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Getting Started with Quantum Geographic Information System

An Introduction to Open-Source Spatial Data Handling (QGIS)

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Spatial data is increasingly used in agricultural production systems. Cut sheets for field leveling, field boundary layers for pesticide and nutrient applications, levee files for irrigation planning, and yield maps from harvest equipment are all examples of spatial data essential to modern production systems. The ability to handle, visualize, modify, and share these data requires specialized software commonly referred to as *geographic information systems* or GIS. Several GIS software packages are available with an assortment of capabilities, industry scopes, and costs.

One well-developed and popular open-source option that is not industry specific is Quantum GIS, or QGIS. QGIS is an official project of the Open-Source Geospatial Foundation (OSGeo) and is continually updated and improved by volunteer contributions to the project (QGIS, 2023). QGIS is compatible with Windows, macOS, and Linux operating systems. The objective of this document is to provide an overview of QGIS software installation, new project creation, installation of plugins, and basic instructions on spatial data import.

Installing QGIS

The current version of QGIS along with associated resources and documentation can be found at: https://www.qgis.org/en/site/index.html. Click the Download button, select either the available "Long Term Version" or "Latest Version" recommended for your system. Alternatively, select one of the drop-down menus for other operating systems. The "Latest" version includes all recent QGIS functionalities additions, but some unresolved issues may create glitches that affect software utilization. The "Long Term Version" does not include the most recent QGIS functionality additions, but most issues and glitches were resolved by OSGeo to maximize user experience. Open the Downloads folder and double click the downloaded QGIS-OSGeoW4-xxx file once to begin installation. Note that it may take a few minutes to complete the executable file download as this is dependent on internet speed. Follow the prompts in the pop-up window to install the program. Once installed, open the QGIS software by double clicking on the new desktop icon. This will open the QGIS interface with an untitled QGIS Project.

Creating a New Project

Upon opening QGIS, a user interface like Figure 1 will appear. Across the top of the user interface are three toolbars surrounded by the purple box ☐ (Figure 1). The uppermost tool bar is called the Menu toolbar. Below the Menu toolbar is the Attributes toolbar, and below the Attributes toolbar, is the Vector toolbar. If you hover over a blank portion of any of these toolbars, each respective name will appear next to the cursor. Likewise, if you hover over any of the buttons in the Attribute or Vector toolbars, the name or action of that button will appear. Some of the more commonly used navigation buttons on the Attributes tab and their hover descriptions are shown in Figure 3. In this initial interface, there is also a "Recent Projects" window represented by the green box ☐ in Figure 1 that may be empty but will populate projects as they are created.

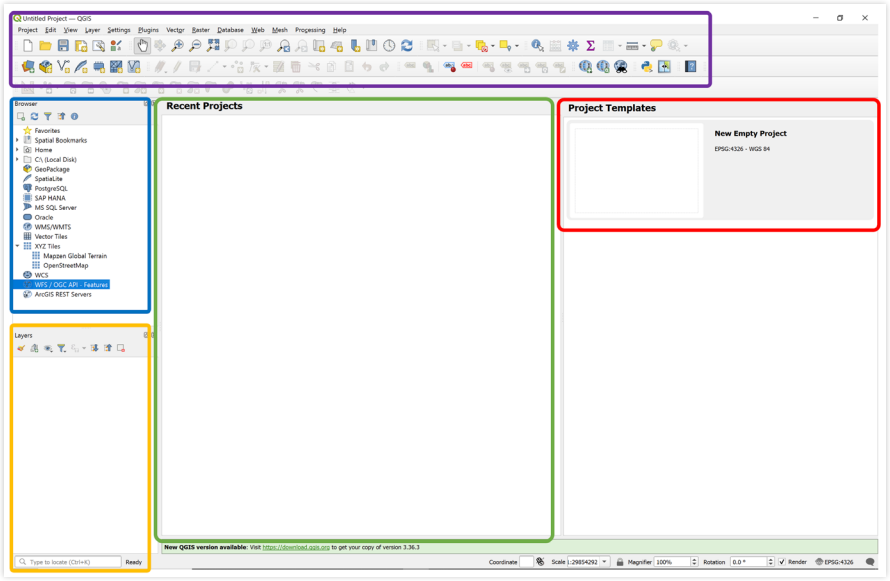


Figure 1. QGIS user interface upon startup includes the Menu, Attribute, and Vector toolbars across the top, and the Browser, Layers, Recent Projects and Project Templates windows.

