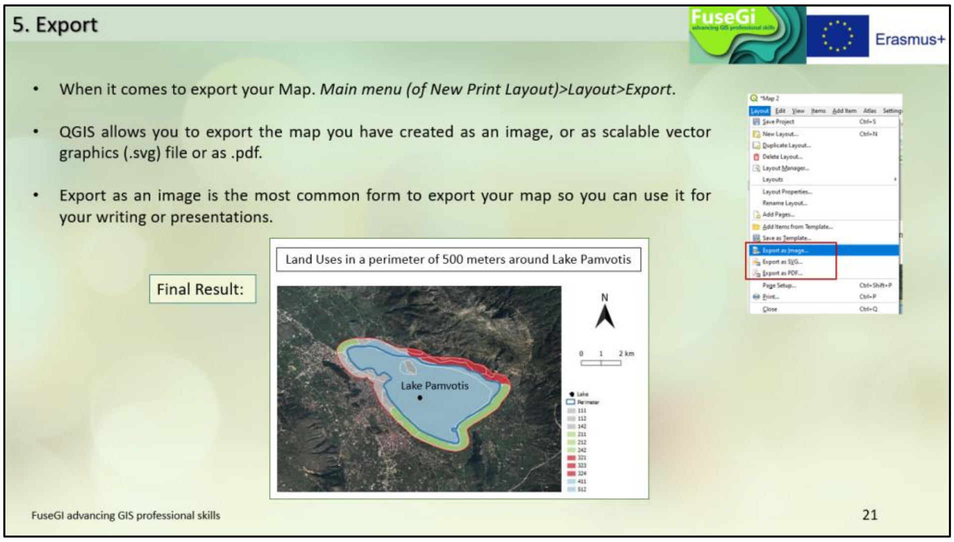

***Figure 80** : Slide 21 of course 6, available through the FuseGI VLE platform.*

3.7 Course 7: Grass GIS

The seventh course **introduces the basics for using another** software, **the Grass GIS software**. This is downloaded and installed along with the QGIS software **(Figure 81).** This course presents us the possible uses of this software, its workspace. Like QGIS software, this software uses raster and vector data; In particular, it allows the processing of images and the processing of public data.

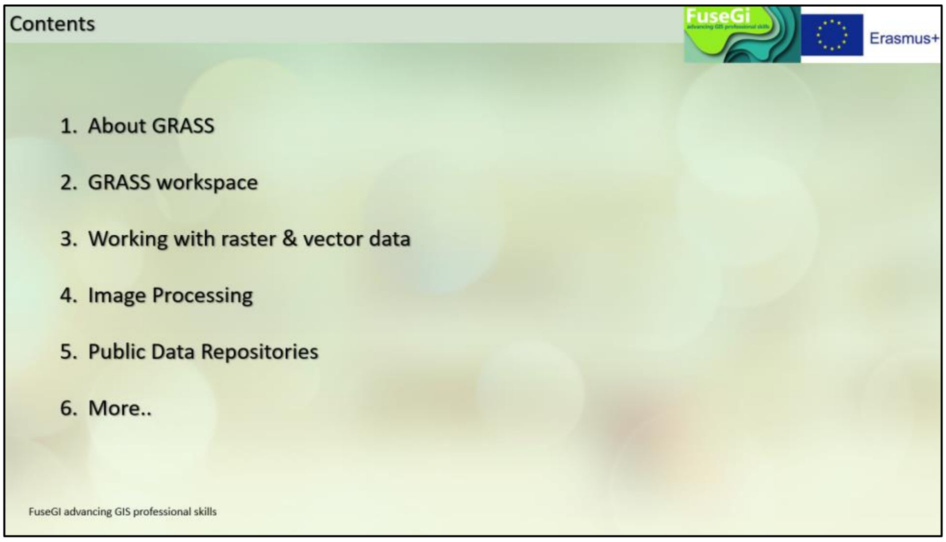

***Figure 81** : Course outline 7, available via the FuseGI VLE platform.*

The seventh course introduces the GRASS GIS software, the follow-up of this course will then allow the user to master the basics of the software to be able to use it in addition to QGIS **(Figure 82).**

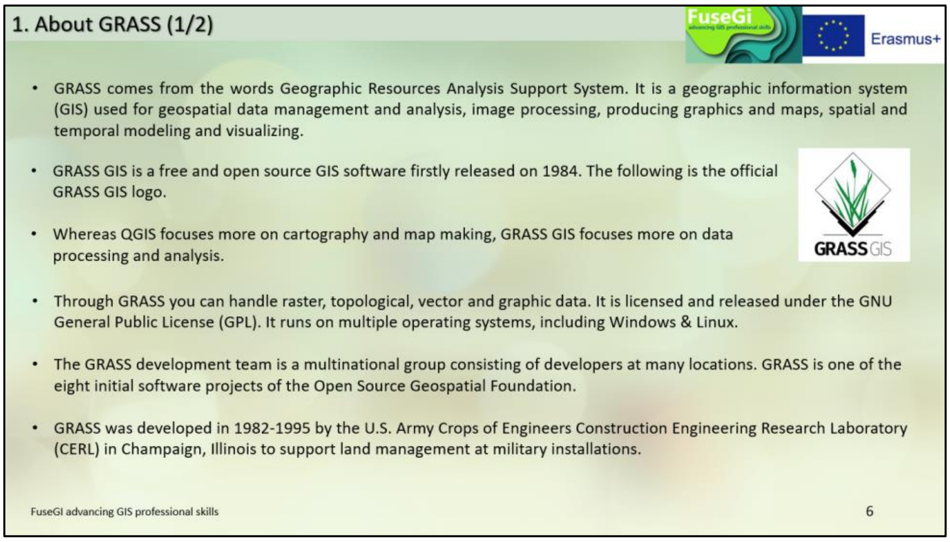

***Figure 82** : Slide 6 of course 7, available through the FuseGI VLE platform.*

The first slides introduce and define the principles for using the GRASS GIS software **(Figure 83).**

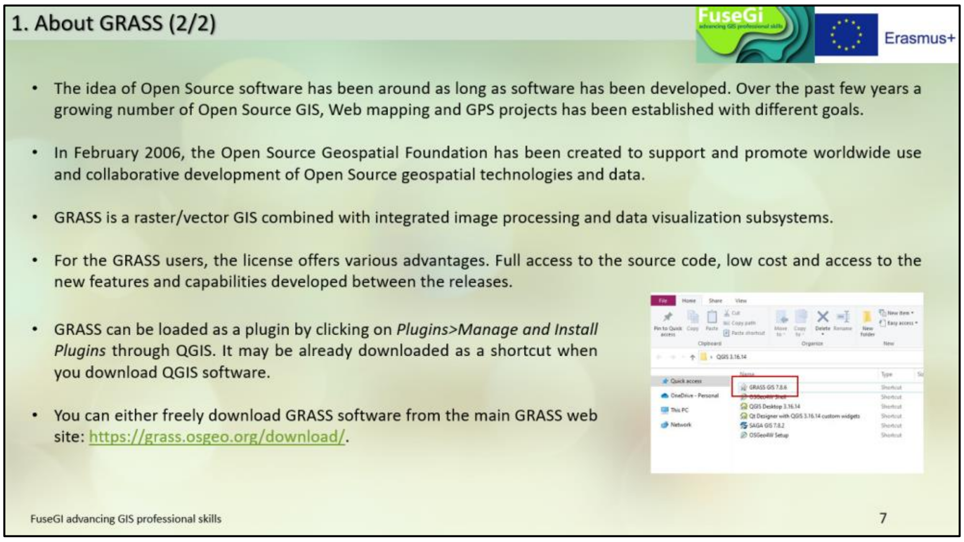

Figure 83 *: Slide 7 of course 7, available via the FuseGI VLE platform.*

It is possible to use the GRASS GIS software in addition to the QGIS software. In addition, GRASS GIS can be used for scientific research or engineering applications **(Figure 84).**

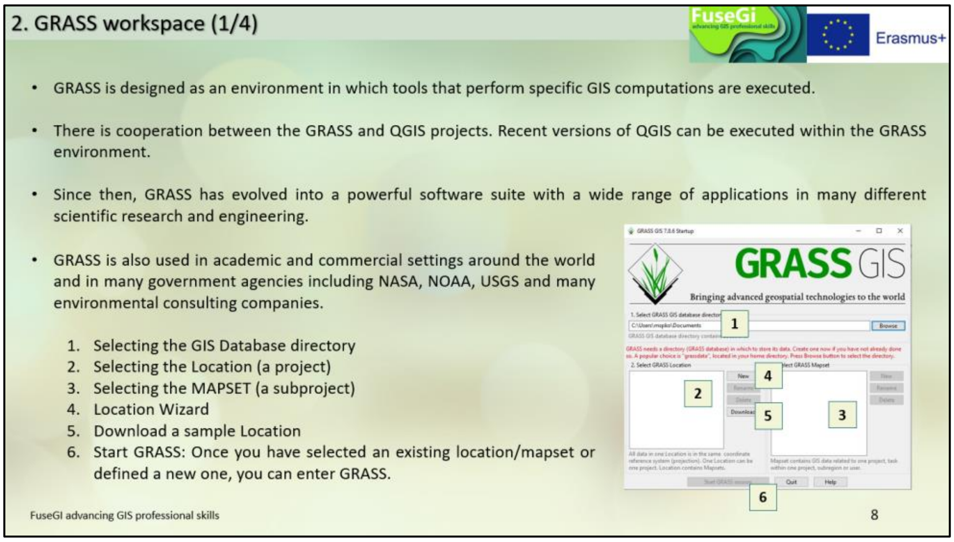

Figure 84 *: Slide 8 of course 7, available through the FuseGI VLE platform.*

The next slide describes the GRASS GIS application workspace **(Figure 85).**

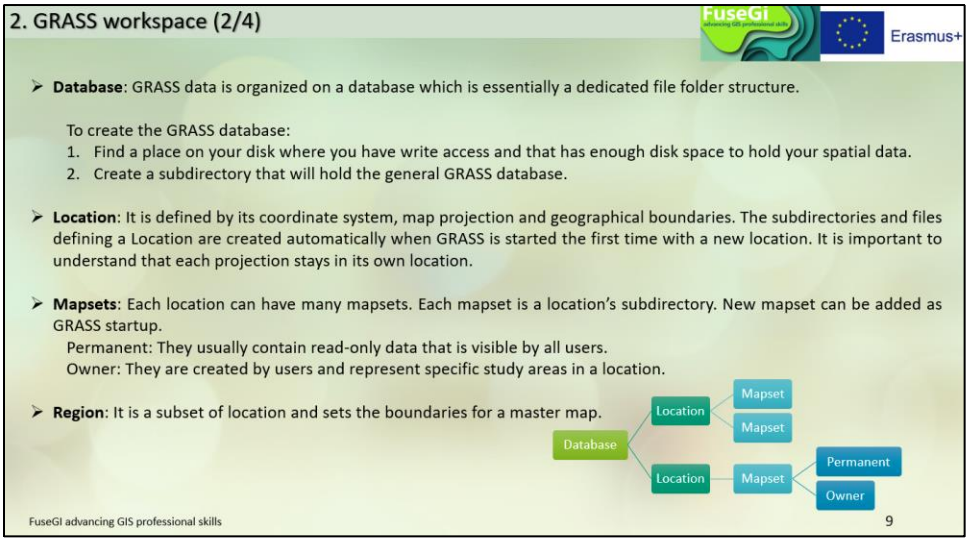

Figure 85 *: Slide 9 of course 7, available through the FuseGI VLE platform.*

The GRASS GIS database can be accessed directly from QGIS by installing an extension of QGIS **(Figure 86).**

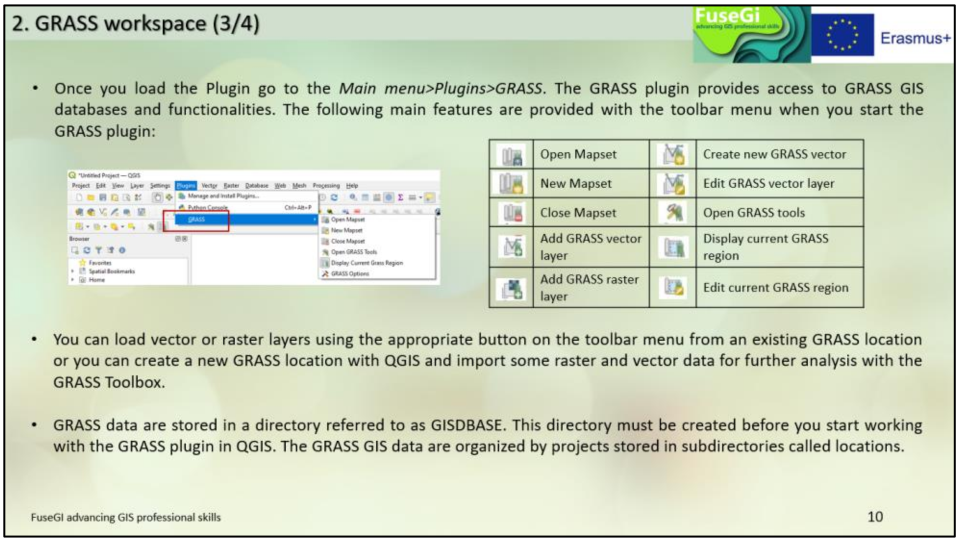

Figure 86 *: Slide 10 of course 7, available via the FuseGI VLE platform.*

Once the extension is installed, it is very simple to use the data from GRASS GIS through QGIS **(Figure 87).**

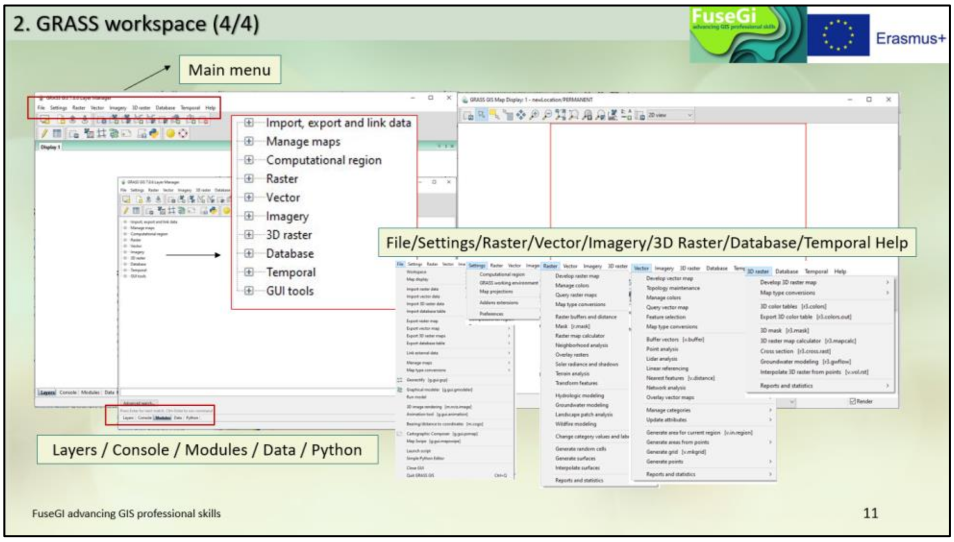

***Figure 87** : Slide 11 of course 7, available via the FuseGI VLE platform.*

Thanks to GRASS GIS, it is possible to process raster or vector type data information. First, the course specifies how to process raster information through GRASS **(Figure 88).**

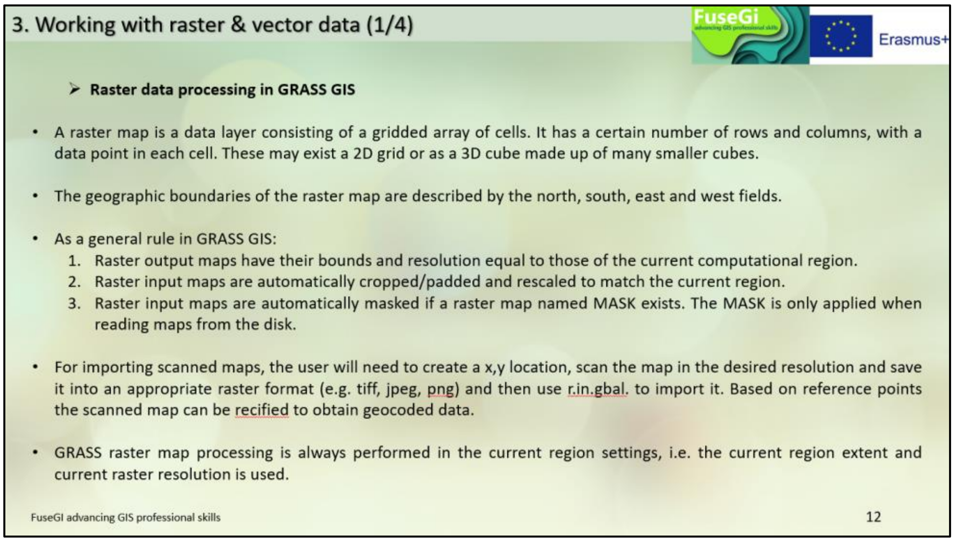

***Figure 88** : Slide 12 of course 7, available via the FuseGI VLE platform.*

Many commands are available to create and analyze raster data using GRASS **(Figure 89).**

