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Instruction Lists

Guide for producing linguistic maps

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1 Introduction

This document contains a work-flow, or set of instructions, for creating publication ready maps of languages using free, open-source software.[1] It should provide you with the basic skills needed to make and customise your own linguistic maps.

This document does not consider in any detail the principles of cartography, why linguists may want to make maps, ethical considerations in making maps, nor how to gather linguistic geographic data. See Gawne and Ring (2016) for a discussion of such topics, in particular page 196–197 on ethical considerations. The present guide is written for those who know what linguistic data/information they want to represent on a map. This guide assumes only a basic level of computer literacy, and you certainly do not need to have any skills in programming to follow this guide. I myself currently have no programming skills.[2]

1.1 Layout of this guide

This guide contains 53 of instruction lists which itemize the steps to carry out each task in the map-making process. It is accompanied by 131 screenshots annotated with arrows and/or boxes pointing out the areas of a window referred to in an instruction lists. Screenshots are indicated in braces; e.g. {sc1 ra} = 'screenshot 1, red arrow'. The abbreviations for annotations are as follows:

- ba = blue arrow
- ga = green arrow
- oa = orange arrow
- pa = purple arrow
- ra = red arrow
- bb = blue box

[1] I would like to acknowledge a number of people who have contributed to this paper. Firstly, those who were at the ANU CartoGIS Unit during my PhD studies: Jenny Sheehan, Karina Pelling, and Kay Dancey. The ANU CartoGIS Unit provided some preliminary training in editing maps in Adobe Illustrator as well as many sound map making principles. Secondly, I want to thank Kwang-Ju Cho, my office-mate during the course of my PhD. Kwang-Ju got me started with QGIS and helped me solve many QGIS problems. Thirdly, I would like to thank Marian Klamer who invited me to Leiden University as a guest researcher at the beginning of 2017 where I first ran a workshop on map-making and wrote the first version of this guide. Finally, I would like to thank Antoinette Schapper who invited me to provide some map-making training to her project in March 2022 and thus gave me the impetus to revise this guide.

[2] A few additional disclaimers about myself may also be in order. I am not a cartographer, graphic designer, GIS expert, or software engineer. I am a linguist writing for other linguists who find themselves wanting, or needing, to make maps. I welcome feedback on this guide from any of these experts, but please bear the purposes of this guide in mind.

- rb = red box

Instructions that refer to software menus are given in italics; e.g. "*File > Save*" means select the menu 'File' and the option 'Save'. The names of windows are also given in italics. Instructions that refer to buttons are given in a monotype font; e.g. "`Apply`" means click the button named 'Apply'. Instructions that refer to text on windows are also usually given in monotype font; e.g. "check: `Layers`" means check the box labelled 'layers'.

This work-flow is is accompanied by a number of files. Following the guide sequentially and using these accompanying files will walk you through the steps to make a map of the languages of Timor Island. These skills can readily be extended to other geographic areas. You do not need to follow this tutorial sequentially, but you may find some steps assume that you have carried out a prior step.

The guide is focussed on making maps with polygons (shapes, blobs) which show the areas of a language, like most of the maps in the Ethnologue (Eberhard et al. 2020), but also contains information on making a maps with single points (§2.4), similar to those in Glottolog (Hammarström et al. 2020). To gain an idea of the kinds of maps this guide will allow you to make, have a look at the maps in Edwards (2020) and Edwards (2021). All these maps were made by the author using the skills outlined here.

1.2 Software and hardware

This software on which this guide is based is QGIS and Inkscape. Both are free, open-source programs, which means you are free to download them and redistribute the code. There are also paid programs that you can use (ArcGIS, Adobe Illustrator) though I do not know the extent to which the work-flow in this document is transferable to those programs.

QGIS is a Geographic Information System (GIS). This is the program in which the basic data for your maps is stored and manipulated. It is the program in which it is easiest to create the polygons/points showing language locations. QGIS can be downloaded from: `http://www.qgis.org/en/site/`. It is regularly updated and updates often introduce new functionality. The version of QGIS that this guide is based on is 3.22 'Białowieża' [bʲawɔˈvʲɛzˌa] the most recent long term release at the time of writing.

Inkscape is a vector graphics editor.[3] This is the program in which to bring the raw data from QGIS up to publication-ready standard. That is, colouring the map, adding labels, and so on. Inkscape can be downloaded from: `https://inkscape.org/en/`. The version of Inkscape that this guide is based on is 1.1.2, the most recent version of Inkscape when I started writing this guide.

When using these programs it is useful, though not necessary to have a mouse and a relatively large screen size. I run these programs from my laptop with an external monitor attached. With a small screen and laptop touch-pad you may find yourself struggling at some points.

2 QGIS

2.1 Settings

The first thing to do is to set up your project in QGIS. Projects in QGIS can be thought of as where the various settings of your maps are saved. The actual maps themselves

[3] Vector graphics are ones with theoretically infinite zoom, as opposed to bitmaps which become pixelated when you zoom.

are saved as separate files and the project holds all these together. You can have a single project for all your maps.

(1) **Creating a project**

1. open QGIS Desktop (not QGIS Browser)
2. *Project* > *New* {sc1 ra}
3. *Project* > *Save As...*
   - Save the project somewhere sensible with a sensible name
   - For the Tutorial and screen shots I called the project "Timor".
4. check that the *Coordinate Reference System* {sc1 ba} is EPSG:4326
   - This should be the default. If not, click on the box indicated by {sc1 ba}. The *Project Properties* window will open. You can select your map projection here. This tutorial uses *Coordinate Reference System = WGS 84* and *Authority ID = EPSG:4326*.
   - If you are using a different map projection, (e.g. centred on the pacific) then you can change the settings in the *Project Properties* window.

Next, display the panels and toolbars which will be used throughout this guide. Some of these panels and toolbars might already be displayed by default in QGIS.

(2) **Displaying panels**

1. *View* > *Panels* {sc2 rb}
2. check: `Layer Order`
3. check: `Layers`

This will display the layers panels. In {sc1} these are displayed on the left hand side of the screen, though exactly where and how they appear may be different for you. In particular, the two panels may appear as tabs {sc3 rb}. You can move the panels to display elsewhere by clicking on the heading of the panel and dragging it around.

(3) **Displaying toolbars**

1. *View* > *Toolbars* {sc4 rb}
2. check: `Advanced Digitizing Toolbar` {sc5 a}
3. check: `Attributes Toolbar` {sc5 b}
4. check: `Digitizing Toolbar` {sc5 c}
5. check: `Map Navigation Toolbar` {sc5 d}
6. check: `Project Toolbar` {sc5 e}
7. check: `Selection Toolbar` {sc5 f}
8. check: `Snapping Toolbar` {sc5 g}

The different toolbars used in this tutorial are shown in {sc5}, though they will almost certainly not display in the order or locations they do in {sc5}. In particular, if all the buttons on a toolbar do not display, there will be a little double arrow » {sc6 ga} which you can click to expand the toolbar and see all the buttons. You can also move where the toolbars display by clicking on the lef-most area of the toolbar {sc5 ra}.

2.2 Layers and polygons

Layers are where the actual maps and information associated with them are contained. You can have multiple layers in a single project. The layers are stacked on top of one

another such that one layer on top of another means that the top one will partially cover the bottom one.

Begin by adding a layer which shows the countries of the world. I find it most useful to have this as the base. The particular countries layer in the accompanying files for this tutorial was downloaded some time ago. I edited it so that Island South East Asia had more detail and I also duplicated the islands of the Pacific so that, for instance, Fiji is not split down the middle. You can find other shapefiles with the countries of the world by putting "country shapefiles" into a search engine.

(4) **Loading layers**

1. *Layer* {sc6 ra} > *Add Layer* > *Add Vector Layer*
2. *Data Source Manager* window opens {sc7}
3. click on the ellipsis next to the box labelled `Vector Dataset(s)` {sc7 ra} and navigate to your shapefile
   - For this tutorial, find *Countries.shp* in the accompanying files.
4. `Add` {sc7 ba}
5. `Close` {sc7 ga}

A single layer is associated with a number of different files. The shapefile (.shp) is the file which shows the features. Other files such as .shx or .dbf contain information about the polygons. The .dbf file has the data in the attribute table (8). Features can be polygons, as in the country layer, or they can be other objects, such as points or lines. A vector layer, like the countries layer, is made up of a series of polygons. Polygons are the shapes or blobs that you see. In the countries layer, each country is a separate polygon, with the exception of Indonesia which I have edited. Polygons can consist of a single shape, or they can contain several discontinuious shapes. For instance, the Philippines polygon in this countries map contains 2,273 individual shapes. A polygons is made up of nodes each connected by a straight line. Technically, no border of a polygon in QGIS contains a curved line. The appearance of a curved lines are created by many nodes next to one another in a series.

A newly loaded layer will have a randomly assigned colour. In {sc6} the countries were assigned a pink colour. Most of the colouring and aesthetic details will be done later in Inkscape but the colours of the landmasses can be changed now. I follow the colours used by the ANU CartoGIS unit for the maps they made for my PhD thesis. I make the landmasses grey, with a darker grey border.

(5) **Setting layer colours**

1. double click tha layer name in the layers panel {sc6 ba} (or right click > *Properties*)
2. *Layer Properties* window opens {sc8}
3. open the `Symbology` section {sc8 ra}
4. `Simple Fill` {sc8 ba}
5. *Layer Properties* displays more details for colours
6. click on the colour next to `Fill color` {sc8 rb}
7. *Select Color* window opens {sc9}
8. change the values
   - For the fill of countries I use RGB 230-230-230 (`HTML notation` #e6e6e6).
9. `OK` {sc9 ba}
10. *Select Color* window closes
11. click on the colour next to `Stroke color` {sc8 bb}
12. *Select Stroke Color* window opens

    - identical to the *Select Color* window {sc9}
13. change the values
    - For borders of countries I use RGB 130-130-130 (`HTML notation` #828282).
14. `OK` {sc9 ba}
15. *Select Stroke Color* window closes
16. `Apply` {sc8 ga}
17. `OK` {sc8 oa}
18. *Layer Properties* window closes

Having set the colour of the countries layer, load a layer with language polygons. First of all, zoom in to the geographic area you are working on.