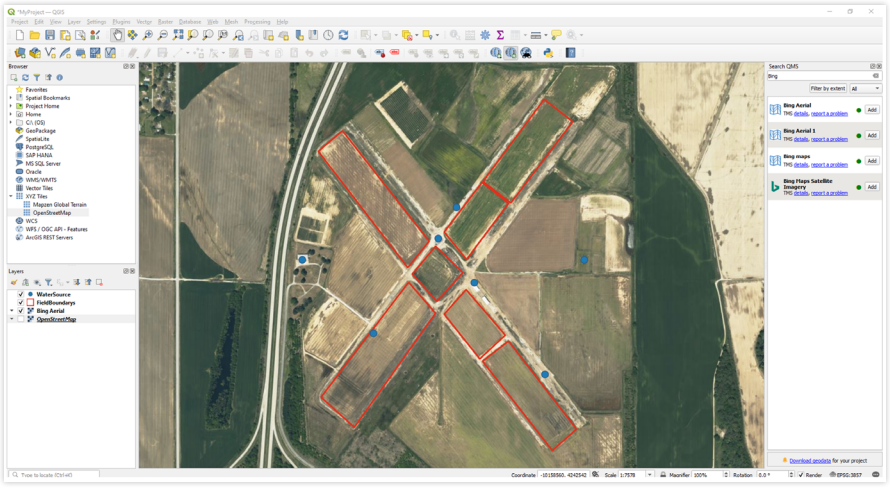
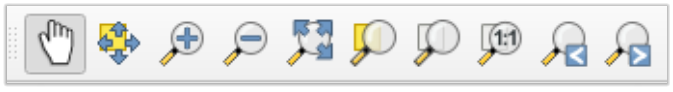


Figure 2. QGIS project opened with the Search QMS window displayed, and Bing Aerial raster layer with vector files representing field boundaries and water source locations imported.

Upon initial startup, inside the "Project Templates" window represented by a red box ☐ in Figure 1, there is the option to create "New Empty Project". Once a new project is created, data layers can be added. Alternatively, begin a new project by navigating to the Menu toolbar and click the "Projects" button and then "New" to create a new project. By default, QGIS will name this "Untitled Project". To properly name a project, navigate to the Menu toolbar again and click on "Project" and "Save As" to save the new QGIS project on a computer drive. Navigate through the folders and choose where to save the new QGIS project. Provide a file name and click on "Save".

Figure 3. Common map navigation options



Getting to know the QGIS interface

In addition to the three toolbars mentioned above, the browser window highlighted with the blue box ☐ in Figure 1 is where the software allows the user to find and load files from a computer into an open project. Only QGIS recognized file types and resources will be displayed in this window, and they can be dragged and dropped into the Layers window represented by the yellow box ☐ if a project is open. Once layers are added to the Layers window, they will be displayed in the map interface (provided the "Display" box is checked for the respective layer). Alternatively, layers from the Browser window

can be dragged and directly dropped into the map interface. Figure 2 shows the user interface with an open project. Notice that layers are both populated in the Layers window and displayed in the map interface. In the next section, adding background maps, raster layers, and vector layers to a blank interface will be discussed.

Community-Built Plugins

One standout feature of QGIS is its extensive ecosystem of community-built plugins, which allows users to tailor the software to specific needs. These plugins are developed by contributors worldwide and undergo a rigorous review process to ensure functionality, security, and compatibility with the latest QGIS versions. Once approved, they are hosted in the official QGIS Plugin Repository at https://plugins.qgis.org/, where over 1,000 options are available for free download.

Plugins extend QGIS's core capabilities by adding specialized tools, processing algorithms, data connectors, or visualization enhancements—such as QuickMapServices for easy basemap integration or Processing Toolbox extensions for advanced geospatial analysis. Core plugins (bundled with QGIS) handle essential functions like georeferencing, while external plugins (mostly Python-based) offer customization options.

To download and install plugins, simply launch the built-in Plugin Manager: Go to Plugins > Manage and Install Plugins from the top menu. In the dialog, use the All tab to browse or search by keyword, then select a plugin to view its details (including ratings, descriptions, and compatibility). Click Install to fetch the latest stable version directly from the repository. QGIS handles the download and activation automatically. Experimental or deprecated plugins can be enabled via settings if needed. Installed plugins appear in the Installed tab for easy enabling/disabling, and QGIS can check for updates on startup, daily, or weekly to keep the toolkit current.

Adding Background Maps

Background maps provide context for a project, assist with orienting the data layers, and often act as a canvas for annotating other features. Example background maps are simple highway maps with state or county boundaries and imagery layers such as Google or Bing Maps. These maps can be imported to a project in different ways. OpenStreetMap is an open-source background highway map that is installed by default with QGIS.

To display OpenStreetMap:

- In the "Browser" window, click the ▶ to expand the "XYZ Tiles" option.
- Double click OpenStreetMap to add it to the map window (also note that it has been added to the "Layers" window.
- A global map may be displayed; use the mouse scroll wheel to zoom to the project's area of interest. Use the navigation options (Figure 3) on the Attribute toolbar to navigate in the mapping interface.

