SRA_Ch3: Data management for spatial risk assessment

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

3.1 Use of geographic information systems in spatial risk assessment

"The overall GIS process within SRA involves following six steps that continue on from the MCDA steps (Figure 3.1). The MCDA and GIS steps are closely linked at GIS step five where the spatial weights resulting from the MCDA described in Chapters 1 and 2 combined with the results of GIS processing to create a final risk map."

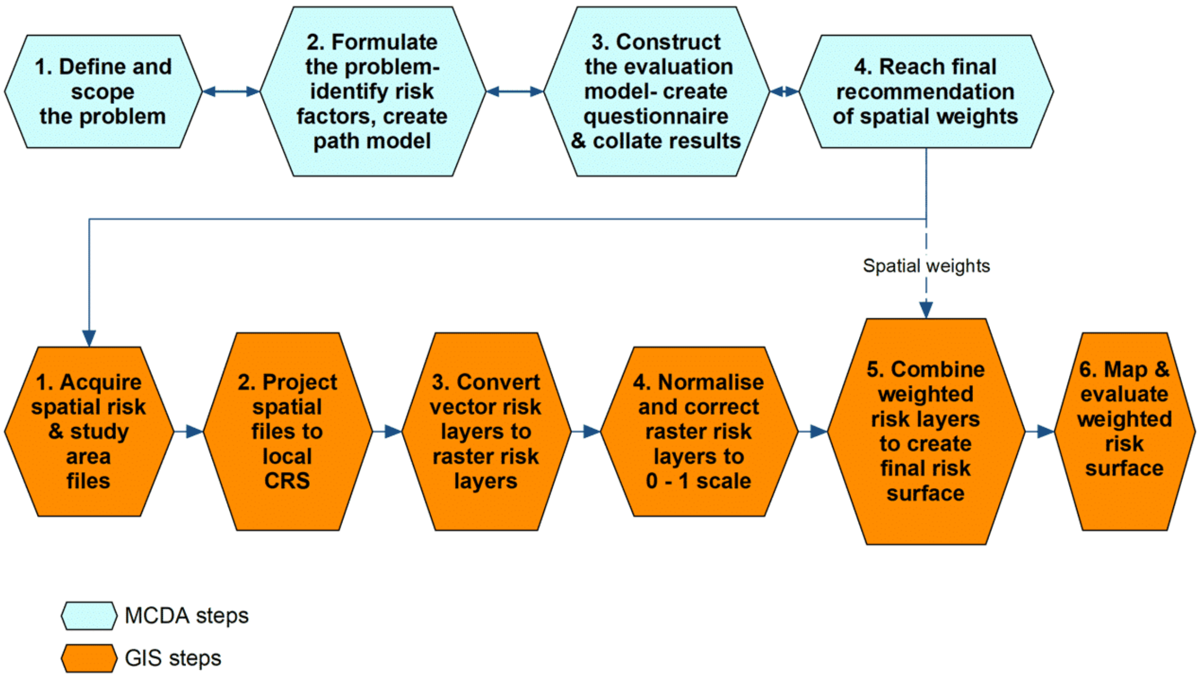


Figure 3.1: Workflow of spatial risk assessment processes

CONTINUE

3.2 Preliminaries

"It is important to understand that GIS spatial data that represent the risk factors required for SRA must be either available in a raster format, or be eventually converted to a raster format to combine the various risk factors into a single SRA map. However, often these spatial data do not exist in raster format and instead, spatial data in other formats, such as spatial lines or spatial polygons, must be firstly sourced and then transformed to the required raster format. This process of acquiring and transforming spatial data consumes much of the work in the GIS component of SRA.

Therefore, the purpose of the GIS steps 3 and 4 is to create separate raster files for each risk factor, creating multiple risk "layers", in forms that can be combined. Increasing pixel values in each layer should represent an increased risk of disease occurrence, and the values should be scaled so that they span values between 0 and 1.

These normalised (values transformed to range 0 - 1) risk layers can then be combined by multiplying each by their own spatial weight created from the MCDA process, and then mathematically added to each other to create a final weighted risk surface."

CONTINUE

3.3 Acquiring digital maps of the study area and spatial risk factors

There are many open-source (free for non-profit use) spatial data repositories. These data have a wide range of types, formats and attributes, and only some may be of value for animal health GIS and SRA purposes. Additionally, their file sizes are often large, meaning they can be slow to download, consume large quantities of computer storage capacity, and need additional processing before they can be used. Additionally, some spatial data may not be available publicly or from government and may need to be collected by the researcher or analyst. Together, this means that considerable effort and time may be needed to locate, acquire, and process spatial data for SRA projects.

"The following subsections describe how to locate open-source spatial data, and some of their types and uses for SRA."

CONTINUE

3.3.1 GADM data

The GADM database of global administrative areas provides digital maps in a range of file formats for state boundaries and lower-level administrative areas:

Spatial data in vector polygon format of country administrative regions can also be downloaded from the GADM website: https://gadm.org/download_country_v3.html

“**For example, Myanmar has formats Geopackage, ESRI “Shapefile”, two R formats (sp and sf) and Google KMZ format. For the purposes of this course, we will use the “Shapefile” format. The files have the suffix “0” for state boundaries, then suffixes in increasing integer numbers for successively smaller administrative regions. The coordinate reference system and datum for these files are longitude/latitude and WGS84, respectively.**”

3.3.2 OpenStreetMap project

OpenStreetMap (OSM, https://www.openstreetmap.org) data are, as suggested by it's name, open-source, and created by public users. Spatial files of a wide range of geographic features are available, but for the purposes of this course we will focus on roads, but many more features are also available (see below).

These OSM data can be acquired directly from within QGIS or from the geofabrik website: http://download.geofabrik.de/

"**The country files are located under the Sub Region, and the Quick Link for the "shp.zip" file for that country provides a download for a zipped shapefile in the file format which we will use, which needs to be unzipped once it is downloaded. These files potentially contain a large number of features, and more information about each can be found at the following links.**"

Population Centres

https://wiki.openstreetmap.org/wiki/Map_Features#Place

Roads —

https://wiki.openstreetmap.org/wiki/Map_Features#Roads

Railways —

https://wiki.openstreetmap.org/wiki/Map_Features#Railway

Ports —

https://wiki.openstreetmap.org/wiki/Tag:landuse%3Dport

Airports —

https://wiki.openstreetmap.org/wiki/Map_Features#Aeroway

Maps of these spatial data features may be converted to vector maps as described in the following tutorial:

https://www.qgistutorials.com/en/docs/3/downloading_osm_data.html

CONTINUE

3.3.3 Livestock demographic and health data

Some freely-available livestock spatial data is available, but it is often aggregated and additionally may not be current. Common sources include:

- Gridded Livestock of the World (GLW) maps provided by FAO
  - These raster format data estimate livestock density (in units of number of animals per pixel), at a resolution of 5 minutes of arc (approximately 10 km at the Equator)
  - The current (July 2021) data is version 3 for the year 2010, with maps available for sheep, pigs, horses goats, ducks, cattle, chickens and buffaloes
  - https://dataverse.harvard.edu/dataverse/glw_3
- Background information about these data are found at http://www.fao.org/livestock-systems/global-distributions/en/, with links from that page to the various species
  - Several maps are available for each species, and the differences between them are described in the metadata file

- The precise year of data collection and resolution of the data varies by country
- For our purposes, the maps produced by the dasymetric method (files contain the "_DA" suffix) in the "tif" format are the most appropriate

- National animal health and surveillance data may also be available (but may not be freely available)

CONTINUE

3.3.4 Miscellaneous data

A wide range of data physical and human geography data can be obtained from the following sources:

UNEP Environmental Data Explorer –

http://geodata.grid.unep.ch

FAO GeoNetwork –

http://www.fao.org/geonetwork/srv/en/main.home

The World Bank DataBank

http://databank.worldbank.org/data/home

CONTINUE

3.4 Case study: Spatial risk assessment for incursion and spread of FMD in Myanmar

3.4.1 Background and data for this case study

"We will use as an example the SRA process undertaken at the OIE-GIS course for animal health run in Nay Pyi Taw, Myanmar, in October 2019. This was a hypothetical example used as a training exercise during the course, with the aim that the course participants could learn the methods and further develop and apply them in their own countries. The participants from Myanmar and the Laos Democratic Republic and representatives from OIE who took part in the exercise were the 'experts' in the MCDA process, from which we have used data in previous exercises. Throughout this chapter."

Spatial risk factor data for this case study includes:

1. Livestock markets

- The raw data is a CSV file that includes the point locations of markets in geographic coordinates (longitutde and latitude) in decimal degrees and market status (active or not active)

2. Roads

- Classified as primary and secondary
- The raw data is an ESRI shapefile with geographic CRS sourced from OSM
- These road categories are handled separately for the exercise to demonstrate the method, although the distinction between primary and secondary roads as risk factors is not made in this case study

3. Pig population density

- The raw data are sourced from FAO's Gridded Livestock of the World source provided as a tiff file and geographic CRS

4. Cattle population density

- The raw data are sourced from FAO's Gridded Livestock of the World source provided as a tiff file and geographic CRS

"Download these data as a single zip file "RawData.zip" from the Stream site - Spatial risk assessment section in the "Spatial risk assessment files" folder. This is a large file and may take several minutes to download depending on your internet speed."

CONTINUE

3.4.2 Create and set up a QGIS project

Each QGIS project needs to be set up and saved so that you can return to the same place in your work as when you left it last. The project file you are about to create stores information on the locations of the various files you work with.

- On the menu bar click "Project" -> "New"
- A blank Layers pane and map palette will appear
- On the menu bar click "Project" -> "Save As" and either create a new folder in your highest level project folder or add it to an existing one if that

is appropriate

- Give the QGIS project a meaningful name to you like “MMR-FMD-SRA”- which identifies the country and purpose of your project
- Click ”Save”

“**You can set various parameters, but for our purposes, the most important is the coordinate reference system (CRS):**

- **On the menu bar click “Project” -> Properties -> CRS (Figure 3.2)**
    a. **Select coordinate reference system that is appropriate for the study area, in this case WGS 84 / UTM zone 48N**
    b. **Click “OK”**

You can set various parameters, but for our purposes, the most important is the coordinate reference system (CRS):

- **On the menu bar click “Project” -> Properties -> CRS (Figure 3.2)**
    a. **Select a coordinate reference system that is appropriate for the study area, in this case, WGS 84 / UTM zone 48N**
    b. **Click “OK”**

