

API-231 / GIS-PubPol

Meeting 02 (Lab Exercise + Problem Set 2)

Yuri M. Zhukov
Visiting Associate Professor of Public Policy
Harvard Kennedy School

February 1, 2024

Goal of lab exercise: Make multi-layer maps

1. Lab exercise
 - a) Map of violence and *terrain* in Afghanistan
 - b) Map of violence and *ethnicity* in Afghanistan
2. Problem set
 - a) Map of violence and ethnicity in Yemen
 - same approach as the second map above ↑
 - name the file `yem_map_2.png`
 - upload map to Canvas (by next Wednesday)

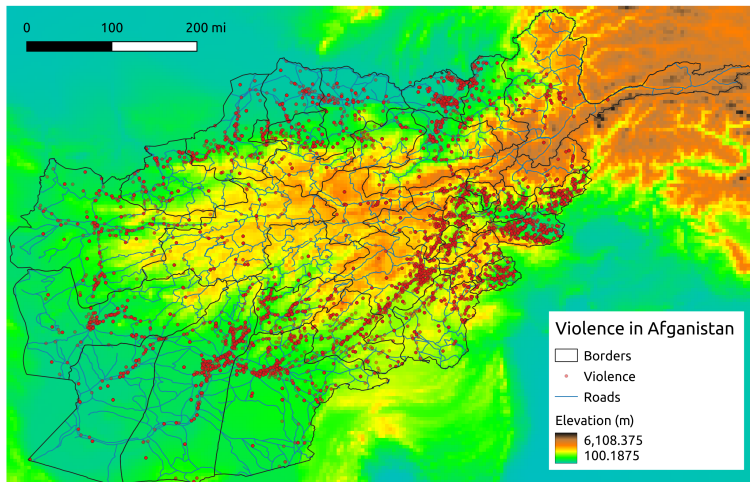


Figure 1: Violence and terrain in Afghanistan (we'll make this)

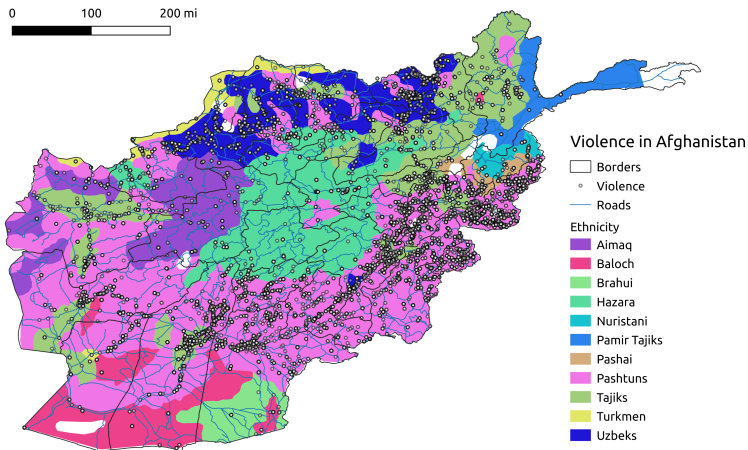


Figure 2: Violence and ethnicity in Afghanistan (this too)

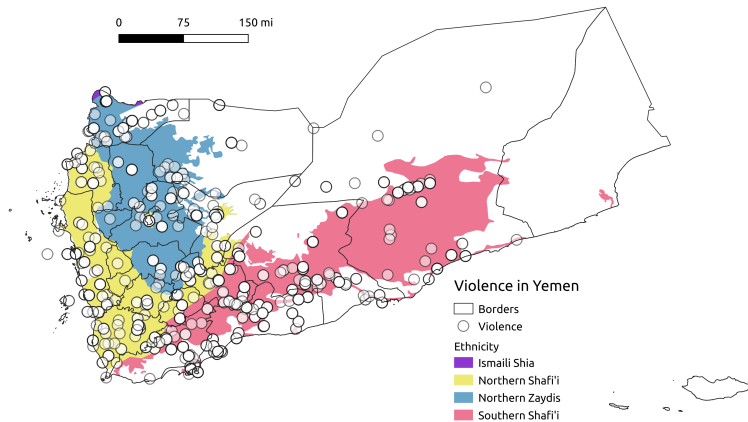


Figure 3: Violence and ethnicity in Yemen (you'll make this)

You can make these plots in QGIS or in R. Instructions for both are below.