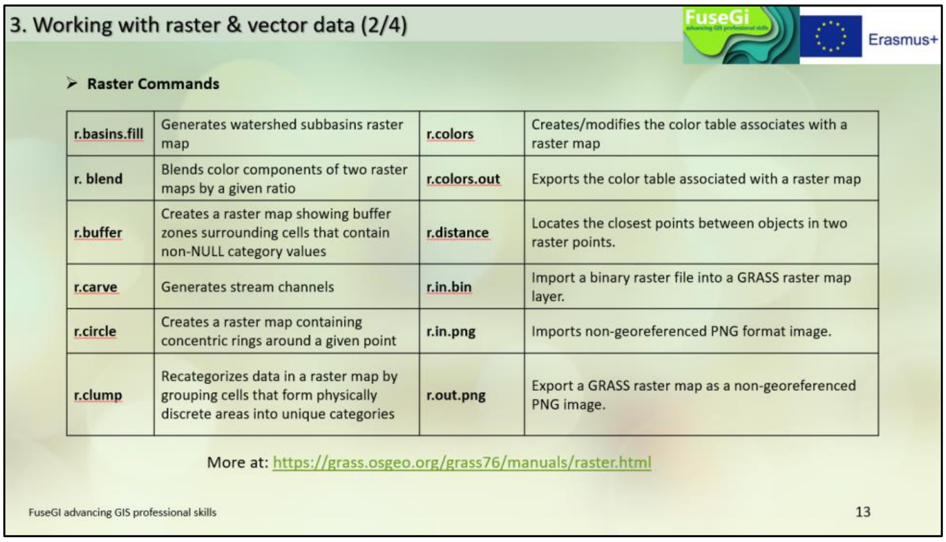

***Figure 89** : Slide 13 of course 7, available via the FuseGI VLE platform.*

In a second step, the course specifies how to process the information of a vector through the GRASS GIS application **(Figure 90).**

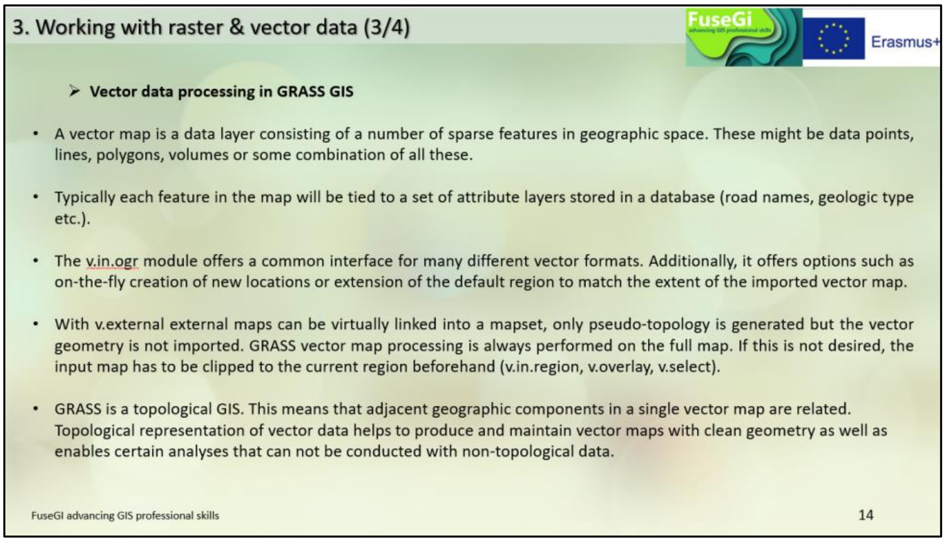

***Figure 90** : Slide 14 of course 7, available through the FuseGI VLE platform.*

Many commands are available to create and analyze vector data using GRASS **(Figure 91).**

3. Working with raster & vector data (4/4)

➢ **Vector Commands**

v.buffer	Creates a buffer around vector features of given type	v.db.droprow	Removes a vector feature from a vector map through attribute selection
v.build	Creates topology for vector map	v.db.droptable	Removes existing attribute table of a vector map
v.class	Classifies attribute data, e.g. for thematic mapping	v.db.select	Prints vector map attributes
v.clip	Extracts features of input map which overlay features of clip map	v.drape	Converts 2D vector features to 3D by sampling of elevation raster map
v.cluster	Performs cluster identification	v.edit	Edits a vector map, allows adding, deleting and modifying selected vector features
v.colors	Creates/modifies the color table associated with a vector map	v.generalize	Performs vector based generalization
v.In region	Creates a vector polygon from the current region extent	v.patch	Creates a new vector map by combining other vector maps

More at: https://grass.osgeo.org/grass78/manuals/vector.html

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Figure 91 *: Slide 15 of course 7, available via the FuseGI VLE platform.*

The GRASS GIS software also allows raster data to be processed as images **(Figure 92).**

4. Image Processing (1/2)

- Satellite imagery is commonly stored in Digital Numbers (DN) for minimizing the storage volume, i.e. the originally sampled analog physical value (color, temperature, ets) is stored a discrete representation in 8-16 bits.
- To obtain physical values from DNs, satellite image providers use a liner transform equation (y=a*x+b) to encode the radiance-at-sensor in 8 to 16 bits. DNs can be turned back into physical values by applying the reverse formula (x-(y+b)/a).
- In GRASS GIS, there are two ways to apply atmospheric correction for satellite imagery. A simple, less accurate way for Landsat is with i.landsat.toar, using the DOS correction method.
- Image data are identical to raster data However, a couple of commands are explicitly dedicated to image processing.
- As a general rule in GRASS:
  1. Raster/imagery output maps have their bounds and resolution equal to those of the current region.
  2. Raster/imagery input maps are automatically cropped/padded and rescaled (using nearest-neighbor resampling) to match the current region.
- GRASS raster/imagery map processing is always performed in the current region settings, ie. The current region extent and current raster resolution is used. If the resolution differs from that of the input raster map(s), on-the-fly resampling is performed (nearest neighbor resampling).

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4. Image Processing (2/2)

- An image processing system has at least five elements: image input, image storage, image analysis, accuracy assessment and information reporting.
- Single and multispectral data can be classified to user defined land use/land cover classes. In case of a single channel, segmentation will be used. GRASS supports the following methods:
  - Radiometric classification:
    - Unsupervised classification (i.cluster, i.maxlik) using the Maximum Likelihood classification method.
    - Supervised classification (i.gensig or g.gui.iclass, i.maxlik) using the Maximum Likelihood classification method
  - Combined radiometric/geometric (segmentation base) classification:
    - Supervised classification (i.gensigset, i.smap)
  - Object-oriented classification:
    - Unsupervised classification (segmentation based: i.segment)

- In case of using multispectral data, improvements of the resolution can be gained by merging the panchromatic channel with color channels. GRASS provides the HIS (i.rgb.his, i.his.rgb) ant the Brovey and the PVA transform (i.pansharpen) methods.
- Atmospheric effects can be removed with i.atcorr. Correction for topographic/terrain effects is offered in i.topo.corr.

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Figure 92 *: Slides 16 and 17 of course 7, available via the FuseGI VLE platform.*

Finally, it is possible to find public data repositories in the course, via links, to access useful data to obtain information on the biosphere or the environment for example **(Figure 93).**

***Figure 93** : Slides 18 and 19 of course 7, available via the FuseGI VLE platform.*

3.8 Course 8: Hydrological Analysis and QGIS Tools

The eighth course is **entirely focused on one discipline, hydrology**. This course is therefore more specific since it is directly related to this field. Nevertheless, it **is not inaccessible to people who do not know this field**. It consists of an introduction to hydrology and a presentation of software used for hydrology. We can also find a description of the useful tools and the procedure to follow for a hydrological analysis **(Figure 94).**

Figure 94 *: Course outline 8, available via the FuseGI VLE platform.*

This course learns, for example, how to use GIS to define a catchment area or flow direction, as well as the basics of hydrology **(Figure 95).**

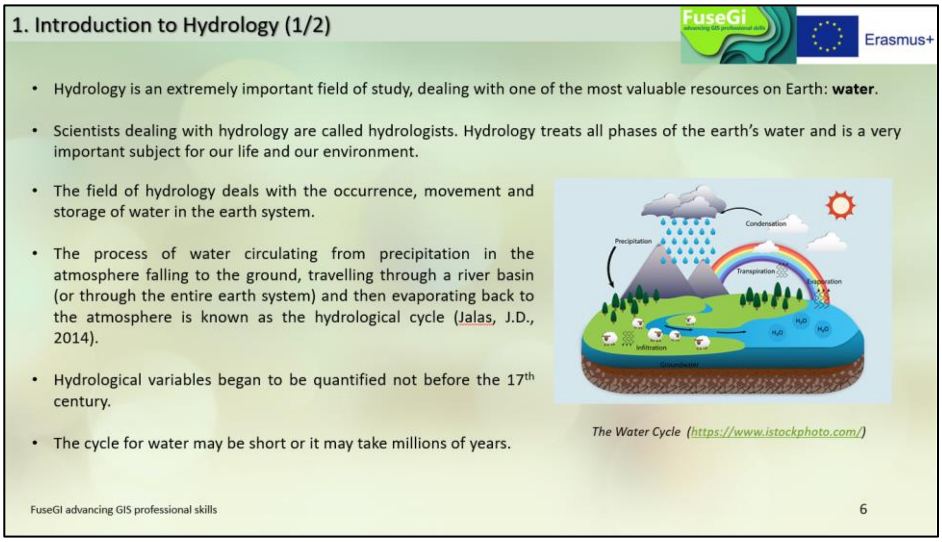


Figure 95 *: Slide 6 of course 8, available through the FuseGI VLE platform.*

The first slides introduce hydrology to participants who are not in this field or to make some reminders for those working or studying in the field of hydrology **(Figure 96).**

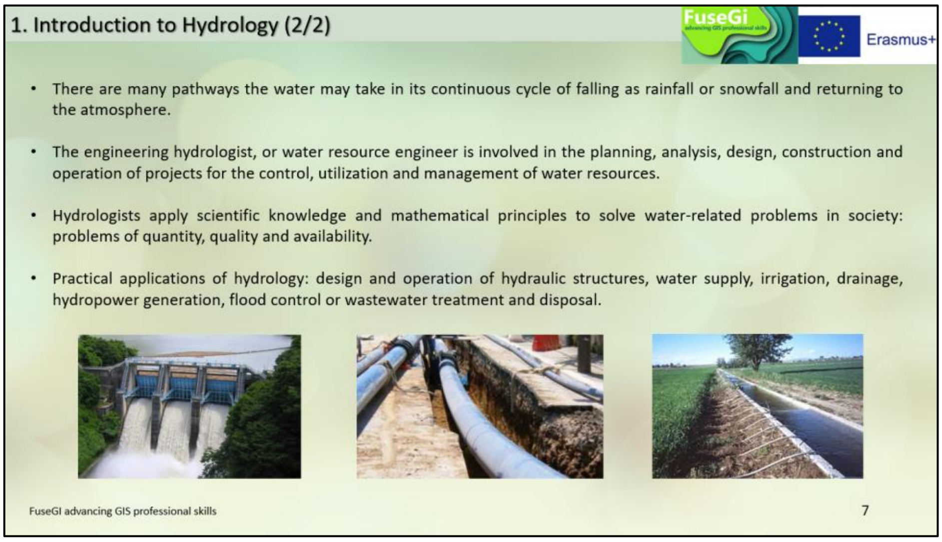


Figure 96 *: Slide 7 of course 8, available via the FuseGI VLE platform.*

Hydrological analysis tools are a very important resource in this area. GIS software is used, but river modeling software or hydraulic modeling software is also used **(Figure 97).**

Figure 97 *: Slides 8 and 9 of course 8, available via the FuseGI VLE platform.*

There is a toolbox available with QGIS that allows hydrological analyses to be carried out. This toolkit is known as SAGA **(Figure 98).**

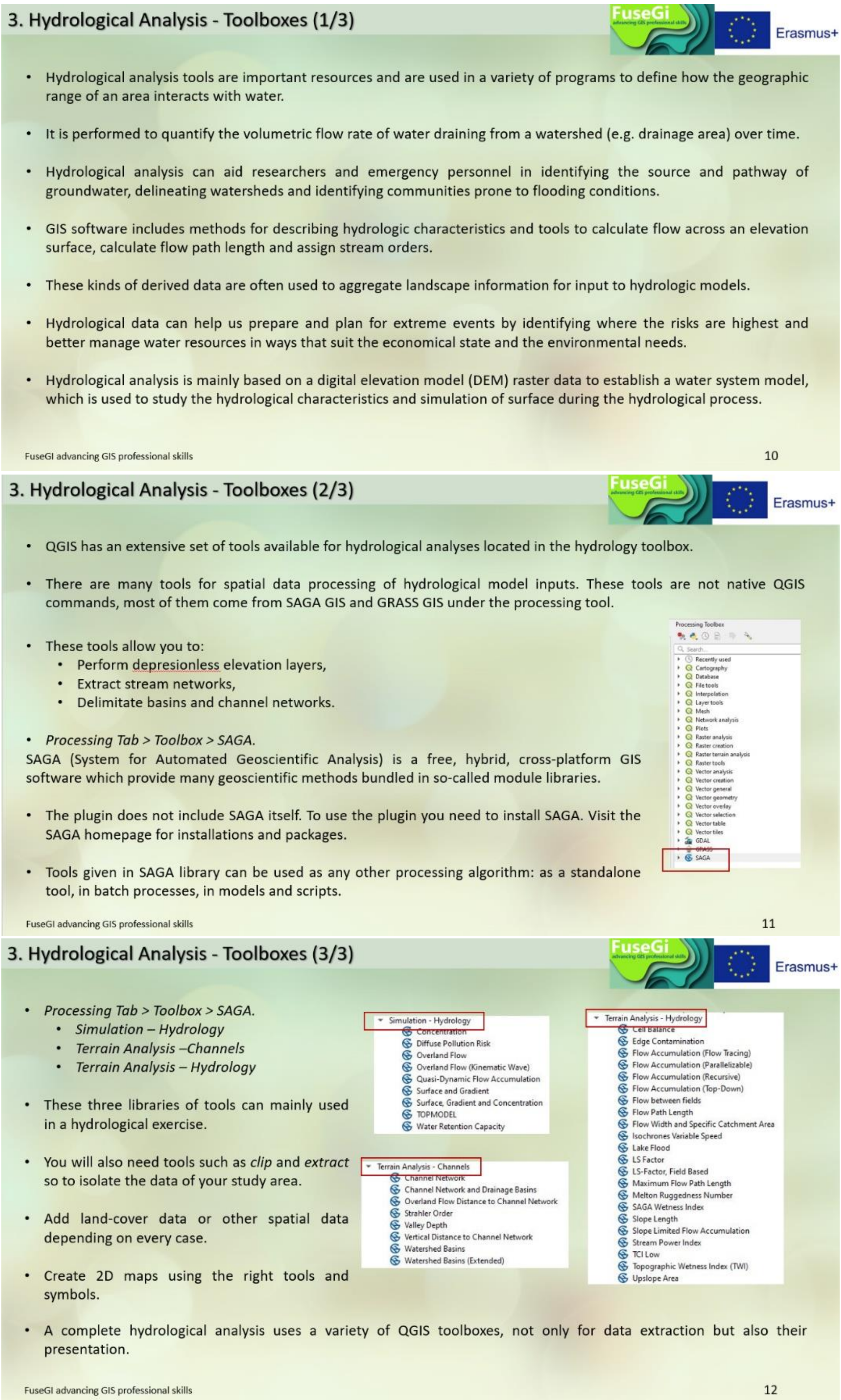


Figure 98 *: Slides 10, 11, and 12 of course 8, available through the FuseGI VLE platform.*

The digital elevation model is widely used in environmental science, whether in hydrology or vegetation cover management. This course allows you to define and create this type of model **(Figure 99).**

