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Introduction

CapeFarmMapper is an online mapping application developed by the Western Cape Department of Agriculture (WCDoA). The purpose of the application is to assist users with spatial information queries and decision making in the fields of agriculture, farm planning and environmental management.

The application provides access to numerous spatial data sets in the WCDoA spatial database, with functionality to view, search and query the cadastral, demarcation and resource layers. Other available tools allow users to create data, import and export user generated spatial data, create maps, share map views and access geoprocessing services on the WCDoA map server.

CapeFarmMapper version 2 has many improvements from the first version in terms of HTML framework used for the user interface, a new mapping API, better layer control, individual graphic manipulation and labelling and additional geoprocessing tools. The application is compatible with all modern browsers e.g. Google Chrome, Firefox, Internet Explorer 10+ and Safari.
**Application User Interface**

The user interface has a responsive design and can be used on desktop/laptop computers and tablet devices.

**Interface Layout**

![Application User Interface Diagram]

Figure 1: The layout of the application user interface

- **Map Canvas**
  The map canvas handles all the user interaction with the layers and graphics. A user can click anywhere on the map canvas to retrieve location and feature information.

- **Panel Icons**
  Icons representing the different panel options. By clicking an icon the panel content on the right side of the page will change.

- **Panel Content**
  All layer options and tools are available in the panel content box. To change the panel content, click a different panel icon.

- **Overview Map**
  Small map to indicate the current extent of the map canvas boundaries. The visibility can be toggled by clicking the arrow icon in the bottom left corner of the map.
Panels
The content of the panel on the right side of the page is controlled by the panel icons in the header bar. The title of panel option will appear when the mouse cursor moves over any of the panel icons.

Layers (1)
The Layers panel consists of three internal tabs: Layers, Query Results and Legend. The Layers tab contains all the available basemap and layer options. The Query Results tab shows the map click results, which includes information from the Surveyor-General, demarcation information and the active resource layers’ values. The Legend tab provides a legend of the classified symbology for the visible map layers.

Navigation (2)
The Navigation panel contains tools to set the map extent, find the user’s location (on a GPS enabled device) and to find a coordinate based location. The current view properties are also described in this panel.

With the navigation toolbar the user can zoom to the initial extent, go back and forth in the map extent history, zoom to the graphics in the map and activate the geolocation.

The panel also provides a facility to find a coordinate using either the Decimal Degrees or Degrees-Minutes-Seconds format.

Search (3)
The Search panel provides the functionality to search the Surveyor-General farm and erven cadastre databases or an address or place from the Esri World Geocoder service. The user can use the SG Region Filter to refine the search extent for any of the Surveyor-General cadastre databases. The results of the search will be added to the map as graphics.

Drawing Tools (4)
The Drawing Tools panel provides flexible drawing, editing and labelling functionality to the user. The available drawing geometries are points, lines, freehand lines, polygons, freehand polygons, circles and rectangles. Once a graphic is created, the user can edit the feature’s text properties, change the symbology of the selected feature and add a label to the feature on the map canvas. The labelling options allow a user to use multiple attributes of the graphic to be displayed in the feature label.
Tools (5)
The Tools panel is a new addition to CapeFarmMapper version 2 and provides the user with server-side geoprocessing tools. Here a user can do coordinate conversion, create buffers around features and generate an elevation profile for selected line features.

Import/Export (6)
The Import/Export panel allows the user to export drawing and selected cadastre features to KML and Shapefile. It also provides an import facility to create graphic features from for GPX, KML/KMZ and Shapefiles.

Map Export (7)
The Map Export panel is used to generate a digital map (JPEG or PDF) of the content on the map canvas. The user can customise the layout and extent of the output map.

Share Map Scene (8)
The Share Map Scene icon opens a modal dialog box with a hyperlink that can be shared. The hyperlink contains a reference to the current map view and active layers and when opened will take the user to a new instance of CapeFarmMapper with all the active layers from the share scene automatically activated.

About (9)
The About icon opens a modal dialog box with information on the application. The four tabs in the dialog box provide different content for “About”, a Help section with links to the user manual, the changelog of updates and modifications, and a Contact section with relevant contact information.
Workflows

This section provides explanations on how to use the application interface, layers and tools as well as how to accomplish different tasks through the workflows described.