(6) **Zooming in**

1. select the `Zoom In` tool {sc10 ba} in the `Map Navigation Toolbar`
2. click and drag around the area you are working on {sc10 bb}
    - The blue rectangle shows the area you are about to zoom into. When you release the click it will zoom into that area.
    - You can also use the mouse wheel to zoom in and out.
3. repeat until the area takes up most of the space on your screen {sc11}
4. you can move around the canvas (what you see) with the `Pan Map` tool {sc10 ba} in the `Map Navigation Toolbar`
    - The `Pan Map` tool works by clicking and dragging.

Add a second layer with language polygons. If you are following the tutorial, repeat the steps in (4) to load *Timor.shp*. The new layer should appear on the canvas. If you do not see any change, check the *Layer Order* panel {sc11 rb}. If Timor is below Countries, then the polygons in the Timor layer will be covered by those in countries. If this is the case, check the `Control rendering order box` {sc11 ra}, then click and drag Timor to be above Countries.

(7) **Selecting polygons**

1. select polygons/features with `Select Features by Area or Single Click` {sc12 ra} in the `Selection toolbar`
    - The selected polygons turn bright yellow. {sc12}
2. deselect polygons with `Deselect Features from All Layers` {sc12 ba}

You can see different information about the languages of Timor by opening the attribute table.

(8) **Attribute table**

1. select a layer in the layers panel
    - Do so by clicking on its name in the layers panel.
2. `Open Attribute Table` {sc12 oa}
3. the attribute table appears {sc13}
4. the columns of the attribute table can be sorted by cliking on the heading

{sc13} shows the attribute table for the Timor layer in the accompanying files. Each row in the table corresponds to a polygon, which in this case represent a language. Different information on the polygon is given in the columns. The attribute table will stay open until closed and it is possible to have the same attribute table open multiple times. If you click on a row in the attribute table, that polygon will be selected on the canvas.

Colours of a layer can also be set according to values in the attribute table. So, for instance, each different language can have a separate colour, or they can be coloured according to genealogical affiliation — if that information is in the attribute table.

(9) **Setting colours according to values**

1. double click a layer in the layers panel
   - For the tutorial, double click on the Timor layer.
2. *Layer Properties* window opens {sc14}
3. ensure you are in the `Symbology` section
4. click `Single Symbol` {sc14 ra}
5. change to `Categorized` {sc15 ra}
6. select a `Value` {sc15 ra}
   - For the tutorial select Language. {sc15 rb}
7. *Classify* {sc15 ba}
   - Each polygon will be assigned a random colour.
8. `Apply` {sc15 ga}
9. `OK` {sc15 oa}
10. *Layer Properties* window closes

Labels for the polygons can also be displayed. I find it is best to edit labels in Inkscape (3.3.3), but if you have lots of polygons it may be helpful to display the labels in QGIS. These labels can be replaced later in Inkscape.

(10) **Displaying labels**

1. double click a layer in the layers panel
2. *Layer Properties* window opens {16}
3. open the `Labels` section {sc16 ra}
4. click on `No Labels` {sc16 ba}
5. select `Single Labels` {sc16 ba}
6. select the value in the attribute table by which to label polygons {sc16 rb}
   - You can set up various properties of the labels with the other options, but I find it is best to actually place and edit labels in Inkscape.
7. `Apply` {sc16 ga}
8. `OK` {sc16 oa}
9. *Layer Properties* window closes

Not all labels will necessarily be visible at all zooms. In principle you could now export this map and edit it in Inkscape (§3). If you have shape files for your area available and are happy with them, you can proceed straight to §3. If you want shapefiles for any area of Island South East Asia, New Guinea, or the pacific contact me and I will be happy to provide them. The next section of this work-flow provides a guide for how to create and edit your own polygons.

2.3 Creating polygons

Create a new layer for the polygons you will create in this section. The tutorial will have you create polygons corresponding to the traditional kingdoms of west Timor, which also correspond very closely to the dialects/varieties of the Meto language/dialect cluster.

(11) **Creating a new layer**

1. *Layer > Create Layer > New Shapefile Layerldots* {sc17}
2. *New Shapefile Layer* window opens {sc18}
3. *File name > ldots* {sc18 rb}
   - Navigate to where you want the new shapefile to be saved and give it a name. I've chosen the name "West Timor" in {sc18}.
4. *Geometry type > Polygon* {sc18 rb}
5. *New Field > "Language"* {sc18 bb}
   - These are the columns that will appear in the attribute table for this layer. Columns can be added now, as well as later.
   - This step instructs you to create a column for language.
6. *Type > Text Data* {sc18 green box}
   - this should be the default setting
7. `Add to Fields List` {sc18 ra}
8. "Language" appears in the *Fields List* below "id"
9. `OK` {sc18 ba}

Your new shapefile will appear in the folder/directory you selected and will also appear in the layers panel (with an arbitrary colour). If your system behaves like mine, the new layer will be at the bottom in the *Layer Order* panel. Move it to the top {sc13 rb}. The simplest way to create polygons is to free draw them by clicking with the mouse.

(12) **Free drawing polygons**

1. Select the new layer by clicking on it in the layers panel {sc19 ra}
2. `Toggle Editing` on {sc19 ba}
   - picture of the pencil in the `Digitizing Toolbar`
3. `Add Polygon Feature` {sc19 ga}
4. left click in the map canvas to draw a shape
   - Each left click will create a node/vertex/axis which is one "corner" of your shape. Click at least three times to create a triangle, or experiment with creating other shapes.
5. right click to create the shape
   - The shape you are creating is shown as a red outline {sc19 rb}.
6. *Feature Attributes* window appears {sc20}
7. enter values into the fields
   - id only takes numbers
   - Language will take text (because it was set up this way earlier)
8. `OK`
9. Your new polygon will appear on the canvas.
10. `Save Layer Edits` {sc19 oa}
11. `Toggle Editing` off {sc19 ba}
    - If you have any unsaved changes a Dialogue box *"Do you want to save the changes to layer <layer name>?"* appears, if you then click `Save` you will not be able to automatically undo (Ctrl+Z) any of the changes you made to the layer.

In all likelihood you don't want this triangle as a feature. It certainly doesn't correspond to a language area in {sc19}. So, delete it.

(13) **Deleting polygons**

1. Ensure the layer the feature is in is selected {sc19 ra}

2. `Toggle Editing` on {sc19 ba}
3. `Select Features by Area or Single Click` {sc19 pa}
4. click on the polygon
5. `Delete Selected` {sc19 black arrow} (backspace/delete on the keyboard)
6. `Save Layer Edits` {sc19 oa}
7. `Toggle Editing` off

2.3.1 Georeferencing

In many cases, you will already have access to a raster map of the area you are working on.[4] The Ethnologue (Eberhard et al. 2020), for instance. has many maps available which show the distributions of languages. Or you may have a map from another source. You can georeference such a map, which will "project" it onto your QGIS canvas. You can then manually trace the polygons from that map into QGIS.

To georeference, you need an electronic version of the map. If the map is in a book you can scan it. To learn how to use georeferencing this tutorial uses a map of the pre-colonial kingdoms of western Timor *WestTimorPrincedoms.jpg* taken from Grimes et al. (1997) who in turn adapted their map from Schulte Nordholt (1971). While georeferencing this raster, QGIS will create a new raster which is warped and/or stretched to match an area of your canvas.

(14) **Georeferencing**

1. hide all layers except the countries layer by unchecking the box in the Layers panel {sc21 ra}
   - This step is not strictly necessary, but will make subsequent steps easier.
2. *Raster* > *Georeferencerldots* {sc21 rb}
3. *Georeferencer* window opens {sc21}
4. `Open Raster` {sc21 ra}
5. navigate to your raster
   - WestTimorPrincedoms.jpg in the accompanying files for the tutorial.
6. the raster opens in the Georeferencer {sc23}
7. `Add point` {sc23 ra}
8. Click somewhere on the raster
   - look for a distinctive landscape feature or border, you will need to match this to the corresponding point on the canvas.
9. *Enter Map Coordinates* window opens {sc24}
   - If you know the exact latitude and longitude of the point you clicked on the raster you can type those coordinates into the X/East and Y/North fields of this window and click OK. If you don't, then match the point you just clicked as close as possible to the corresponding point in the QGIS map canvas.
10. `From Map Canvas` {sc24 ra}
11. *Georeferencer* window minimizes
    - If you don't want it to minimize, uncheck the `Automatically hide georeferencer window` {sc24 ba}
12. click on the corresponding point in the QGIS canvas
13. *Geroreferencer* and *Enter Map Coordinates* windows maximize, *Enter Map Coordinates* window has the coordinates of the point you clicked {sc25}

[4] A raster is an image composed of pixels.

