



# ECOSYSTEM SERVICES AND QGIS

A brief introduction for site managers

## SUMMARY

This leaflet provides a brief introduction to mapping ecosystem services with QGIS. This guidance document is especially useful for site managers getting started in GIS, but also for more experienced users as a document to fall back on.

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## ECOSYSTEM SERVICES

Ecosystem services imply all direct and indirect contributions of ecosystems to human welfare, such as food, materials and energy sources, but also climate regulation, mediation of natural hazards, spiritual and intellectual interactions with nature etcetera (Fig 1).

### Examples of ecosystem services



Source: PBL, WUR, CICES 2014

Figure 1. Examples of ecosystem services. Source:

The ecosystem services approach is often perceived as a perfect means to improve the link between site managers on the one hand and numerous stakeholders on the other. Namely, it is believed that the ecosystem services concept could help communicate the importance of nature's benefits to the various businesses, policy makers, governments and citizens. This increases the appreciation for, and understanding of nature and its conservation, and sometimes even leads to additional funding.

Rooted in the science of geography, the field of Geographic Information Systems (GIS) has considerably evolved within the last five decades. GIS systems nowadays serve as powerful tools (platforms) for data input, management, analysis and presentation; providing a myriad of functions that help us reveal patterns, trends, and relationships about both natural and human phenomena and activities.

Nevertheless, over time, GIS applications have become easier to use. You do not need an expensive training course just to get started in GIS - there are a lot of available training materials and guides online that can help beginners and casual users to get a first glimpse and start using GIS for basic operations.

One of the applications for GIS tools is to help integrate the ecosystem services concept into the daily work of a site manager. By using some simple tools and operations, it is possible to come up with simple estimates of the ecosystem services delivered by your specific site, and to produce illustrative maps for communication purposes.

### **WHY QGIS?**

QGIS is a free and open source GIS application with a wide range of users and a strong community of volunteer developers. This basically means that QGIS enables a continuously growing number of capabilities provided by both core functions and plugins. At the same time, answers for probably any question (problem) that can be encountered along the way, can be found. Moreover, algorithms developed and/or used in other freeware GIS software, such as GRASS GIS and SAGA GIS, are also available through the QGIS interface.

### **HOW CAN GIS BE USEFUL FOR MAPPING AND ASSESSMENT OF ECOSYSTEM SERVICES?**

According to Burkhard and Maes (eds 2017), the mapping and assessment of ecosystem services has made rapid progress in the last few decades. This is largely due to the advances in technology (computing power, modelling and GIS) and the evolution of various approaches to assessing ecosystem services (participatory mapping and biophysical modelling), as well as to the consensus that the maps of ecosystem services provide a direct connection between them and the landscape (and therefore with policy). Regarding the use of GIS in the mapping of ecosystem services, they recognise three general approaches:

- (1) analysis tools built into GIS software packages, applicable for simple land cover-based analyses and indicator-based mapping (e.g. EcoValuator);
- (2) disciplinary biophysical models applied for the assessment of ecosystem services, appropriate for more complex model-based analyses of services that integrate expertise from specific disciplines (e.g. hydrological models such as SWAT);
- (3) integrated modelling tools designed specifically for assessments, which can assess trade-offs and scenarios for multiple services (e.g. InVEST).

However, Burkhard and Maes also stress that a mapping approach and/or the tools used will mostly be determined by the type of ecosystem services, as well as the mapping context - time and data availability, mapping skills, accuracy required and overall aims of that certain case study.

Does this mean that the ecosystem services cannot be mapped, assessed and/or communicated at all without in-depth knowledge of GIS? Well, the better the knowledge on GIS, the better analyses can be conducted.

However, even basic knowledge of GIS can help you gather and analyse available data (starting with the extent and the distribution of the ecosystems), map ecosystem services (e.g. by using the ecosystem services matrix) and communicate certain problems or results with other stakeholders (e.g. by producing and sharing the map in the appropriate (e.g. jpeg or pdf) format).

### **THE PURPOSE OF THIS LEAFLET**

The purpose of this leaflet is not to give the reader, you, a comprehensive overview of all the functions and possibilities of QGIS, nor to give an extensive comparison between various options (tools) that could be used to map and assess the ecosystem services. The idea is to get you started in GIS. Through this guide we hope to give you confidence to jump into the world of GIS. By giving you access to the basic terminology so you can find the best fit for your case studies, we aim to nudge you to seek both examples of good practice and advice of fellow colleagues and to help you understand better what options are at your disposal. Even a basic proficiency in GIS can facilitate communication with stakeholders and reduce the possibilities for mistakes due to potential misunderstandings. And for those who already use GIS, albeit sporadically, the following cheat sheet might help them to remember the basic functions quicker.