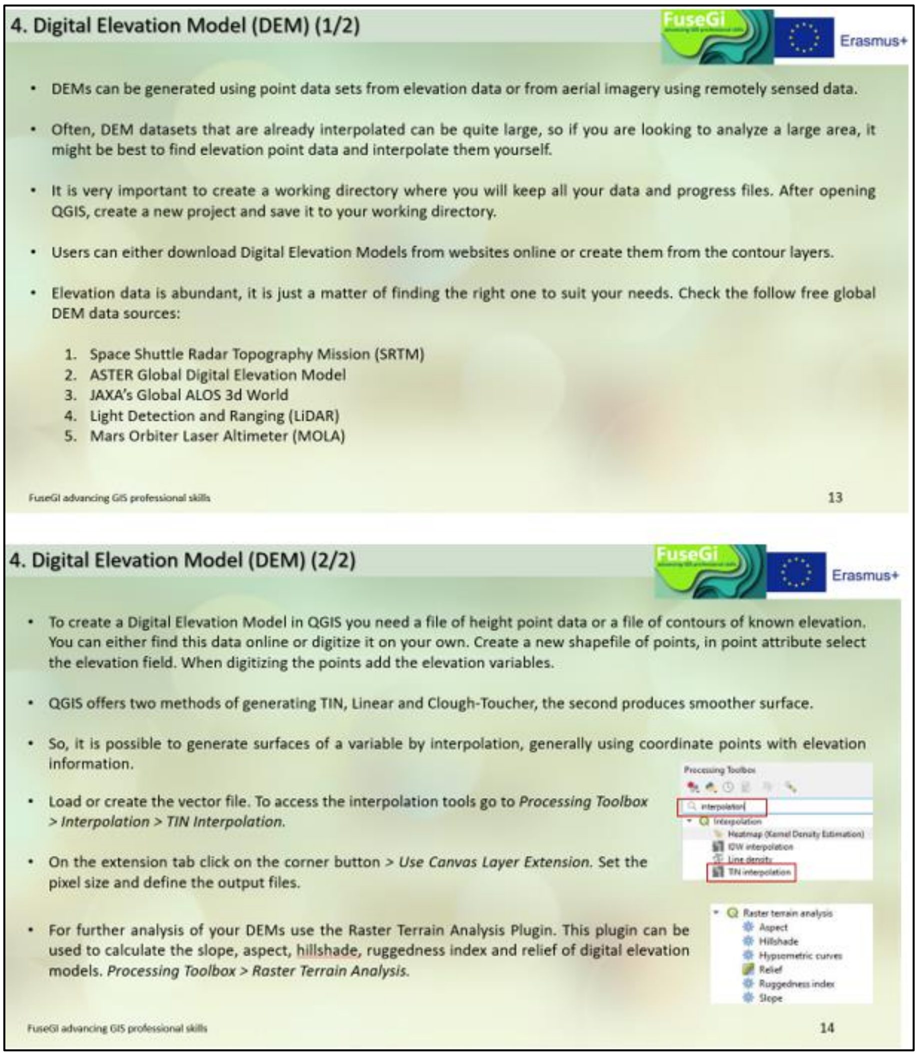


Figure 99 *: Slides 13 and 14 of course 8, available via the FuseGI VLE platform.*

In addition, the digital elevation model allows the creation of rainwater and surface water flow direction **(Figure 100).**

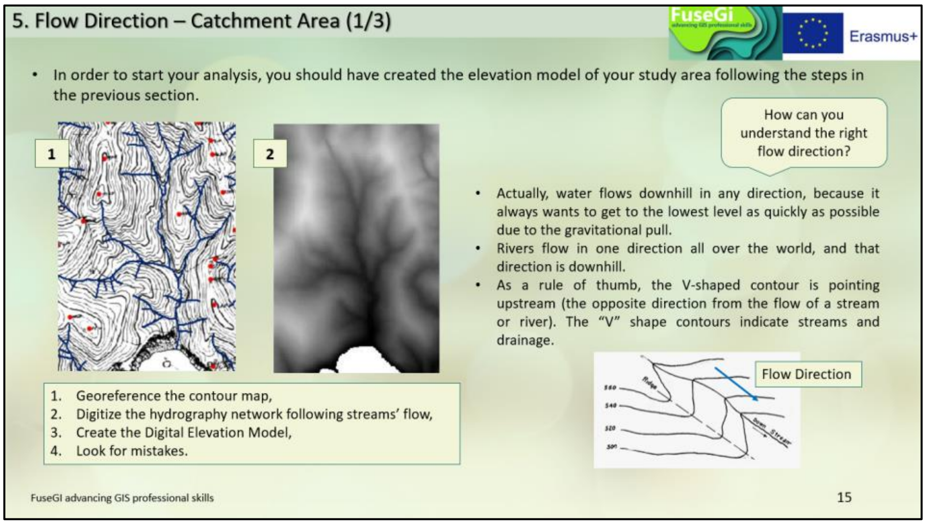


Figure 100 *: Slide 15 of course 8, available through the FuseGI VLE platform.*

Then, it is possible to determine the watershed in different areas **(Figure 101).**

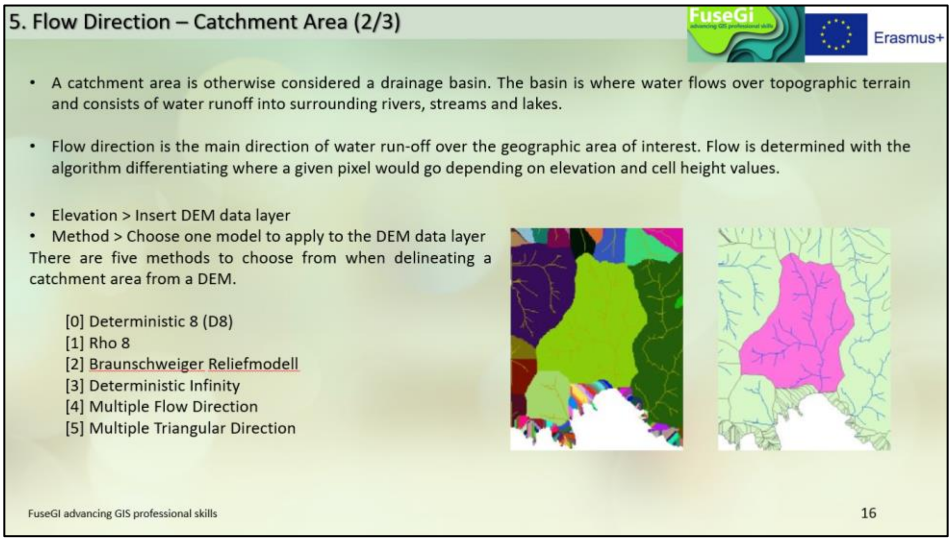


***Figure 101** : Slide 16 of course 8, available through the FuseGI VLE platform.*

And finally, it is possible to perform additional analyses, such as determining the importance of the different watercourses in the watershed using the SAGA tool **(Figure 102).**

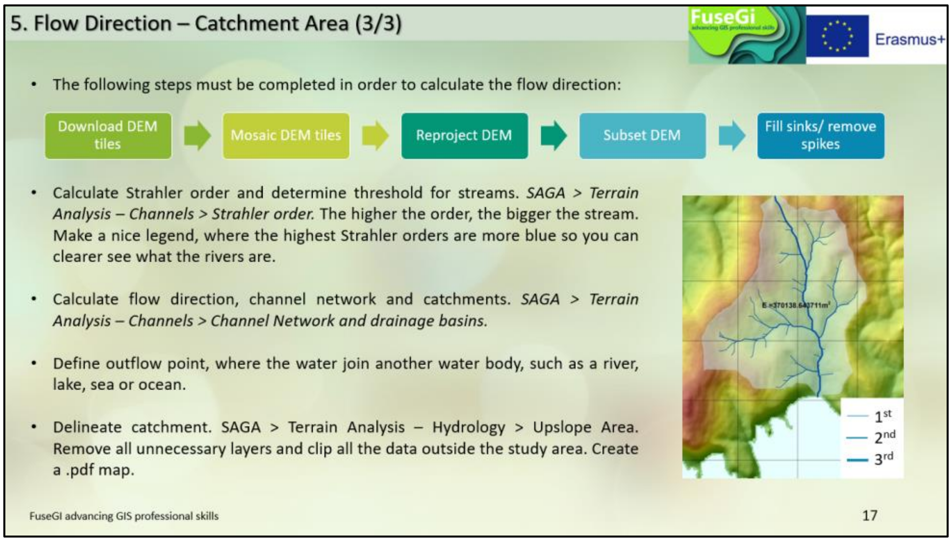


***Figure 102** : Slide 17 of course 8, available through the FuseGI VLE platform.*

3.9 Course 9: Web Scraping Applications in QGIS

The ninth and final course of the platform is specific to learning "web scraping", i.e. searching for information online and **processing this information with online tools or with software such as QGIS.** This course consists of the introduction of the notion of "web scraping" then the method of searching for online data, the presentation of a realistic case study in the field of health, and finally the method of using "web scraping" and QGIS **(Figure 103).**

***Figure 103** : Course outline 9, available via the FuseGI VLE platform.*

First, web scraping involves importing online data into spreadsheets such as Excel **(Figure 104).**

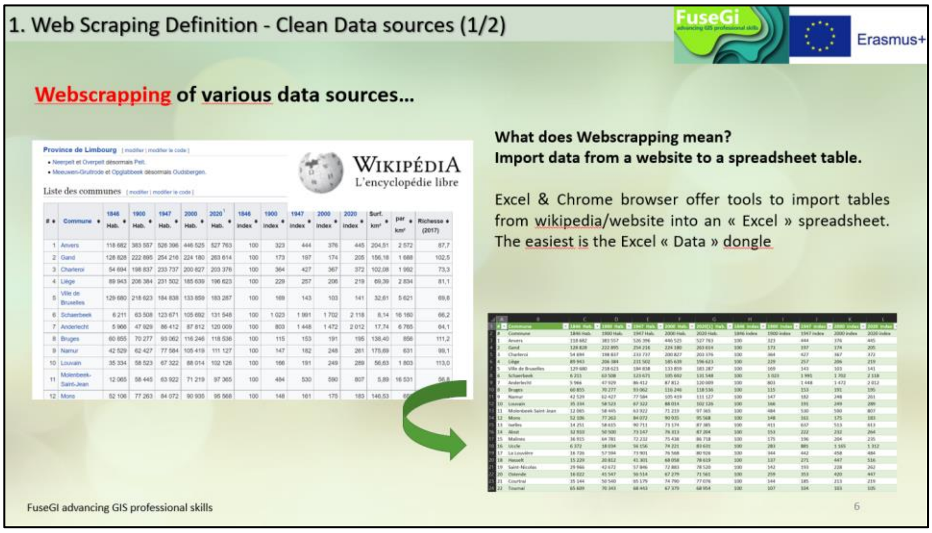


***Figure 104** : Slide 6 of course 9, available through the FuseGI VLE platform.*

The process is simple to execute, just follow the instructions available in the course **(Figure 104).**

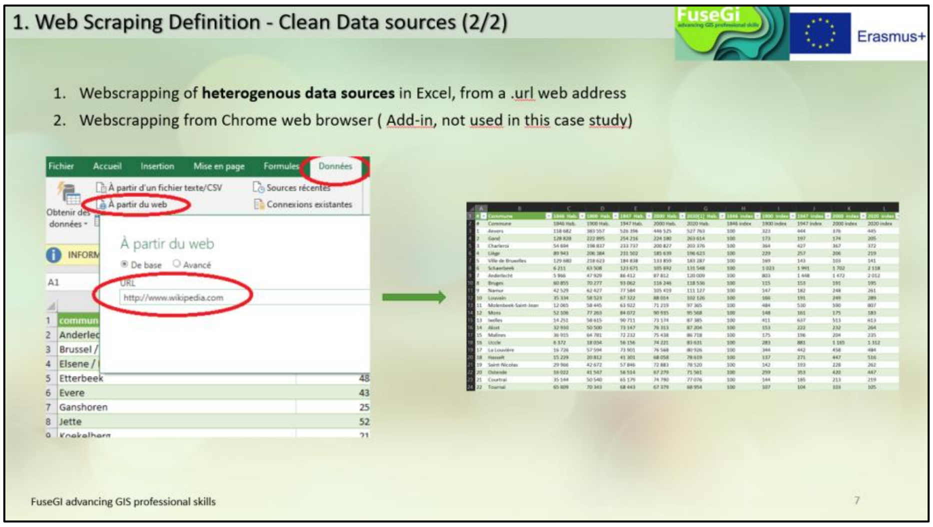


***Figure 105** : Slide 7 of course 9, available via the FuseGI VLE platform.*

The export of this data is a rather simple process but can cause some problems, some solutions of which are given in the course **(Figure 106).**

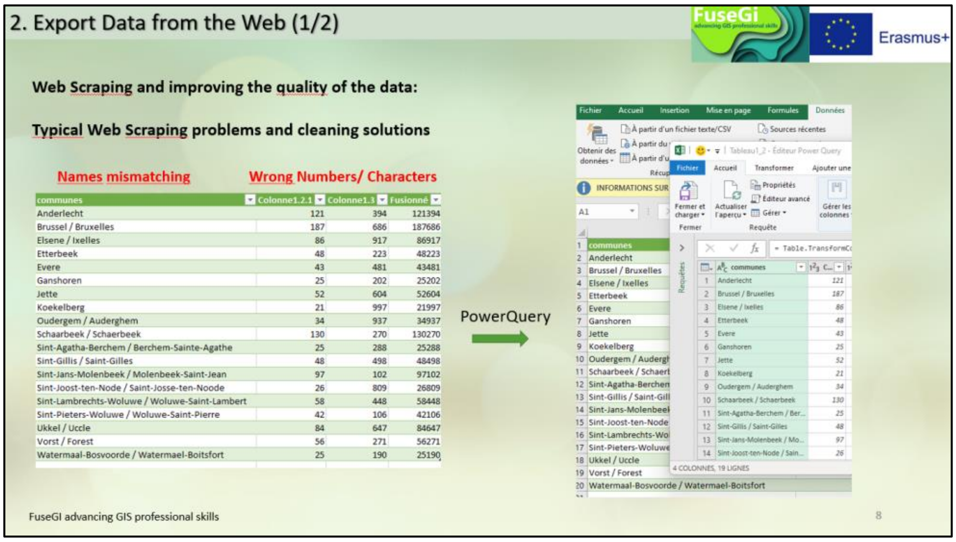


***Figure 106** : Slide 8 of course 9, available via the FuseGI VLE platform.*

When extracting data, the use of a table such as Excel is essential **(Figure 107).**

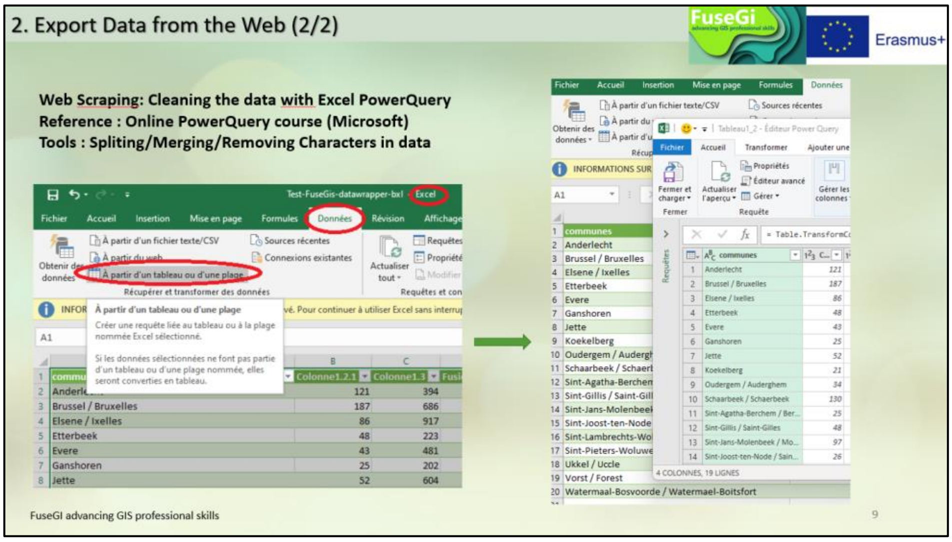


Figure 107 *: Slide 9 of course 9, available via the FuseGI VLE platform.*

A case study on web scraping is available to practice its use. This course introduces this case study **(Figure 108).**

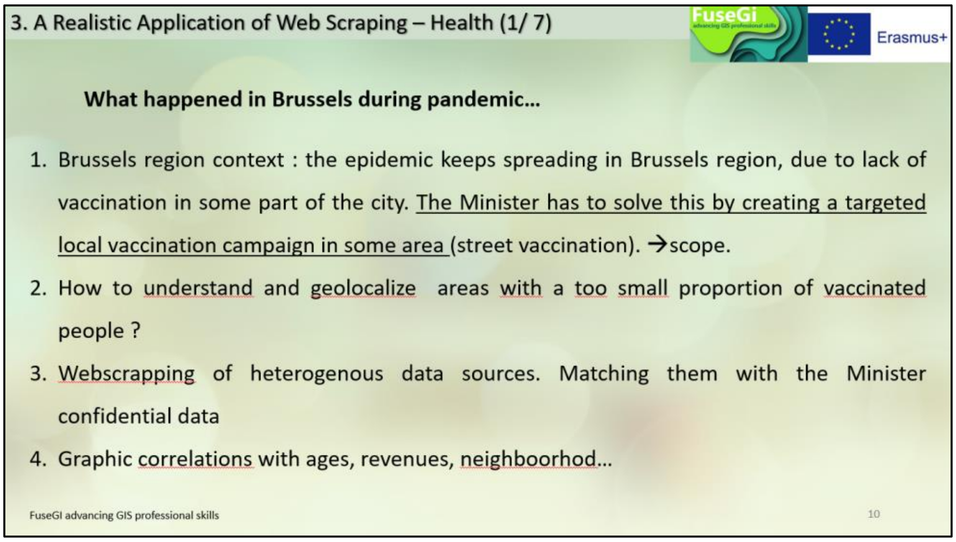


Figure 108 *: Slide 10 of course 9, available through the FuseGI VLE platform.*

It is important to use a . Json to delimit the contours of municipalities **(Figure 109).**