14. `OK` {sc25 ra}
15. repeat this process multiple times with different points
    - The more points you have, and the further apart from one another they are, the more accurate the projection will be.
    - For this tutorial, I had six points, as circled in {sc26}
16. *Settings* > *Transformation Settings...* {sc26 rb}
17. *Transformation Settings* window opens {sc27}
18. *Transformation type = Helmert* {sc27 rb}
19. *Resampling method = Linear* {sc27 bb}
20. *Target SRS = EPSG:4326 - WGS 84* {sc27 green box}
    - If you are using a different map projection you need to match the *Target SRS* to match that of your QGIS project
21. *Output raster* > ... {sc27 ra}
    - select a sensible location for the new warped raster. QGIS should automatically have it in the same folder as the original raster and should automatically name it after this original raster followed by _modified.
22. `OK` {sc27 ba}
23. Start Georeferencing {sc26 ra}
24. "**Georeference Succesful**: raster was successfully georeferenced." appears at the top of the Georeferencer window.
25. the new raster will also appear in QGIS {sc28 ra}
    - In all likelihood it will be under the other layers, if so move it in the layer order panel to be above them {sc28 rb}.

(15) **Drawing a polygon according to a raster**

1. double click the new raster in the Layers window {sc28 ra}
2. *Layer Properties* window opens {sc29}
3. open `Transparency` section {sc29 ra}
4. set the transparency to around 50% {sc29 rb}
5. `Apply` {sc29 ba}
6. `OK` {sc29 ga}
7. *Layer Properties* window closes
8. select the layer you wish to draw a polygon in {sc30 ra}
9. `Toggle Editing` on {sc30 ba}
10. Zoom In on the area you wish to trace
    - in the tutorial zoom in to "Molo" {sc30}
11. `Add Polygon Feature` {sc30 ga}
12. left click repeatedly following the borders of the feature
13. once the polygon is done, right click
14. *Feature Attributes* window appears {sc31}
15. enter the id and language name
16. `OK`

The polygon can still be edited. For the polygon I created while writing this guide, there is a little green cross indicated in {sc30 rb}. This indicates that the polygon has a problem at that point, a self-intersection {sc34} or a duplicate node. In this case it is a duplicate node. Bad polygons need to be fixed or they cause problems later. Similarly, at the bottom of {sc30 bb} the polygon I drew deviates from the shape of the one I was imitating. To fix such problems, adjust the part(s) of the polygon that need attention.

(16) **Adjusting Polygons**

1. zoom in as close as you can on the relevant area {sc32}
2. `Toggle Editing` on
3. `Vertex Tool` {sc32 ra}
   - This allows you to modify the individual nodes which make up the polygon.
4. hover over the polygon
   - This shows where the nodes are, represented by red circles.
   - Clicking on one will "grab" it, allowing you to move it.
5. Hover over a line between two nodes.
   - The line will be highlighted. {sc32 rb} Clicking it will "grab" the line allowing you to move both nodes at either end of the line.
6. Hover over the line in roughly the middle of two nodes.
   - A red + will appear, as in {sc33 rb} Clicking again will create a node at that point. This node will be automatically selected allowing you to move it where you want.

You can use the functions outlined above to adjust the edges of the polygon to more closely match the shape you are manually tracing.

(17) **Removing bad nodes**

1. zoom in on the relevant area(s) {sc33}
2. `Toggle Editing` on
3. `Vertex Tool` {sc29 ra}
4. adjust one of the borders/nodes slightly to reveal where bad nodes are {sc33 bb}
   - For some reason you have to adjust a node to reveal bad nodes. I don't know they aren't revealed by just clicking on the polygon.
5. click on the node(s) with the green cross
6. hit delete on the keyboard, or move the node
7. `Save Layer Edits`

If you have so many bad nodes that fixing them manually is impracticable, put "Handling Invalid Geometries (QGIS3)" into a search engine. There are various tutorials online for how to deal with bad nodes automatically.[5]

In some cases, manually tracing features using the georeferencer is your only option. The more time you spend doing it, the better you will get at it. However, this is a fairly long process which can be sped up by adapting pre-existing polygons. In the case of Timor, for instance, most of the princedoms have borders the coast. By copying the polygons that comprise Timor the coast borders can be used for a map of the kingdoms of western Timor.

2.3.2 Using pre-existing polygons

There are various ways to use pre-existing polygons to create your own. All involve copying other polygons and then editing them in some way.

(18) **Copying a polygon**

1. select the layer with the polygon to be copied {sc35 ra}

[5] `https://www.qgistutorials.com/en/docs/3/handling_invalid_geometries.html` is one tutorial I have used in the past to handle bad geometries.

2. `Select Features by Area or Single Click` {sc35 ba}
3. select polygon to be copied
   - For the tutorial select Timor-Leste.
4. *Edit* > *Copy Features* {sc36} (or Ctrl+C)
5. `Deselect Features from All Layers` {sc35 ga}
6. select the layer into which the polygon is to be copied {sc37 ra}
7. `Toggle Editing` on {sc37 ba}
8. *Edit* > *Paste Features* (or Ctrl+V)
9. `Save Layer Edits`

The nation of Timor-Leste is a multipart polygon. That is, it consists of multiple discontinuous polygons. Three of these are easily visible: the eastern part of Timor, the enclave of Oecusse, and the island of Atauro. (There are also three small offshore islands Timor which are part of this polygon.)

For the kingdoms of west Timor, only the Oecusse enclave is needed. To discard all the other parts of Timor-Leste, it needs to be split. This can be done with a plugin called *Multipart Split*. A plugin is an extra tool that is not automatically available in the software. To install a plugin, you need an internet connection.

(19) **Installing a plugin (Multipar Split)**

1. *Plugins* > *Manage and Install Plugins…* {sc38 rb}
2. *Plugins* window opens {sc39}
3. type "Multipart" in the search bar {sc39 rb}
4. select Multipart Split {sc39 ra}
5. `Install Plugin` {sc39 ba}
6. `Close` {sc39 ga}

(20) **Splitting a multipart polygon**

1. ensure that the layer with the multipart polygon is selected {sc40 ra}
2. select the multipart polygon {sc40}
3. `Toggle Editing` on {sc40 bb}
   - If following the tutorial sequentially, it should be on. You can tell that it is on if the borders of the selected polygon turn red {sc40}.
4. `Split Feature Parts` {sc40 oa} in the `Advanced Digitizing Toolbar`
5. message appears: *"Multipart split plugin: Splited* [sic.] *1 multipart features into X single part ones."*
   - In the tutorial Timor-Leste will be split into 6 single part features.
6. `Deselect Features from All Layers` {sc40 pa}
7. select the polygons to be deleted
   - This can be done through the attribute table if you can't find some.
8. `Delete Selected` {sc40 black arrow}
9. `Save Layer Edits`

For the other kingdoms of western Timor there are (currently) no corresponding polygons. Nonetheless, you can copy the rest of western Timor then manually split it into different chunks.

(21) **Manually splitting a polygon**

1. copy the polygon to be split into the appropriate layer by following the procedure in (18)

2. ensure that the appropriate layer is selected {sc41 ra}
3. select the (new) polygon
4. zoom in to an area which has a coastal border {sc41}
5. `Toggle Editing` on {sc41 ba}
6. `Split Features` {sc41 ga}
   - Do not select `Split Parts` which has a similar symbol and is next to `Split Features`. Hover over the button to check which one you have selected.
7. starting outside the selected feature {sc41 rb}, left click once, then click repeatedly following the border
   - A red line will appear showing the part that will split off.
8. once you reach the end of the border, click outside the selected polygon {sc41 bb}
9. right click to create the split.
10. `Open Attribute Table` {sc41 oa}
11. select the new feature and name it
12. `Save Layer Edits` {sc41 ba}

This procedure can be repeated multiple times for the other kingdoms. For Molo, part of the border has been created (that which borders Amfo'an), the rest could then be cut from the larger feature. Some of the borders of the new polygon need to be adjusted, as they do not match the raster very well. One such instance is indicated in {sc41 pb}. Adjusting these borders would create a gap between the two kingdoms, which can be dealt with by using snapping. Snapping allows you to adjust nodes so that they are in exactly the same position as another node.

Zoom in to the part of the polygon to be adjusted {sc42} and adjust the nodes following the procedure in (16). Because the nodes of each polygon are in the same locations, it can be quite fiddly to select the nodes corresponding to the polygon you are trying to adjust. You might need to move some of the nodes of the other polygon out of the way to get to the ones you actually want to move. The polygon which is being adjusted will be shaded red. Use snapping to adjust the nodes of the neighbouring polygon.

(22) **Snapping**

1. `Enable Snapping` {sc42 ra}
2. *Advanced Configuration* > *Open Snapping Options...* {sc43 ra}
3. *Project Snapping Settings* window opens {sc44}
4. Set up the settings as follows: {sc44}
   (a) `Active Layer` {sc41 rb}
   (b) `Vertex`
   (c) `12 px`
   (d) `Topological Editing`
   (e) `Avoid Overlap on Active Layer` {sc41 bb}
   (f) `Topological Snapping on Intersection`
   (g) `Self-snapping`

Now, when you move nodes from one polygon they will snap with those of another polygon. That is, they will occur in exactly the same place. You can tell a node you are moving has snapped because it will have a purple/pink border {sc45 rb}.

If there are only a few nodes which need to be snapped, then doing it manually is fine. However, when there are many nodes to be snapped this is impracticable. For this, you should use tracing, as outlined below. For the tutorial fill in the area labelled

Ambenu. If you have been following the tutorial sequentially, that section was copied in (18). If so, delete it before moving onto the next step.

(23) **Tracing**

1. zoom in to the area where the new polygon will be created {sc46}
2. `Enable Snapping` {sc46 ra}
3. `Enable Tracing` {sc46 ga}
4. `Add Polygon Feature` {sc39 oa}
5. left click once somewhere outside the appropriate area
6. left click to snaps a node to the border to be traced
7. left click elsewhere along the border and nodes will be generated at every point between the first point and the second {sc47}
8. right click to make the feature

Tracing is a very useful feature of QGIS. The feature you are tracing does not need to be in the same layer you are editing. If you open snapping options and select `Advanced Configuration` {sc48 rb} you can select the layer you want to trace from. You can also split features (21) with tracing to create a split in one layer according to a border in another layer.