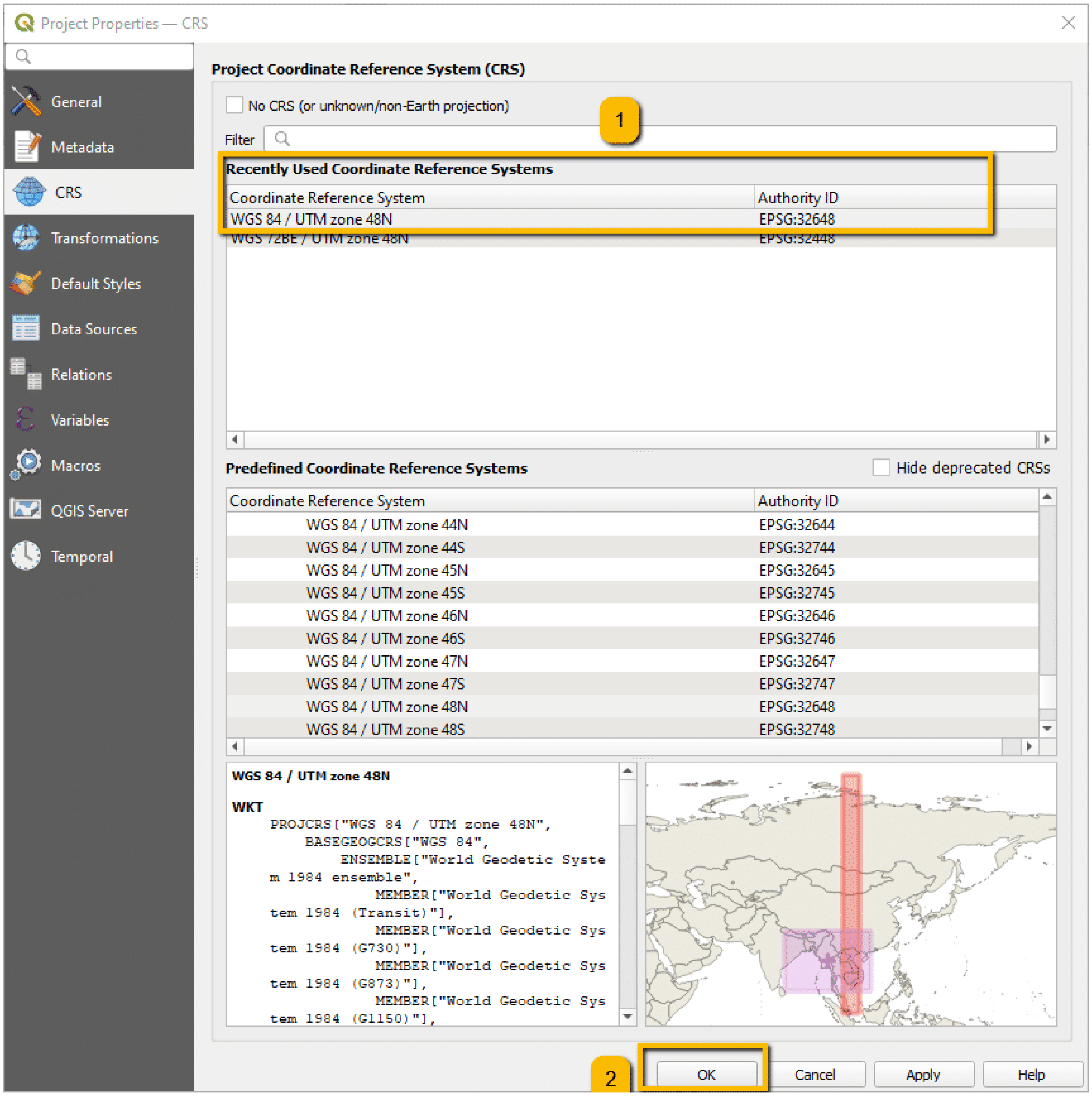
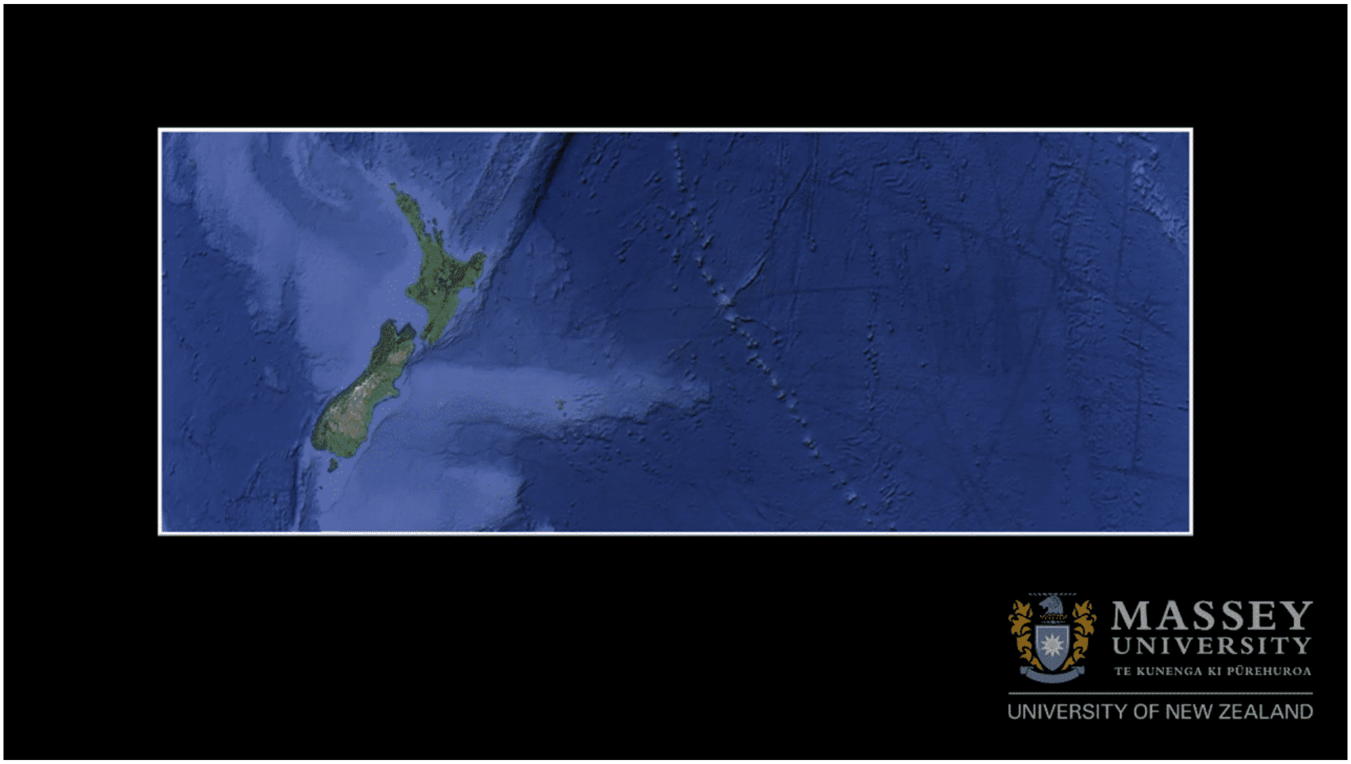


Figure 3.2: Set project CRS

Click ▶ to play the video



CONTINUE

3.4.3 Project file management

It is important to organise an SRA project in a way that makes it easy to store and later locate the large number of spatial data files in an SRA project that need processing. If spatial data are stored in a disorganised way, the work of the analyst will be harder, take longer and be more error-prone.

Each analyst will eventually need to use a system that is meaningful to them, but if you are uncertain of where to start, I suggest the following folder names and structure to organise files, with each indent denoting a separate level of sub-folders, followed by a description of files to store in them. The names in speech marks are the names that are used in the exercises in this course, but you can use names that make sense to you, don't type in the speech marks, use identical case of letters (upper or lower) and don't use spaces in folder or file names.

The suggested QGIS spatial project structure is set out in the following way:

- "SEACGISCourse2022"- Project folder with an informative name
    - "QGISProj"- folder for QGIS project file (should be defined when project first created and never changed)
    - "Data"- folder for storage of all types of data you use in your project (mainly spatial data in this project)
        - "RawData"- Folder for all data in the original form that you acquire it
            - "Geo-Admin"- Spatial data of administrative regions, typically spatial polygons of the study area
            - "Geo-Features"- Spatial data on geographic features, such as roads, population centres etc.

    - "Geo-Livestock"- Spatial data on livestock populations, typically raster files of cattle, pig population density

- "ResData"- Folder for all data that you process for later use, with the same subfolder structure as the "RawData" folder. When a file from a "RawData" subfolder is processed, save it in its new form into the subfolder of the same name in the "ResData" folder. Add one additional folder:
    - "Geo-Final"- Folder to store final spatial SRA result files

"**The GIS steps create intermediate files which should be renamed and saved for checking for obvious errors. If the files are renamed in a systematic way, then each file representing a step in the process can be readily retrieved.**

The result of one operation are usually passed to the next operation, and if an error arises, it is easier to troubleshoot backwards one step at a time to find and solve the problem, rather than starting from the last step when you don't know at which step the problem occurred.""

3.4.4 Import raw project spatial files

Complete the following steps to organise your raw data and results files:

- Create folder named “Data” within the “SEACFMDGISCourse2022” folder
- Create folder “ResData” within the “Data” folder
- Download the raw data in a zip file “RawData.zip” from the Stream site (click HERE) - Spatial risk assessment section in the “Spatial risk assessment files” folder
- Unzip the file into the “Data” folder
- You will have created a “RawData” folder within the “Data” folder, and further subfolders for files according to the type of geographic features they represent (Figure 3.3)
    - “Geo-Admin” with GADM administrative region shapefiles
    - “Geo-Features” with livestock markets, OSM features such as roads etc
    - “Geo-Livestock” with pig and cattle population density raster files

- “Geo-Admin” with GADM administrative region shape files
- “Geo-Features” with livestock markets, OSM features such as roads etc

- “Geo-Livestock” with pig and cattle population density raster files

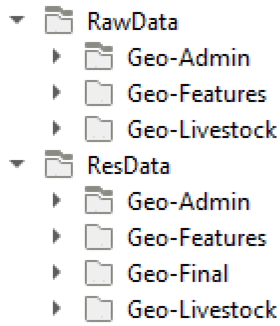
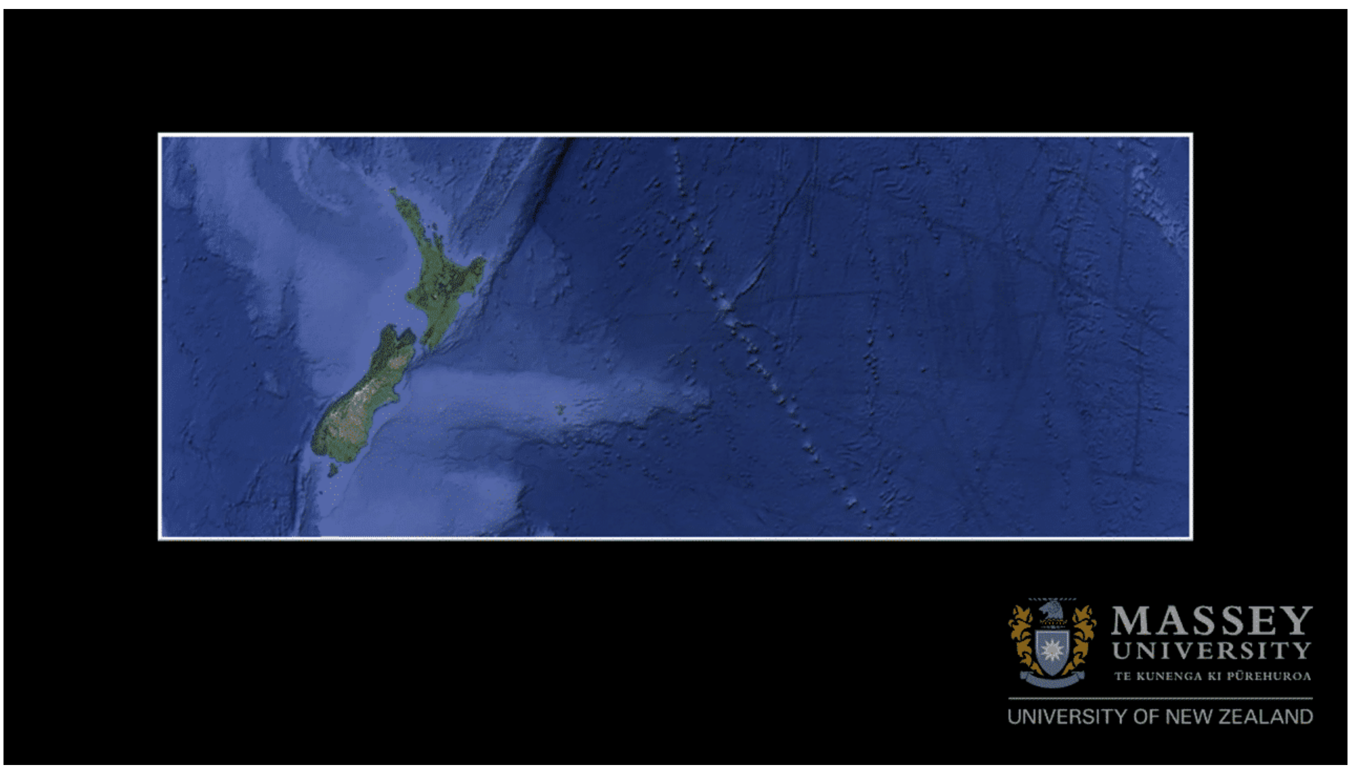


