Cross-Border Sustainable Renewable Energy Acceleration in Ukraine - Mapping Synergy Renewable Energy Acceleration Areas between Ukraine, EU Member States, and Moldova

Task 9. GIS Mapping

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Implemented by the Energy Community Secretariat

CONTENT

INTRODUCTION

The Energy Community Secretariat, with assistance from the European Climate Foundation (ECF) under its Ukraine Programme, is implementing a project aimed at establishing Cross-Border Renewable Energy Acceleration Areas (RAAs) in Ukraine.

This initiative targets five critical regions - Lvivska, Zakarpatska, Ivano-Frankivska, Chernivetska and Vinnytska Oblasts, chosen for their strategic positioning along Ukraine's borders with the EU and Moldova and their environmental significance. These oblasts encompass protected natural areas and substantial renewable energy potential, serving as a focal point for advancing Ukraine's green recovery, energy transition, and integration into the EU energy market.

This Report represents the results of the implementation of the GIS maps for potential REAAs, including explanatory notes on data sources and methodologies.

The Report is structured in three chapters:

- Chapter 1 of the Report describes the database used for mapping purposes.
- Chapter 2 presents the criteria on renewable energy potential and infrastructure readiness, detailing the methodological basis for developing the corresponding criteria groups, their structure across the defined clusters (zones), and the key steps applied to generate thematic maps based on these criteria.
- Chapter 3 describes geodata package for the purposes of online publication.

1. MAPPING INFORMATION BASE

1.1. Structure of the database for mapping purpose

The database contains feature classes representing the input and output datasets used for assessing renewable energy potential and infrastructure readiness within the identified clusters for the purposes of RAAs designation.

Name of database: Energy.gpkg

Format: GeoPackage

List of database classes:

Name	Type	Description
Rooftops and Facades of Buildings	polygon	State-owned, municipal buildings (schools, hospitals, offices, factories, warehouses, commercial centres, residential complexes) suitable for solar PV installation on rooftops and facades, with sufficient structural capacity, surface area, irradiation and grid connection.
Transport Infrastructure Corridor	polygon	Right-of-way land outside settlements and noise barriers/canopies within settlements along roads of state importance, suitable for installing horizontal or vertical solar PV panels where space, irradiation and grid access allow.
Parking Areas	polygon	Road service facilities, including designated stopping places and parking lots, where canopy or ground-mounted solar PV can be installed with adequate area, irradiation and access to medium-voltage grid infrastructure.
Farms solar energy	polygon	Individual farmsteads outside settlements with roofs and facades suitable for solar PV, meeting irradiation, structural load, available area and proximity to medium/high-voltage grid and substations.
Farms wind energy	polygon	Farm areas meeting minimum average annual wind speed, slope, accessibility by public roads, and proximity to grid connection points, suitable for siting wind turbines and associated infrastructure.

Name	Type	Description
Waste sites	polygon	Engineered municipal solid waste landfills and similar sites on non-agricultural, deteriorated land suitable for ground-mounted solar PV, with sufficient area, irradiation and connection to medium/high-voltage grid.
Industrial sites solar energy	polygon	Active, underused or abandoned industrial lands (including industrial parks) suitable for solar PV deployment, with adequate open area, irradiation and existing or planned medium/high-voltage lines and substations.
Mines and quarries	polygon	Inactive, phase-out or partially active mines, mine waste heaps and quarries, including sites under just transition or rehabilitation plans, suitable for solar PV where irradiation, space and grid access are sufficient.
Industrial sites wind energy	polygon	Industrial areas that satisfy wind speed, slope, accessibility and grid proximity criteria, suitable for installation of wind turbines and related infrastructure at industrial scale.
Artificial Inland Water Bodies	polygon	Artificial reservoirs, ponds and canals (excluding irrigation and drainage canals) with sufficient water surface area, irradiation and nearby grid infrastructure for floating or bank-mounted solar PV.
Urban Wastewater Treatment Sites	polygon	Settlement and local wastewater treatment facilities with available area, sufficient irradiation, road access and nearby medium/high-voltage grid for installing solar PV and associated BESS/PCS.
Degraded Land Not Usable for Agriculture solar energy	polygon	Degraded and low-productive lands with disturbed surfaces or eroded, waterlogged, saline or contaminated soils, unsuitable for agriculture but suitable for solar PV where irradiation, area and grid connection conditions are met.

1.2. Lists of attributes for database classes

Class Name	Type	Attribute	Description
Rooftops and Facades of Buildings Transport Infrastructure Corridor Parking Areas Farms solar energy Farms wind energy Waste sites Industrial sites solar energy Mines and quarries Industrial sites wind energy Artificial Inland Water Bodies Urban Wastewater Treatment Sites Degraded Land Not Usable for Agriculture solar energy	Text	Name	Layer Name
	Double	Area	Area (m^2)

2. DESCRIPTION OF THE RENEWABLE ENERGY POTENTIAL AND INFRASTRUCTURE READINESS MAPS SET

2.1. List of thematic maps

To present the results of the analysis for each of the renewable energy potential and infrastructure readiness criteria groups, the following thematic maps were created: Areas protected under international legislation.