Another way to create your own shapefiles from other shapefiles is by merging them. This is how I made most of the language shapefiles in the Timor layer. I took shapefiles for the administrative divisions of Indonesia and Timor-Leste, and merged them. I'm fortunate that in this part of the world the administrative divisions correspond fairly well to ethnolinguistic boundaries. Many administrative shapefiles can be downloaded from the internet Just type the country and "administrative shapefiles" into a search engine and see what you can find.

I have modified the shapefiles that correspond to the landmass of Timor so that the coastline matches exactly the shapefiles I have for administrative divisions. If the administrative divisions you download do not match the country shapefiles you are working with, you can modifying the country shapefile, and/or the administrative shapefiles so that they do match. If the administrative divisions are more detailed than the country shapefiles the easiest way to do this is to merge all the administrative shapefiles into a single shapefile (following the procedure outlined in (24) below), then replace your original country shapefile with that, by following the procedure in (18).

(24) **Merging polygons**

1. load the shapefiles you want to merge (4)
   - For this tutorial, load *Desa_WestTimor.shp* which contains *desa* (≈village) adminstrative shapefiles for western Timor.
   - If nothing appears, the newly loaded polygons are probably at the bottom of the Layer Order panel {sc49 ra}.
2. select the layer which has the newly loaded polygons {sc49 ba}
   - In this tutorial this is *Desa_WestTimor*.
3. select the polygons to be merged {sc50}
4. *Edit* > *Copy Features* (or Ctrl+C)
5. `Deselect Features from All Layers` {sc50 ra}
6. hide the layer from which the features were copied by unchecking the box in the Layers panel {sc51 ra}
   - This just makes it easier to see the layer you are working with.
7. select the layer where the new polygon will be {sc51 ba}
8. `Toggle Editing` on {sc51 ga}

9. *Edit* > *Paste Features* (or Ctrl+V)
10. `Merge Selected Features` {sc51 oa} in the `Advanced Digitizing Toolbar`
11. *Merge Features* window opens {sc53}
    - If your features have values (e.g. names), you can, select one feature here to apply those values to the newly merged feature by clicking `Take attributed from selected feature`
12. `OK` {sc53 ra}
13. `Open Attribute Table` {sc52 pa}
14. Name the new polygon
15. `Save Layer Edits`

In the case of the kingdoms of west Timor, the modern administrative divisions often have names based on these historic divisions. So the best way to open the attribute table and select all the parts of an area like Amarasi is to select all the *kecamatan* (districts) with "Amarasi" in the name. Remember, you can sort columns in the attribute table by clicking on the heading.

Sometimes the polygons will not merge prefectly and some of the old borders between them may remain. If this is the case, you can delete the nodes with the `Vertex Tool` {sc32 ra} (16). If there are many remaining borders, draw another polygon over these borders with `Add Polygon Feature` {sc19 ga} (12), then merge that polygon with the other one.

The methods outlined here are how I created the polygons of languages in the Timor Layer. Mostly I merged administrative polygons. For some languages, such as Welaun, I used information collected in the field and drew the polygon as outlined in (12). (Actually, I split Welaun out of the Tetun polygon [21]).

2.4 Point Layers

Polygons are one way of representing the locations of languages. For some purposes, however, you may want languages to be represented by single points. This is the method used in a lot of online maps, such as those in the World Atlas of Language Structures Dryer and Haspelmath (2013). Point layers are also useful for representing the locations of villages.

Point layers are most easy to add from an appropriately formatted text file which has longitude and latitude coordinates for the points you want to add. These can be obtained from a variety of sources. Glottolog (Hammarström et al. 2020) provides such data for nearly all languages of the world. Otherwise, you can use Google maps or Mapcarta (`https://mapcarta.com`) to get coordinates from a specific location.

QGIS can load a point layer from a comma-separated values (CSV) file. The column containing the latitude values should be headed "latitude" and the column containing longitude values should be headed "longitude". These columns can be in any location in the file. The CSV can have lots of other columns for all sorts of information: language name, genealogical affiliation etc. When the CSV file is loaded into QGIS all this information will be in the Attribute table of the point layer.

A CSV file can be prepared in a spreadsheet program, such as Microsoft Excel (*save as* > *other file formats* > *CSV*) or LibreOffice. In the accompanying files I have provided *GreaterTimor_point.csv* which can be used for this tutorial. The data in this CSV comes partly from Glottolog and partly from my own knowledge. The first six lines of this file are given in Table 1 to illustrate the structure of a CSV file. These lines laid out tabular format in Table 2.

Table 1: Sample CSV File

```
name,id,iso,longitude,latitude,Family,Subgroup1
E Tetun,east2473,tet,126.01121,-8.95634,Austronesian,Timor-Babar
Fehan Tetun,sout2898,tet,124.9928,-9.41385,Austronesian,Timor-Babar
Foho Tetun,nort2869,tet,124.91446,-9.16003,Austronesian,Timor-Babar
Habun,habu1241,hbu,126.03315,-8.68059,Austronesian,Timor-Babar
Kairui-Midiki,kair1265,krd,126.14737,-8.73037,Austronesian,Timor-Babar
```

Table 2: Sample CSV File in Tabular format

name	id	iso	longitude	latitude	Family	Subgroup1
E Tetun	east2473	tet	126.01121	-8.95634	Austronesian	Timor-Babar
Fehan Tetun	sout2898	tet	124.9928	-9.41385	Austronesian	Timor-Babar
Foho Tetun	nort2869	tet	124.91446	-9.16003	Austronesian	Timor-Babar
Habun	habu1241	hbu	126.03315	-8.68059	Austronesian	Timor-Babar
Kairui-Midiki	kair1265	krd	126.14737	-8.73037	Austronesian	Timor-Babar

(25) **Loading point layer from text**

1. *Layer* > *Add Layer* > *Add Delimited Text Layer...* {sc54}
2. *Data Source Manager* window opens {sc55}
3. click ... {sc55 ra} and navigate to the file to be loaded
   - For this tutorial it is *GreaterTimor_point*.
   - QGIS should automatically identify the latitude and longitude columns and mark the X field as longitude and the Y field as latitude {sc55 rb}.
4. `Add` {sc55 ba}
5. `Close` {sc55 ga}
6. ensure the new layer is visible in the *Layer Order* panel {sc56 ra}

The points will appear as circles with an arbitrarily assigned colour. You can show the names of the points by displaying the labels (10). You can also find a specific point by opening the attribute table, selecting the point, then `Pan Map to Selection` {sc56 ga}.

To format the colour and shape of the points, the same principles apply as for polygons. In the case of point layers, I generally find it easier to set up the shape/colour in QGIS rather than Inkscape. Distinguish between the two genealogies present in this area: Austronesian and Timor-Alor-Pantar, as outlined below.

(26) **Changing properties of points**

1. select the point layer in the layers panel {sc56 ba}
2. double click this layer (or right click > Properties)
3. *Layer Properties* window opens {sc57}
4. open the `Symbology` section
5. select `Categorized` in the top bar {sc57 rb}
6. select the `Value` {sc57 bb}
   - For this tutorial, select Family.
7. `Classify` {sc57 ra}
8. `Apply` {sc57 ba}
9. double click the dot next to one of the families {sc57 ga}
10. *Symbol Selector* window opens {sc58}

    - You can select one of the predefined symbols, or you can click on `Simple Marker` {sc58 rb} for the complete range of options {sc59}.
11. `OK`
12. *Symbol Selector* window closes
13. `Apply` {sc58 ba}
14. `OK` {sc58 oa}
15. *Layer Properties* window closes

When you are working with a CSV file, you can update the file externally (e.g. in notepad, or Excel) and automatically update the file in QGIS by selecting the layer and hitting `Refresh` {sc56 oa}. This works fine for simple edits, such as changing a value in a column. But it tends not to work so well if you do things like delete an entire column.

2.5 Preparing the map for export

Before exporting the map, there are two remaining things that it is best to set up in QGIS: latitude and longitude markers and a scale bar.

(27) **Creating latitude and longitude grid**

1. *Vector > Research Tools > Create Grid* {sc60}
2. *Create Grid* window opens {sc61}
3. *Grid Type > Line* {sc61 rb}
4. *Grid extent = -180,250,-90,90 [EPSG:4326]* {sc61 bb}
    - This grid whill cover the entire map.
    - If you only want a grid for part of the map, select different coordinates. Thus, for instance 121,130,-7,-12 [EPSG:4326] will make a grid just over the area of Timor.
5. `Horizontal spacing` = 1.000000
6. `Vertical spacing` = 1.000000
7. Grid CRS {sc61 ra} should match that of your map.
    - For this tutorial EPSG:4326 - WGS 84 is correct
8. *Grid > Save to File* {sc61 ba}
    - Save it somewhere sensible.
    - This will save your latitude and longitude grid as a shapefile which means it won't need to be recreated every time you open QGIS.
9. `Run` {sc61 ga}
10. `Close` {sc61 oa}
11. a grid matching latitude and longitude points will appear on you map, as in {sc62}

The map is now ready for export to be edited in Inkscape. For this part of the tutorial, use the Timor layer. Display this layer by checking the box in the layers panel {sc62 ra}. The other layers that should be visible are the new latitude and longitude layer, and the Countries layer. Hide all other layers.