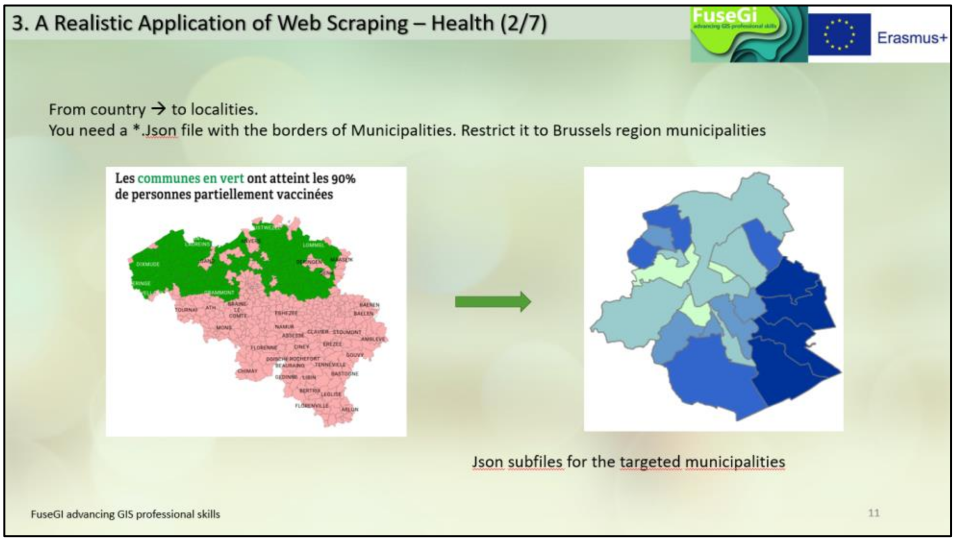


***Figure 109** : Slide 11 of course 9, available through the FuseGI VLE platform.*

The general steps of the case study as well as the purpose of the case study are detailed in this course. The case study includes more specific and simple steps to follow **(Figure 110).**

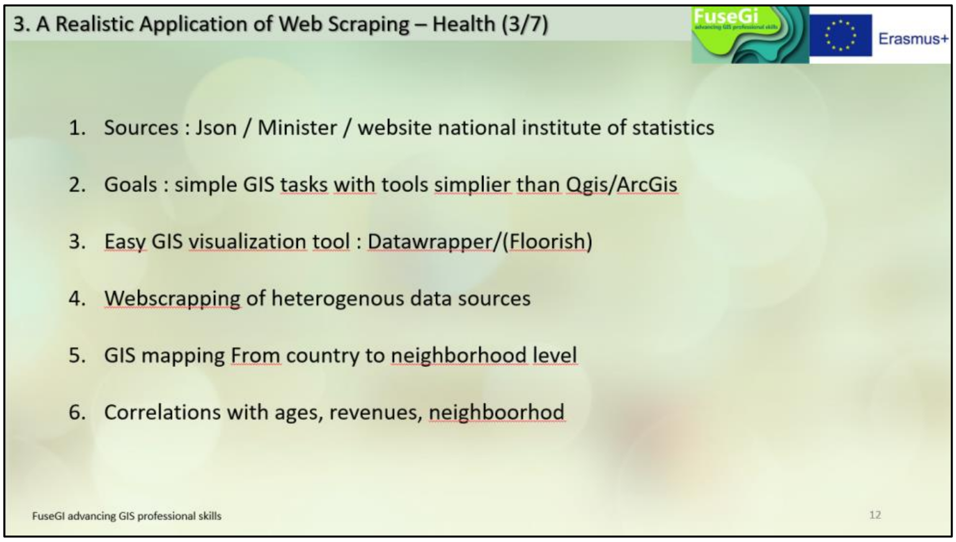


***Figure 110** : Slide 12 of course 9, available via the FuseGI VLE platform.*

In the example of the course, the cartographic representation is created using the online tool "Data wrapper", not with the QGIS software **(Figure 111).**

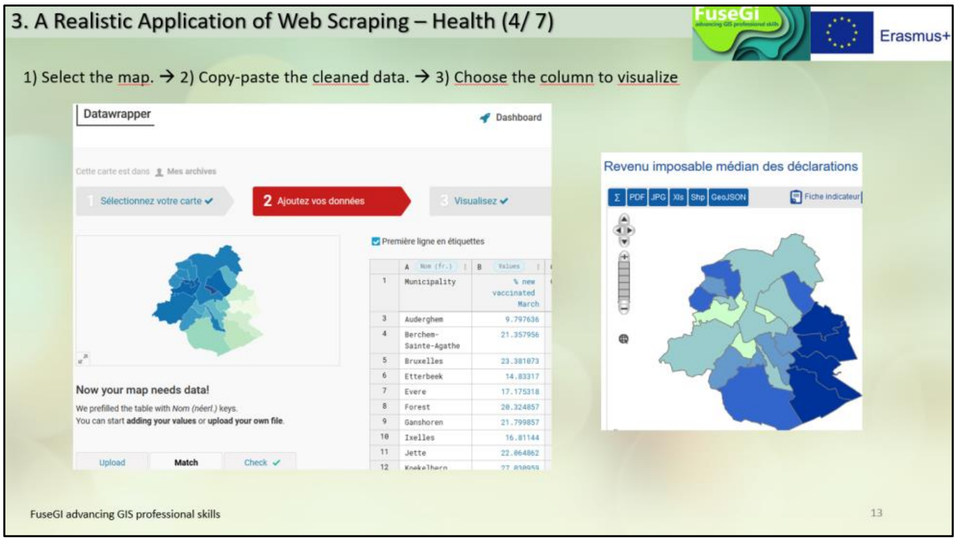


Figure 111 *: Slide 13 of course 9, available via the FuseGI VLE platform.*

The data is also sorted through the use of a table such as Excel or LibreOffice **(Figure 112).**

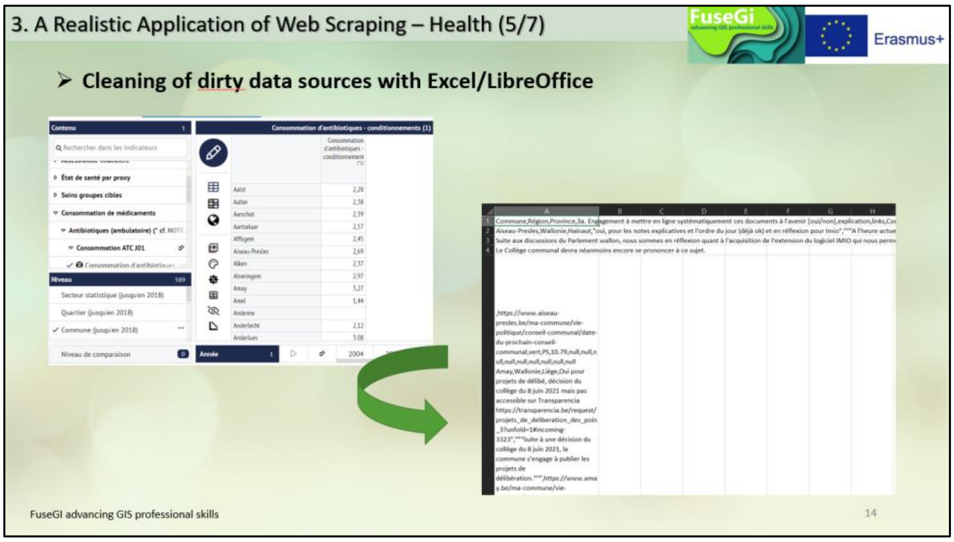
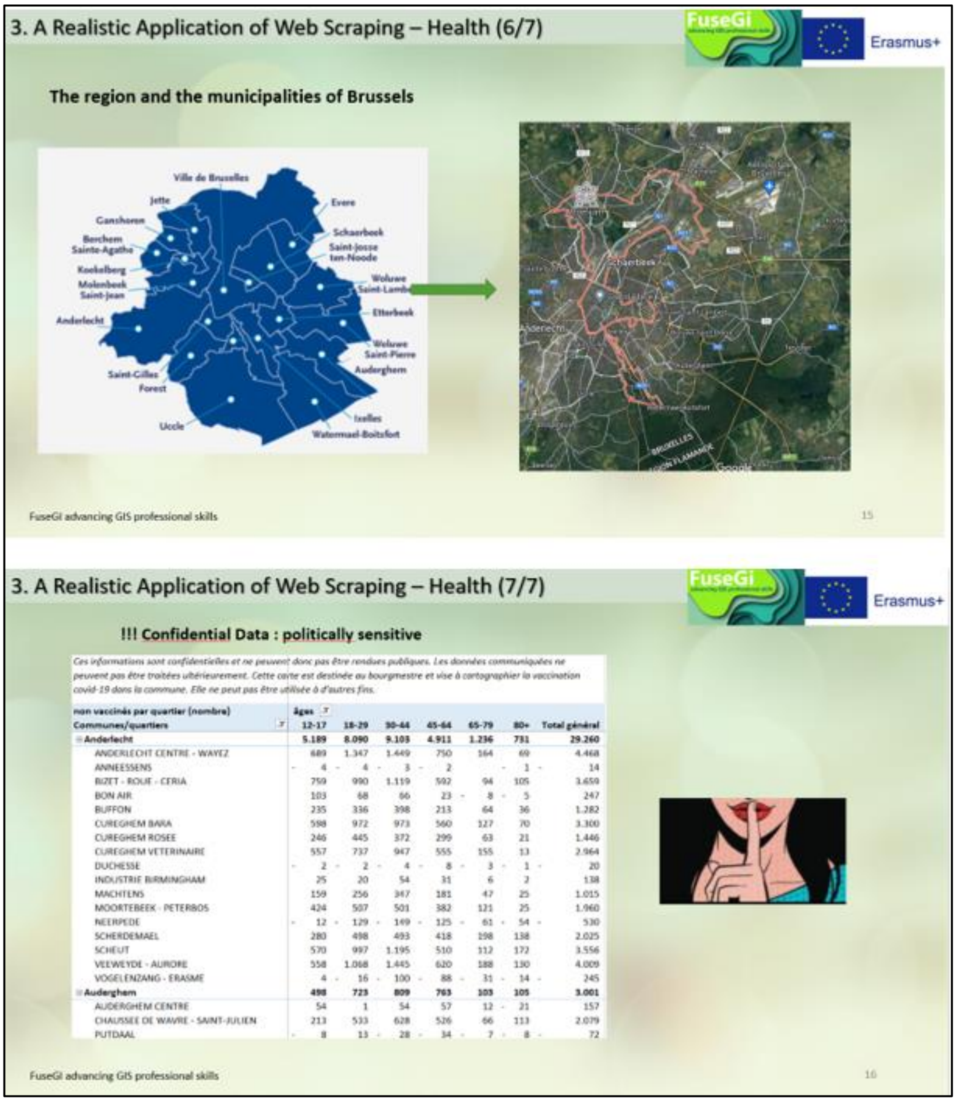


Figure 112 *: Slide 14 of course 9, available via the FuseGI VLE platform.*

These data are actual data of the vaccinated or unvaccinated population in the region and municipality of Brussels **(Figure 113).**



non vaccinés par quartier (nombre)	Âges						
Communes/quartiers	12-17	18-29	30-44	45-64	65-79	80+	Total général
Anderlecht	**5.189**	**8.090**	**9.103**	**4.911**	**1.236**	**731**	**29.260**
ANDERLECHT CENTRE - WAYEZ	689	1.347	1.449	750	164	69	4.468
ANNEESSENS	4	4	3	2		1	14
BIZET - ROUE - CERIA	759	990	1.119	592	94	105	3.659
BON AIR	103	68	66	23	8	5	247
BUFFON	235	336	398	213	64	36	1.282
CUREGHEM BARA	598	972	973	560	127	70	3.300
CUREGHEM ROSEE	246	445	372	299	63	21	1.446
CUREGHEM VETERINAIRE	557	737	947	555	155	13	2.964
DUCHESSE	2	2	4	8	3	1	20
INDUSTRIE BIRMINGHAM	25	20	54	31	6	2	138
MACHTENS	159	256	347	181	47	25	1.015
MOORTEBEEK - PETERBOS	424	507	501	382	121	25	1.960
NEERPEDE	12	129	149	125	61	54	530
SCHERDEMAEL	280	498	493	418	198	138	2.025
SCHEUT	570	997	1.195	510	112	172	3.556
VEEWEYDE - AURORE	558	1.068	1.445	620	188	130	4.009
VOGELENZANG - ERASME	4	16	100	88	31	14	245
Auderghem	**498**	**723**	**809**	**763**	**103**	**105**	**3.001**
AUDERGHEM CENTRE	54	1	54	57	12	21	157
CHAUSSEE DE WAVRE - SAINT-JULIEN	213	533	628	526	66	113	2.079
PUTDAAL	8	13	28	34	7	8	72

Figure 113 *: Slides 15 and 16 of course 9, available via the FuseGI VLE platform.*

When using this data in QGIS, it is possible to add vector files from the region. These files provide details on the data according to the location of the data **(Figure 114).**

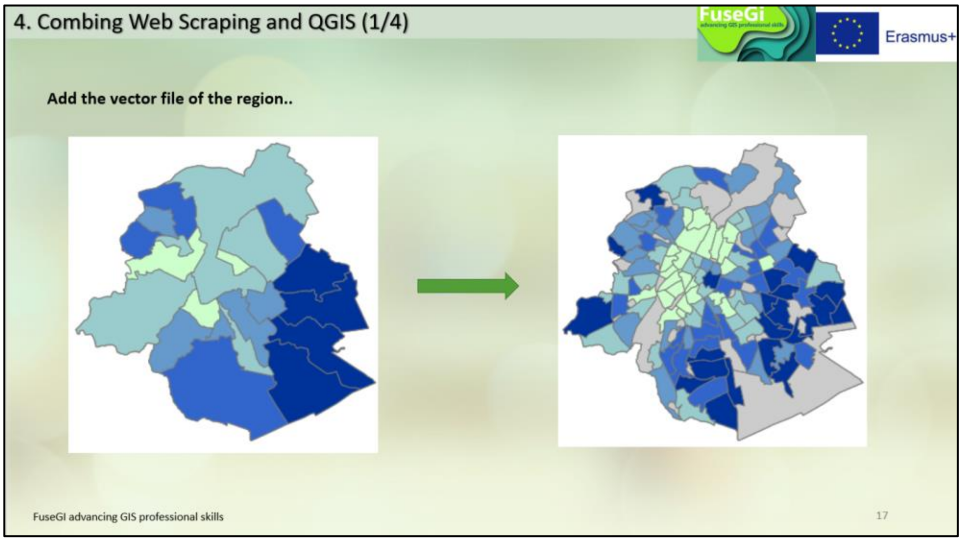


***Figure 114** : Slide 17 of course 9, available via the FuseGI VLE platform.*

It is also possible to correlate average incomes with the percentage of vaccination or to correlate the average ages of populations with vaccination rates in the region and municipality of Brussels **(Figure 115).**