## GIS VOCABULARY

**ATTRIBUTES** - descriptive characteristics of features, i.e. text or numerical information that describe the features (e.g. number of inhabitants in a town, type of forest, name of river). They are easily read from the attribute data saved in an attribute table that accompanies every vector layer.

**COORDINATE REFERENCE SYSTEM (CRS)** - a system that helps to specify every place on the earth by a set of three numbers, called coordinates (x, y and z). In other words, CRS defines, with the help of coordinates, how the two-dimensional, projected map in your GIS is related to real places on the earth.

**FEATURES** - different objects or events represented in a map. A feature is anything you can see in the landscape - houses, roads, trees, rivers, etc. represented in a GIS Application. There are three main feature types: points (a feature shown just as xy location – e.g. meeting place, bird observation, bus stop), polygons (surfaces, e.g. lake, patch of forest or grassland, buffer zone around rare bird nest) and lines (e.g. roads, rivers). Every type of features is stored in a different layer.

**LAYER** - a dataset where the group of georeferenced features (objects or events located in geographical space) is stored together with their attributes. One of the most popular layer types is shapefile (used e.g. in QGIS and ArcMap).

**PLUGIN** – The QGIS application has been built in a way that allows for many new features and functions (so-called ‘plugins’) to be easily added to the application. QGIS plugins are implemented either as *Core Plugins* (maintained by the QGIS Development Team and which are automatically part of every QGIS distribution) or *External Plugins* (those written by individual authors (developers) for a specific purpose and stored either in the ‘Official’ QGIS Repository at or in external repositories maintained by the individual authors).

**RASTER DATA** - raster data in GIS are matrices of discrete cells that represent features on, above or below the earth’s surface. Each cell in the raster grid has the same size, and cells are usually rectangular (in QGIS they will always be rectangular). Typical raster datasets include remote sensing data, such as aerial photography, or satellite imagery and modelled data, such as an elevation matrix. Unlike vector data, raster data typically do not have an associated database record for each cell. They are geocoded by pixel resolution and the X/Y coordinate of a corner pixel of the raster layer.

**SHAPEFILE** - an ESRI<sup>1</sup> vector data storage format for storing the location, shape, and attributes of geographic features. To be usable, a shapefile has to have at least four file components - namely, .shp, .shx, .dbf and .prj files. When making a shapefile (i.e. saving data in a .shp format), .shx,, .dbf and .prj files components are automatically generated.

**VECTOR DATA** - geographical data stored as a series of X, Y coordinate pairs inside the computer’s memory. Vector data is used to represent points, lines and areas (polygons). Vector data provides a way to represent real world features within the GIS environment.

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<sup>1</sup> <https://www.esri.com/en-us/about/about-esri/overview>

## QGIS CHEAT SHEET (MOST USEFUL FUNCTIONS FOR BEGINNERS)

### DOWNLOAD AND INSTALLATION

Standard installers are available for MS Windows and macOS, while the packages or software repositories are provided for other operating systems as well. For more information and instructions for your operating system check <https://download.qgis.org>. For a new user, it is always better not to install *the latest version*, but the latest LTR (i.e. *long term release*) version, since it is the most stable one.

### SETTING THE (FIRST) PROJECT

*Before you start a GIS project, it is important to first align your map with real places on earth. Map projections try to transform the earth from its spherical shape to a planar (2D) shape (i.e. to portray the surface (portion) of the earth on a flat piece of paper or, in this case, a computer screen), while a coordinate reference system (CRS) defines how this 2D, projected map in your GIS is related to real places on the earth. Many countries have agreed upon their official reference systems and available maps and datasets usually have their CRS indicated in their supporting documentation. Moreover, most GIS and mapping platforms support automated transformation between coordinate systems, as well as the 'on-the-fly projection', a functionality which allows the user to overlay layers, even if they are projected in different systems. However, it is important to keep track of the layers' CRSs, since the overlaid layers with different CRS cannot deliver an output (e.g. they cannot be merged or intersected).*

Preferred **projection** can be set under the **SETTINGS > OPTIONS > CRS**. At the same time, under the tab **MAP TOOLS** one should also check the distance, area and angle **units** and choose the preferred ones (these are important as they will be used for most measurements). Most European countries have their own specific CRS in which the most data will be available. Before you start make sure to check which one that is<sup>2</sup>.