(28) **Exporting SVG for Inkscape**

1. *Project > New Print Layout...* {sc62}
2. *Create Print Layout* window opens {sc63}
3. name the print layout
4. `OK`
5. *Print Layout* window opens {sc64}

6. left click on the white canvas
7. open *Item Properties* panel {sc64 ra}
   - If you cannot see this panel, *View > Panels* and select it.
8. `Size` = A4 {sc64 ba}
   - A4 is default, so no changes are probably needed.
   - This is based on the assumption that your map will be in a document which uses A4 pages.
9. `Orientation` = Portrait {sc64 ga}
   - If your map is particularly wide and you plan to rotate it in your paper/book, then set the orientation to landscape.
10. `Add Map` {sc64 oa}
11. click and drag
    - The map that appears is roughly equivalent to what you see on the QGIS canvas. You can adjust it by changing what you see in the canvas and re-adding the map, or you can change the extents {sc65 rb} in the *Item Properties* panel for the map according to longitude and latitude.
12. `Add Scale Bar` {sc65 ra}
13. left click on the map you have added
14. *New Item Properties* window opens
15. `OK`
16. Scale bar appears
    - Do not worry at this stage about setting the scale bar up properly. This will be done later in Inkscape. The important thing is to add the scale bar at this stage so that its length is correct for the map you have added.
17. *Layout > Export as SVG...* {sc67}
    - If you have a fresh install of QGIS you will receive a message "The SVG export function in QGIS has several problems ..." as in {sc68}. Don't worry about this, the bugs that it mentions are not serious. You can check *Don't show this message again* and `Close`.
18. select a sensible location to save the file
19. *SVG Export Options* window opens {sc69}
20. check `Export map layers as SVG groups` {sc69 rb}
21. uncheck `Simplify geometrics to reduce output file size` {sc66 bb}
22. `Save`

2.6 Simplifying objects

The countries layer provided in the accompanying files has a large number of vertices/nodes. This means that the polygons have highly detailed borders or coastlines, particularly in the area of Island South East Asia. For the most part this is good, as it means that a map of a small area or island will be accurate.

However, this level detail is not necessary for maps of a large area, like all of Island South East Asia in a locator inset map §3.4.3. Furthermore, this level of detail increases the file size and can cause Inkscape to lag and/or freeze while editing the map. There are various ways to simplify shapefiles to reduce the number of vertices. The simplest way is to check the box in step 21 of the export process outlined in (28) above. However, sometimes this alone is not enough. Shapefiles can be simplified in Inkscape after the export (40), or in QGIS before the export.

(29) **Simplifying in QGIS**

1. navigate to the folder where your shapefiles are, make a copy of the files that comprise the Countries layer, and rename them something like "Countries_simplified"
2. load this layer into QGIS (4)
3. select this layer {sc70 ra}
4. `Toggle Editing` on
5. `Simplify Feature` in the `Advanced Digitizing Toolbar` {sc70 ba}
6. click on a feature
   - You can click on individual features, or click and drag over multiple features. If you click and drag over multiple features, there will be a short lag (about five seconds) while it loads.
   - What the simplified features will look like is displayed in transparent red, like the visible part of Timor in {sc71}
7. a little window opens in the top right hand corner {sc71 rb}
8. *Method* = any, except smooth
9. select one of *Map units/Pixels/Layer units* in the box next to Tolerance {sc71 bb}
10. set the *Tolerance*
11. `OK`

With a higher tolerance, more vertices will be deleted and the simplified shapes will look less like the originals. Experiment with different tolerances and different units at different zooms until you have something you are happy with. Changing the values will cause the red-outline preview to update. The more features you have selected, the longer this lag will be. For the area of Island South East Asia in the provided shapefiles, 0.025000 layer/map units or 1.0 pixels is about the maximum tolerance. Above that, the islands look bad even when zoomed out.

Apart from simplifying features, you may also want to delete tiny islands, or copy them into a separate layer so that their stroke can be set to be thinner than other islands (§3.3.1). The method for deleting tiny islands is outlined below. While trialling this, I found that QGIS tended to freeze if I tried to use Ctrl+Z to undo certain steps. If this happens, close QGIS from the task manager and start again. Similarly, some of the steps take some time to process. The longest step when I trialled this took 20 seconds to process. If something is taking a long time, leave the computer for about five minutes. If it still hasn't processed by the time you come back, QGIS may have frozen. Close the program from the task manager and start again, with less ambitious goals. That is, applying the commands to less features.

(30) **Deleting tiny islands**

1. navigate to the folder where your shapefiles are, make a copy of the files that comprise the Countries layer, and rename them something like "Countries_simplified"
2. load this layer into QGIS (4)
3. select this layer in the *Layers* panel
4. select the area conatining the tiny islands you want to delete with `Select Features by Area or Single Click` {sc72 ra}
   - In {sc72} I selected pretty much all of Island South East Asia
5. `Toggle Editing` on
6. `Split Feature Parts` {sc72 ga} (19), (20)

    - Depending on the area that you have selected this can take a while to process. For the area selected in {sc72} this took 20 seconds.
7. `Deselect Features from All Layers` {sc72 oa}
8. reselect the features that were in the area you selected
    - After `Split Feature Parts`, QGIS weirdly does not recognise that the features are all selected.
9. `Open Attribute Table` {sc72 pa}
10. `Open field calculator` {sc73 ra}
11. check `Only update X selected features` {sc74 ra}
12. check `Create a new field` {sc74 ba}
13. `Output field name` = area {sc74 ga}
    - The actual name doesn't matter.
14. type "$area" in the Expression field {sc74 oa}
15. `OK` {sc74 pa}
16. a new column appears in attribute table {sc75 ra}
17. sort the area column by clicking on the heading {sc75 ra}
18. `Deselect Features from All Layers` {sc72 oa}
19. scroll in the Attribute table until values appear in the new column
    - this was row 2899 when I trialled this {sc76}
20. select this row and the next X number of rows, where X is the number of tiny islands you want to delete
    - Do this by scrolling down to the appropriate row and Shift + clicking.
    - With the attribute table sorted by the new area column, the further down you go the bigger the islands you select will be.
21. `Delete Selected` {sc72 black arrow}
    - If you try to undo this, QGIS will likely freeze.
    - Or if your want to put the tiny islands in a different layer copy or cut them from the *Edit* menu.
22. `Save Layer Edits` {sc72 grey arrow}
    - This may take some time. It should be less than 20 seconds.

If you are making a map of Indonesia, you can select all polygons with an area up to 6,000,000 at step 20 above without any significant loss. In the examples used for the screen shots, I selected all rows with an area below 100,000 (which was 3369 features). Which features these were are shown in {sc77} and the size of the features selected can be seen in {sc78}, which zooms in on the southern part of Rote Island. These are extremely small islands that would probably not even be missed if I were making a map just of Rote. Nonetheless, each of these islands has dozens of vertices. If you select and delete all features below the size of 6,000,000 you will be deleting millions and millions of vertices, thus saving a significant amount of space and making Inkscape run a lot more smoothly.

3 Inkscape

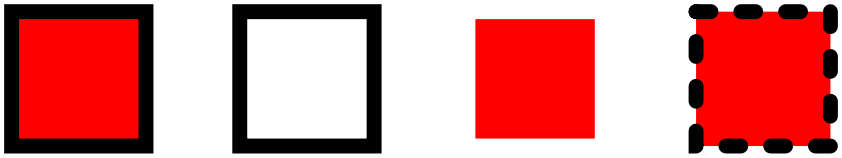
The map is now ready for editing in Inkscape. Before proceeding, it is recommended to do the first tutorial for Inkscape to get to grips with the basic functionality of the program.[6] This guide will assume that you have completed this tutorial. Inkscape also

[6]The basic tutorial for Inkscape is at `https://inkscape.org/learn/tutorials/`

comes with its own guide can be consulted if you find yourself lost at any point.[7]

Before going further, an explanation of some terminology. Most elements/shapes in Inkscape (and other vector graphics editing software) have two parts. The "fill" and the "stroke". The stroke is the outline or border of the shape and the fill is what is inside. For a simple square, like the first one in Figure 1 below, the fill is red and the stroke is black. The second square has no fill, the third square has no stroke, and the fourth square has a dashed stroke.

Figure 1: Squares



3.1 Inkscape and page settings

With that terminology in mind, open up your newly created SVG in Inkscape. The first thing to do is to disable *Scale stroke width*. This setting means that as you resize a shape, the thickness of the stroke is resized with it. If the size of an object is increased, the stroke becomes thicker. This makes tweaking maps, as described in (52), a pain.

(31) **Disable Scale stroke width**

1. *Edit* > *Preferences...*
2. *Preferences* window opens
3. *Behaviour {sc1 ra}* > *Transforms {sc1 ba}*
4. uncheck `Scale stroke width` {sc1 rb}

Now set up some settings for the map. The first relate to the page or the canvas of this map. Although the end result is a vector graphic with (theoretically) infinite zoom, I usually set the page assuming that the map will appear in a publication with roughly A4 sized pages. This means that when I am editing the map I immediately have a rough idea of how it will appear and can avoid making objects or text too small.