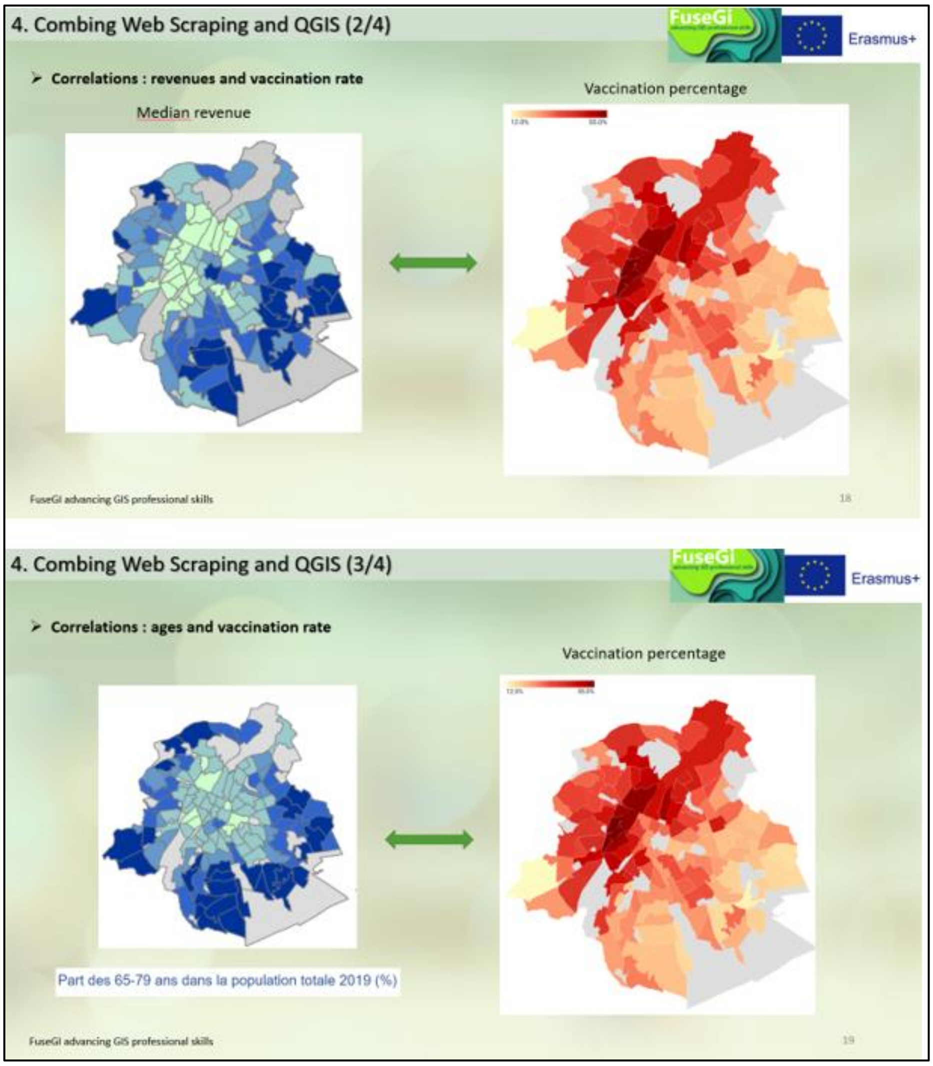


***Figure 115** : Slides 18 and 19 of course 9, available via the FuseGI VLE platform.*

Then, it is possible to make assumptions about the observed correlations **(Figure 116).**

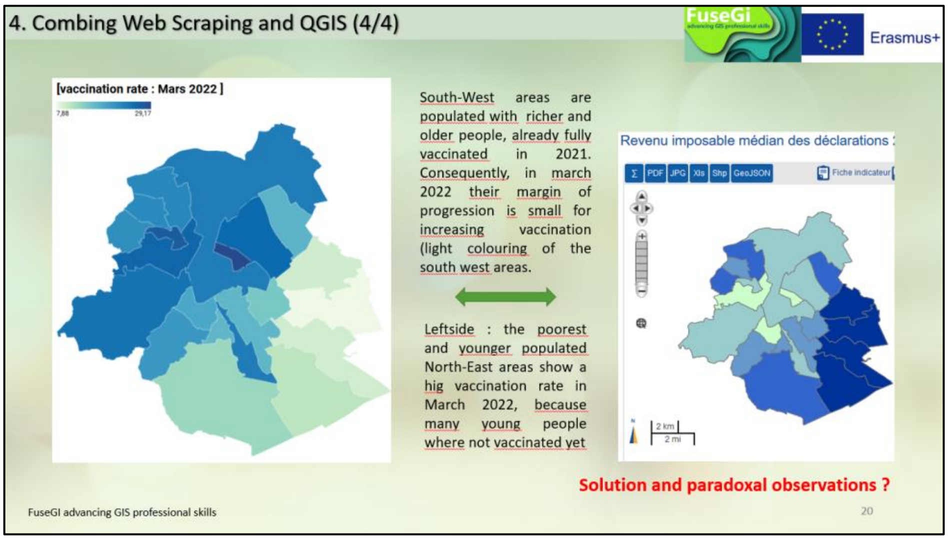


***Figure 116** : Slide 20 of course 9, available via the FuseGI VLE platform.*

Finally, this course concludes with practical observations concerning the use of web scraping and QGIS **(Figure 117).**

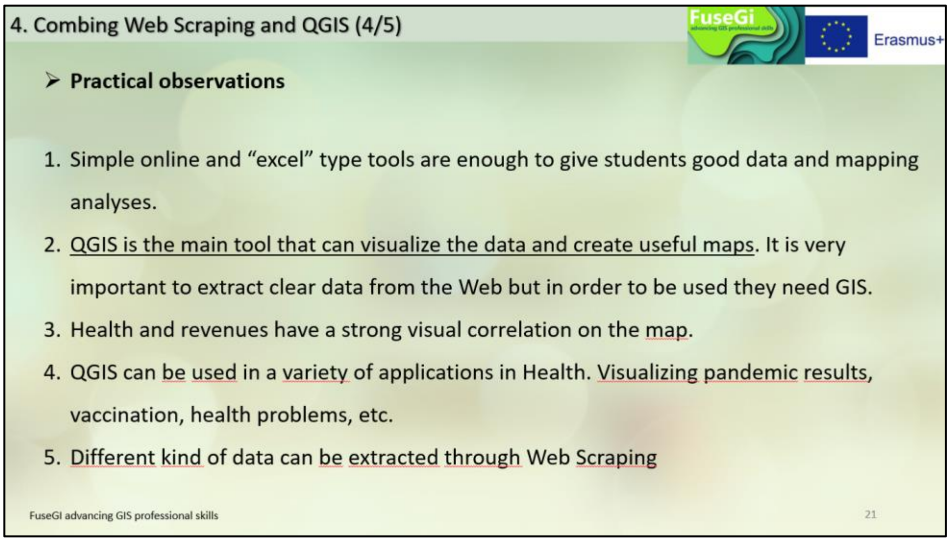


Figure 117 *: Slide 21 of course 9, available via the FuseGI VLE platform.*

4 The case studies

The case studies aim to **put into practice the theoretical knowledge acquired** through the courses. The **four available case studies** are linked to the three areas applied throughout the project, i.e. **forestry**, **health** and **hydrology**. Of these four case studies, one focuses on forest, one on health and the last two are oriented towards the field of hydrology. Despite the different areas of the case studies, **each brings essential knowledge to fully use GIS**.

4.1 LULC/FOREST case study

This first **case study is intended to take ownership of LULC**, i.e. **land use and land cover** for a defined area. The area studied is the island of Chios located in Greece. LULC is a dynamic feature that is useful to track relevant changes in land cover. This case study is created to test the skills acquired during the courses, aiming to map forest changes in Chios in three areas of different altitudes. The main questions are: **How has forest changed the last 10 years in Chios. Is there gain or loss of forest and is this gain/loss dependent to elevation?** The instruction for this exercise is given in the form of a succession of steps to follow **(Figure 118).** This sequence of steps is intended to answer a specific question **(Figure 119).**

1. Download 2012 LULC data from Copernicus site, following the directions provided online.
2. Clip the polygons that correspond to Chios, using the provided polygon boundary
   - √ *Course 5 (hint – spatial analysis))*
3. Dissolve LULC polygons, into classes of the first MAES level
   - √ *Course 5 (hint – spatial analysis)*
4. Use Google earth basemap to identify and digitise LULC changes. Cut polygons where the change has occurred and enter the new class code, in a new column in the attribute table.
   - √ *Course 4 (hint – digitization)*
5. Reclassify DEM into 3 elevation zones (0 - 500 - 800 - top)
   - √ *Course 5 (hint – spatial analysis)*
6. Convert raster elevation zones to vector elevation zones
   - √ *Course 5 (hint – spatial analysis)*
7. Intersect LULC polygons with the 3 polygon elevation zones
   - √ *Course 5 (hint – spatial analysis)*
8. Find the area of changes in each zone
   - √ *Course 4 (hint – attribute table)*
9. Create a map that shows the areas where there is gain of forest (use green colour) or loss of forest (use orange colour), while you also shoe the forest that remains unchanged, the elevation zones, as well as a table with the respective areas (in hectares) foe each of the 3 elevation zones
   - √ *Course 6 (hint – map layout)*

Figure 118 *: sequence of steps to complete the LULC exercise, available on the FuseGI VLE platform.*

Basic question

How has forest changed the last 10 years in Chios? Is there gain or loss of forest and is this gain/loss dependent to elevation?

Figure 119 *: Final question of the exercise, available on the FuseGI platform.*

This exercise can be done in about 8 hours for people who are new to the field of GIS and are not familiar with using QGIS software.

As a first step, it is important to upload all the data available on the platform in the "provided material" space. Then simply launch the QGIS software and start the exercise. First, add the polygon downloaded from the island of Chios, then add the LULC **(Figure 120).**

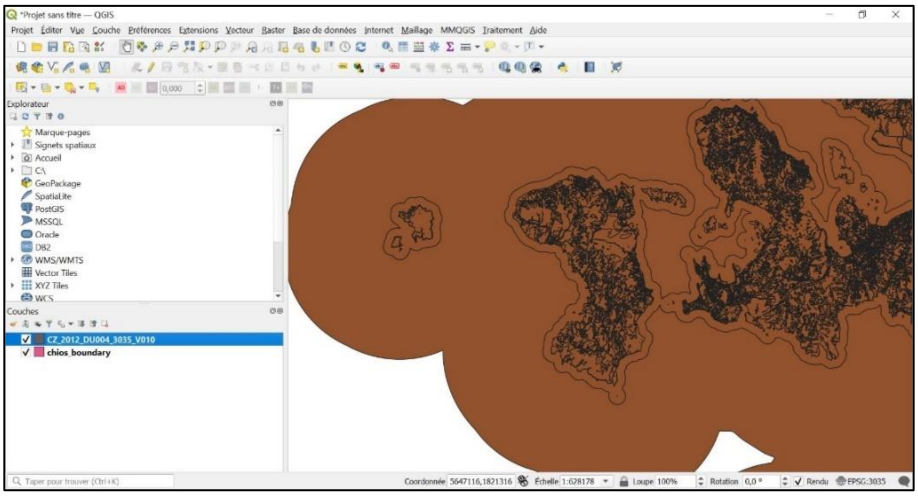


Figure 120 *: Overview of the "Chios polygon" layers and LULC in the QGIS software.*

It is possible to cut the LULC directly to the shape of the polygon or to do it in the next step. In this example, we have chosen to categorize LULC into different classes. All you have to do is change the symbology of the LULC layer using the "categorized" symbol type and selecting the value with which we want to categorize the polygon. Next, change the style and select a style downloaded with the data for the exercise **(Figure 121).**

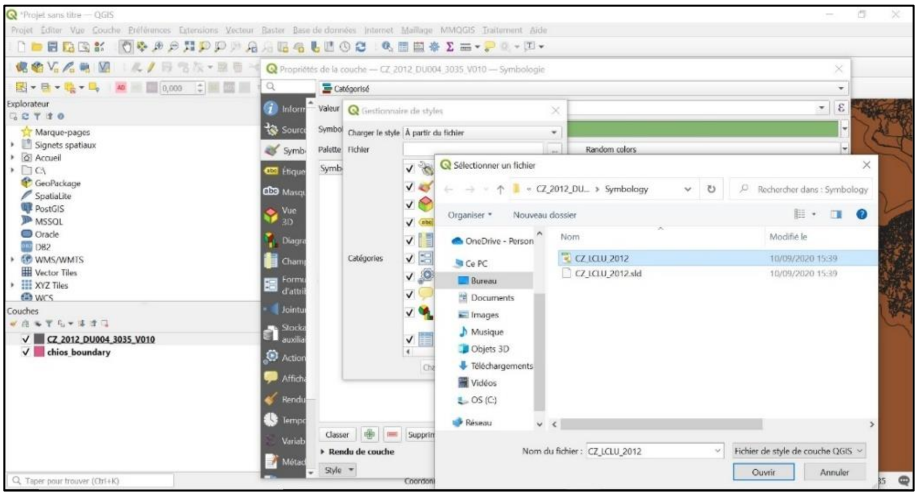


Figure 121 *: Overview of the path to change the style of LULC.*

We then obtain the map of Europe of several colors corresponding to different types of land cover **(Figure 122).**

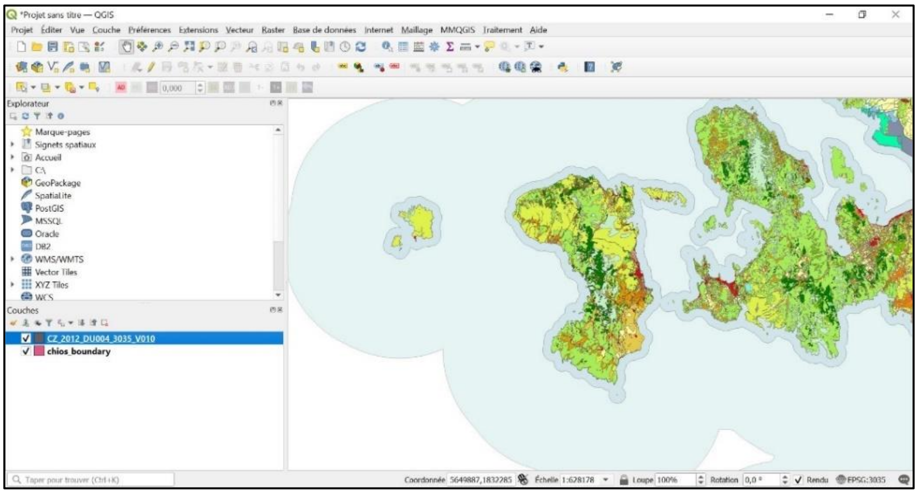


Figure 122 *- The result of changing the style of the LULC layer.*

To make loading in QGIS faster, it is important to cut the studied area with the "Cut" tool **(Figure 123).**

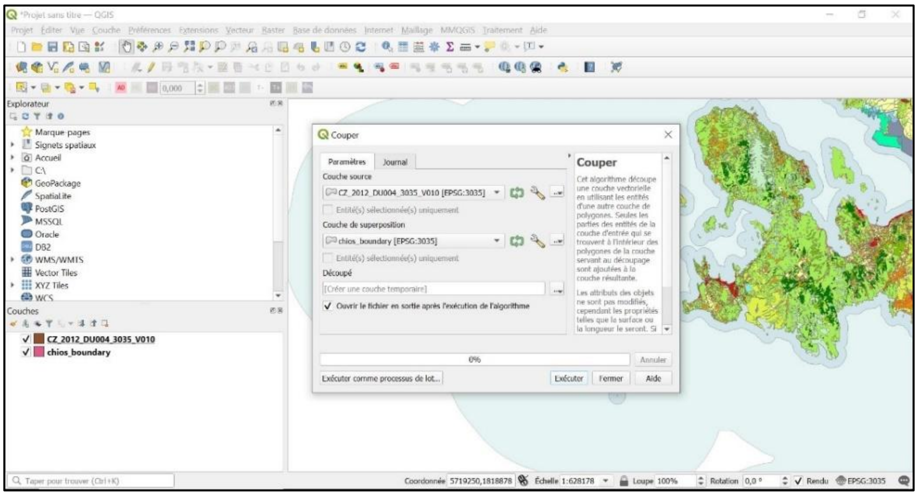


Figure 123 *: Using the "cut" tool.*

We then obtain the following result **(Figure 124):**

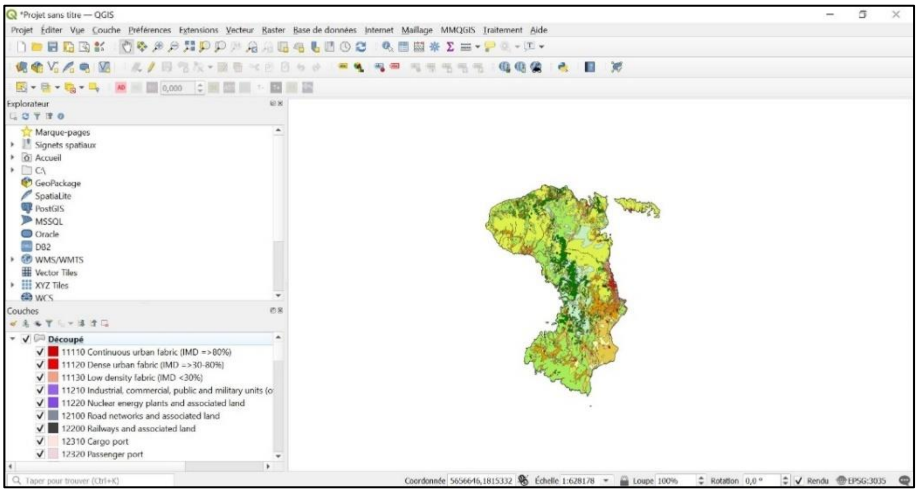


Figure 124 *: Result of cutting the LULC layer.*

Next, it is requested to add Google Earth in order to visualize the vegetation differences between the LULC and the aerial view **(Figure 125).**