The most commonly used **panels and toolbars**, which you can arrange on the interface according to your own preferences, are:

- Layers Panel
- Layer Order Panel
- Project Toolbar
- Attributes Toolbar
- Map Navigation Toolbar
- Manage Layers Toolbar

Later on, additional panels and toolbars can be added, depending on the user's confidence and preferences.

**Plugins** add additional functionality to QGIS - there is a collection of plugins ready to be used, i.e. to be installed directly from the QGIS Plugin Manager within the QGIS application. For example, one of them, **PLUGINS > MANAGE AND INSTALL PLUGINS... > QUICKMAPSERVICES**, provides a quick access to various datasets and base maps (e.g. Bing maps, Google maps, OpenStreetMap (OSM) etc.).

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<sup>2</sup> <http://www.crs-geo.eu/crs-national.htm>

## BASICS

GIS systems work with many different types of data; some of the most used ones are vector and raster data. **Vector data** is stored as a series of coordinate pairs and is used to represent different features (different objects or events represented in a map): points, lines and areas (often called 'polygons'). Some of the examples include the habitat or land-use maps (usually areas, i.e. polygons), species distribution (areal as polygons or observations as points), rivers or roads (often depicted as lines). Every type of features is stored in a different layer - a dataset where the group of georeferenced features (objects or events located in geographical space) is stored together with their attributes (descriptive characteristics of features - eg. number of inhabitants in a town, type of forest, name of river). One of the most popular layer types is shapefile (used e.g. in QGIS and ArcMap). On the other hand, **raster data** are stored as a grid of values and if you zoom in enough, you will be able to see individual cells of the data grid that makes up the the raster image. The most common examples are topographic, satellites and digital orthophoto maps.

Remark: If you want to make shapefile data available for others to view through a web browser keep in mind that it must contain at least the .shp, .shx, .dbf, and .prj files components of the shapefile.