A. Maps reflecting RE potential and infrastructure readiness criteria groups for Lviv Oblast

1. Rooftops and Facades of Buildings: map of buildings potentially suitable for solar PV installation based on structural, spatial and grid-related criteria.
2. Transport Infrastructure Corridor: map of right-of-way areas and noise barriers/canopies along state-importance roads suitable for horizontal or vertical PV installations.
3. Parking Areas: map of road service facilities and parking lots potentially suitable for solar canopy deployment.
4. Farms (Solar and Wind Energy): map of farmsteads suitable for mounted photovoltaic and wind systems

5. Industrial Sites (Solar and Wind Energy): map of operational, underused, or abandoned industrial zones that meet the technical and environmental criteria for deploying renewable energy technologies, including ground-mounted or rooftop solar installations and wind turbines with their associated infrastructure.
6. Artificial Inland Water Bodies: map of artificial reservoirs, ponds and canals appropriate for floating or shoreline solar installations.
7. Degraded Land Not Usable for Agriculture: map of degraded or low-productive lands suitable for PV installations.

B. Maps of renewable energy resource potential

Solar energy potential

8. Global Horizontal Irradiation – Lviv Oblast
9. Global Horizontal Irradiation – Ivano-Frankivska Oblast
10. Global Horizontal Irradiation – Chernivetska Oblast
11. Global Horizontal Irradiation – Zakarpatska Oblast
12. lobal Horizontal Irradiation – Vinnytska Oblas
13. Global Horizontal Irradiation – Integrated map for all 5 Oblasts

Wind energy potential

14. Wind Speed at a Height of 100 m – Lviv Oblast
15. Wind Speed at a Height of 100 m – Ivano-Frankivska Oblast
16. Wind Speed at a Height of 100 m – Chernivetska Oblast
17. Wind Speed at a Height of 100 m – Zakarpatska Oblast
18. Wind Speed at a Height of 100 m – Vinnytska Oblast
19. Wind Speed at a Height of 100 m – Integrated map for all 5 Oblasts

C. Maps of electricity grid connection potential

20. Grid Connection Potential – Lviv Oblast
21. Grid Connection Potential – Ivano-Frankivska Oblast
22. Grid Connection Potential – Chernivetska Oblast
23. Grid Connection Potential – Vinnytska Oblast
24. Grid Connection Potential – Zakarpatska Oblast

2.2. Mathematical basis for a map creation

The maps were created in the open source QGIS software. To create map layouts, digital maps were created, on the basis of which printing layouts were formed.

The mathematical basis for creating maps consists of choosing a coordinate system, scale and map layout.

The Web Pseudo-Mercator coordinate system (EPSG:3857) based on the WGS 84 datum was chosen as the coordinate system. This choice was due to several factors:

1. Reducing certain visual distortions of the territory in the coordinate system WGS 84.

2. Compatibility with web publication.
3. Speed of processing base map data.

The original data was not converted and remained in the coordinate system WGS 84.

The scale of the maps for printing was chosen taking into account the standard sizes of A3 paper sheets -1:2 500 000

The layout orientation was chosen in landscape format due to the configuration of the study area.

2.3. Thematic basis for map creation

Thematic maps were created based on a combination of thematic layers that were collected in the database.

A base topographic map of the world was used as the base.

The basic order of layer organization:

- bottom layer - base topographic map;
- upper layers - thematic polygonal layers.

Main elements of thematic content:

- map name – placed in the middle of the map;
- map legend – located in the lower left corner; the legend contains conventional designations of the thematic content of the map, namely graphic symbols for displaying thematic layers.

The colour scheme for colouring objects was selected based on the Protocol on GIS in the REAA project.

2.4. Basic steps for creating printed thematic maps

1. Start a New QGIS Project.

Launch QGIS: Open QGIS Desktop. It will start a new blank project by default. (If a project is already open, we can create a new one via Project > New).

Save QGIS project with Project > Save As to avoid losing work. QGIS project files (.qgz) store layer references, styles, etc., which is helpful if need to revisit the map design later.

Load the data: Add GeoPackage vector layers to the project. Click Layer > Add Layer > Add Vector Layer, choose .gpkg file, and select the relevant layers to import (it possible also drag and drop the GeoPackage from the Browser panel).