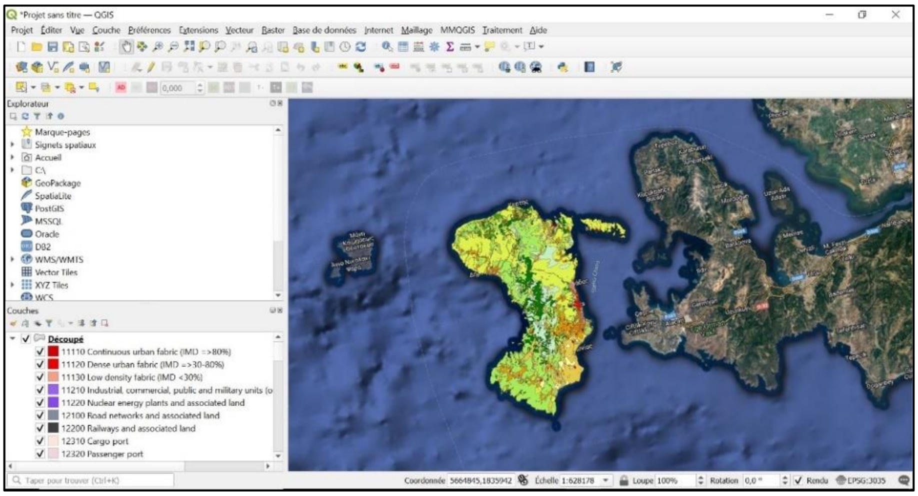


Figure 125 *: LULC layer superimposed with the aerial view of Google Earth.*

The next step is to add a DEM layer. DEM layers are raster-like layers presented with the "tif" extension **(Figure 126).**

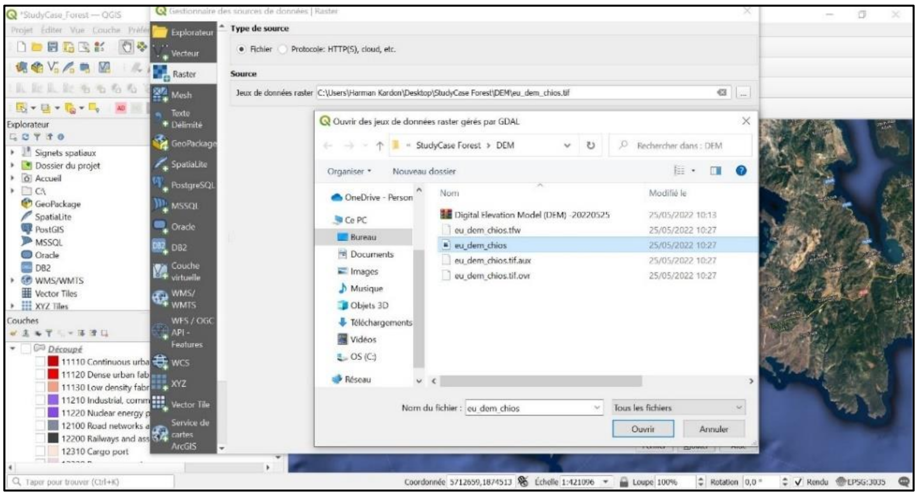


Figure 126 *: The path to add the DEM raster layer.*

We then obtain a raster type layer of the different altitudes on the island of Chios. It is possible to modify the style by categorizing it with the different altitude levels, but this step is not mandatory **(Figure 127).**

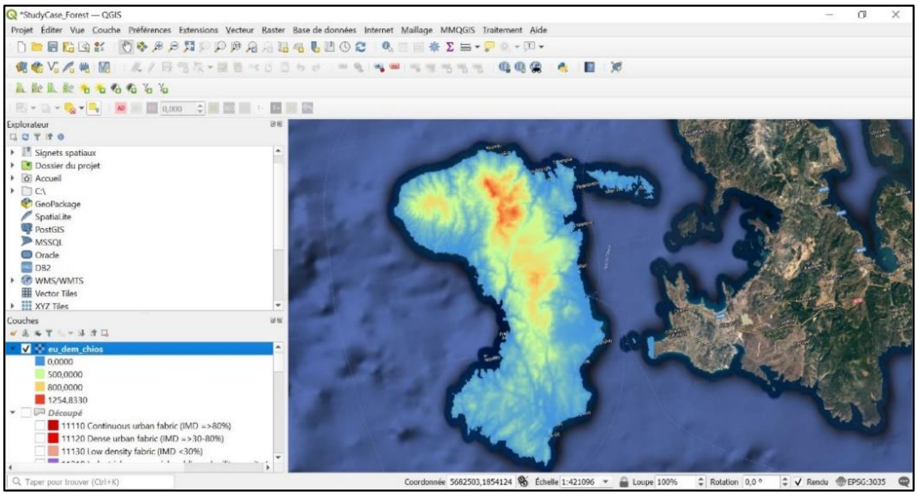


Figure 127 *: Categorization of the different altitude levels.*

Next, the raster must be reclassified using the "reclassify by table" tool. This step will assign a new value based on the ranges specified in a fixed table **(Figure 128).**

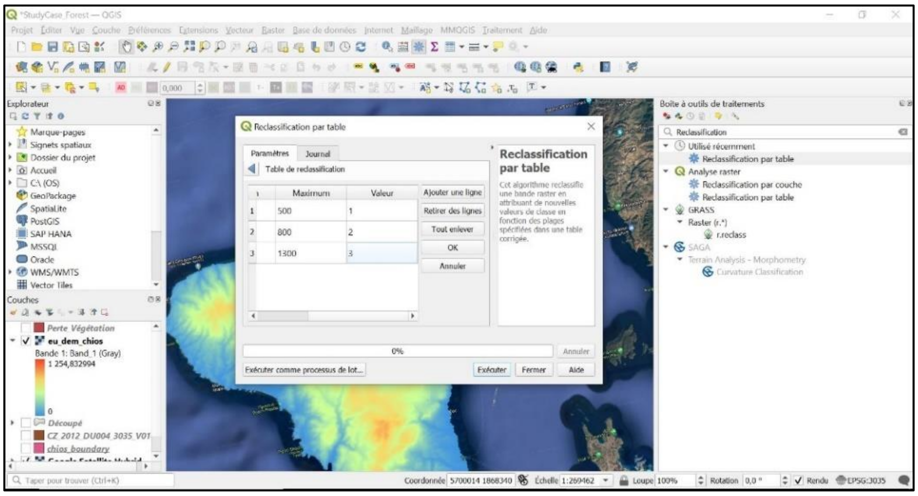


Figure 128 *: Preview of the table to modify using the "reclassification by table" tool.*

We then get a map with only three different elevation zones **(Figure 129).**

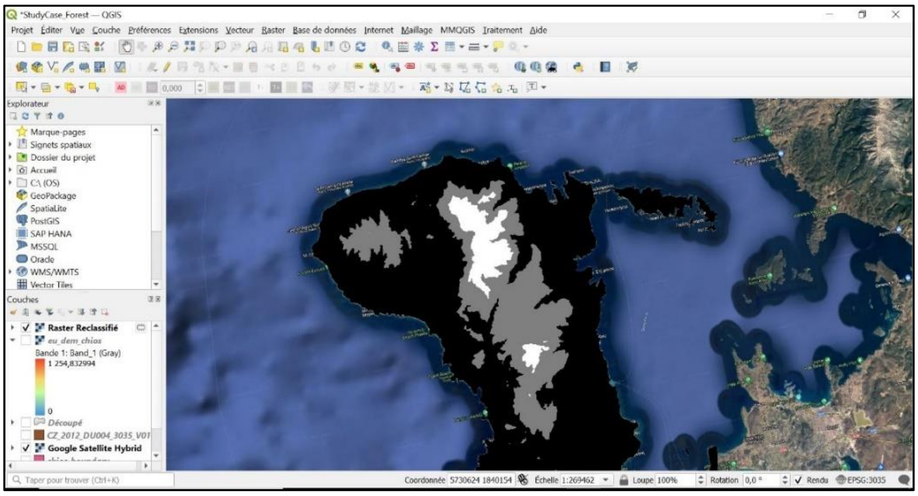


Figure 129 *: Result obtained by reclassifying the raster layer to DEM.*

Then, it is asked to polygonize the DEM raster into a vector using the "polygonize" tool. This tool creates a polygon with an attribute indicating the pixel value of the polygon **(Figure 130).**

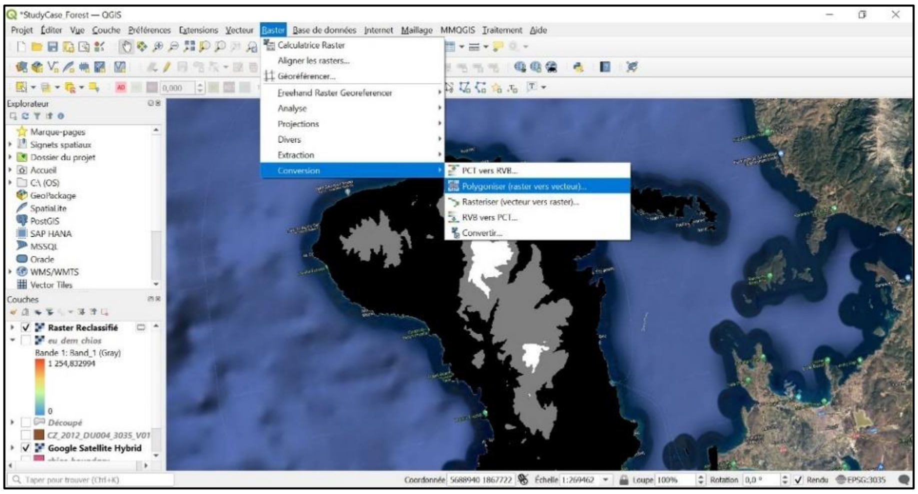


Figure 130 *: The path to follow in order to polygonize the raster layer into a raster layer.*

It is therefore possible to merge the layers of the vectorized DEM and those of the LULC using the "intersection" tool **(Figure 131).**

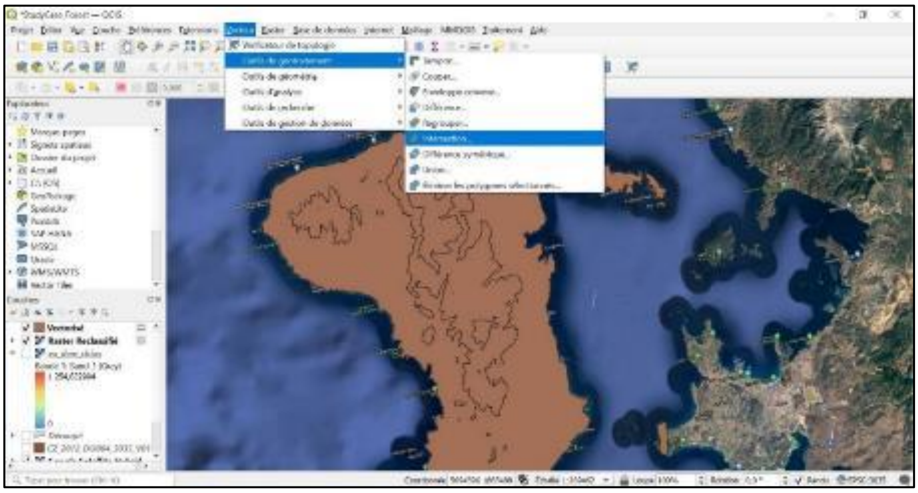


Figure 131 *: Path to follow in order to use the "intersection" tool.*

The result obtained then corresponds to the two merged layers, in color the LULC and the black lines the limits of the three different altitudes of the DEM **(Figure 132).**

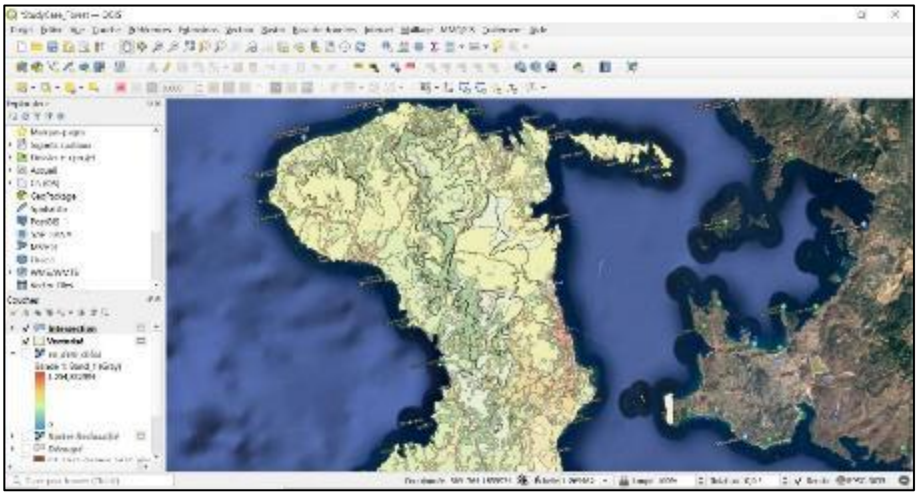


Figure 132 *: The result of using the "intersection" tool merging the LULC layer and the boundaries of the DEM altitude zones.*

Finally, the final step is the creation of a map representing changes in vegetation cover, whether it is a gain in forest or a reduction in forest **(Figure 133).**

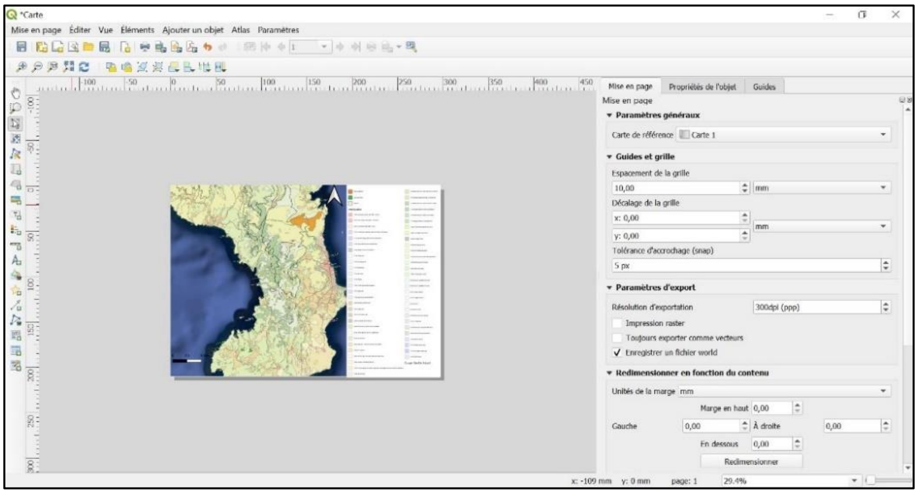


Figure 133 *: Creation of the cartographic representation representing changes in vegetation cover as a function of altitude.*

Finally, it is possible following this practical case to determine what are the changes in vegetation cover in the three different altitude zones. In the area closest to the sea, vegetation cover has increased, while in the highest area at higher altitudes it has decreased. On the other hand, it remains unchanged in the average altitude zone.

4.2 Health Case Study

This second **case study is intended for online data search** and the **use of online tools**. The sector studied is the European city of Brussels in Belgium. This case study is created to test the skills learned during the courses, aiming to determine the rate of people vaccinated in each neighborhood of the city. The goal is to make a preliminary study of vaccinations in order to plan a new vaccination campaign **(Figure 134).**

Where and in which range of ages should the vaccination campaign be focused ?

What you have learned for matching Covid vaccination data and GIS visualization of webscrapped datasets ?