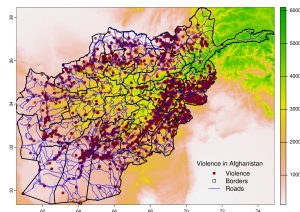


Figure 4: Map 1 in R

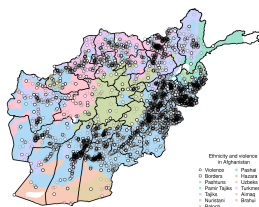


Figure 5: Map 2 in R

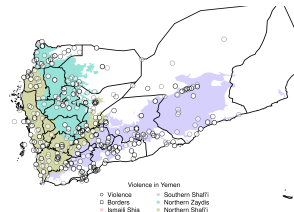


Figure 6: PS02 in R

We will put multiple types of data on same map:

Category	Type	Format	Data source
Elevation (meters)	Raster	.tif	ETOPO
Province borders	Vector (polygon)	.shp	GADM
Roads	Vector (polyline)	.shp	DCW
Violence (1989-2016)	Vector (point)	.csv	xSub/UCDP
Ethnic settlement patterns	Vector (polygon)	.shp	GeoEPR

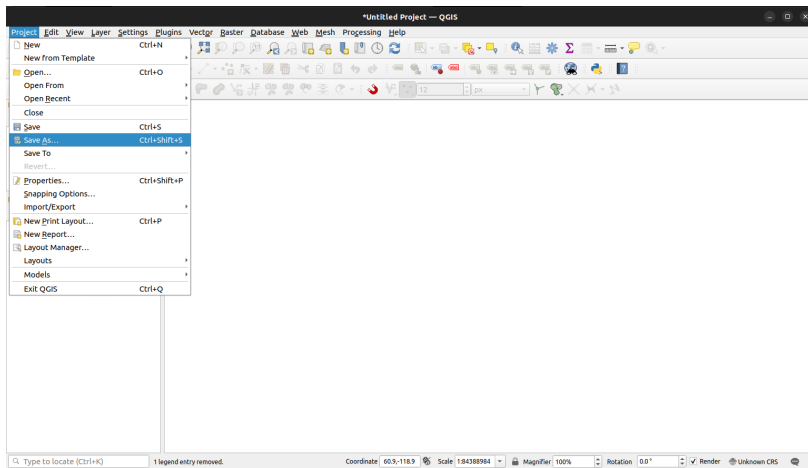
These are all in the PS02.zip file posted on Canvas.

Let's open QGIS...

QGIS

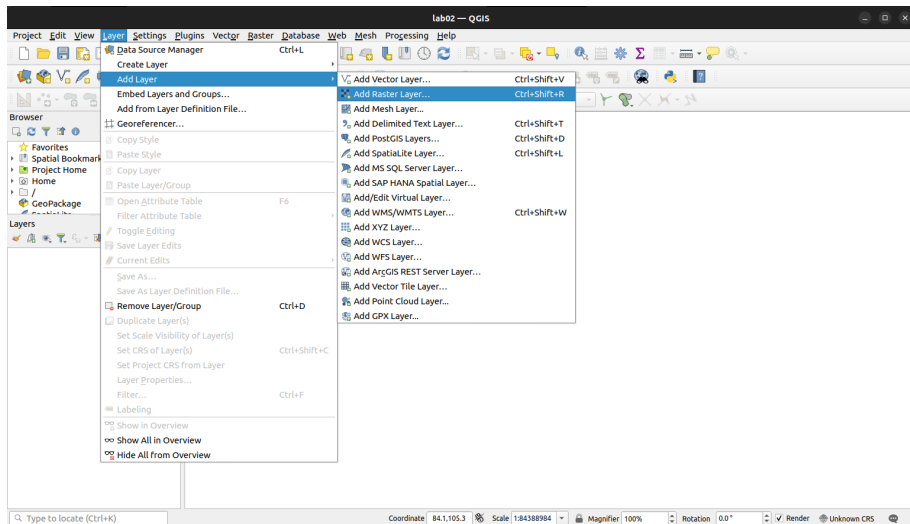
Save your progress!

Go to Project → Save As...



Map 1

Load elevation data: Layer → Add Layer → Add Raster Layer...