2. Add a Topographic Base Map and GeoPackage Layers.

QGIS doesn't include detailed base maps by default, but we can add one via web services or plugins. A simple method is to install the QuickMapServices plugin (go

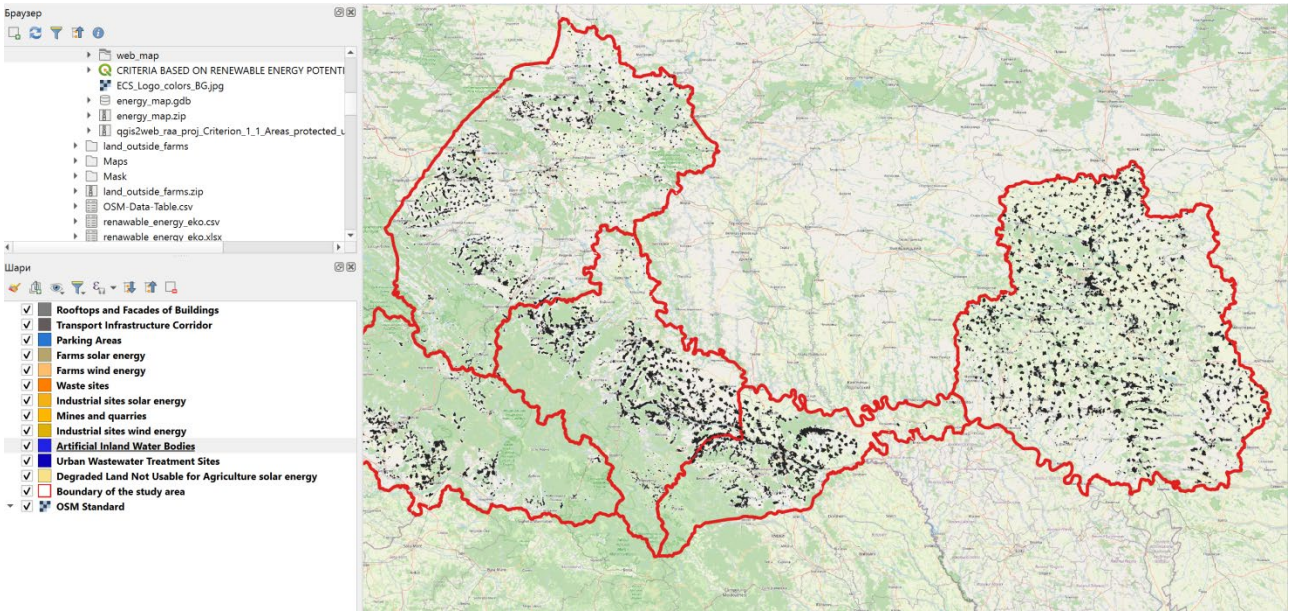
to Plugins > Manage and Install Plugins, search for "QuickMapServices", and install it).

After the base map is in place, make sure that thematic data layers (the GeoPackage vectors) are added. They should draw on top of the base map. If not, reorder them in the Layers panel (drag layers so the base map is at the bottom). At this stage, each layer will have a random default color/symbol. Next, you'll customize their styling.

3. Style the Thematic Layers.

Open Layer Properties: To adjust a layer's appearance, open its Layer Properties window. Double-clicking the layer name or right-clicking and selecting Properties..., then go to the Symbology tab.

Choose symbol and color: In the Symbology tab, we will see options depending on the layer geometry (point, line, or polygon). For polygon layers, we can set a Fill color and an Outline (Stroke) color/width.

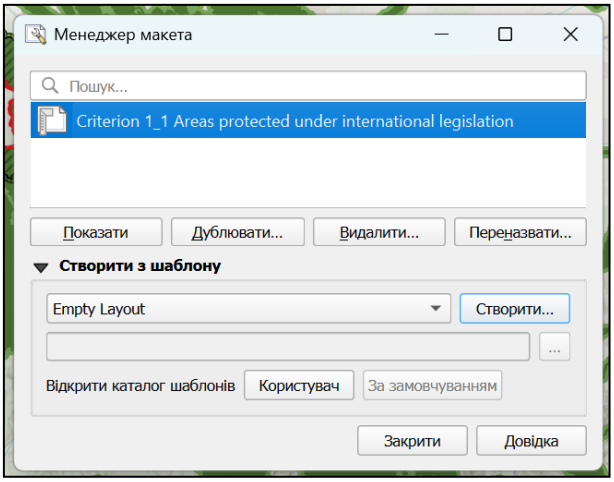


4. Create a Print Layout.

The Print Layout allows to arrange the map and other map elements on a page for export.

In QGIS main window, go to Project > New Print Layout.... When prompted, give the layout a name (e.g., "Final Map Layout") and click OK. A new layout window will open, showing a blank page.