Figure 134 *: Health Case Study Objectives, available on the FuseGI platform.*

As with the first case study, the steps to follow are available on the FuseGI platform **(Figure 135).**

1. Find the .*Json map file with municipalities borders
   - √ *Course 4 (hint – import data)*
2. Web Scraping of population data (from wikipedia or Ministery website)
   - √ *Course 9 (hint – Web Scraping)*
3. Cleaning the dataset (Exel, PowerQuery) & matching the 2 datasets (population, vaccination, revenues)
   - √ *Course 9 (hint – clean data)*
4. Insert excel data to an attribute table
   - √ *Course 2, 4 (hint – attribute table)*
5. Create a simple calculation between the 2 data sets : Vaccination rate = (vaccinated people)/(municipality population)
   - √ *Course 2, 4 (hint – statistics, attribute table)*
6. Create map using the right scale of colours
   - √ *Course 6 (hint – map layout)*
7. Observe, explain and finally publish your results online :

Figure 135 *: Steps to complete the health case study.*

After downloading the data available on the FuseGI platform, we must add the polygon layer representing the city of Brussels and the different districts on QGIS **(Figure 136).**

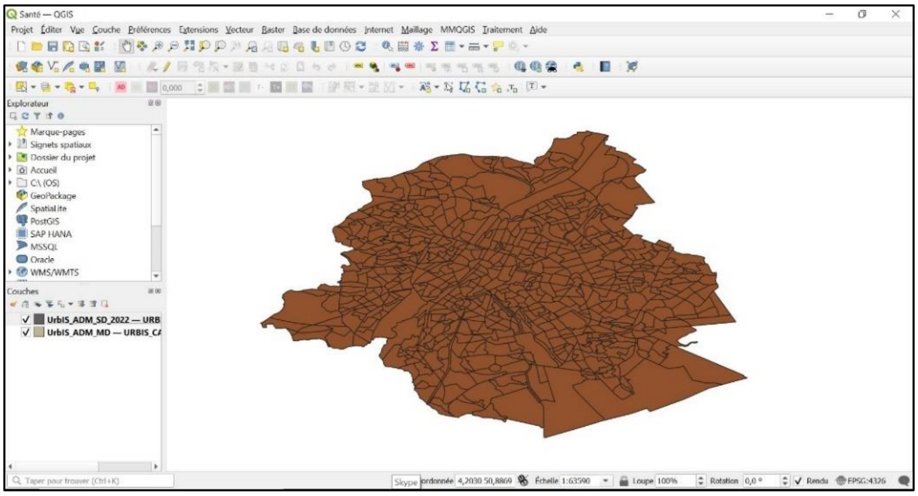


Figure 136 *: Preview of the "polygon" layer added in the QGIS software.*

Then, after finding the necessary data on the internet, it is possible to load this data on a spreadsheet, such as Excel, by adding the data "from the web" **(Figure 137).**

Figure 137 *: Overview of loading data "from the web" into an Excel spreadsheet.*

The data can thenbe exported to QGIS, or can be used with on-line processing tools **(Figure 138).**

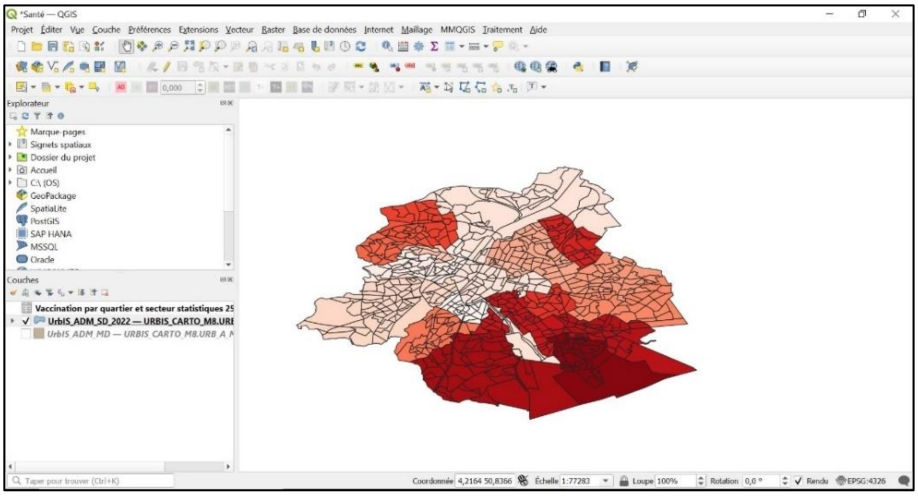


Figure 138 *: Data processing using QGIS software.*

Finally, the last step is the creation of the cartographic representation of the vaccination rate by neighbourhood in Brussels **(Figure 139).**

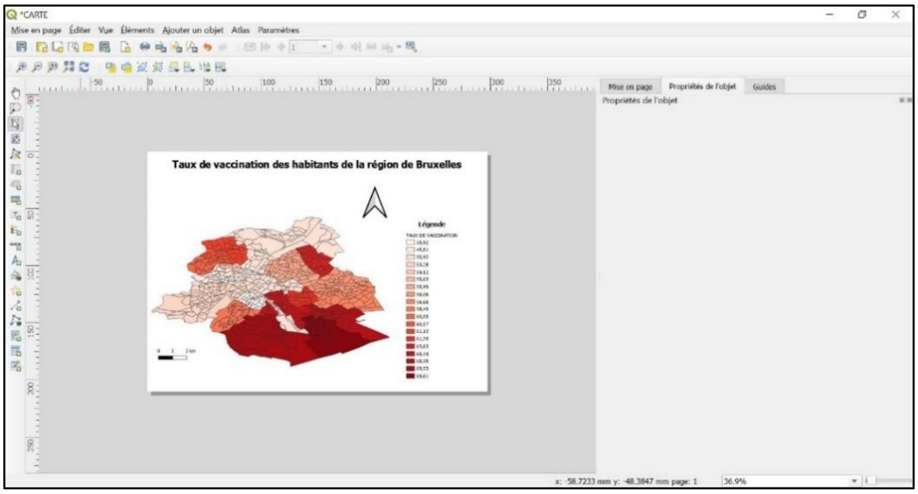


Figure 139 *: Creation of the graphical representation of the vaccination rates of the inhabitants of Brussels using the QGIS software.*

After making such a map, whether using QGIS or online tools, it is then possible to determine in which neighborhood it is important to carry out a new vaccination campaign.

4.3 Case Study 1 in Hydrology

This third case study is **intended to use useful tools in the case of a hydrological study**. In this exercise, users of the platform will have to assess the alteration of the coastline of a lake in Greece, which affects the residential areas and land use around it.

This case study is created to test the skills acquired during the courses, aiming to **map changes in water bodies** and **alterations in lake hydromorphology (Figure 140).**

Basic question

How were the lake and its rivers modified in a 45-year period affecting the coastal area?

Figure 140 *: Objective of the hydrology case study n°1, available on the platform.*

The instruction for this exercise is given in the form of a succession of steps to follow **(Figure 141).**

1. Georeference both images

   √ Course 4 (hint – georeference)

2. Digitize coastline

   √ Course 4 (hint – polygon)

3. Create a buffer zone of 200m starting from the coastline towards the inland area (coastal habitat zone) for both years

   √ Course 5 (hint – geoprocessing)

4. Calculate difference in lake perimeter (m), lake area (m2), and buffer area (m2) among years

   √ Course 2, 4 (hint – attribute table)

5. Find what kind of Land Uses (CLC lvl2) substituted the area that used to be covered by water

   √ Course 5 (hint – spatial analysis)

6. Place images on DEM

   √ Course 8 (hint – SAGA > Terrain Analysis) or Course 7 using GRASS

7. Deploy Hydrographic network using the DEM

   √ Course 8 (hint – SAGA > Hydrology > Channels)

8. Calculate Strahler order

   √ Course 8 (hint – SAGA > Hydrology > Calculate Strahler Order)

9. Define lake catchment area and all sub-basins

   √ Course 8 (hint – Catchment area) or Course 7 using GRASS

10. Create a map pointing out the differences in LULC of the coastal habitats (buffer) with fully deployed hydrographic network

   √ Course 6 (hint – map layout)

***Figure 141** : List of steps to complete the case study, available through the FuseGI VLE platform.*

After downloading the two aerial photographs of the lake dating from 1969 and 2016, you must launch the QGIS software to georeference the photographs **(Figure 142).**

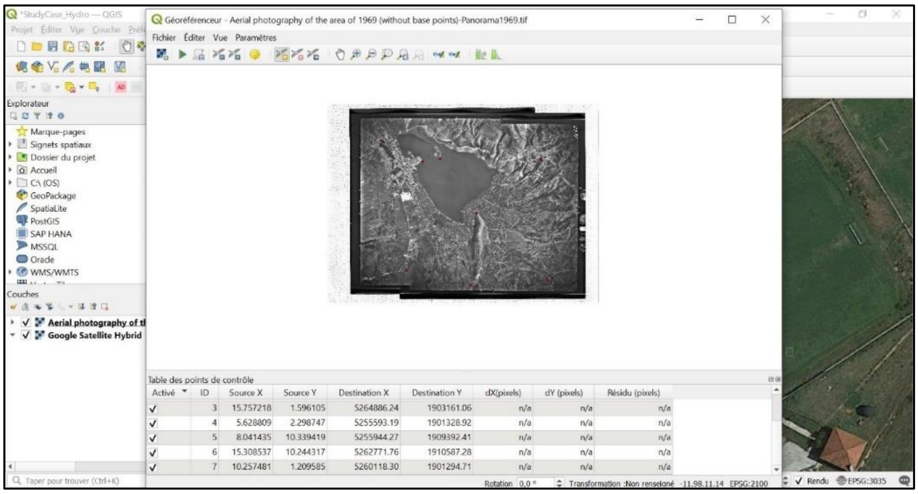


***Figure 142** : Georeferencing of an aerial photograph, with QGIS software.*

Georeferencing makes it possible to obtain aerial photographs of the lake at exactly the same location as the lake observed with Google Satellite **(Figure 143).**

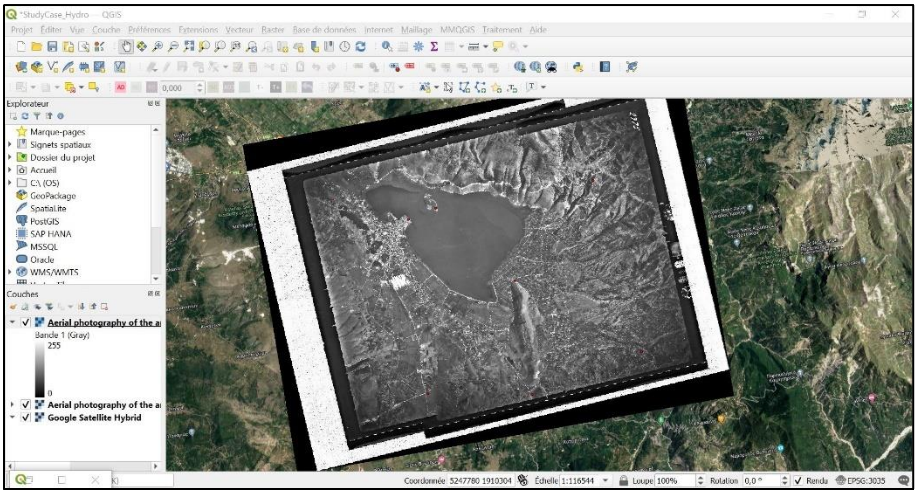


Figure 143 : Georeferencing result of aerial photography.

Then, we must digitize the shores of the lake by adding a new Shapefile **layer (Figure 144).**

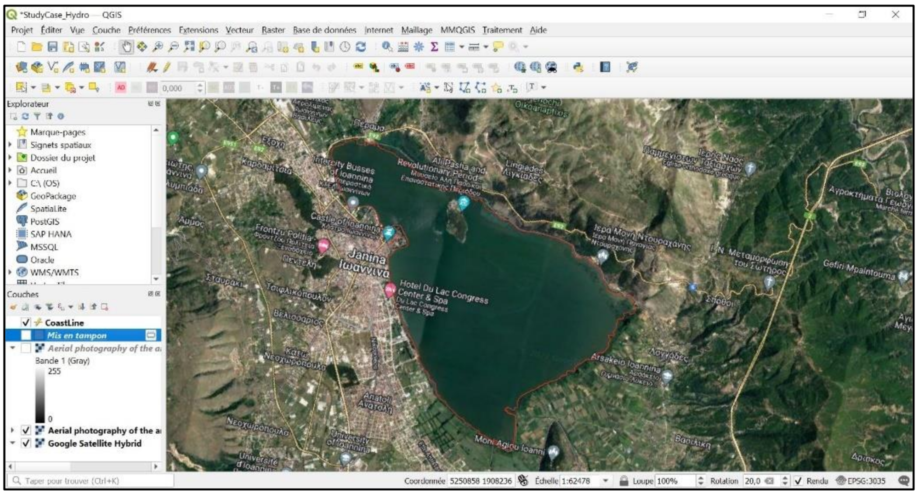


***Figure 144** : Definition of the shores of the lake by creating a shapefile.*

It is then possible to use the "buffer" tool to create a 200-metre buffer zone from the lake shore **(Figure 145).**

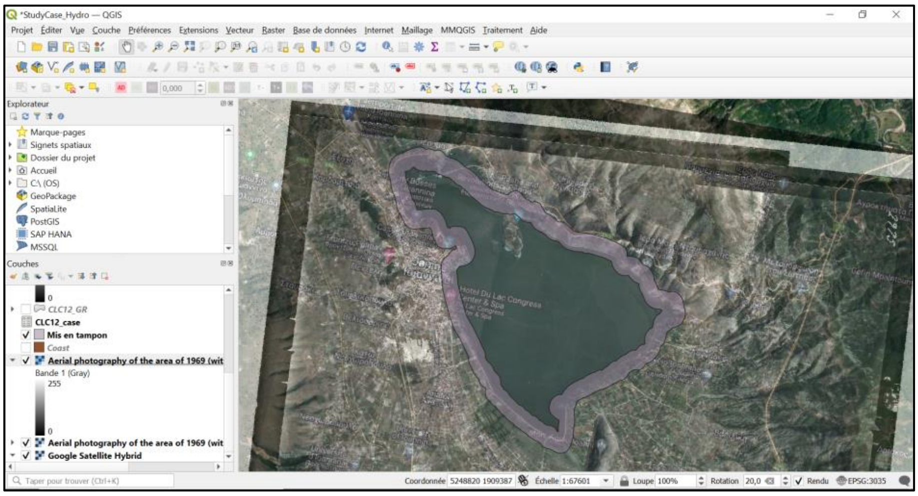


***Figure 145** : The result of using the "buffer zone" tool.*

Using the attribute table and the field calculator tool, it is possible to calculate the lake perimeter, lake area and buffer zone area **(Figure 146).**

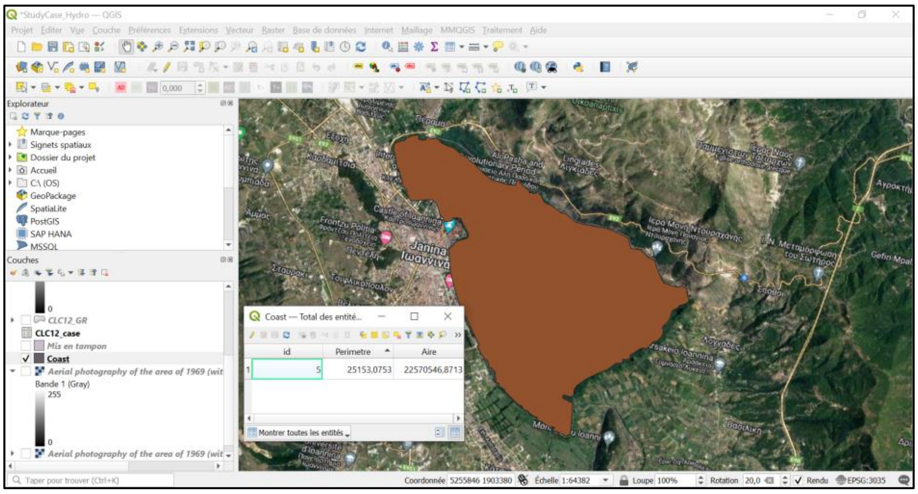


***Figure 146** : Calculations of the perimeter and area of the lake, using QGIS software.*

By spatially analyzing the area, it is possible to find out how the land around the lake is used over the years. Then the DEM can be added. To facilitate its use, use the "cut" tool to obtain the DEM for the lake area only and avoid excessive loading times **(Figure 147).**

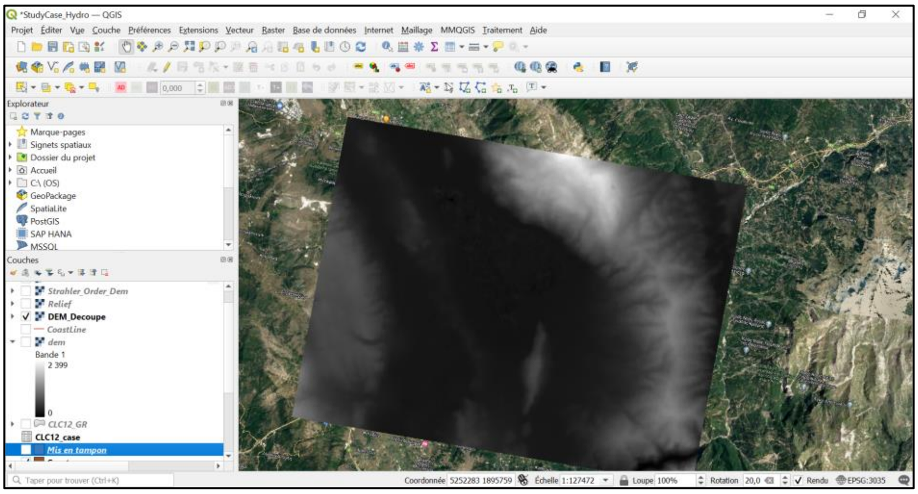


***Figure 147** : Added the trimmed DEM layer in the QGIS project.*

With the help of the DEM layer, it is then possible to start the more in-depth hydrological analysis, such as highlighting the hydraulic network in the area studied **(Figure 148).**