Press the ... button to select the file

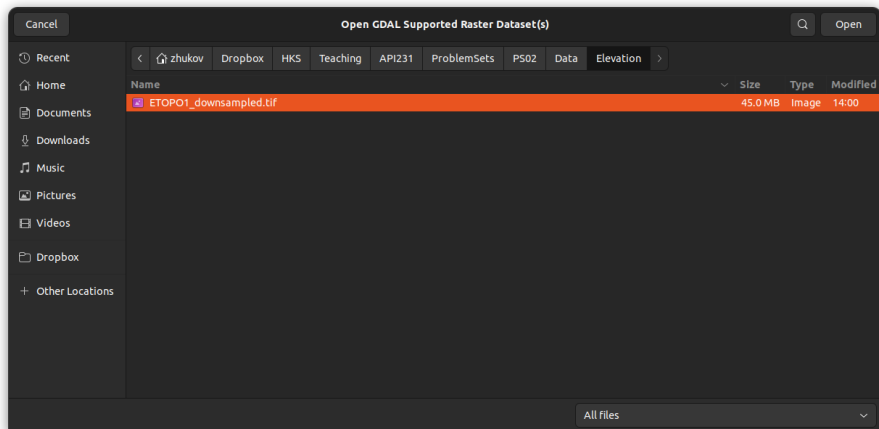
Source type

☒ File ☐ Protocol: HTTP(S), cloud, etc.

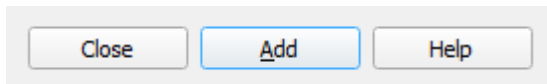
Source

Raster Dataset(s) 

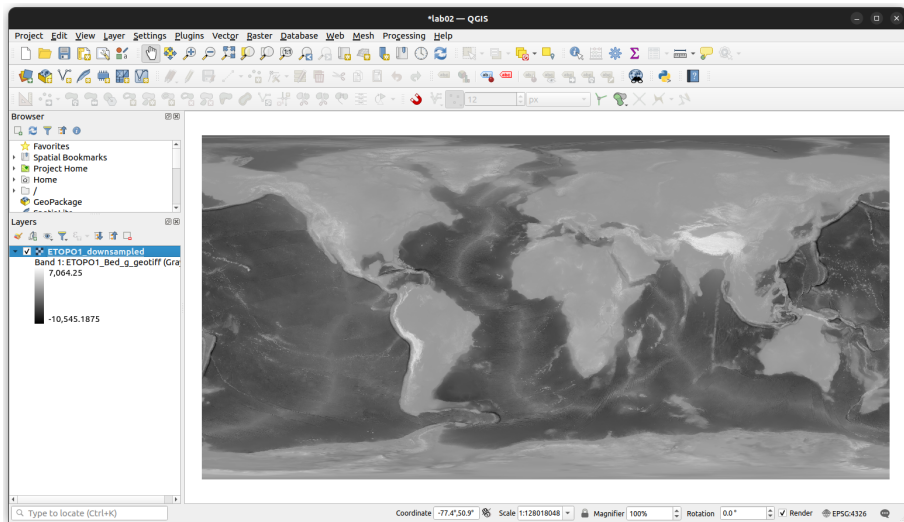
Navigate to ETOP01_downsampled.tif file in Data/Elevation/ folder, click Open



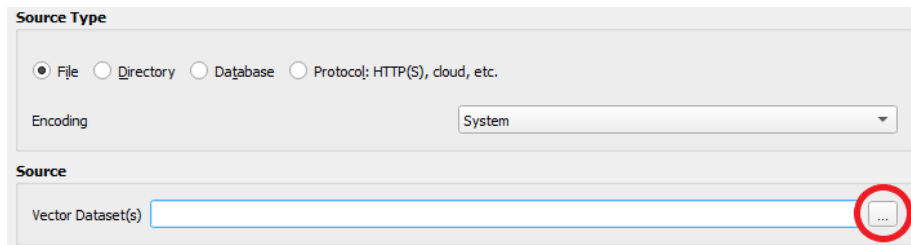
Click Add on next screen and go back to main window.



You should now see a global elevation raster



Load Afghanistan borders: Layer → Add Layer → Add Vector Layer...
Click ... in dialog box to select the file.