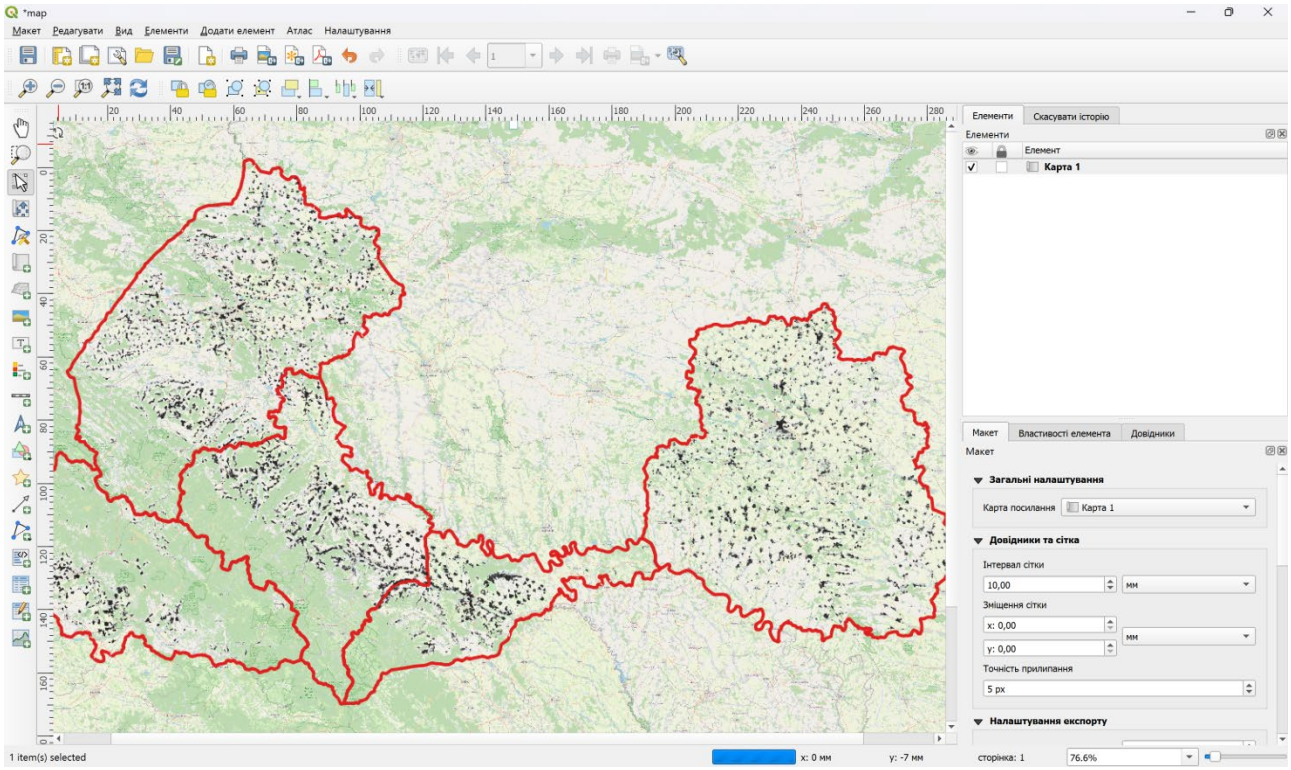
Go to Layout > Page Properties on the top menu. In the Item Properties panel on the right, set the page Size A3 and landscape Orientation. Add the map canvas to the layout: Click the Add Map button. Upon releasing the mouse, the current QGIS map view will appear in that frame on the layout.



5. Design the Layout.

In QGIS Print Layout, we can insert various items via the toolbar or the Add Item menu. After adding each item, we can fine-tune its appearance in the Item Properties panel.