Using the Map

The map canvas is the main component of the application interface. It is used to view the various available layers, create and manipulate features with the drawing tools and to execute the geoprocessing tools on selected features.

Moving the map: The user can move the map extent around by holding the left mouse button down and dragging the map.

Change zoom level: To change the zoom level the user can either use the zoom control buttons in the top left corner of the map or use the mouse scroll wheel.

Zoom to area: A user can zoom to a selected area by holding down the Shift button on the keyboard and drawing a rectangle on the map.

Clicking on the map: By clicking anywhere on the map within the Western Cape boundary, the user will be presented with a popup dialog containing information of the cadastre at the click location, as well as details of any of the actively selected layers in the Resource Layers section. The user can switch between the Surveyor-General and Resource Layers information tabs in the popup, which will stay active for any further map click events.

In the Surveyor-General tab of the popup window there are three function links for each identified item:

- **Select**: highlights the selected cadastre item with a red outline and adds the item to the search results in the Search panel.
- **Focus**: zooms in to the identified cadastre.
- **Add Graphic Feature**: Converts the cadastre boundary to a drawing graphic feature and adds the graphic to the list of drawing graphics, which can be edited like any other drawing graphic.
The Surveyor-General tab in the popup also contains a **Click to download** link that enables the user to download any available scanned diagrams from the Surveyor-General database for the selected cadastre. Clicking the link will open a dialog box with download links to each of the available diagram documents.

![Surveyor-General Diagrams](image)

The Resource Layers tab of the popup shows the identify result for any visible Resource Layers item. The **Convert Feature to Graphic** function link allows the user to convert the identified feature of for any vector layer item to a drawing graphic. This graphic can be modified with the drawing tools and also be used as an input for the geoprocessing tools. This functionality makes it easy to capture/convert many features from a layer to drawing graphics without having to redraw and digitise the features.

![Resource Layers](image)

For the long term climate layers (Rainfall, Temperature, etc.), the identified result is accompanied by a **View Graph** function link, which will open a dialog window that contains a bar graph of the long-term monthly values for the selected climate parameter. The Data Table button will expand the graph values as a table.

![Climate Graph](image)
Using the Layers

The layers form the base of all map queries in CapeFarmMapper, providing information on Surveyor-General cadastre and underlying resources. All layers are contained in the Layers tab of the Layers panel.

Changing the Basemap: The basemap refers to the background imagery or map in the map canvas. To change the basemap the user has to click the Basemap dropdown list and select any of the basemap options. A check mark next to the name of a basemap option indicates that it is the currently selected and active basemap. Note that not all basemaps have all the visibility scale levels available, e.g. the Esri Delorme basemap is only visible up to zoom level 12 (1:144,448).

The Sentinel-2 basemaps provide 10mx10m resolution imagery from the Sentinel-2 satellite. On selecting any of the Sentinel-2 basemaps, a date picker will appear in the top left corner of the map. Sentinel-2 provides imagery every 5 days for the same area – in CapeFarmMapper only satellite scenes with less than 50% cloud coverage are selected for display. The three Sentinel-2 basemap options are:

- Natural Colour: a natural colour image utilising only the RGB bands.
- NDVI: Normalised Difference Vegetation Index is a common remote sensing method used to indicate vegetation activity by measuring the values in the Near Infrared spectrum. For the NDVI layer, red areas indicate poor or no vegetation activity, while the greener areas indicate healthier and more vigorous the vegetation activity. Blue is an indication of water or high reflective surfaces like building roofs.
- SWIR: The Short-wave Infrared layer is used to visualise vegetation activity. The bright green areas indicate healthy vegetation, while the brown to red areas indicate poor or no vegetation activity. The SWIR layer is also handy to identify land clearing activities or burn scars.