Figure 3.3: Suggested data folder structure

Click ▶ to play the video



CONTINUE

3.4.5 Project, save and visualise spatial files

Spatial files are frequently available with the geographic CRS (longitude and latitude measured in degrees) and must be projected to the local CRS with distance units because SRA requires GIS operations that require distance-based calculations. We will be dealing with different spatial data types- areal (such as administrative regions), point (such as locations of livestock markets), lines (such as roads) and raster (such as livestock density), many of which need to be projected first before further processing, but the process is essentially the same for each data type.

3.4.5.1 Spatial areal files- study area

A spatial areal file is always necessary to define the study area and create a boundary for your analysis. Import the study area file of the state of Myanmar into your QGIS project in the following steps:

- Left-click and drag the study area spatial file (RawData/Geo-Admin/gadm36_MMR_0.shp) from the Browser Pane onto the map palette

- In Layers Pane right-click on the layer file -> Export -> Save Features As … -> Dialog box (Figure 3.4)
    a. File name “MMR_0” in Layers Pane “-Admin" (this is the directory in which you are saving the projected file and the name you are giving to it)
    b. In CRS box change to “Project CRS: EPSG:32646 - WGS 84 / UTM zone 46N
    c. Click OK

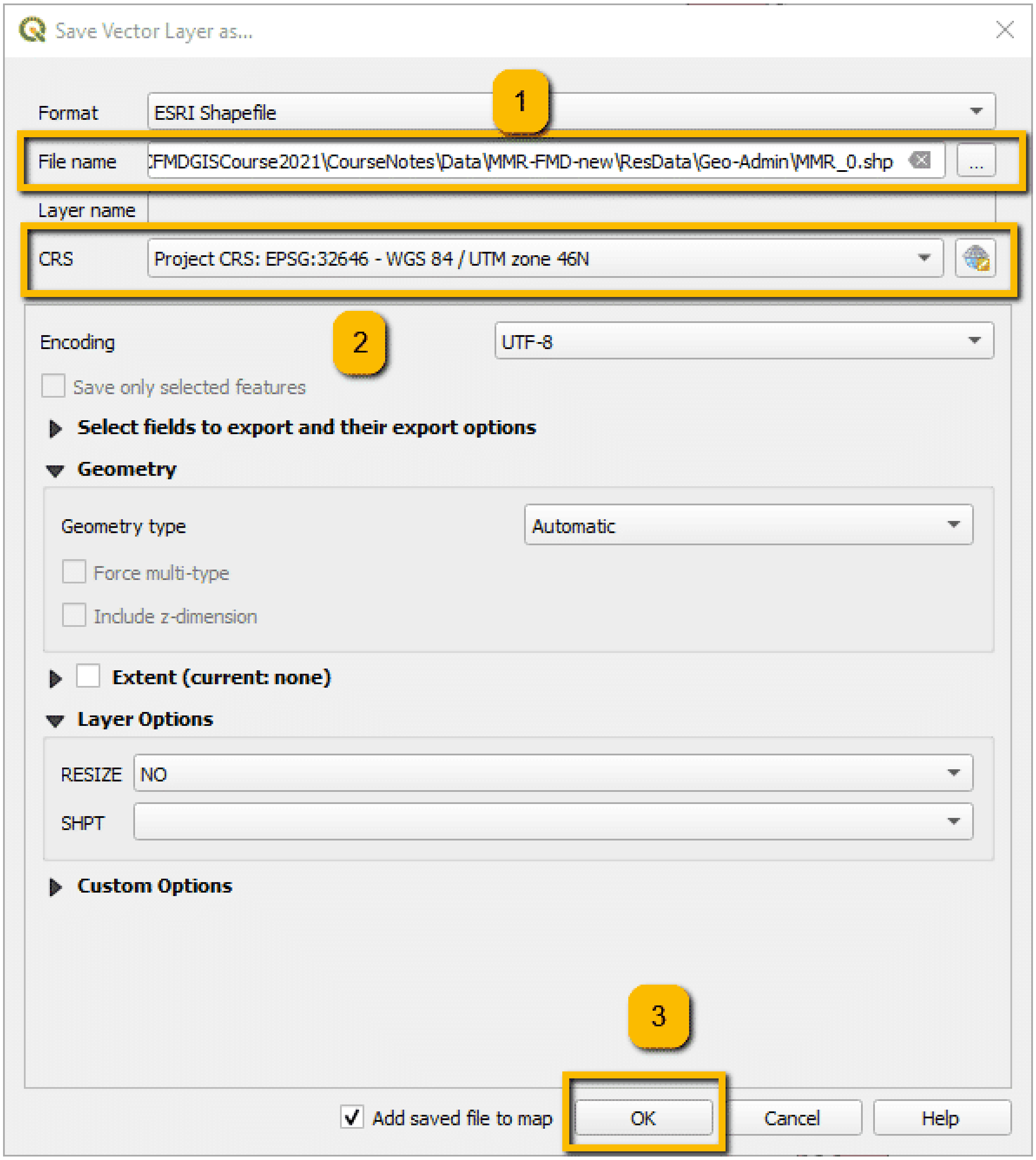


Figure 3.4: Project raw study area file to local CRS and save to new folder

"View the projected study area map (Figure 3.5) (your colour and fill settings may vary from those shown)"

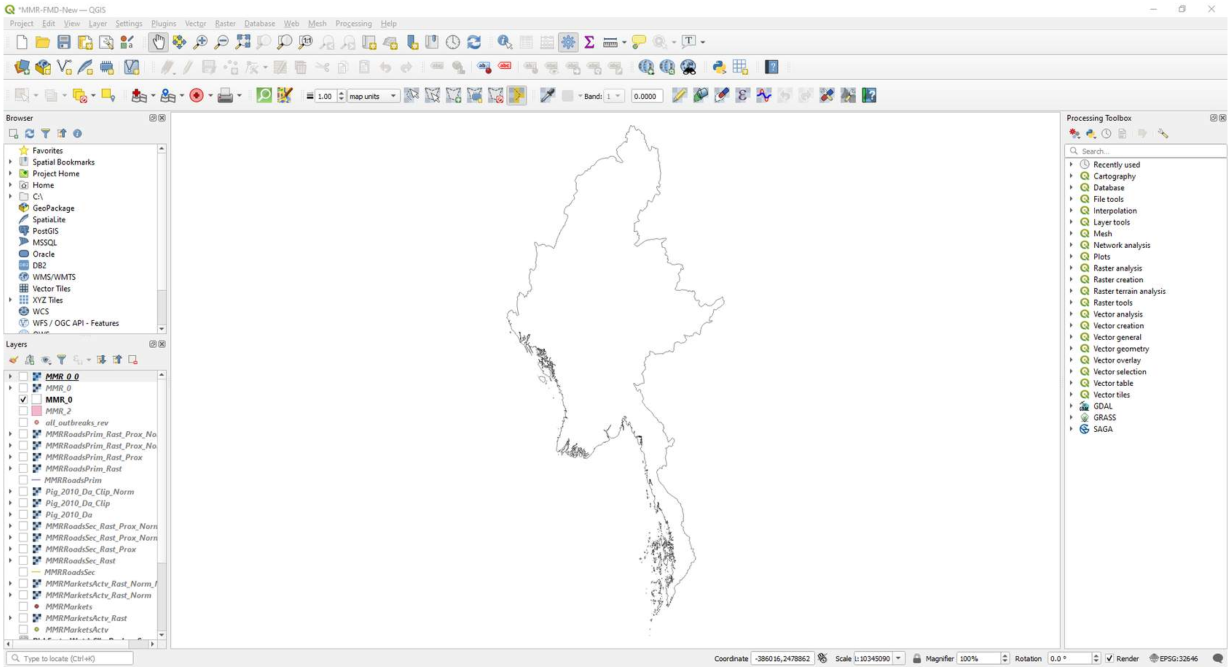
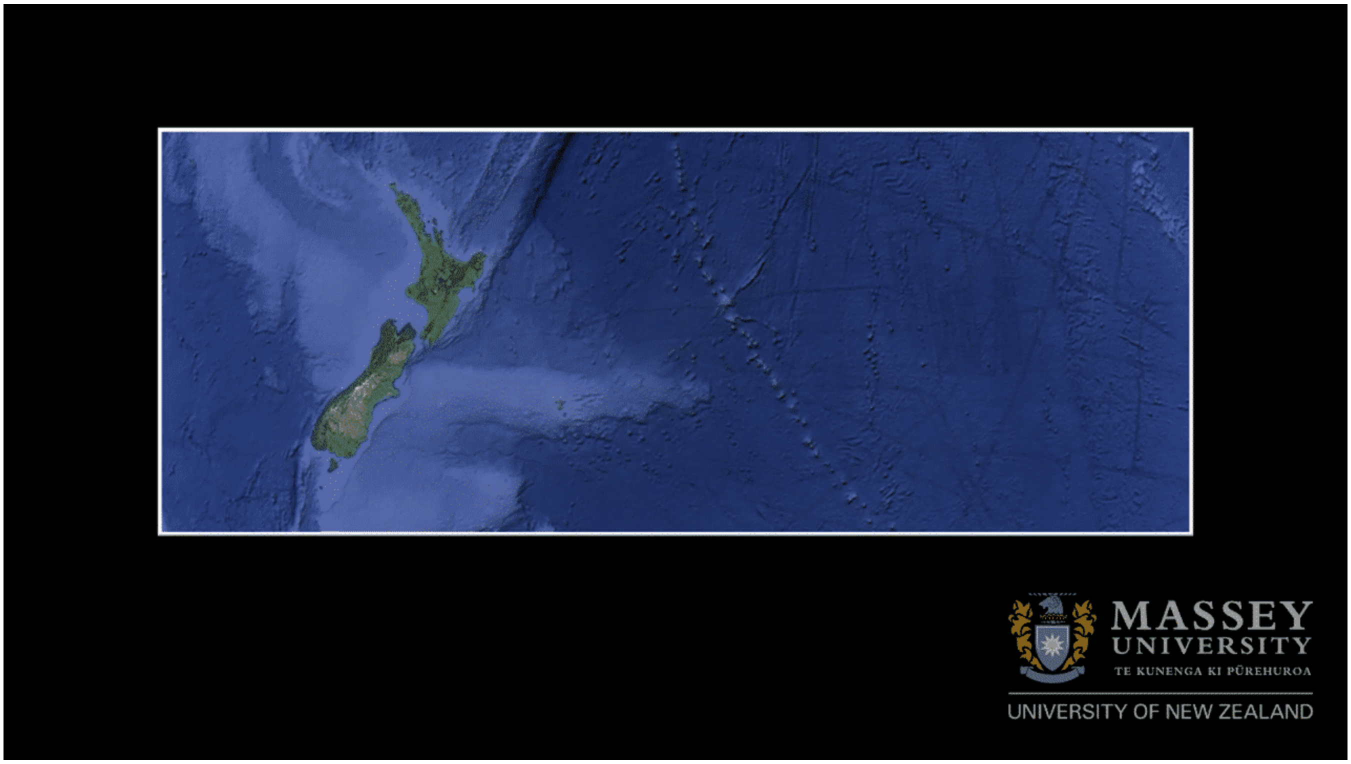


Figure 3.5: View of the projected study area map

Click ▶ to play the video



3.4.5.2 Spatial areal risk factors

Areal risk factors include those where a risk factor, for example, livestock movement numbers, are aggregated at an administrative region level (note that in this exercise no spatial areal risk factor files are used).