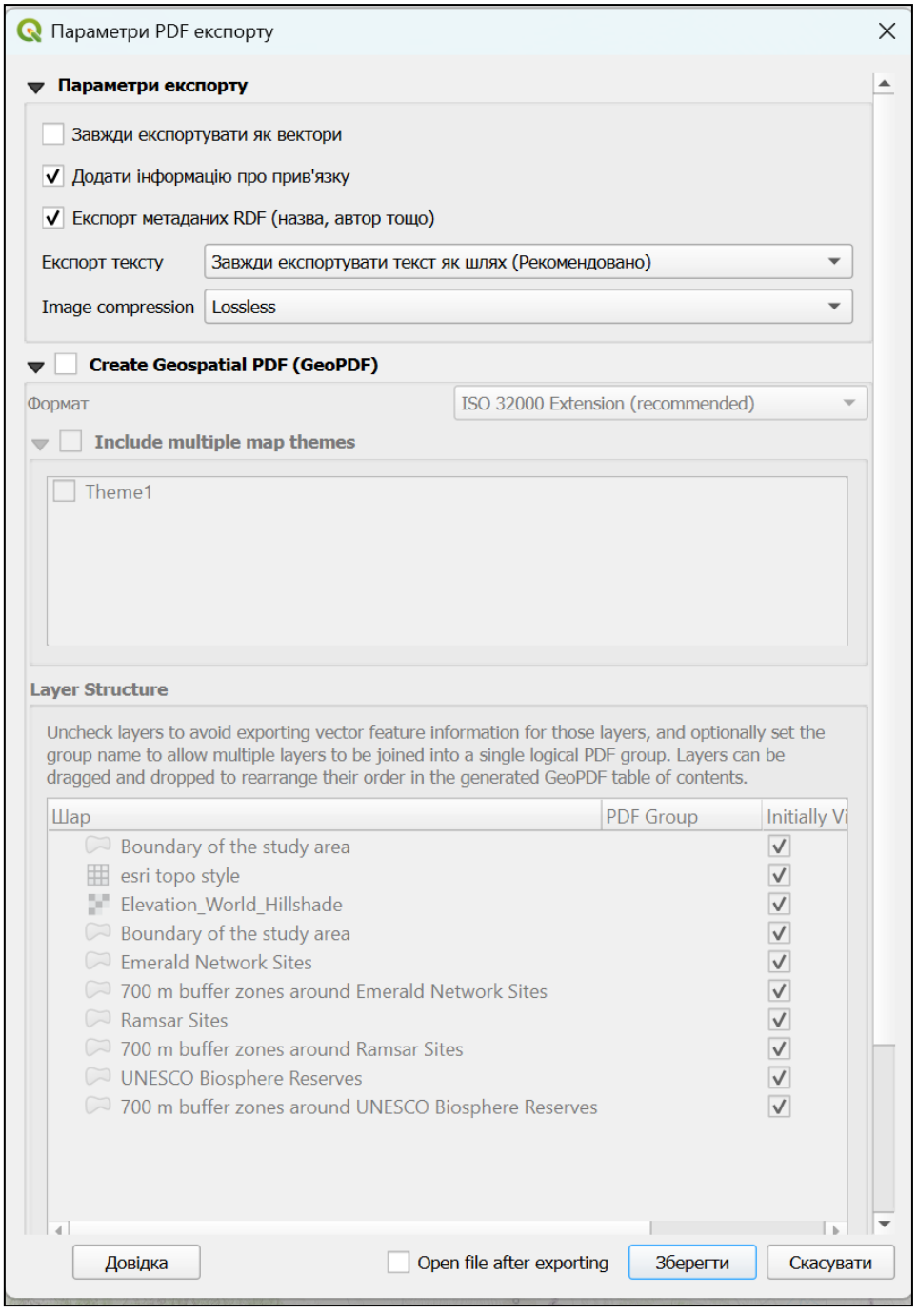
To add the legend, click the Add Legend tool, then click on the layout where you want the legend to appear. The legend reflects layer names and styles (colors/symbols) as set in the Layers panel.



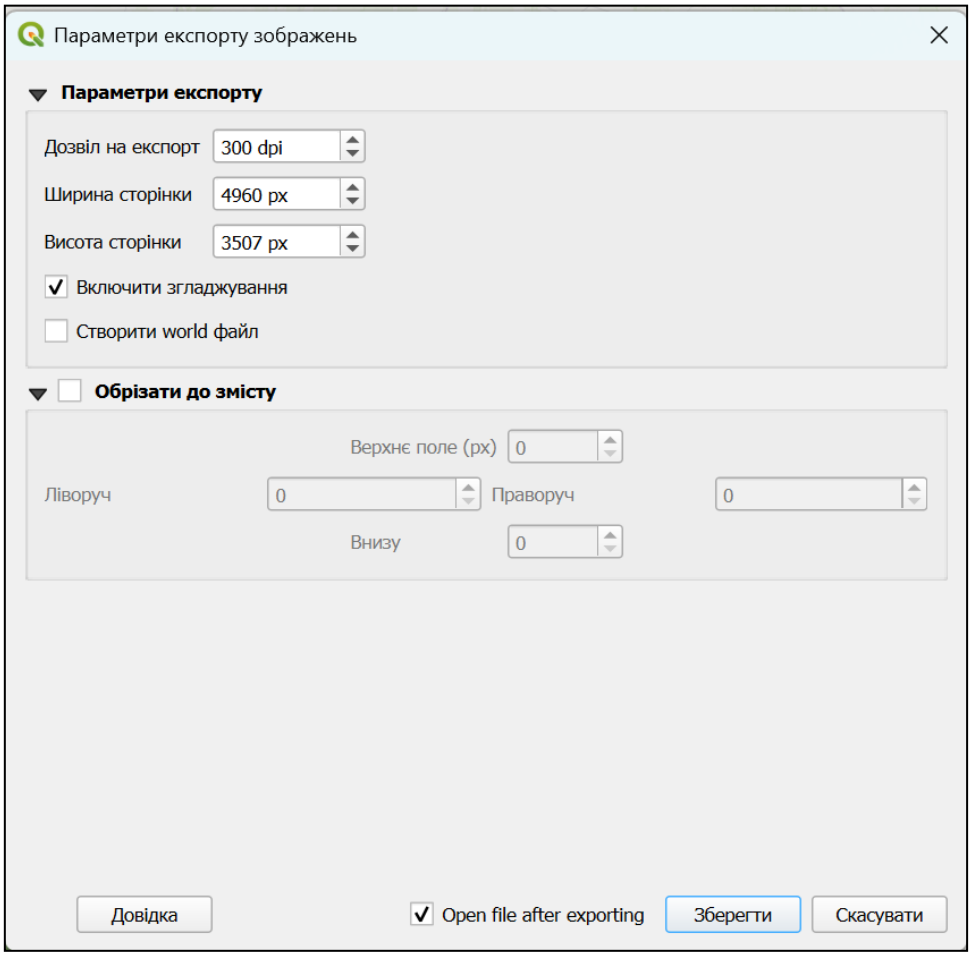
6. Export the Final Map to a Print-Ready Format.