Surveyor-General Layers: The Surveyor-General layers are official demarcation layers for farm and erven cadastre, town boundaries and administrative regions in the Western Cape and are sourced from the Department of Rural Development and Land Reform: Chief Surveyor-General Office. The user can activate any of these layers by clicking the checkbox to the left of the layer name. The Labels option for the layer becomes available by moving the mouse cursor over the layer item.
**Demarcation Layers:** These layers are official demarcation boundaries as provided by the Municipal Demarcation Board and indicate demarcation boundaries down to ward level. The user can activate any of these layers by clicking the checkbox to the left of the layer name. The Labels option for the layer becomes available by moving the mouse cursor over the layer item.

**Resource Layers:** The resource layers provide information on agriculture, natural resources, conservation, land cover and land use in the Western Cape. Some layers are available for the full extent of South Africa. These layers are categorically grouped for ease of use. Clicking the category title will extend the layers list to see all the layers available in the selected category.

Each layer can be activated by clicking the checkbox to the left of the layer name. The two icons that appear to the right of the layer title upon moving the mouse cursor over the layer item are for the layer settings and layer information. The layer settings will enable the user to set the layer opacity (transparency) with the slider input, while selected layers will also have a Definition Filter to limit the layer features based on a filter value, e.g. the Crop Census layer can be filtered to show only feature of crop type "grapes". The layer information retrieves the metadata of the selected layer and is displayed in a modal dialog box.

CapeFarmMapper 2 also allows multiple resource layers to be displayed and queried simultaneously. The layer order is determined by the order of activation, i.e. the first activated layer is at the bottom while the second activated layer will be displayed on top of the first. The order of display can be manipulated by activating the layers in the desired order. The Surveyor-General and demarcation layers are always displayed on top of the resource layers.

**Custom Layers:** Users that have access to additional ArcGIS Rest Services can add their own Map Service or Image Service layers from the selected Rest service endpoints. The user must first select the Rest service type from the Select Type dropdown list and then provide the Service URL and optionally the service index of the layer. After adding the Rest service layer, the layer item will appear in the Custom Layers list with the same functionality as any of the Resource Layers.
**Layer Query:** The Query Results tab in the Layers panel provides the cadastre, demarcation and resource layers information of a map click event. This is the same information as displayed in the popup of a location based query. The Show Map Information Window checkbox provides the user with the option to show or hide the map popup window on a click event, but the identify results will still be displayed in the Query Results tab of the Layers panel.

**Layer Legend:** The layer legend refers to the classified symbology of any active layer and is available in the Legend tab of the Layers panel.

**Map Navigation**
The Navigation panel provides functionality for further map navigation.

**Zoom to home extent:** To return to the initial map extent (Western Cape), the user can click the Full Extent button on the Navigation Toolbar.

**Zoom to previous extent:** To return to the previous zoom extent, the user can click the Previous Extent button on the Navigation Toolbar.

**Zoom to next extent:** To go to the next extent of the zoom history, the user can click the Next Extent button on the Navigation Toolbar.

**Zoom to drawing graphics:** The user can zoom to all the drawing graphics in the map by clicking the Zoom to Graphics button on the Navigation Toolbar.

**Show user location:** A user can determine his/her current location by activating the geolocation with the Show My Location button on the Navigation Toolbar. Once active, the map will center on the device location and an orange pulsating marker will appear on the map. The user’s location information will be displayed in the User Location section of the Navigation panel. The geolocation can be deactivated by clicking the Deactivate tracking button. Clicking the Mark location button will create a point graphic on the map at the location indicated by the orange location marker.

**Find a location by coordinate:** Find or navigate to a coordinate based location with the Find Location tool in the Navigation panel. The user can enter the geographic
coordinates (with WGS84 datum) in decimal degrees or degrees-minutes-seconds in the Latitude and Longitude text boxes and then clicking on the Go to location button. Clicking the Mark location button will create a point graphic on the map at the given location.

**Search for cadastre or address/place**

The Search panel provides functionality to find farm or erf cadastre from the Surveyor-General database, as well as an address or place as geocoded in the Esri World Geocoding Service.