(32) **Page settings**

1. *File* > *Document Properties* (Shift+Ctrl+D)
2. *Document Properties* panel opens {sc2}
   - This panel will probably open on the right part of the screen.
3. `Display units: px` {sc3 ra}
4. `Page Size` = A4 {sc3 ba}
5. check `Portrait` {sc3 ga}
6. click `Background color` {sc3 oa}
7. *Background color window* opens {sc4}
8. set the RGB to 255–255–255
9. set the Alpha (opacity) to 100 {sc4 ra}
   - HTML `ffffffff`
   - Alpha is transparency. 0 is completely transparent, 100 completely non-transparent.
10. close *Background color* window and *Document Properties* panel

[7] The Inkscape Beginners' Guide can be consulted at `https://inkscape-manuals.readthedocs.io/en/latest/`

3.2 Cleaning up

The export from QGIS creates objects which are not needed. This stuff needs to be removed so it doesn't interfere further down the line. The file also needs to be cleaned up a little to prepare it for editing. Open the Inkscape layers panel in *Layer > Layers...* (Shift+Ctrl+L). If you have been following this tutorial sequentially you should have six layers:

- Scalebar
- Map 1: Timor
- Map 1: Countries
- Map 1: LatLon (the latitude and longitude grid created in QGIS)
- Map 1: Background
- Page

Next to each of these layers is a little eye and a lock. If the lock is open, the layer is editable. If the eye is open, the layer is visible. Click on the lock to prevent the layer from being editable, click on the eye to make the layer invisible. It is a good principle to keep all layers locked except the layer you are currently editing. This avoids accidentally editing or deleting objects from other layers. To some extent, I will assume that you are unlocking and locking layers as you go throughout this tutorial. It is often useful to also hide layers you are not working on. This makes it easier to focus on what you do want to edit and also makes Inkscape run more smoothly.

Using the procedures below, delete the *Map 1: Background* layer and the *Page* layer, move the *Scalebar* layer, and rename *Map 1: Timor* to *Languages* and *Countries* to *Islands*.

(33) **Editing layers**

1. Deleting layers
   (a) right click a layer in the *Layers* panel
   (b) *Delete Current Layer* {sc4}
2. Renaming layers
   (a) right click > *Rename Layer* (or double click the name)
3. Moving layers
   (a) Select the layer
   (b) `Lower the current layer` {sc5 ra} (Shift+Ctrl+Page down)

The export from QGIS creates ghost/invisible objects that should be deleted to avoid causing problems later. If you are following the tutorial, start with the *Islands* layer.

(34) **Deleting ghost objects**

1. unlock the relevant layer
2. *Edit > Select All* (Ctrl+A)
   - For the *Islands* layer two objects should be selected, as in {sc6}. One with all the islands, and another invisible rectangle equal to the page width.
3. deselect everything except the invisible object
   - For the Islands layer, this requires shift + clicking on one of the islands. Simply shift + clicking elsewhere is insufficient, it requires clicking on one of the islands.
   - Deselect the islands so that only the invisible object is selected.
4. *Edit > Delete* (delete)

The method outlined above can also be used to remove the ghost object in the layer containing the longitude and latitude lines. The languages layer is a bit more complex because the languages are not grouped, thus deselecting them all is tedious. To delete the ghost object in this layer you can either group all the languages together by dragging a box around them with the select tool {sc6 ra} (but not selecting the invisible box), then follow the procedure above. You can also change the stroke of all the objects (§3.3.1) which will then make the box visible and able to be selected by clicking.

3.2.1 Deleting objects

The current map has many islands and several languages that should not be in the final map. Even if you adjusted the settings in QGIS to have exactly the map you wanted, the bugs with the current SVG export function probably mean that there are objects outside of your desired area. To do delete these objects I find it best to start by adding a frame around the part of the map I want to keep, then deleting the objects outside this frame. For the tutorial, include the area indicated within the red box in {sc7}.

(35) **Adding a frame**

1. create a new layer {sc8 ra}
2. name the layer "Frame"
3. toggle snapping off {sc8 ba}
   - placing the rectangle correctly is a pain with snapping on
4. ensure that only the Frame layer is unlocked
5. draw a rectangle around the area that will be in the map {sc8 ga}
6. *Object* > *Fill and Stroke* (Ctrl+Shift+F)
7. set the `Fill` {sc9 ra} to have no paint {sc9 ba}
8. set the `Stroke paint` {sc10 ra} of the rectangle to RGB 0-0-0 (black)
9. set the `Stroke style` to 1.0px {sc10 ba}

Carry out the procedure below for each layer with objects outside the frame. (If the scale bar is outside the frame, do not delete it.) Alternately, if you think you might want to change the border of your map later to include some of these objects, you can move them all into a new layer and hide that layer.

(36) **Deleting objects**

1. unlock the layer
2. ungroup groups of objects (Ctrl+Shift+G) when some members of the group are outside the frame
3. use the `Select and transform objects tool` {sc10 ga} to select objects outside the frame
4. *Edit* > *Delete* (delete)
5. lock the layer

Some objects may remain both within and outside the frame. This is the case for the island of Flores in the map used for the tutorial. To delete the part(s) outside the frame use the cut path function, as explained below.

(37) **Cutting objects**

1. unlock the layer with the frae and the layer with the object extending outside the frame

2. select the frame
3. *Edit* > *Duplicate* (Ctrl+D)
    - the duplicated frame will get deleted in the process of cutting
4. select the object to be cut and ensure it is a Path {sc11 rb}
    - it may be a "group of 1 object", in which case ungroup it (Ctrl+Shift+G)
5. select one of the frames in addition to the object (shift + click)
6. *Path* > *Cut Path* (Ctrl+Alt+/)[8]
7. the object will break into multiple parts and lose its fill, as in {sc12}
8. delete the parts that are outside the frame
9. give the object the same fill as the other objects
    - You can do this through the *Fill and Stroke* panel or use the dropper in the left toolbar {sc20 ra}.

The part of Flores which is within the frame should only be a single part. However, it may have broken into multiple parts, in {sc13}. If so, you can rejoin the parts as outlined below.

(38) **Joining objects**

1. zoom in where the split occurs
    - You can use `Edit paths by nodes` {sc14 ra} and click on one of the objects to see where this is {sc16 rb}.
2. shift+click to select both sections with `Edit paths by nodes` {sc15 ra}
3. select the end node of each section {sc15 rb}
4. `Join selected nodes` {sc15 ba}

Given the number of nodes in the example, it is basically impossible to select only the end nodes at step 3 without selecting some additional nodes. This is fine. Just draw a box around around the area which contains these nodes with `Edit paths by nodes` {sc14 ra}.

Once the objects outside the frame have been removed, resize the map to fit the canvas better. Strictly speaking, this is not necessary but resizing the map allows you to judge easily how visible things would be in the final map. If you are following the tutorial sequentially, you will have set the canvas to be A4 in QGIS at step (28). If you are using a different page size or have not followed the tutorial sequentially, set up the page size in the *Document Properties* panel (Ctrl+Shift+D).

(39) **Resizing**

1. make all layers visible
2. unlock all layers
3. *Edit* > *Select All in All Layers* (Ctrl+Alt+A)
4. `Select and transform objects` {sc16 ra}
5. Ctrl + click on one handle, represented by a little arrows {sc16 ra}, and drag it to increase the size of everything
    - Ctrl + click means that the aspect ratio of the objects is retained. If you just use a simple click, the objects will become stretched and distorted.
6. resize it to roughly fit the page, as in {sc17}
7. lock all layers

[8] The keyboard shortcut for cut path (Ctrl+Alt+/) no longer works with my computer after updating Inkscape. I don't know if this is a problem with the latest version of Inkscape, or a problem with my computer.

There may be quite a bit of lag while resizing the objects. If you have been following the tutorial sequentially, it will lag, but should be bearable. If it is truly unbearable then simplify the objects before resizing.

(40) **Simplifying in Inkscape**

1. Select the objects
2. *Path* > *Simplify* (Ctrl+L)

There will often be a slight lag between issuing the command and the simplification taking effect. The more objects you simplify in one go, the longer the lag. Objects can be simplified multiple times with the shape becoming less and less like the original with each iteration. For particularly large files with an extremely high level of detail, you may not even be able to open the file in Inkscape without it crashing. In such cases you will need to simplify the shapes in QGIS (§2.6).

After resizing, hide islands that are completely covered by languages. They aren't visible and increase the file size with no benefit. Hiding them can also make Inkscape lag less. At the same time, deleting them is a bit risky in case you want to use them later. In the case of Timor Island, these objects can be reused later to indicate the national borders. To hide objects, move them to another layer and hide that layer.

(41) **Moving objects to a different layer**

1. create a new layer for the hidden islands
2. lock and hide this new layer
3. unlock the layer with the objects
4. select all the objects to be moved to the new layer
5. *Layer* > *Move Selection to Layer Below/Above* (Shift+Page down/up)
6. repeat until they are in the hidden layer.
7. The layer they are in is highlighted in the layers panel {sc18 rb}

Be careful not to hide islands which have no languages on them, though of course you can always move these back into the visible layer if you realise later you've accidentally hidden them.

3.3 Formatting

3.3.1 Stroke

The first thing to format is the thickness of the stroke of the islands and the language polygons. I have found that a thickness of about 0.520px is about right. For particularly small objects, such as islands in an inset map (§3.4.3), a thinner stroke may be appropriate.

(42) **Editing stroke**

1. unlock the appropriate layer
2. *Edit* > *Select All* (Ctrl+A)
3. *Object* > *Fill and Stroke...* (Ctrl+Shift+F)
4. `Stroke style` {sc19 ra} = 0.520 px {sc19 ba}
   - hit enter after typing 0.520 for the change to take effect
5. the colour of the stroke can be changed in the `Stroke paint` tab {sc19 ga}
   - in this tutorial the colours of the stroke were already set in QGIS
   - For islands, I use a stroke colour of RGB 130-130-130.
   - For language polygons, I use black (RGB 0-0-0).

3.3.2 Colours

If your map is appearing in a paper or book, most of your readership will be probably read a PDF on the computer. Even those who like to print things off to read them will have access to the electronic version. I am a strong believer in the use of colour in the age of electronic publication. However, publishers often do not support colour for various reasons, and some even request grey-scale images for electronic versions of their publications. Given this, no map you make should rely on colour. Readers should be able to identify languages without having to distinguish between colours. One way to do this is to use patterns (e.g. stripes, dots) instead of colours. If this is something you want to do, consult the Inkscape guide on "Patterns".[9]

As you are selecting the colours for your map, consider what colours look good together. I personally like to use a variety of colours in pastel. Pastels are muted and give the map a more professional feel. They also look fine if the map is converted to grey-scale. Text sitting on top of a pastel is also easy to read. Some people like a consistent theme, such as browns and khakis. Refer to the Inkscape tutorial "Interpolate"[10] to learn how to generate a range of shades of a single colour. I have used this function to give languages belonging to a single subgroup cohesion.