QGIS supports exporting to PDF (vector) and image formats like TIFF, PNG, JPEG at chosen resolutions.

Export as PDF (vector): This is recommended for many academic purposes because PDF will preserve vector graphics (your linework, text, and vector shapes stay crisp at any scale). In the Layout window, click Layout > Export as PDF (or the PDF icon on the toolbar). Choose a save location and file name, then confirm. QGIS will generate a PDF of your layout. y default, text is embedded and vectors retained, so the PDF can be zoomed or printed high-res without quality loss.



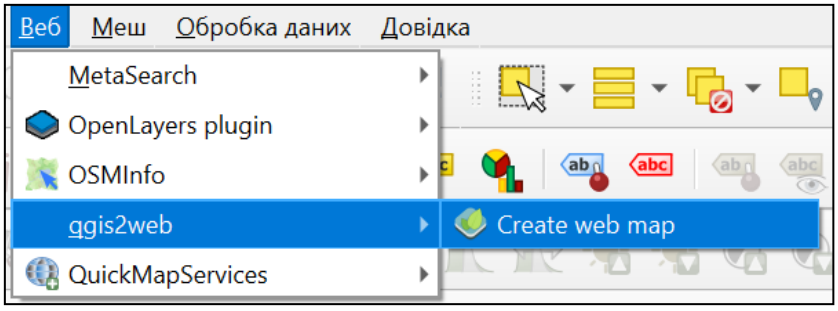
Export as Image (TIFF/JPEG): If a high-resolution image file is required. Use Layout > Export as Image. In the dialog, choose TIFF (or JPEG) and enter the resolution 300 DPI for print.



3. GEODATA PACKAGE FOR THE PURPOSES OF ONLINE PUBLICATION

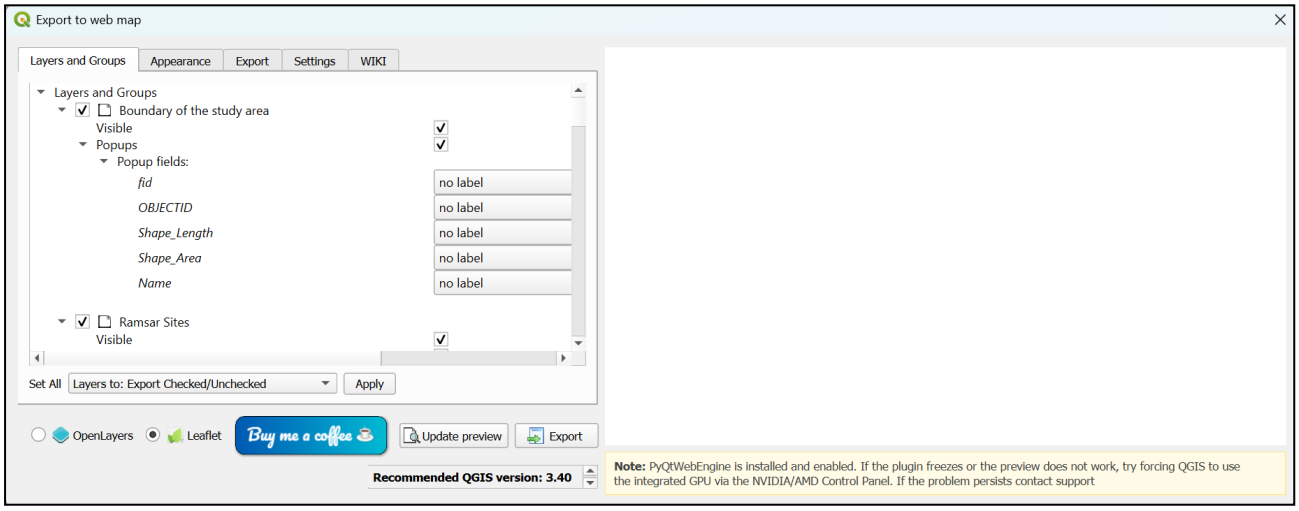
Publishing to the web is done using the qgis2web plugin, which allows you to get a web page project with an interactive map. It replicates as many aspects of the project as it can, including layers, extent and styles (including categorized and graduated). No server-side software required.