**Searching for a farm or erf:** The user must select either the Surveyor-General Farm or Surveyor-General Erf option from the Search Database list and type the search value in the search text box. The search value can be any of the following options:

- farm name, e.g. Nooitgedacht (as registered per title deed)
- parent farm number, e.g. 123
- erf number, e.g. 123
- subdivision/portion number and farm number, e.g. 1/123
- Surveyor-General unique 21-digit code, e.g. C06100000000012300001

The user also has the option to limit the search results to a selected Surveyor-General administrative region by selecting the region from the SG Region Filter dropdown list. To start the search, the user can press the Enter key or click on the search icon. The results of the search will be added to the

![Figure 2: Search results from a farm name search](image)
map as graphics (red cadastre boundaries) and a list of the results will be displayed in a table below the map or at the bottom of the Cadastre Search panel as clickable items. The search results list is sorted by Surveyor-General region and then by cadastre number.

**Search for an address or place:** The Esri World Geocoding Service allows a user to search for a place by common name or an official address by typing the search value in the search text box. The search options are:

- Address, e.g. 123 Strand Street, Cape Town
- Place, e.g. V&A Waterfront

To start the search, the user can press the Enter key or click on the search icon. The results will appear as a list of clickable items at the bottom of the Cadastre Search panel.

**Drawing and Editing Features**

The drawing tools are available in the Drawing Tools panel and allow the user to create, edit and label user drawings or imported feature graphics. The feature graphics created with the drawing tools form part of a temporary graphics layer on the map canvas. A separate graphics layer is used for the search results graphics.

**Drawing features**

The drawing toolbar gives the user the option to draw points, lines, freehand lines, polygons, freehand polygons, circles or rectangle geometries. Activate the geometry type by clicking on the button for the geometry type, after which the Deactivate Drawing button will appear below the drawing toolbar. The user can zoom in and out and move the map around while creating the features.

The following methods are used to draw the different geometry types:

- **Points:** single click in the map at the desired location of the point. A user can zoom in on the map beforehand to attain better accuracy.
- **Line:** start with a single click on the map and continue creating the line with a series of single clicks, ending the line feature with a double click.
- **Freehand Line:** hold down the left mouse button from the start to the end of the line drawing, releasing the left mouse button when the line is complete.
- **Polygon:** start with a single click on the map and continue creating the polygon with a series of single clicks, ending the polygon feature with a double click.
• **Freehand Polygon**: hold down the left mouse button while delineating the polygon boundary and release the left mouse button when the polygon is complete.

• **Circle**: starting at the center of the circle feature, hold down the left mouse button and drag the circle boundary until it reaches the desired size, releasing the left mouse button when the circle is complete.

• **Rectangle**: starting at any corner of the rectangle feature, hold down the left mouse button and drag the rectangle boundary until it reaches the desired shape and size, releasing the left mouse button when the rectangle is complete.

• **Ring/Hole**: start with a single click on the map and continue creating the polygon with a series of single clicks, ending the polygon feature with a double click. The hole polygon must be drawn within an existing polygon feature.

After a feature drawing is complete, the properties for the feature are calculated and set and appears in the Graphics Properties section of the Drawing Tools panel. The application automatically assigns geometry attributes for each feature, which is also included when the graphic is exported.

**Editing a feature**

Once a feature is created or imported, the user can modify the feature’s shape or position with the geometry editing facility. To activate feature geometry editing, click the Edit Features button below the drawing toolbar. Click on the feature you want to edit – the feature will be selected and the vertices for the feature geometry will appear.

The original vertices are small grey points, while the ghost vertices (optional vertex handles) are displayed as small white points. The user can move these vertices to modify the feature’s shape.

To delete a vertex, right click on the vertex and click Delete in the vertex popup. The user can also use the extent boundary vertices (white squares) to change the feature’s size. The top white square vertex can be used to rotate the feature. To remove the feature from the map while in edit mode, click the Delete Feature button below the drawing toolbar.
Identifying a feature
Each graphic feature on the map will have geometry specific attributes assigned to it, as well as additional attributes in the case of imported feature graphics. To view a feature’s attributes, the user must activate the Feature Info tool (the button turns green once active) below the drawing toolbar. All the graphic features will appear in a table below the map and the user can either select the feature from the table or click the feature on the map canvas. The selected feature’s attributes will be displayed in the Graphics Properties section of the Drawing Tools panel.