Source Type

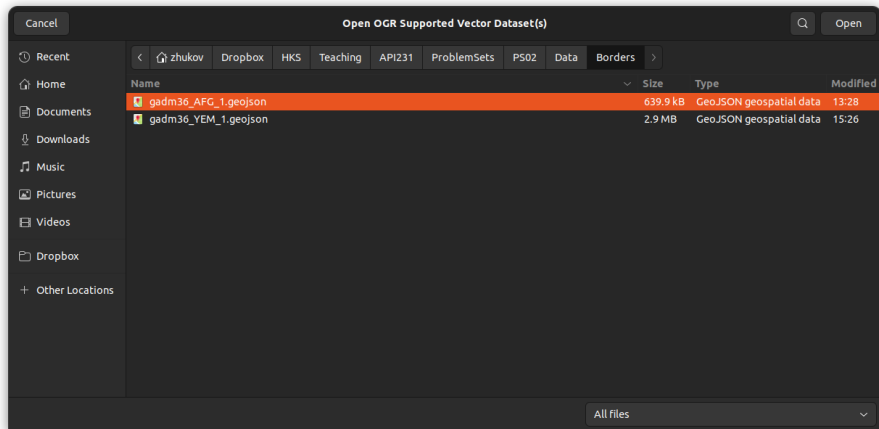
☒ File ☐ Directory ☐ Database ☐ Protocol: HTTP(S), cloud, etc.

Encoding System

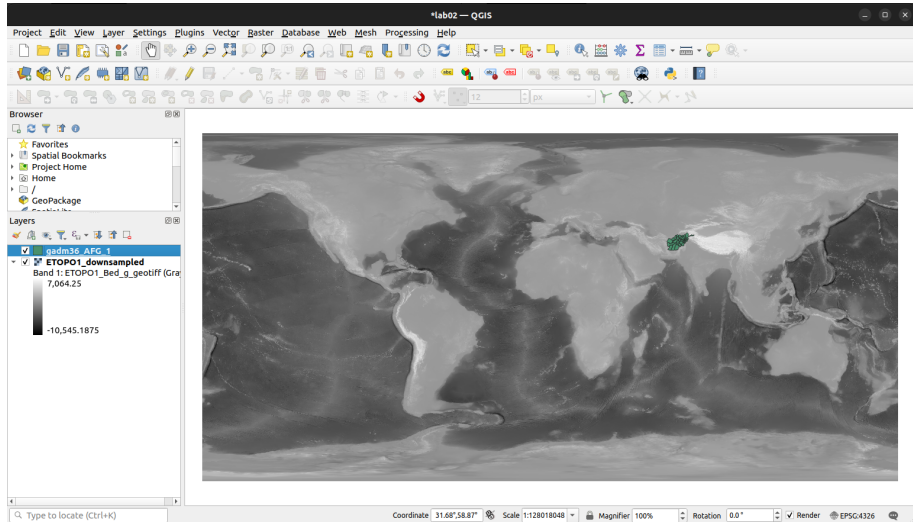
Source

Vector Dataset(s) ...

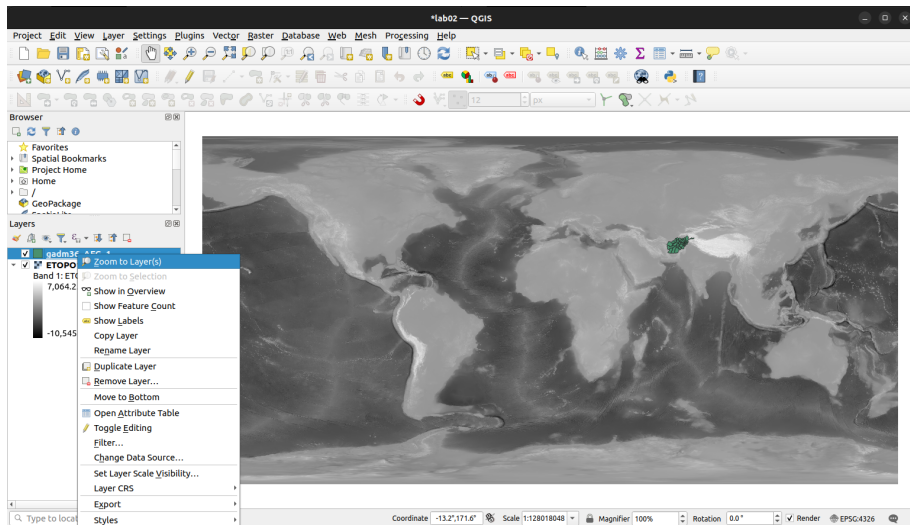
Navigate to `gadm36_AFG_1.geojson` in `Data/Borders/` folder.
Click `Open`, then `Add`