Latest stable version: 3.30.0



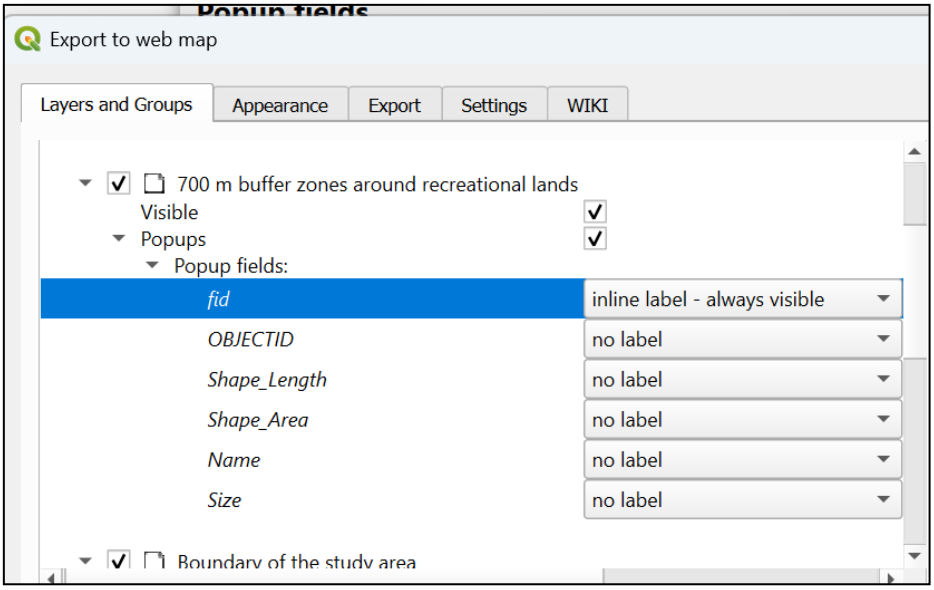
Before starting work, project settings were made:

- Set project title, abstract, background and highlight colours in Project > Properties... > General/Metadata.
- Give layers correct names in Layers Panel.
- Give layer columns correct names via Layer > Properties > Attributes Form > Fields > Alias.
- Hide fields which don't appear in popups by changing their Widget Type to "Hidden".