Changing graphic feature attributes
The user has the option to change a graphic’s attributes by using the property edit facility. To select a feature for editing, activate the Feature Info button below the drawing toolbar and then click the feature on the map canvas – the feature’s current attributes will then appear in the Graphics Properties section. The user can then click on the edit icon to activate the attribute edit text boxes, which are used to define the graphic’s ID and Comment attributes. Once the new attributes have been entered, click the check mark icon to save the feature’s modified attributes.

Labelling a feature
The labelling tools provided in the Drawing Tools panel give the user the option to add feature attribute text to the map canvas. To label a feature, activate the Label Feature button below the drawing toolbar and then click a feature in the map. The automatically assigned graphic identifier is the default label for the feature, which will be placed on the map at the click location. The user can change the label location at any time while the Label Feature button is active, by clicking on the feature at different locations. Once the feature label has been placed on the map, the user can use the options in the Label Properties section of the Drawing Tools panel to manipulate the colour, size, position and feature attributes displayed in the label. Multiple attributes can be displayed in the label by selecting different attribute...
fields from the Label Fields options list. The label for the feature can be removed from the map by clicking the Remove Feature Label button.

**Import, Export & Saving Features**

A key feature of CapeFarmMapper is the ability to store map graphics, which can be either feature drawings or cadastre boundaries from selections and search results, to offline files, as well as the ability to import files from different formats to graphic features on the map. The export and import tools are available in the Import/Export panel.

**Exporting features**

The feature export facility allows a user to download the drawing features or cadastre selection features. The user can choose which graphic feature set to download from the Select Feature Set options. Click the Export button to initiate the export process, which is a server-side geoprocessing utility to create KMZ and Shapefiles of the selected feature set. Once the server-side process is complete, the export utility will create download links for the resulting KMZ and Shapefiles. The attributes of each feature of the selected feature set will be transferred to the features in the export files.

**Import features**

The feature import utility makes provision for the importing of GPX, KML, KMZ and Shapefiles. Only vector format features can be converted to map graphics. For Shapefiles, the user must first create a ZIP file of all the shapefile components (*.shp, *.shx, *.sbx, *.sbn, *.prj, *.dbf) before selecting the ZIP file for upload.

Use the Choose File button to select the file to import and click the Import File button to start the import process, which is also a server-side process. The features from the selected import file will be converted to map graphic features and will retain all the feature attributes. The imported features can also be identified and modified like any drawing graphic.

**Local Storage**

The Local Storage facility provides the ability to quickly save or load graphics in the map without having to import or export spatial data files. The user can store any current graphics in the map to a new or existing local storage item in the application memory. The Local Storage data will only be available on the PC or Laptop that the application was used.
Geoprocessing Tools

The Tools panel is a new addition to CapeFarmMapper 2 and provides the user with user-friendly geoprocessing tools that normally require advanced desktop software. Each tool panel can be activated by clicking any of the tool icons.

Buffering

The buffering tool can be applied on any of the drawing features to create a polygon feature to a certain distance around the input feature. The user needs to specify the buffer distance and select the distance units (meters or kilometres) before activating the Buffer Select button. Then the user must click on a feature graphic to generate the buffer polygon, which will be displayed with a red dashed line around the input feature. The resulting buffer polygon feature is added to the drawing graphics feature set and is available for export to KML or Shapefile.

Line Segments

The Line Segment tool is used to create point markers at a specified distance from another. First the user must create a line graphic to serve as the baseline for the distance markers. Then the user can specify the segment lengths or distance between markers by entering a value in Distance text box and selecting the unit type.

Activate the tool by clicking the Segment Select button and then click on the line graphic in the map. The distance segment markers (point graphics) will be created on top of the selected line, starting at the initial drawing point of the line in the direction of the last vertex of the line.
Converting Conversion

The Coordinate Conversion tool enables a user to project a coordinate from one coordinate system or projection to another. The available projection conversion options are:

- Geographic
- Africa Albers Equal Area
- Transverse Mercator (central meridian 17-33)
- Universal Transverse Mercator (33-36 South)

The user can also use any of the following input and output datums to apply coordinate transformations:

- WGS 1984
- Cape

The user must specify the input and output coordinate details with the available options and then click the Convert Input Coordinate button to get the resulting output coordinate values. Once the coordinate is converted it can be plotted on the map as a graphic by clicking the Plot Point button.