> **"In this example of SRA for the occurrence of FMD in Myanmar, no spatial areal risk factor was chosen in the causal path diagram, so the method is not fully shown here, but if it were, the following options could be used to**

create spatial point data representing polygon centroids of level 2 administrative regions"

Highlight the polygon layer for which you want to identify centroids

Menu bar -> Vector -> Geometry tools -> Centroids -> Dialog box (Figure 3.6)

1. Select input layer
2. Check "Create centroid for each part"
3. Click "Run"

Save the centroids in the appropriate folder with a meaningful name as a new point vector layer with the project CRS

Process the administrative region centroids as if they were spatial point data

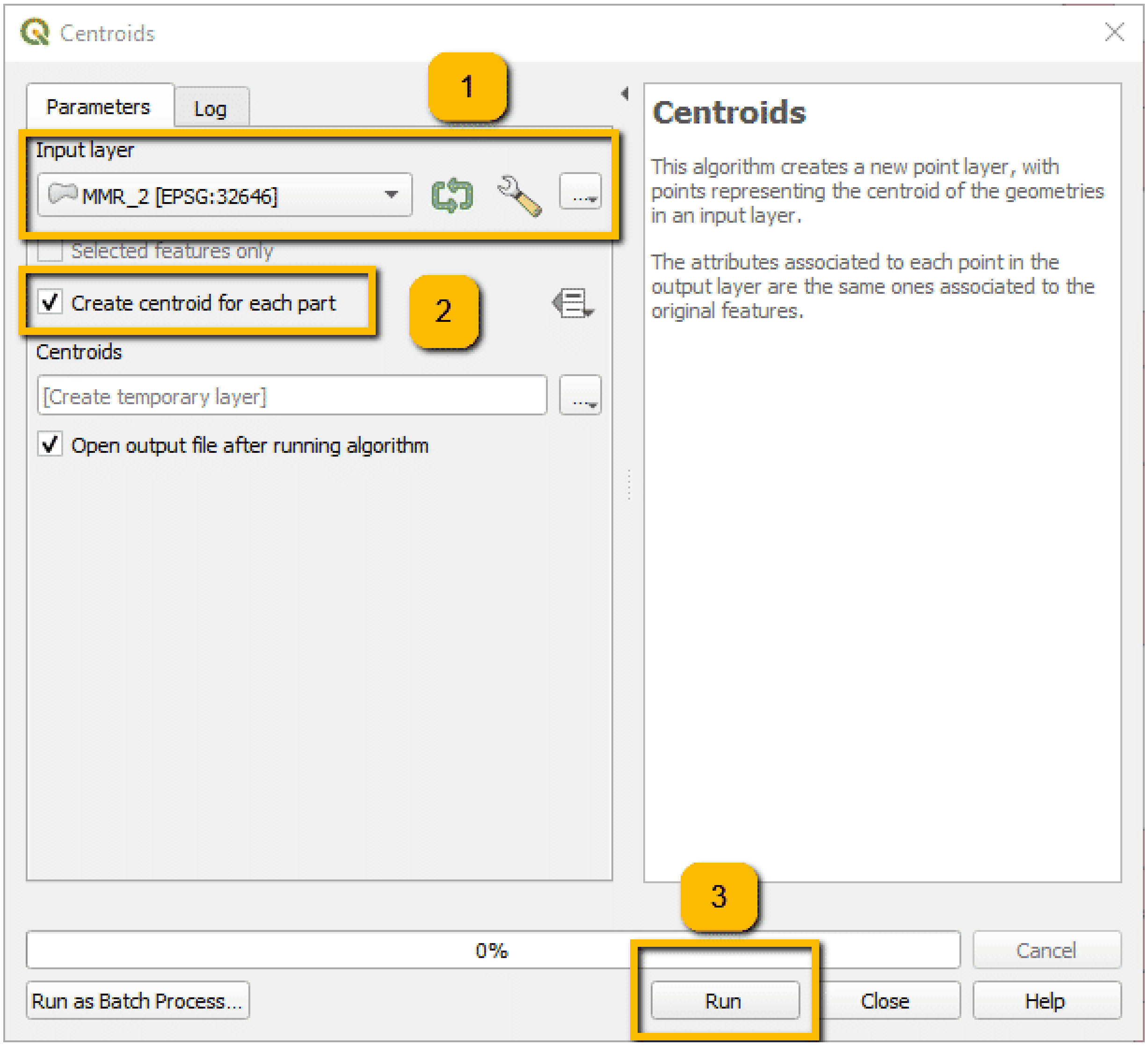


Figure 3.6: Calculate polygon centroids

CONTINUE

3.4.5.3 Spatial points risk factors

Examples of spatial points risk factors are animal market locations, administrative area centroids, etc. provided as csv or other file types.

Import and project CSV or other point location data:

Data Source Toolbar (2nd row, left hand side): Open Data Source Manager -> Delimited Text (left pane) -> Dialog box … (Figure 3.7)

1. Filename: Click folder button on far right and navigate to "Data/RawData/Geo-Features" folder and select "MMRMarkets.csv" file
2. File format: Select appropriate delimiter- CSV (comma separated values) if not already selected
3. Record and Fields Options: Check "First record has field names"
4. Geometry Definition
    a. X field should display "Longitude" and the Y field display "Latitude"
    b. Geometry CRS should display "EPSG:4326 - WGS 84"- this is appropriate for the longitude-latitude coordinates used in the CSV file
5. Click Add, Click Close- the file is added to the Layers pane and displayed on the Map Palette

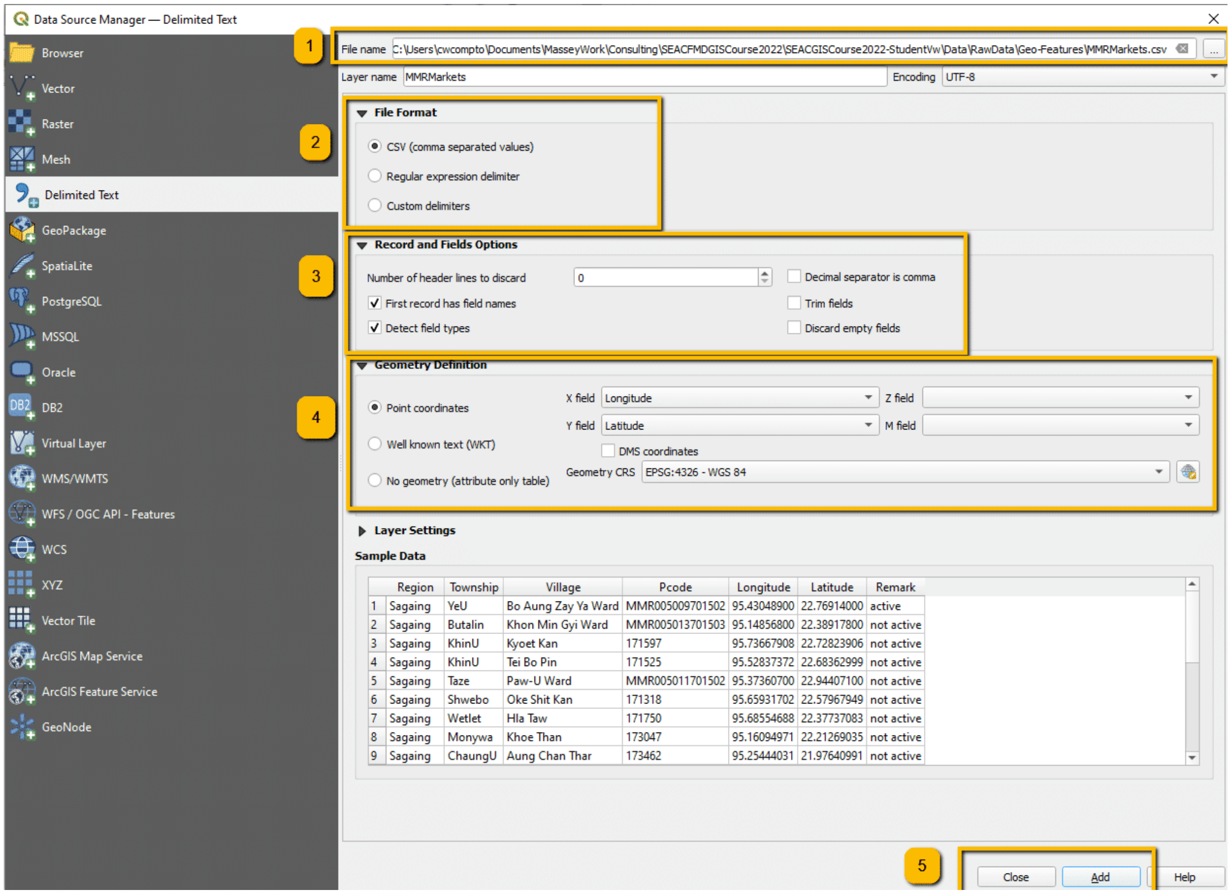


Figure 3.7: Import CSV data file with spatial features

Save as a new layer projected with correct CRS:

In Layers Pane right-click on the MMRMarkets layer file -> Export -> Save Features As ... -> Dialog box ... (Figure 3.8)

1. Format ESRI Shapefile and File name: Save as “MMRMarkets” in Data/ResData/Geo-Features directory
2. In CRS box check projection is defined as “Project CRS: EPSG:32646 - WGS 84 / UTM zone 48N”

3. Check that all the fields are selected (the default)
4. Select “Point” for the geometry type
5. Extent: Tick check box -> Calculate from layer -> Select “MMR_0” (if MMR_0 is in the Layers Pane)
6. Click OK