Often, more detail in a background map is necessary. As an example, the boundaries of an agricultural field may be helpful; however, this level of detail is simply not included in OpenStreetMap. Imagery layers from satellite are great when this level of detail is required; however, they take a few extra steps to be displayed in QGIS. These imagery layers require the installation of a plugin, as mentioned above, from imagery providers. In this case, the installation of the plugin "QuickMapServices" will provide access to an open-source background layer for map context.

To install QMS plugin and display open-source background imagery:

- On the "Menu" toolbar select "Plugins", then "Manage and Install Plugins..."
- On the left-hand side of the "Plugins" window, select the "All" tab and search "QuickMapServices".
- Select "QuickMapServices" in the results window, and press "Install Plugin", then "Close".
- On the "Menu" toolbar, select "Web" then "QuickMapServices, and then "Search NextGIS QMS" .

- A “Search NextGIS QMS” window appears on the right side of the screen, type “Bing”.
- Next to “Bing Maps Satellite Imagery”, select “Add”.
- A satellite imagery layer should be displayed, and a new “Bing Maps” layer should appear in the “Layers” window. *If imagery does not appear, make sure it is not behind another layer by unchecking anything above it in the “Layers” window.*
- In future project sessions, the QMS Search window may not appear by default and must be reopened.

To reopen the QMS Search window:

- Navigate to the “Vector Toolbar” and select the “Search QMS” button  again.
- The “Search QMS” window will reappear on the right side of the screen.

Adding imagery (raster layers)

A **raster** is a layer of continuous cells representing an image or often a continuous phenomenon. Examples of raster layers include aerial imagery such as drone or satellite collected images, and modeled data including digital elevation models and vegetative indices.

To add a raster layer to the QGIS project:

- Navigate to the Menu toolbar and click “Layer” > “Add Layer” > “Add Raster Layer”.
- In the “Source” search bar click “...”
- Navigate to the imagery layer, select “Open” and then “Add”.
- Or simply drag the file from file explorer to the map area.

Importing vector layers

Vector layers represent points, lines, or polygons such as the locations of wells, levees, and field boundaries, respectively. Vector files can be exported from field machinery, downloaded from online databases, and shared from mobile devices. More information can be found on spatial data types in the University of Arkansas System Division of Agriculture Factsheet 2216 found at https://www.uaex.uada.edu/publications/pdf/FSA2216.pdf. When importing and using vector layers, it is also important to consider Coordinate Reference Systems (CRS). CRSs defines how spatial data coordinates relate to real-world locations, enabling accurate mapping and analysis in QGIS. QGIS will attempt and often succeed at detecting a layer’s CRS upon importing it. It is possible to import a layer with a different CRS than that of the current project. QGIS will attempt to “reproject” the imported layer “on-the-fly”. In this case, the layer’s CRS will be retained, but it will be projected using the project CRS and displayed in the correct location. If a layers CRS is not defined, not found by QGIS or, on-the-fly reprojection fails, a warning appears, and users are directed to select or transform the layers CRS to align datasets, ensuring proper geographic representation and calculations.

To import vector files into a QGIS Project:

- Navigate to the Menu toolbar and click “Layer” > “Add Layer”
- Notice all the different layer types that can be added along the left side of the Add Layer window.
- Make sure that the “Vector Layer” tab is selected
- In the “Source” search bar, click “...”.
- Navigate to the desired import.
- Click “Add”. The new layer should now appear in the “Layers” window and in the map window.
- Or simply drag the file from file explorer to the map area.

Adjusting layer display order

While working on a project, it may be necessary to adjust how a layer is displayed. Layers are overlayed on the map in the same order they are displayed in the Layers window. Therefore, one layer may hide another one below. To move the hidden layer forward, change the display order in the Layers window.

To change the display order or layers:

- Navigate to the Layers window, left click, and hold the layer that needs to be moved.
- While holding, drag and drop the layer to the desired location.

- Alternatively, layers can be unchecked in the Layers window to make other layers visible.

Conclusion

QGIS is a powerful open-source mapping software that allows for the viewing and manipulation of spatial data including vector and raster layers. Agriculture systems are increasingly generating and utilizing spatial data for production decisions, field operations planning, and input management. QGIS can be used to organize and manage these data sets. This publication has discussed the installation of QGIS, starting a new project, displaying background maps, adding vector layers (points, lines, and polygons), and adjusting how these layers are organized to facilitate visualization analysis.

References

QGIS. Welcome to the QGIS project! (2023). https://www.qgis.org/en/site/index.html

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