Users must note that the Transverse Mercator projection uses a scale factor of +1.0, which is a south-oriented format of the standard surveying projection format with negated values for the X and Y coordinates.

Elevation profile

The elevation profile tool allows a user to generate an elevation graph for a selected line graphic. The line graphic must be created beforehand with the drawing tools and can be of any length or orientation. The elevation profile tool makes use of the Esri Profile Service, which is based on a 24mx24m elevation model.

To generate the profile graph, the user must activate the Profile Line button and then click on a line graphic. The resulting profile will be displayed below the map canvas as an interactive graph. A user can move the mouse cursor over the graph to view the elevation height (middle point label) at the specific point, as well as the distance from the start of the line (top point label) and the difference in elevation from the starting point (red or green point label). The geographical location of the graph
point is also indicated by a green cross on the map. The download link in the top right corner of the graph gives the user the option to download the elevation profile data as a CSV file.

![Elevation profile generated for a selected line drawing graphic](image)

**NDVI Graph**

The NDVI graph tool is used to generate a temporal NDVI graph for a selected area for a period of up to 3 years. NDVI is short for Normalised Difference Vegetation Index and is a common remote sensing method used to indicate vegetation activity. Sentinel-2 satellite data is used to calculate the statistics for the zone selected by the user. For best results, it is advised that the tool is used for a single crop field or area of homogenous vegetation type at a time.

First the user must create a polygon in the map by either drawing the polygon or converting a feature to graphic. After activating the NDVI Zone Select button, the user can click on the polygon area to generate the NDVI graph. The resulting graph displayed in the dialog window contains three data series - NDVI maximum, NDVI mean and NDVI minimum - and is interactive so that the user can determine the NDVI value at a certain date. The graph values are based on all the pixels contained
within the polygon zone selected with the tool. Once the graph is generated, the user can export a static PNG image of the graph by clicking the Export to PNG button.

**Zonal Statistics**

The Zonal Statistics tool is used to summarise any of the available Data Layers for a selected area e.g. summarise the area per crop type on a farm. The user must create a polygon area first by either drawing the polygon or converting a feature to graphic, then select a Data Layer which to summarise. After activating the Statistics Zone Select tool, click on the polygon area and await the results, which will be displayed as a sortable table in a dialog window. The data table can be exported to a CSV file, which in turn can be used in a spreadsheet program like Microsoft Excel. A link to each zonal statistics result will be added below the Statistics Zone Select button so that the user can refer back to it during the active session.
Map Export

The Map Export panel offers an quick and easy map export utility with which the user can generate a downloadable digital map of the map canvas and the active layers and graphics. The available options can be used to define the resulting map page layout, page size and map extent, which will be generated on a predefined template hosted by the Map Server.

The options for Extent defines the visible area of the output map and can be used in the following way:

- **Current Scale**: the centre of the current map view will be placed at the centre of the output map at the same visible scale, which is dependant on the scale of the basemap image service.
- **Current Extent**: the full extent of the current map view will be fitted to the output map content box, which will result in a difference in map scales between the application map view and the output map.
- **Western Cape**: the full extent of the Western Cape will be used as the bounding box for the output map.
- **All Graphics**: the full extent of all graphics in the map will be used as the bounding box for the output map.
- **At Scale**: the centre of the current map view will be placed at the centre of the output map with a scale as defined by the user in the scale text box.

Once the user has set all the export options, the Export Map button can be clicked to initiate the map generation on the server side. The server will return the export map and open a dialog window containing a link to download the map document. The map export results of the active session are also added as a link below the Export Map button.
Sharing a map scene

As described in the Panel section of this document, the Share Map Scene utility provides a means to share the current map view with active layers to other users and is useful for interactive information sharing. By clicking the Share Map Scene icon, a modal dialog box opens with a hyperlink that can be copied and shared.

The hyperlink contains a reference to the current map view and active layers and when opened in a browser, will take the user to a new instance of CapeFarmMapper with all the active layers from the share scene automatically activated.