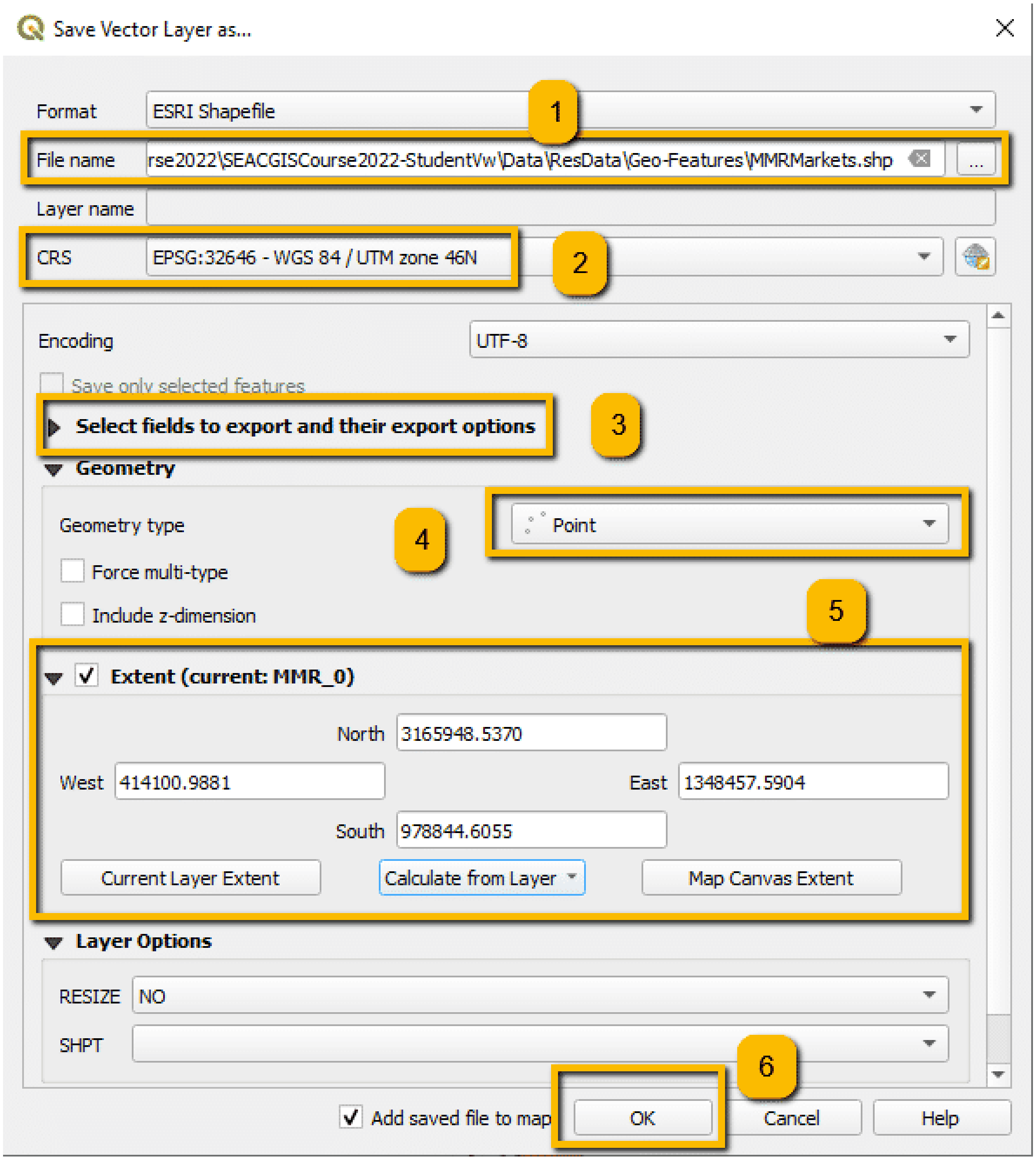


Figure 3.8: Project and save file

Filter MMRMarkets so that only the geographic features (in this case the "active" markets) that should be analysed are retained:

- Right-click MMRMarkets in Layers pane
- Click on “Open Attribute Table”
- Click on “Select/filter features using form” button (Figure 3.9)

1. Click in “Remark” field and type “active” (it will auto-fill)
2. Select “Equal to (=) toggle button to right (not”Contains” as the other category is “not active” and that option would select those also)
3. At bottom of form, click “Select Features” button then close or minimise the form

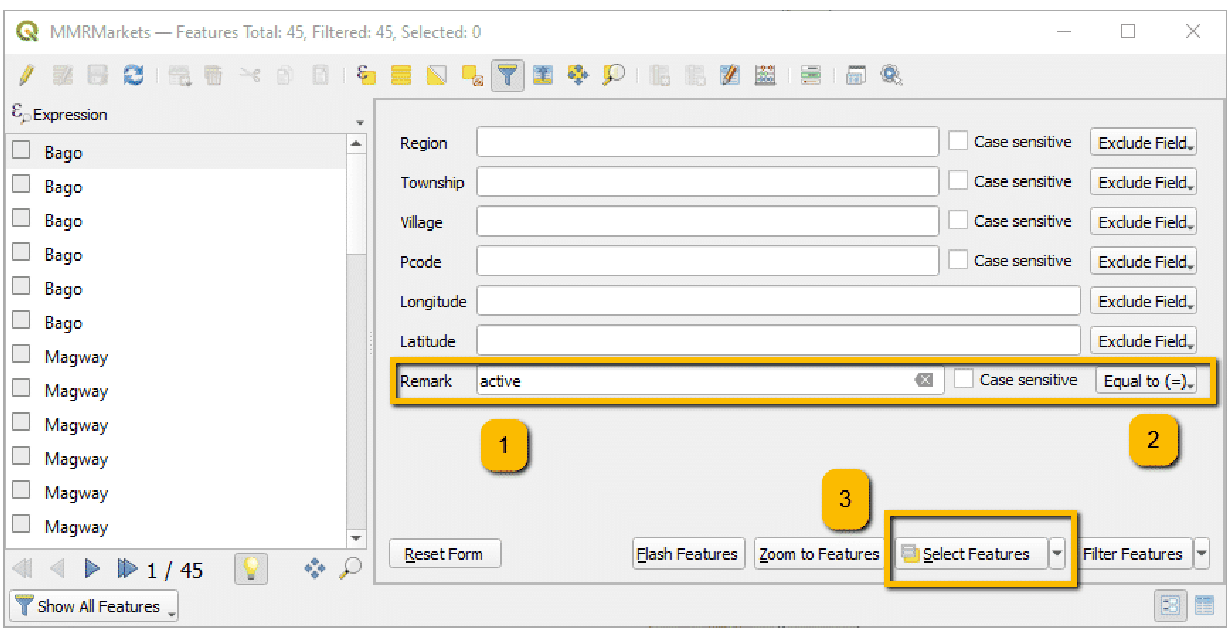


Figure 3.9: Filter and select only active markets for analysis

Save selected features as a new file:

Right-click MMRMarkets in Layers pane -> Export -> Save Selected Features as -> Dialog box … (Figure 3.10)

1. File name : Locate ResData/Geo-Features folder and type "MMRMarketsActv"
2. CRS: Select "Project CRS: EPSG:32646 - WGS 84 / UTM zone 46N"
3. The tick box "Save only selected features" should be selected
4. Select Point Geometry
5. Add a extent for the layer from the MMR_0 study area shape file
6. Click OK

View projected spatial points file (Figure 3.11)

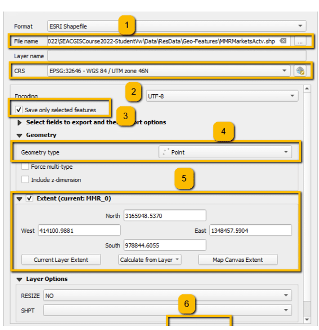


Figure 3.10: Save selected features as a new file

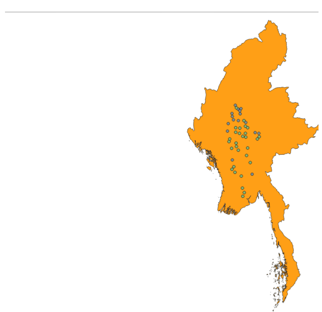
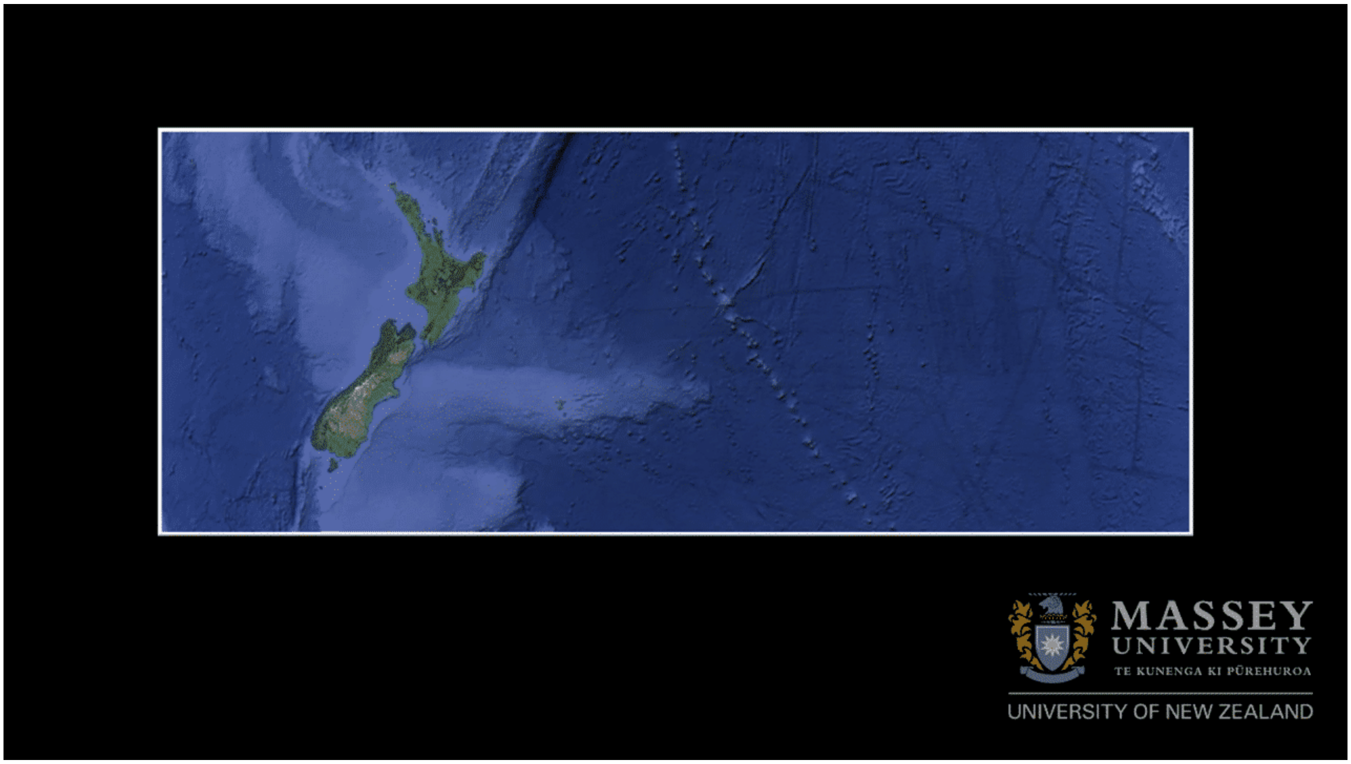
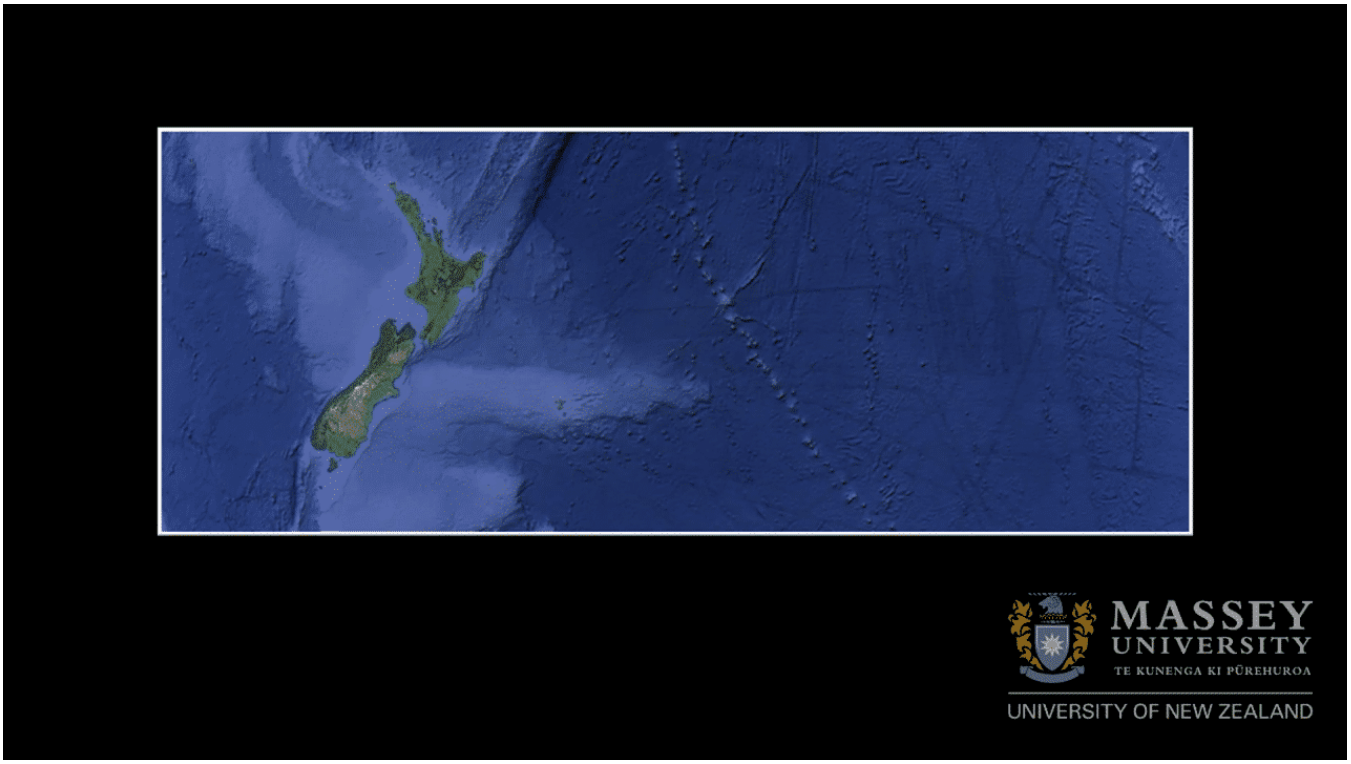