As your are colouring in your map, remember that the eye groups similar colours together. If you have a large language polygon, like the Meto polygon dominating the western part of Timor, avoid giving polygons near it a similar colour. Otherwise, the difference between the polygons will not be immediately obvious and the reader may initially assume they are the same language.

Inkscape has a feature called "swatches" which allows you to save colours you like to reuse them. However, in the past I have had issues with swatches. such that entire polygons would not display when I saved the map in another format.[11] As a result, I no longer use the swatch feature of Inkscape. Instead I have an SVG saved which has boxes with all the colours I like to use. I then copy this palette into my document and use the dropper tool {sc20 ra} to change the colours of the polygons. Once I am done, I hide the palette or delete it. The palettes I have used for my maps are provided in the accompanying files as *Palette.svg*.

(43) **Changing colours**

1. select an object
2. *Object* > *Fill and Stroke...* (Ctrl+Shift+F)
3. `Fill` {sc20 ba}

3.3.3 Labels

Before discussing the mechanics of labelling, a few comments on fonts may be useful. Think about the fonts you will use for labelling, and try to harmonise them with the paper/book/presentation that the map will be appearing in. At the same time, don't obsess about it. It is a pain to constantly change fonts when you reuse a map for a venue with a different font. It is probably best to choose a font you are happy with, and stick with it. After a lot of experimentation, I have settled on Linux Libertine. Linux

[9] `https://inkscape-manuals.readthedocs.io/en/latest/using-patterns.html`

[10] `https://inkscape.org/doc/tutorials/interpolate/tutorial-interpolate.html`

[11] The issue I had with swatches was somehow connected to adding new colours to the swatch palette. But which polygons failed to display weren't just the ones with the newly added colours. I never got the bottom of the issue, so gave up using swatches altogether. I do not know whether these issues have been fixed in more recent editions of Inkscape.

Libertine has excellent Unicode coverage in multiple styles (bold, italic, bold italic etc.) and is free and open source. It is distributed under the SIL Open Font License, which means you can use the font in commercially sold products.

The most important things to label on your map are the languages. Other objects, such as islands can also be labelled. For language names I use boldface, for island names I use italics in the same grey colour as the borders of the islands. For a map which is going to fit onto an A4 page, 11-13pt size is about right. Bigger is usually better, but takes up more room. Labels for the languages take up a lot of space and it is often quite a juggle to fit all the labels onto a map. Whenever possible it is best to place a label on/in a polygon.

(44) **Adding labels**

1. add a layer for labels
   - Having all the labels in one layer makes it easier to update the style of all the text if needed.
2. `Create and edit text objects` {sc21 ra}
3. left click on the map canvas and type your label
4. use the *Text and font* panel (Ctrl+Shift+T) {sc23 rb} for font, size, and style
   - You need to hit `Apply` {sc21 pa} for the changes to take effect.
5. the alignment of multi-line text (like "Meto cluster" in {sc21}) can be changed by selecting `Text alignment` {sc21 ba}
6. `Spacing between letters` {sc21 ga} can be used to compress text
   - This should be used sparingly. In {sc21} reducing the space between letters allows "Mambae" to fit on its polygon, but another option would be to use a pointer (see below).
7. use the *Align and Distribute* panel (Ctrl+Shift+A) to position text
   - "Meto cluster" in {sc21} is centred on its polygon by using `Centre on horizontal axis` and `Centre on vertical axis` {sc22 rb}. Both the text and the polygon need to be selected to use alignment.

Once you have added text there are two ways to edit it. Firstly, you can select it with the select tool {sc21 oa} and then change the options in the *Text and font* panel {sc21 rb}. Once you have changed the options, hit `Apply` {sc21 pa} for them to take effect. Secondly, you can select `Create and edit text objects` {sc21 ra} and click into the text. This is the only way to change the options in the top panel, like alignment and letter spacing.

3.3.4 Pointers

When the text does not fit within a polygon, it can be placed outside of it with a pointer connecting the label and the polygon.

(45) **Adding pointers**

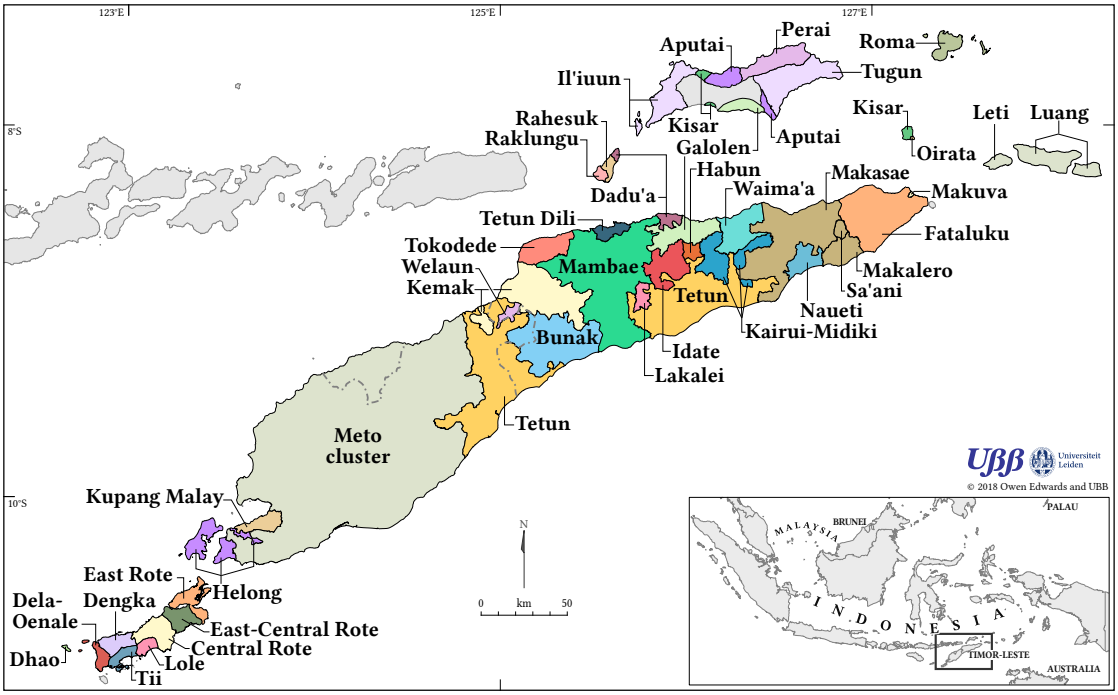
1. add a layer for pointers
2. `Draw Bezier curves and straight lines` {sc23 ra}
   (a) left click once for the beginning of the line
   (b) left click to make nodes where the line bends
   (c) right click to finish and create the line
3. `Create a sequence of paraxial line segments` {sc23 ba} for right angles.
   (a) left click, then hold the Ctrl key for a horizontal or vertical line
   (b) while holding the Ctrl key, click to create a line at 90° to the first line.

(c) right click to create the right angle

4. `Create a sequence of straight line segments` {sc23 ga} can make lines at 15° angles when the Ctrl is held down
5. Once you have drawn all your pointers, *Edit* > *Select All* (Ctrl+A) and open the *Fill and stroke* panel to set the thickness.
   - I generally use 0.640px for pointers.

Wherever possible, it is best to use right angles and/or make pointers parallel to one another as this looks neater. Compare, for instance, the image on the left in {sc24} with the one on the right. Right angles, as in {sc23} are better still. The map in Figure 2 shows a variety of pointers from which you can draw inspiration. This includes pointers with multiple "arms" for languages in multiple locations (Ili'uun, Kisar), fork/trident-like pointers (Helong, Luang). As well as labels with multiple pointers (Galolen).

Figure 2: Languages of Timor



3.3.5 Covers and offsets

In some cases a label or pointer overlaps with a language border or another pointer. If it is just a pointer crossing a language border, it is fine to leave it as is. However, if a label crosses a language border the result is bad, as in {sc25 rb}. Similarly, if a pointer crosses another pointer the result is bad. To resolve this, remove the part of the border where the label crosses. I have found the best way to do this is to make a line of identical colour to the polygon on top of the border. That is, cover the border, rather than removing it. The method to do this is below.

(46) **Covers**

1. duplicate the polygon and move the copy to a new layer
2. draw a rectangle around the text {sc26}
3. Select the rectangle and new polygon
4. *Path* > *Cut Path* (Ctrl+Alt+/) (37)
5. colour the line below the label the same as the polygon {sc27}

6. delete the other part(s) of the border created after *Cut path*
7. set the thickness of the cover to be greater than that of the border
   - In {sc27} I made the thickness 1.0px
8. when the languages layer is displayed the result is much better {sc28}

For pointers that cross other borders, a white rectangle can be placed between the pointers, as in the Welaun and Kemak pointers in Figure 2, enlarged as {sc29}. In this case, I duplicated the pointer for Welaun, changed the colour, increased the thickness considerably, then lowered the Kemak pointer below both this cover and the Welaun pointer. I determined the thickness by visually inspecting the result when zoomed out. Note also that the cover for the Welaun pointer is slightly transparent. In general, overlapping pointers should be avoided whenever possible. I only produced the result in {sc29} after trying many other options. In the end, overlapping pointers seemed to be the best approach.