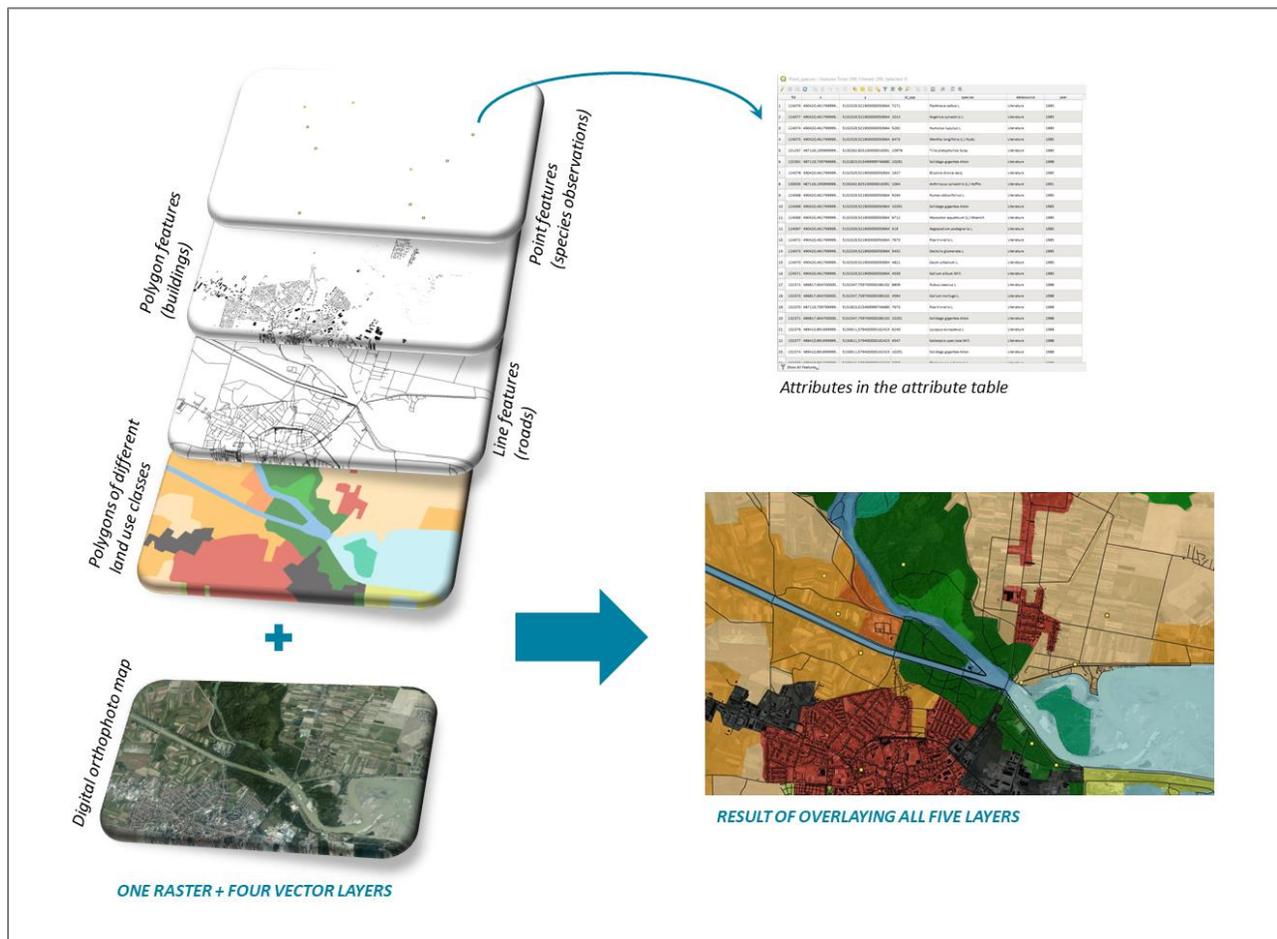


Figure 2. Example of different data and feature types.

## FEATURES:

**PAN MAP** by using the  button

**ZOOM TO LAYER** by using the  button.

**IDENTIFY FEATURES** by using the  button in order to get information on features in a pop-up window.

**SELECT FEATURE(S)** by using the  button

**ZOOM TO SELECTION** by using the  button

## DATA ANALYSIS

*Even if you are trying to stay clear of complex data analyses, there are few functions that will help you to take a closer look at the received data or to prepare your own map. Some of the essential ones are listed below.*

**ADD VECTOR LAYER** by using the  button

**ADD RASTER LAYER** by using the  button

**NEW SHAPEFILE LAYER** can be created by clicking on the  button and choosing the point, line or polygon type.

**ADD DELIMITED TEXT LAYER** by using the  button in order to make a new shapefile out of some data stored in the delimited text or csv format (e.g. produced from some field data stored in an MS Excel file).

**ADD WMS/WMTS LAYER** by using the  button in order to add some datasets published online on some other organisation's server, without having to download them first (the data you see is an image, i.e. raster).

**ADD WFS LAYER** by using the  button in order to add some datasets published online on some other organisation's server, without having to download them first (the data you see is a vector).

**LAYER > LAYER PROPERTIES** enables you to see certain information about the layer (source and CSR, metadata etc.), but also to choose preferred symbology and set the labels.

**LAYER > SAVE AS** enables you to save the content (or selection) as a new shapefile, or transform the data to some other format (e.g. csv or kml), but also to some other projection.

**OPEN ATTRIBUTE TABLE** by using the  button in order to find all the attributes that the analysed vector has. Attributes are descriptive characteristics of features, eg. number of inhabitants in a town, type of forest, name of river.

**OPEN FIELD CALCULATOR** by using the  button in order to perform calculations on the basis of existing attribute values or defined function (e.g. to calculate length or area of geometry features).

**VECTOR > GEOPROCESSING TOOLS > BUFFER...** helps to create buffer(s) around the desired feature(s) either based on a fixed distance or on a distance field.

**VECTOR > GEOPROCESSING TOOLS > CLIP...** allows you to overlay layers in such a way that the output contains only the areas from the original layers that intersect with the layer you are overlaying – the so-called *clip layer*.

**VECTOR > GEOPROCESSING TOOLS > DISSOLVE...** will merge features based on input field, thus all features with identical input values are combined to form one single feature.

**VECTOR > GEOPROCESSING TOOLS > INTERSECTION...** allows you to overlay layers in such a way that output contains areas where both layers intersect.

**VECTOR > DATA MANAGEMENT TOOLS > MERGE VECTOR LAYERS...** allows you to merge several shapefiles within a folder into a new shapefile, based on the layer type (point, line or area).