Figure 3.11: Map of active livestock market locations in Myanmar

Click ▶ to play the video


MASSEY
UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND



CONTINUE

3.4.5.4 Spatial lines risk factors

Examples of these types of data are the road network as proxy variables to represent legal (primary roads) or illegal animal/animal product movements (secondary roads), or borders with neighbouring countries across which there is illegal movement of animals or animal products.

Open the spatial lines file:

Browser Pane: Drag spatial lines file “gis_osm_roads_free_1” from RawData/Geo-Features/ onto Map PaletteFilter the road type required

- Select “gis_osm_roads_free_1” in Layers Pane
- Attributes Table toolbar: Right click -> Open Attribute Table -> Dialog box (Figure 3.12)

1. Click icon “Select/filter features using form”
2. Select “fclass” field and type in “primary” (the category will autofill) and the right hand option box should read “Contains”
3. Click Select Features and close dialog box

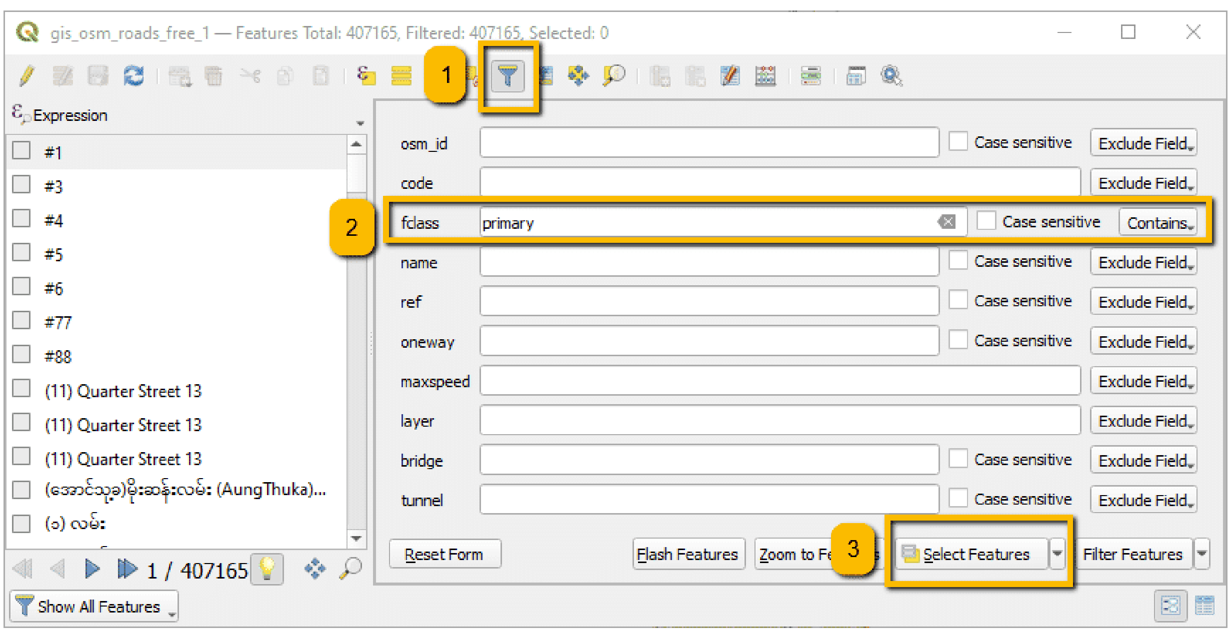


Figure 3.12: Dialog box of settings to filter primary roads

Export the selected features as a new projected layer:

In the Layers pane, right-click the layer from which features have been selected (gis_osm_roads_free_1)-> Export -> Save Selected Features As … -> Dialog box (Figure 3.13)

1. Choose format (ESRI Shapefile) and create file name: "…ResData-Features.shp"
2. CRS: (EPSG:32646)
3. Check "Save only selected features"
4. Geometry type "LineString"
5. Extent- calculated from MMR0 study area extent
6. Click OK

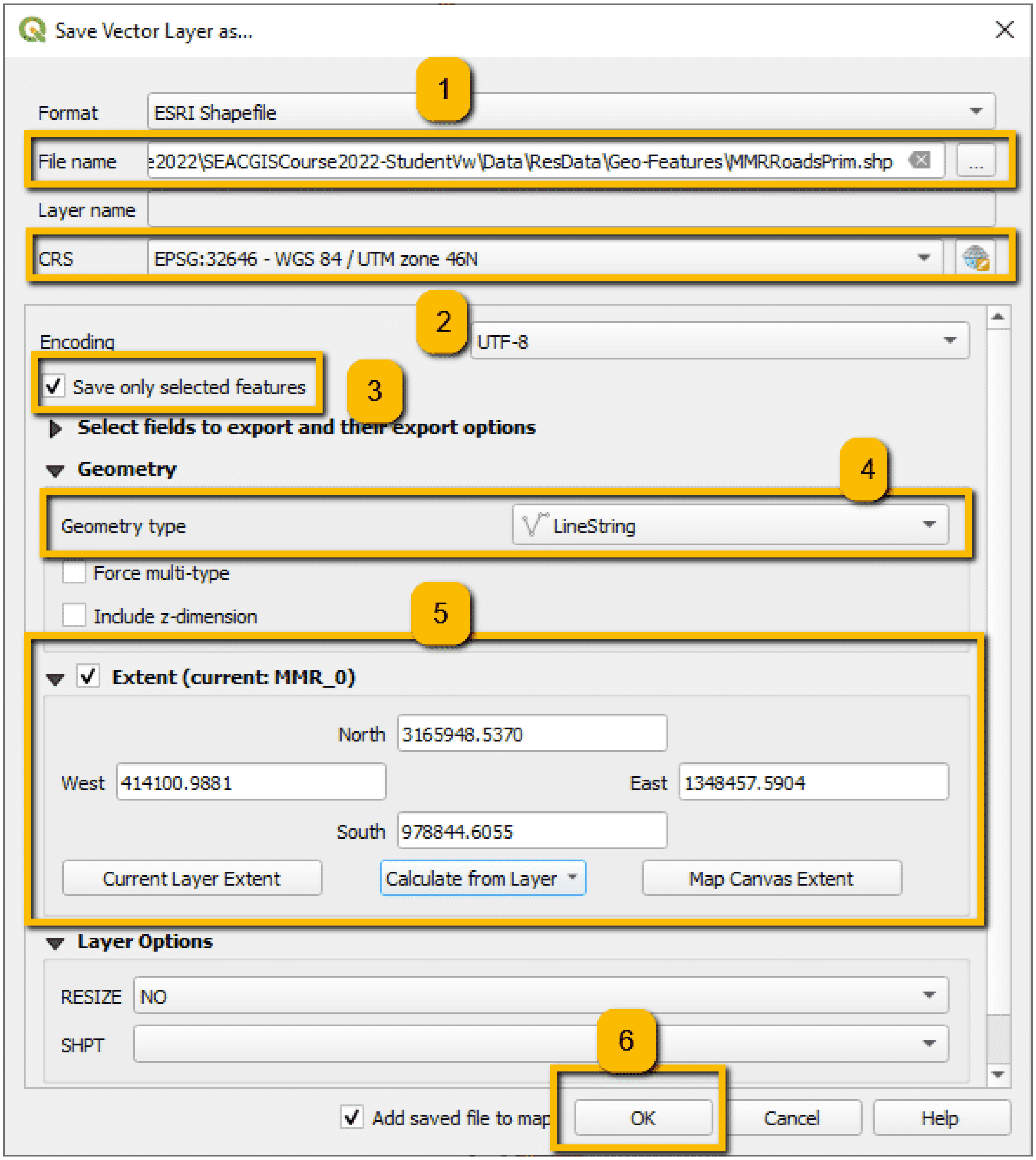
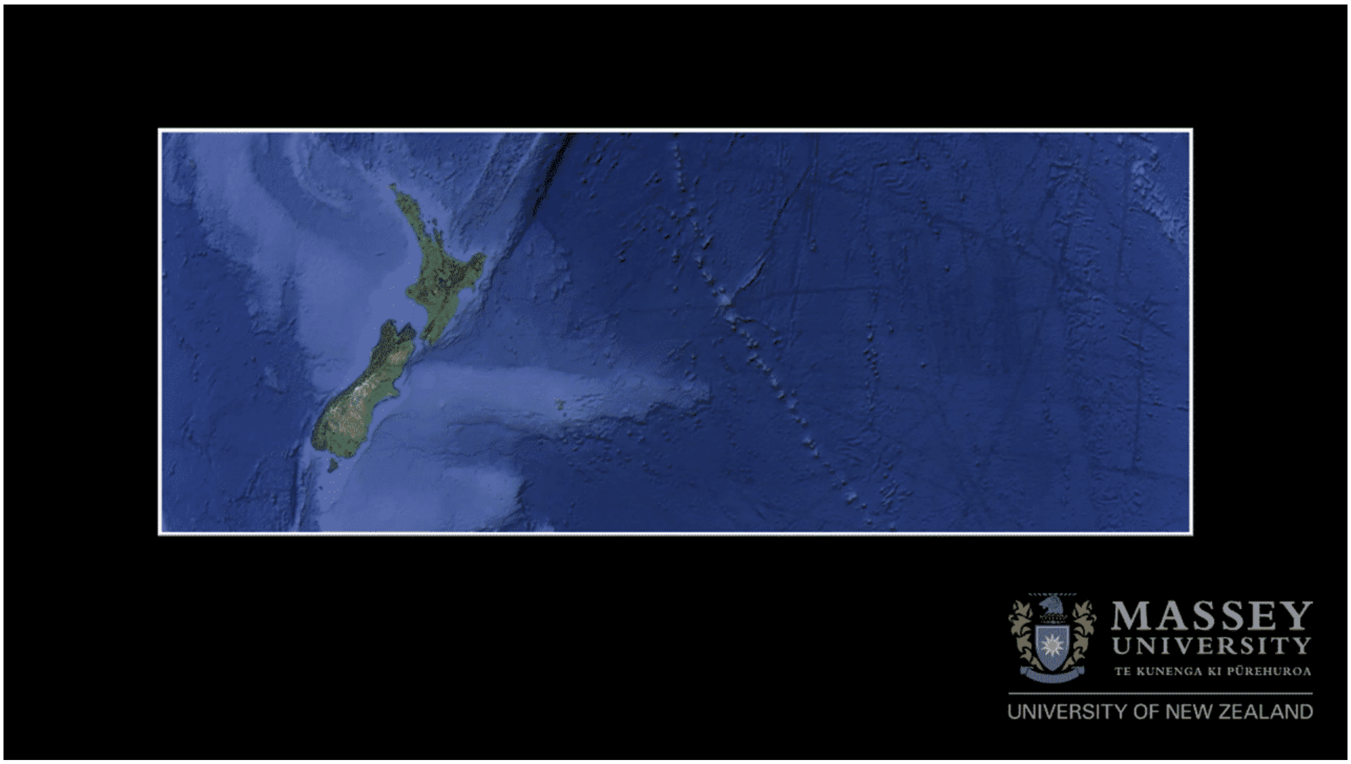