Alternately, in some situations you may wish to create an offset, like the white shading around Fataluku in {sc32}. There are two kinds of offsets, *dynamic offset* and *linked offset*. Normally, a linked offset is what you would use for text. However, I have found that the linked offset in Inkscape can behave strangely.[12] As a result, I tend to use dynamic offsets.

(47) **Offset**

1. select the text
2. *Edit* > *Duplicate* (Ctrl+D)
3. *Object* > *Lower to bottom* (End) {sc30}
   - Duplication and lowering are not necessary if you use linked offset.
4. *Path* > *Dynamic offset* {sc31}
5. adjust the thickness of the offset by dragging the little diamond {sc32 rb}
6. set the colour of the offset in the *Fill and Stroke* panel {sc32 bb}

What colour the offset should be depends on the map, If the text crosses international borders on a country, for instance, it makes sense to make the offset a solid colour the same colour as the land. In {sc32} I made the text white with opacity/transparency of 60%.

3.4 Other objects

Once you have finished labelling your map, it is now communicating most of the information you want it to: the locations of languages and what these languages are called. However, there are a variety of other objects that you will probably want to place on you map.

3.4.1 Scale bar

Adding a simple scale bar is fairly straightforward. We can use the scale bar exported from QGIS to get the lengths correct.

(48) **Scale bar**

1. show and unlock the layer with the scale bar from QGIS
2. ungroup (Ctrl+Shift+G) the parts of the scale bar

[12] When a file with a linked offset is reopened, the linked offset seems to grow (without being visible) to the top-left corner of an A4 page. Unlocking and re-locking the layer usually fixes this.

3. select one unit of the scale bar to see the length {33 rb}
    - In {sc33 rb} 112.837px = 100km.
    - In {sc33 rb} I had to move part of the scale bar to select one unit.
4. draw a horizontal line {sc34 ra} with the paraxial line setting {sc23 ba}
5. set the length of the line to that of the scale bar segment {sc34 rb}
6. set the thickness of the line to 0.550px {sc34 bb}
7. create a vertical line and set the height to 0.3px {sc32 rb} and thickness to 0.550px {sc35 bb}
8. duplicate this vertical line five times (Ctrl+D)
9. open the *Align and Distribution* panel (Ctrl+Shift+A)
10. `Relative to: Last selected` {sc36 ra}
11. select a vertical line, then the horizontal line; `Align right sides` {sc36 ba}
12. select a vertical line, then the horizontal line; `Align left sides` {sc36 ga}
13. select all vertical lines; `Distribute centres equidistantly horizontally` {sc36 oa}
14. select all the vertical lines, then the horizontal line; `Align bottom edges` {sc36 pa}
15. add text "0", "km", and "100" as separate objects {sc37 ra} at about 6pt size[13]
16. select "0" and the left-most vertical line of the scale bar; `Centre on vertical axis` {sc37 ba}
17. repeat for "100" and the right-most vertical line
18. select "km", then the horizontal line; `Centre on vertical axis` {sc37 ba}
19. select "0", "km", and "100" and Align bottom edges {sc37 ga}
20. select all text, Ctrl + click to drag it down to just above the scale bar

If you want a compass element like in Figure 2, you can copy it from Palette.svg in the accompanying files. I have not figured out an easy way to make this in Inkscape and have simply reused the one that came with the SVGs made for my PhD thesis by the ANU CartoGIS unit. Once you have made your scale bar, you can group all the elements together (Ctrl+G) and delete the QGIS scale bar.

To decide the length of your scale bar, zoom out and have a look at the overall map. For this map of Timor I find a scale bar with 100km to be too long. Hence, I only used 50km in Figure 2. If you decide to shorten your scale bar, then change the length of the horizontal line by the appropriate fraction (e.g. 50%) and realign the parts of the scale bar.

3.4.2 Enlargement

If your map has a large number of languages in a small area, you may wish to make an inset which increases the size of that area so that it is easier to label. In this tutorial I will use Rote to illustrate how to make an enlargement inset.

(49) **Enlargement**

1. create a new layer for the enlargement {sc38 rb}
2. create a box around the area to be enlarged
3. set the thickness of this box to about 0.65px
4. select this box, elements within this box, and the scale bar {sc38 bb}

[13] For some unknown reason, when I tried to add text to the same layer as the scale bar it displayed weirdly. This seemed to be a problem with all text in that layer, (including text that I moved into it). I have no idea what was going on. If you encounter a similar problem, type the text into a different layer and move your scale bar to that layer.

5. *Edit* > *copy* (Ctrl+C)
6. lock all layers except the enlargement layer
7. select the enlargement layer
8. *Edit* > *paste* (Ctrl+V)
9. move the copied objects to where the enlargement will be
    - In the tutorial, the top left hand corner of the map is a good place.
10. resize the enlargement and scale bar (39)
11. if the enlargement covers objects, as it does in {sc39}, select the frame and set the fill to white
12. select the frame, *Object* > *Lower to bottom* (End)
13. move the enlarged scale bar into the area of the enlargement and adjust it as appropriate {sc40 rb}
    - When the frame of the enlargement has a fill, it can be quite tricky to select elements on top of it. If it is causing problems, temporarily move the frame to a locked layer.
    - In {sc40} I divided the length by 2.5 and changed the final measurement to be 20km.
14. give the enlargement a title {sc40 bb}
15. add "see enlargement" to the corresponding area of the map {sc40 green box}
16. label the languages of the enlargement {sc41}
    - I generally keep labels and pointers of the enlargement in the same layers as other labels or pointers.

3.4.3 Locator inset map

A locator inset map shows the location of the main map, as in the bottom right hand corner of {sc42}. A locator map can be created through the same process as your main map, though you will almost certainly want to simplify (§2.6) the map that you use as a locator. Once you have exported the locator map from QGIS, copy it into your main map and resize it as appropriate. I put the locator map in the same layer as the frame.

For this tutorial, you can ISEA.svg provided in the accompanying files. The box showing the location of the main map is RGB 50-50-50 with a thickness of 3.5px. A cover (§3.3.5), in the form of a rectangle has placed below the text "TIMOR-LESTE" and this box {43 rb}. Letters of "INDONESIA" which overlap with this box have partially transparent whiteness around them {sc43 bb} created through a dynamic offset (47). The curved text for "MALAYSIA" and "INDONESIA" in this locator inset was made through *Text* > *Put on Path*. See the Inkscape guide for how to put text on a path.[14]

3.4.4 Latitude and Longitude marks

Latitude and longitude marks can be placed in the correct places by aligning them with the grid exported from QGIS. For latitude and longitude marks I use a straight line of 0.3px thickness with a length of about 8px. I put these in the same layer as the frame. I use 6pt for the text corresponding the the latitude/longitude mark {sc45}.

(50) **Latitude and Longitude marks**

1. draw a vertical/horizontal line with `Create a sequence of paraxial line segments` {sc41 ra}

[14] `https://inkscape-manuals.readthedocs.io/en/latest/putting-text-on-path.html`

2. set the thickness to 0.3px
3. set the length to 8.0px
4. select the line and one of the latitude/longitude lines
5. *Object > Align and Distribute* (Ctrl+Shift+A)
6. `Centre on horizontal axis` {sc44 ba} for latitude
7. `Centre on vertical axis` for longitude
8. select the line(s) and the frame
9. `Align left edges` {sc44 ga} or `Align right edges` {sc44 oa} for latitude.
10. `Align top edges` or `Align bottom edges` for longitude.

3.5 Exporting

When you have finished your map you can save it in a variety of formats through *File > Save As…*. To save the file as a raster, you can export it as a PNG.

(51) **Exporting as PNG**

1. *File > Export PNG Image…* (Ctrl+Alt+E)
2. *Export PNG Image* panel opens {sc46}
3. `Drawing` {sc46 ra}
4. `300.00 dpi` {sc46 ba}
   - 300dpi is the standard size for publication. For a higher resolution map, you can increase the dpi.
5. `Export As…` {sc46 ga} to select where the PNG should be saved
6. `Export` {sc46 oa}

3.6 Minor updates

Once you have completed your map, you may find that your want to update some aspects of it at a later point. If these updates only affect a small number of polygons it does not make sense to go through the whole process outlined in this document. Instead, just update the polygons that need updating.

(52) **Minor updates**

1. update the relvant polygons in QGIS
2. export the new polygons
3. copy the new polygons into your map {sc14}
4. set the stroke to be the same as that of the old polygon
5. select the old polygon
6. note its width and height {sc47 rb}
7. note its position on the canvas {sc47 bb}
8. delete the old polygon
9. group the new polygons
10. change the position and size to match that of the old polygon {sc48}

The new polygons must cover the same area as the old polygons for this process to work. In some cases, this may mean copying additional polygons which do not need to be updated. So, for instance, if I needed to change the position and/or shape of Kisar Island {sc49 ra}, I would also copy the islands of Wetar to its west and Leti to its east, as selected in {sc49}. I would group them, resize and reposition this group according to

the properties of the corresponding group already present. Once in place and resized, I would ungroup them, delete the new Wetar and Leti objects, and delete the old Kisar object. THis would leave the new Kisar in place.

(53) **Merging polygons in Inkscape**

1. select the polygons to be merged
2. ensure that they are all Paths {sc50 rb}
3. *Path* > *Union* (Ctrl++)

If the polygons do not merge fully and some of the borders remain as in {sc51}, you can use the node tool {sc51 ra} to delete them, or you can draw another shape over them as in {sc52} and then merge that shape with the one below, producing {sc53}. This process would then be repeated by zooming in on the borders that still remain. You can also merge the polygons in QGIS (24) and then export them to an SVG. The merge function in QGIS tends to work better than Inkscape, though you may also have some remaining borders there too.

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