## MAP PRODUCTION

*Maps are indispensable visualisation tools that enable us to convey a message, even without using too many words, to a wide range of stakeholders. Maps often help us get the bigger picture of the researched phenomenon. Although the choice of map elements depends on the context, audience and the map-maker, there are certain elements that every map should have: (1) elements that ensure the proper reading of the map (i.e. scale information, map direction and legend of all the used symbols); (2) elements that provide context (title and information on the projection, cartographer's name and/or affiliation, date of production and used data sources); and, if needed, (3) elements that are used selectively to assist in effective communication (clipping lines, locator maps, inset maps etc.).*

*Remark: Since the GIS map file is not an image, in order to use your map outside the GIS software you have to export its map file to another format - e.g. jpeg or pdf. Map exporting (or printing) is handled via the print layout.*

Features:

**PROJECT > NEW PRINT LAYOUT** or use the  button to open the print layout, which enables you to arrange all the relevant map elements, save it as a template and export it to the desirable format.

**ADD MAP** to the page by using the  button (you can move it by clicking it and dragging it around)

**SELECT / MOVE ITEM** by using the  button

**MOVE ITEM CONTENT** (i.e. content of the map) by using the  button

**ADD LEGEND** by using the  button

**ADD SCALE BAR** by using the  button

**ADD PICTURE** by using the  button and then choosing the **SEARCH DIRECTORIES** in the *Item Properties* Panel in order to add, for example, the north arrow: a symbol (usually an arrow) that indicates the true north on the map (the direction to the North Pole)

**ADD LABEL** by using the  button in order to enter further relevant information, e.g. the author of the map, date of production and info on data sources used to produce it

**VIEW > PANELS > ITEM PROPERTIES PANEL** helps you customize the size, fonts, spacing, frame, legend contents etc.

**SAVE AS TEMPLATE** by using the  button

**EXPORT AS PDF** by using the  button

**EXPORT AS IMAGE** by using the  button

**PRINT LAYOUT** by using the  button

## SOURCES AND FURTHER READING:

**A short introduction to ecosystem services for site managers:** a leaflet developed in 2017 by the Eurosite's Economics and Ecosystem Services Working Group. <https://www.eurosite.org/wp-content/uploads/ESS-brochure-v06-WEB-1.pdf>

**A Gentle Introduction to GIS** prepared by the QGIS Project and available at [https://docs.qgis.org/3.4/en/docs/gentle\\_gis\\_introduction/](https://docs.qgis.org/3.4/en/docs/gentle_gis_introduction/)

**QGIS Training Manual - Release 3.4** prepared by the QGIS Project and intended to provide all the materials needed to run a 5 day course on QGIS, PostgreSQL and PostGIS, but structured with content to suit novice, intermediate and advanced users alike. [https://docs.qgis.org/3.4/en/docs/training\\_manual/](https://docs.qgis.org/3.4/en/docs/training_manual/)

**QGIS User Guide - Release 3.4** prepared by the QGIS Project as the original user guide of the described software QGIS. [https://docs.qgis.org/3.4/en/docs/user\\_manual/index.html](https://docs.qgis.org/3.4/en/docs/user_manual/index.html)

**Mapping Ecosystem Services** (2017) by Benjamin Burkhard and Joachim Maes (Eds), provides a very good conceptual background for the concept of ecosystem services and gives a very broad overview of different approaches and tools for mapping and assessment of ecosystem services at different levels. Furthermore, the **Chapter 3 Background mapping** gives a very good overview of basics of cartography and mapping techniques <https://ab.pensoft.net/articles.php?id=12837>

## EUROSITE: Economics and Ecosystem Services Working Group

The concept of ecosystem services can be useful for site managers. However, the application of the concept is not yet straightforward or already incorporated in the strategic decisions or day to day activities of site management organisation. Therefore, Eurosite's Economics and Ecosystem Services Working Group helps and supports the Eurosite members to take action and make ecosystem services work for them.

The main goals of the Economics and Ecosystem Services Working Group are to:

- raise awareness of the ecosystem services and natural capital concepts among the managers of protected sites;
- build capacity among site managers on how to implement ecosystem services in their day-to-day work by finding and sharing examples of practical applications;
- find ways to utilise the ecosystem services approach to generate additional funding for site management.

The Working Group was formed in 2013. It meets regularly throughout the year and holds annual demand-driven workshops on relevant topics.