Figure 3.13: Dialog box of settings to project and save primary roads shape file

"View the primary road network

Then, repeat the filter and projection steps for the secondary roads as for the primary road network"

Click ▶ to play the video



CONTINUE

3.4.5.5 Spatial raster files

Examples of possible spatial risk factor layers that can be obtained as raster files are disease vector or reservoir or target animal species density from FAO Gridded Livestock of the World, such as those for livestock species like pigs or cattle.

Pig population as indicator for risk of swill feeding:

Browser Pane: Drag spatial lines file “gis_osm_roads_free_1” from RawData/Geo-Features/ onto Map PaletteFilter the road type required

- Browser Pane: Drag “5_Pg_2010_Da.tif” from “-Livestock" folder onto Map Palette
- Processing Toolbox (box on right hand side of screen)
- Add search term “Warp” to search bar and enter
- Double-click GDAL Raster projections-Warp (reproject) -> Dialog box: (Figure 3.14)

1. Input layer: “5_Pg_2010_Da”
2. Target CRS: EPSG:32646 - WGS 84 / UTM zone 46N”
3. Click “Run”

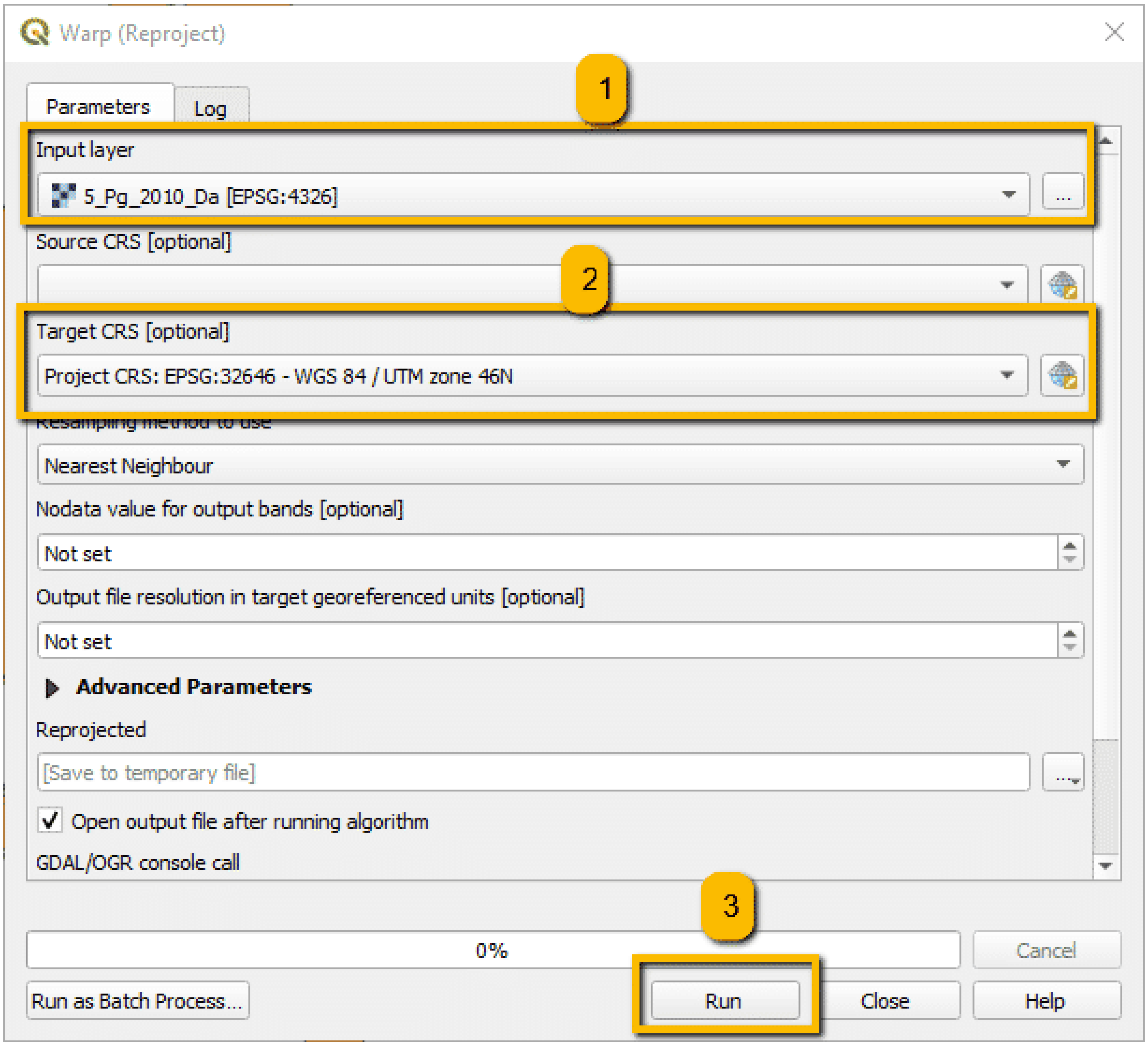


Figure 3.14: Dialog box of settings to warp (re-project) pig population density from geographic to project CRS

A new raster file named "Reprojected" has appeared in the Layers pane:

- Click on "Reprojected" file in Layers pane
- In top line of menu bar click Raster -> Extraction -> Clip raster by Extent -> Dialog box (Figure 3.15):

1. Input layer: Reprojected
2. Clipping extent: Click button to right and select “Calculate from layer” -> MMR_0
3. Run

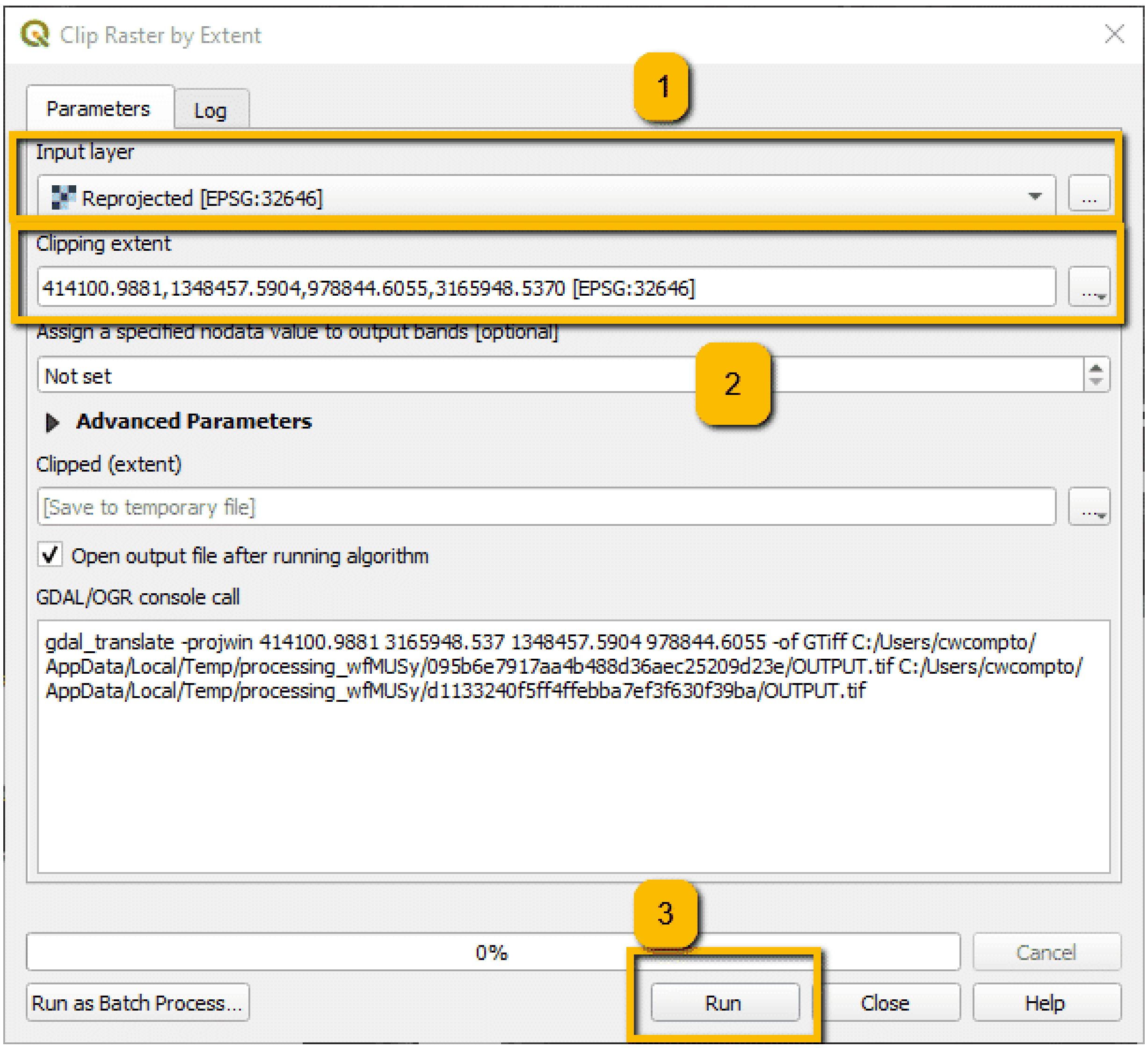


Figure 3.15: Dialog box of settings to clip projected pig population density to extent of study area