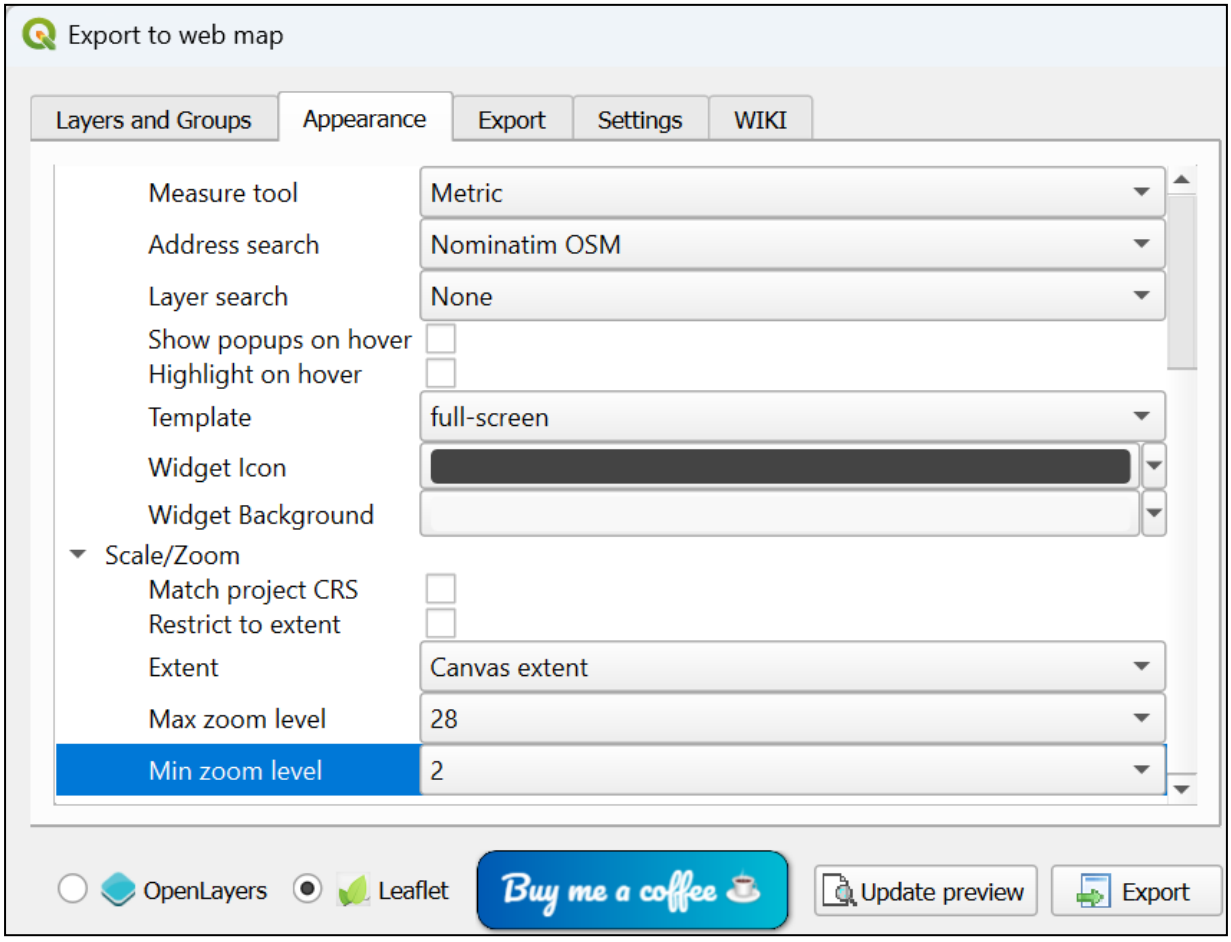


Plugin settings:

- Leaflet library was selected as the publishing method.
- Visibility was selected for layers and fields during publishing.
- Attribute display method: inline label - always visible (displays field name on the same line as data)



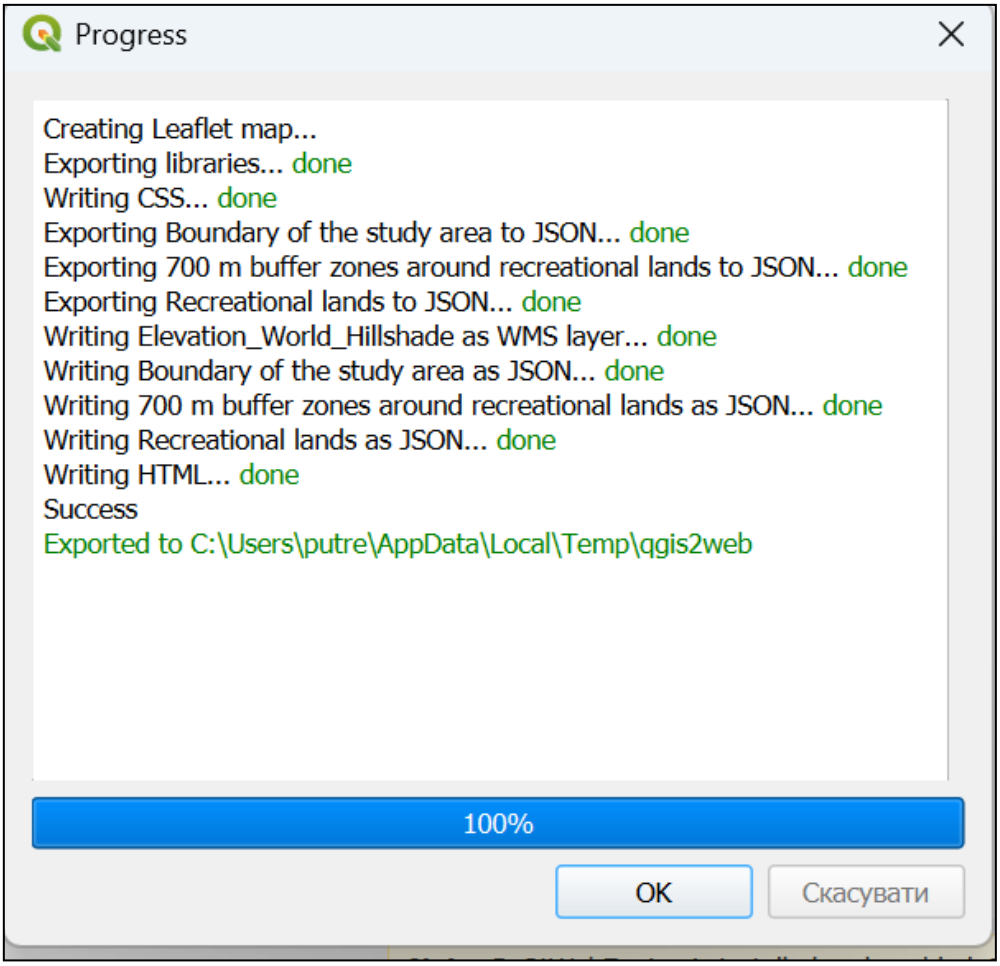
- Header placement: upper left
- Abstract: lower right
- Layers list: Collapsed
- Measure tool: Metric
- Address search: OSM
- Template: full-screen
- Extent: Canvas extent



On the export tab, select the folder to store the web map.

In the settings, you can change the number of objects visible during preview. The default is 1000 objects.

After clicking the export button, a web map is generated. The map creation process is displayed in the form of a progress window.



The finished map is checked. The name of the folder with the files is renamed according to the name of the map.