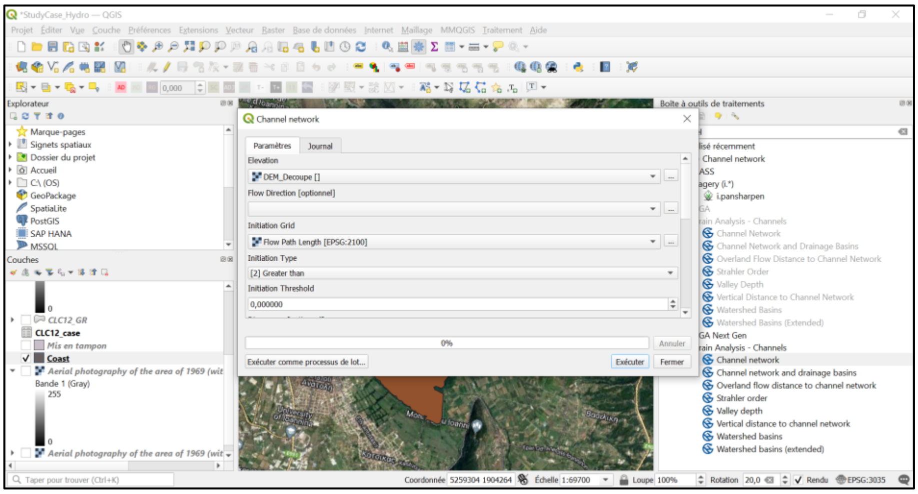


***Figure 148** : Use of the tool "SAGA - channel network" to highlight the hydraulic network of the sector studied.*

The hydrological study continues with the use of the SAGA tool "Strahler Order" **(Figure 149).**

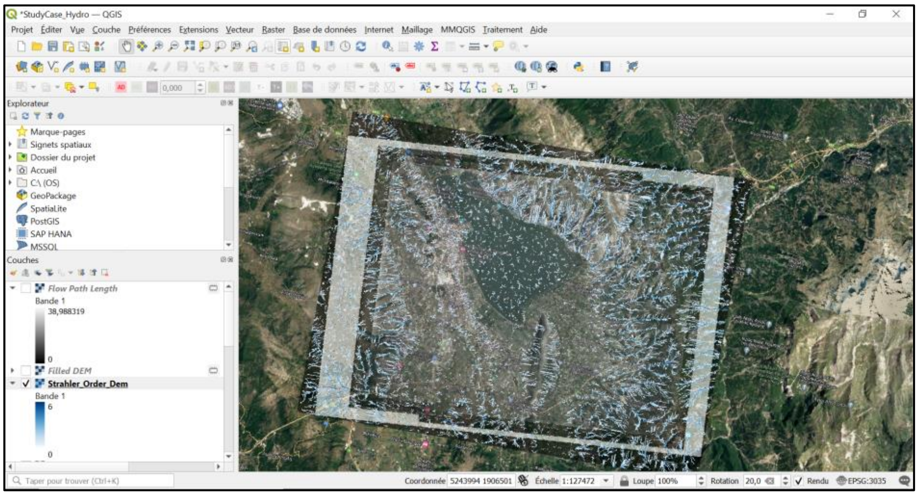


***Figure 149** : Result obtained after using the "SAGA - Strahler Order" tool in the QGIS software.*

And finally, we want to define the watershed of the lake as well as the sub-basins. Forthis, it is necessary to use a last SAGA tool available in QGIS, the tool "catchment area" **(Figure 150).**

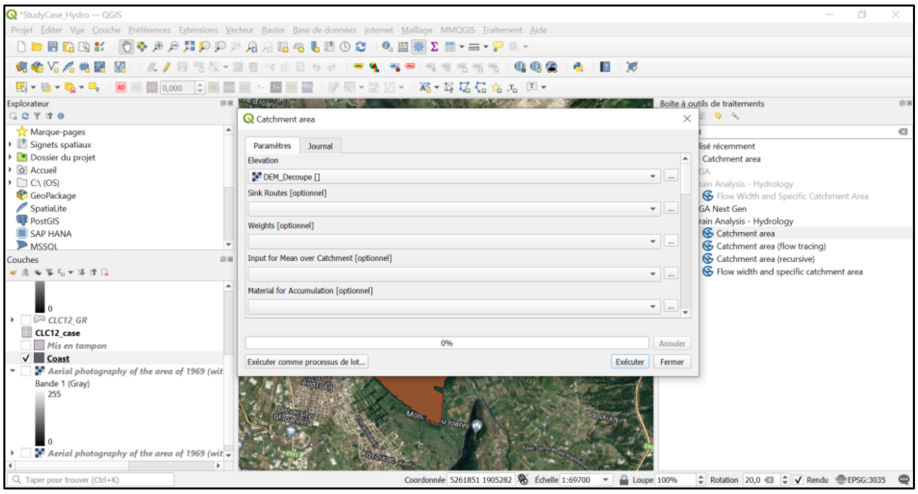


__Figure 150__ : Using the "SAGA - catchment area" tool in the QGIS software.

At the end of this analysis, it is possible to create a cartographic representation of the area studied **(Figure 151).**

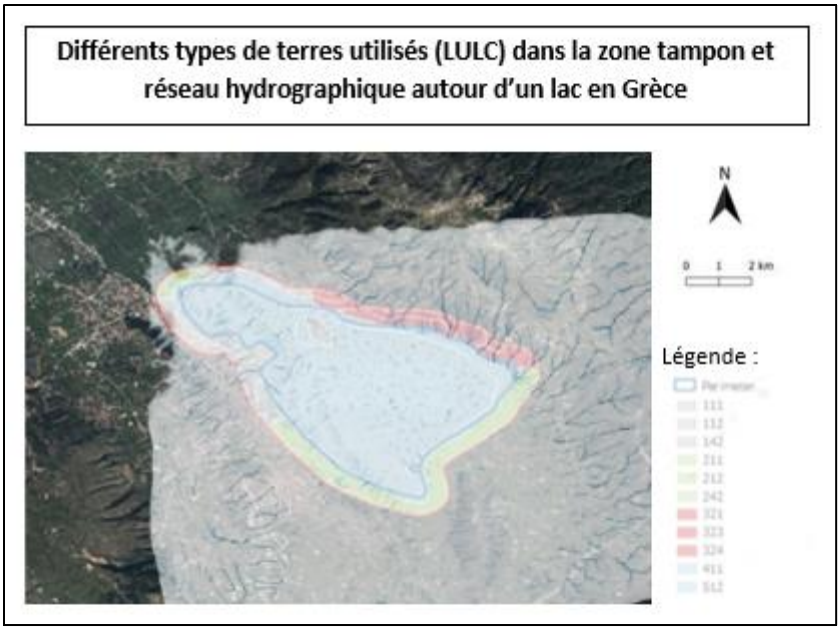


__Figure 151__ : Cartographic representation of the different types of land used (LULC) in the buffer zone and the river network around the lake in Greece.

4.4 Case Study 2 in Hydrology

This last **case study is intended for the handling of the attribute table.** In this exercise, users of the platform will have to prioritize rivers according to their sensitivity, using several criteria in the perspective of climate change, in the PACA region in France. To do this, you will first have to download the data from the "provided material" section on the FuseGI platform. The steps to complete this case study are also available on the platform (Figure 152**) (Figure 153).**

At the end of this work, we should be able to assess a degree of sensitivity (from low to high) to each section of rivers (WFD Surface Water Body), based on information provided by several existing databases, and better direct the program of measurements.

1. Select the water bodies whose linear is entirely within the scope of the PACA region

Use the MDORiviere and Région_PACA tables

2. Select appropriate column from existing databases or spreadsheet to meet chosen criteria

We want to cross the pressures related to the low water level of a river with the altitude of the catchment area, which are two contributory factors to strong thermal variations. The statistical processing of the monitoring data shows that the temperature range (variability) mostly characterizes the mid-mountain sectors and, to a lesser extent, the high mountain territories.

3. Assign degrees for each assessment (3 numerical levels)

	Field	Evaluation	Coding
Low water pressure	low water levels	Low	1
		Medium	2
		High	3

	Field	Evaluation	Coding
Altitude of Water Body	Alt_cat	LOW	1
		HIGH	2
		MID	3

Figure 152 *: List of first steps in this Hydrology 2 case study, based on the FuseGi platform.*

4. A cross-checking must be carried out with these two criteria in order to get three levels (low = 1, medium = 2, high = 3) in a new column and a new row (variations being amplified by low water level of the river and low water renewal):

		Altitude of Water Body		
		1	2	3
Low water pressure	1	Low	Low	Medium
	2	Low	Medium	High
	3	Medium	High	High

5. The other criteria are added to the result obtained by crossing, to have a total maximum score of 10 at the end.

	Fields	Criteria	Coding
Influence of groundwater	Geol_cat CE_exogene	C	0
		if CE_exogene and S	0
		S	+1

	Evaluation	Coding
Pressures on hydromorphology	Low influence	+1
	Medium influence	+2
	High influence	+3

	Evaluation	Coding
Pressures on riverine system	Low influence	+1
	Medium influence	+2
	High influence	+3

6. Categorize the total score (number of classes and interval of your choice) to get a spatial representation of the target area.

Figure 153 *: List of final steps in this Hydrology 2 case study, based on the FuseGi platform.*

After opening the QGIS software and adding the region layer as well as the MDORiviere layer, it is possible to cut the MDORiviere layer in order to keep only the part concerned by our case study, i.e. the part of the PACA Region. You must then add the downloaded table by following the following path "layer", then "add a layer", then "add a spreadsheet layer". Then, in order to facilitate the processing of data between the table and the cut MDORiviere layer , it is necessary to go to the parameters of the latter and create a join between the two layers **(Figure 154).**

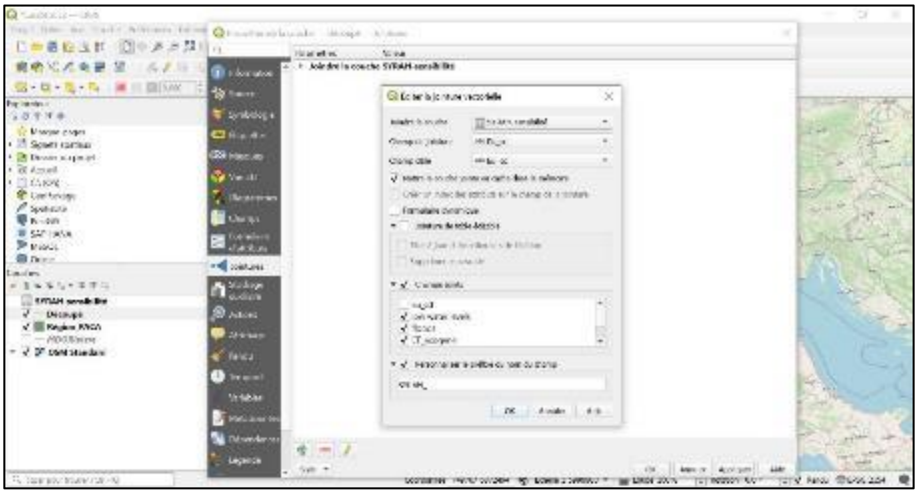


***Figure 154** : Steps to join the table and the MDORiviere layer in the QGIS software.*

Once the join is done, when we open the attribute table, we find both the attributes of the MDORiviere layer cut and those of the table **(Figure 155).**

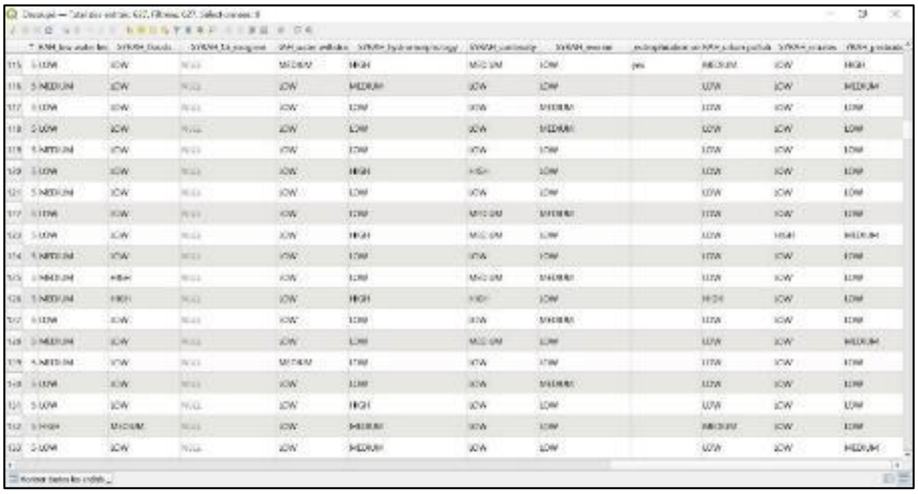


***Figure 155** : Preview the attribute table after joining the two layers.*

It is then possible to perform all the steps of data classification thanks to the attached attribute table and to obtain the most sensitive rivers in the face of climate change (in red) and those least sensitive (in white) **(Figure 156).**

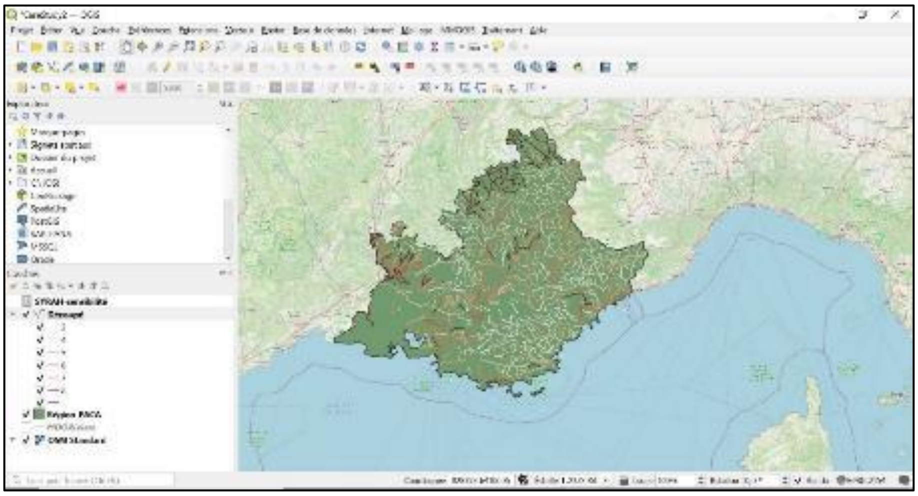


Figure 156 *: Result after classification of data, in red the most sensitive rivers and in white the rivers least sensitive to climate change.*

5 Innovation, Tangibility and Transferability

IO4 training toolkit assists end users to deal with geospatial data and their transformation into trustworthy and actionable information; through GeoInformatics (GI), which include a number of different technologies, processes, and methods that allow the effective acquisition, processing and analysis of accurate and up-to-date geospatial data. Concerning Quality indicators measurement, 9 training videos and an equal number of guides were developed to assist new GIS users to get familiar with commands processes and applications' usefulness and to also work as a guide for more GIS-experienced users. Two different types of modules (teaching and/ or training) are supported and more are considered (with modifications) giving the possibility for the toolkit to be included even in life-long learning courses.

Innovation

The teaching material produced contains several novel and innovative elements, which can be found from the design phase up to the teaching phase, as:

- All materials in the toolkit are novel, free of rights and created within the consortium.
- It assists the enhancement of competencies of professionals supporting digital education.
- It bridges academic and professional needs in different key environmental and health sectors.
- It covers simultaneously market skills gaps and educational/cognitive ones.
- It supports distance training novelties: different forms of communication and learning (Hybrid supported besides asynchronous through chats), two-way evaluation process, self-assessment, supplementary data provisioning, without fixed time courses but of relative duration
- It endorses different teaching methods: connection making, increased autonomy, no limits hands on practice.

Tangibility

A lot of effort was put, in order to create tangible results, since design phase of the teaching material, as:

- Has homogenous but yet flexible structure for each course within the VLE.
- Offers ability for adaptation and evolvement, i.e., adaptive international curriculum (from postgraduate to continuing education for engineers) targeting skills acquired in GIS.
- Adopts no discrimination policy with provision for inclusive and equitable online learning environment

Transferability

The main concept was to develop a tool that could easily be transferred and either adopted as it is or evolved, depending on the users' needs. Having this in mind the two major aspects were covered:

- The toolkit supports openness in all stages: the entire tool is based on freeware (QGIS) supporting openness in its entity using explicitly creative commons rights, open data, open courses and free books and manuals in the PowerPoints and in the supplementary material and operating through an open VLE platform. This also enhances the innovative character of the produced toolkit.
- This IO includes a detailed methodological approach, with rational explanation, which is easily transferable to other developers.