A new raster file named “Reprojected” has appeared in the Layers pane:

- Right-click this file “Clipped (extent)” -> Export -> Save Raster Layer as: (Figure 3.16)

1. Filename (Create new folder named “Geo-Livestock” in “ResData” folder and save file with name “Pig_2010_Da_Clip
2. CRS should read “EPSG:32646 - WGS 84 / UTM zone 46N”
3. Extent Calculate from layer MMR_0
4. Click OK

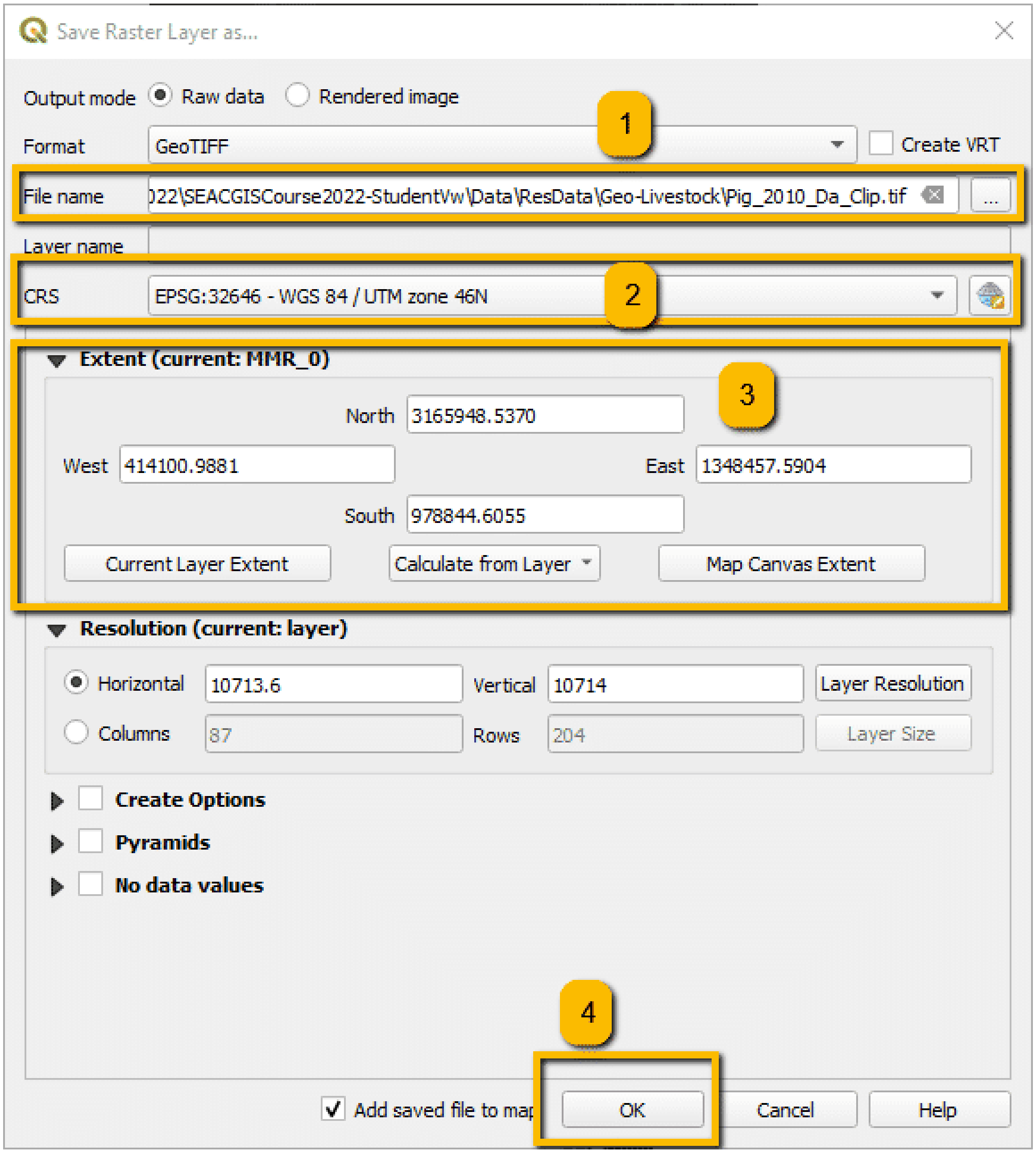
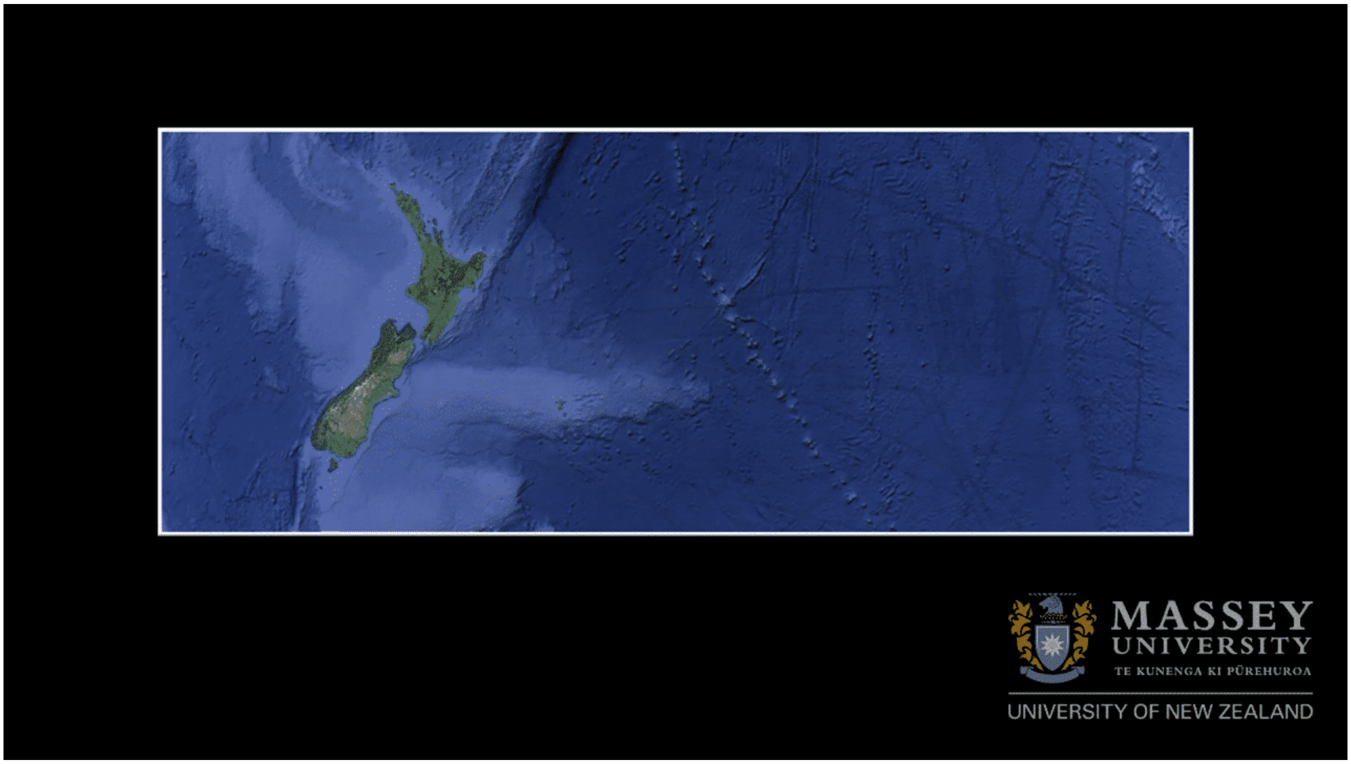


Figure 3.16: Dialog box of settings to save clipped pig population density as a new raster file

"Repeat steps for the cattle population density as an indicator of risk of susceptibility to infection. Replace "Pig" with "Cattle" in the file names."

Click ▶ to play the video



“**Create a table that allows you to answer the following questions:**

- **Describe the spatial distribution of the risk factors chosen for this exercise.**
- **How might the distributions of each risk factor relate to or interact each other and what might be the effect of these patterns on the epidemiology of FMD that we are concerned with?**

Hint: You will need to adjust the order that maps are layered and the symbols they use to appreciate the patterns in the data."

CONTINUE

Exercise 3.1: Describe the spatial risk factors

"**Create a table that allows you to answer the following questions:**

- **Describe the spatial distribution of the risk factors chosen for this exercise**
- **How might the distributions of each risk factor relate to or interact with each other and what might be the effect of these patterns on the epidemiology of FMD that we are concerned with?**

Hint: You will need to adjust the order that maps are layered and the symbols they use to appreciate the patterns in the data."

Have you completed the table in Exercise 3.1?

- ◯ Yes
- ◯ No

SUBMIT

CONTINUE

The visual appearance of spatial patterns of each risk factor and how they might relate to or interact with each are shown in Table 3.1.

Table 9.2: Spatial patterns and relationships of risk factors assessed for occurrence of FMD in Myanmar

Spatial risk factor	Visual pattern	Relationship to other risk factors
Livestock markets	Concentrated in central MMR and few others extending to delta regions	Closely associated with primary roads and livestock density (particularly cattle)
Roads (primary)	Mainly in central MMR and extending to Delta region. Few in border areas	Associated with cattle and pig population density
Roads (secondary)	Follow primary road network with few additional roads in border and coastal regions	As above
Pig population density	Concentrated in central and delta regions of MMR	Associated with road networks

Spatial risk factor	Visual pattern	Relationship to other risk factors
Cattle population density	Similar pattern to pig population density	Associated with road networks and livestock markets

"**It seems that FMD-susceptible livestock are concentrated in central Myanmar and this industry is serviced by a denser road network and several livestock markets- all factors that would contribute to the incursion and spread of FMD.**"

CONTINUE

Congratulations - end of lesson reached

NEW ZEALAND FOREIGN AFFAIRS & TRADE

OIE

MASSEY UNIVERSITY TE KUNENGA KI PŪREHUROA UNIVERSITY OF NEW ZEALAND

Australian Government Department of Agriculture, Water and the Environment

CONTINUE