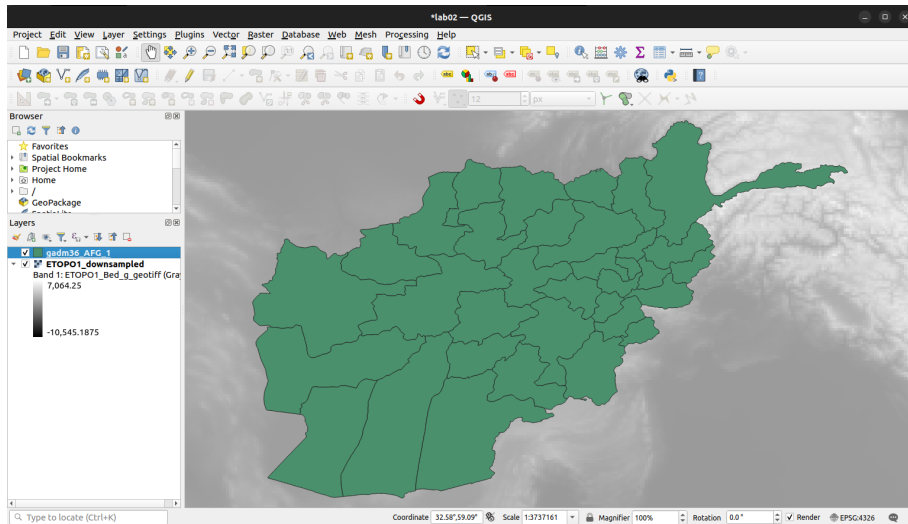
Afghanistan's borders should appear on the map. But they are hard to see



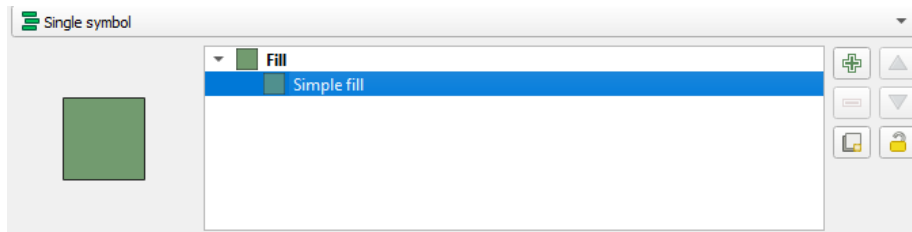
Right click on gadm36_AFG_1 in the layer menu. Click Zoom to Layer



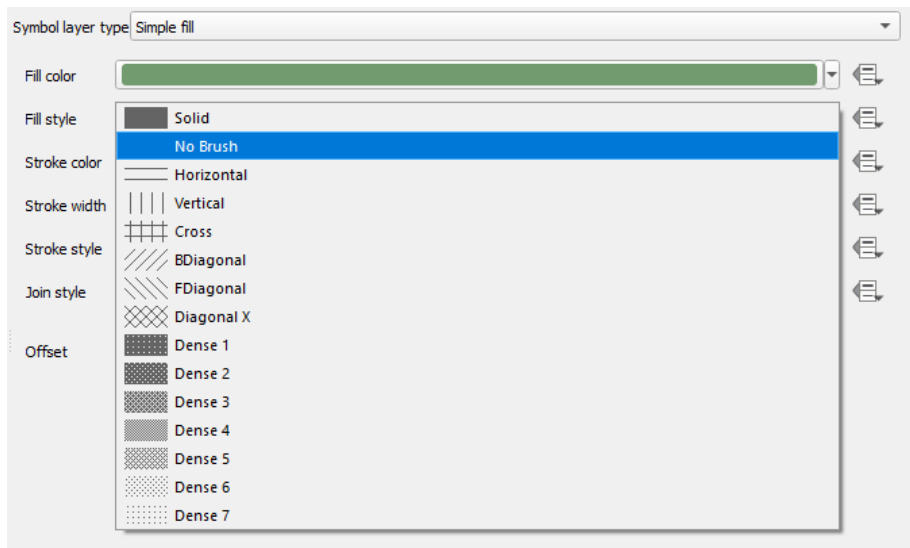
Now we can see Afghanistan, but the elevation layer is hidden behind it



Make polygons transparent: Right-click on gadm36_AFG_1 in layer menu, click on Properties. Highlight Simple fill in the symbology menu.



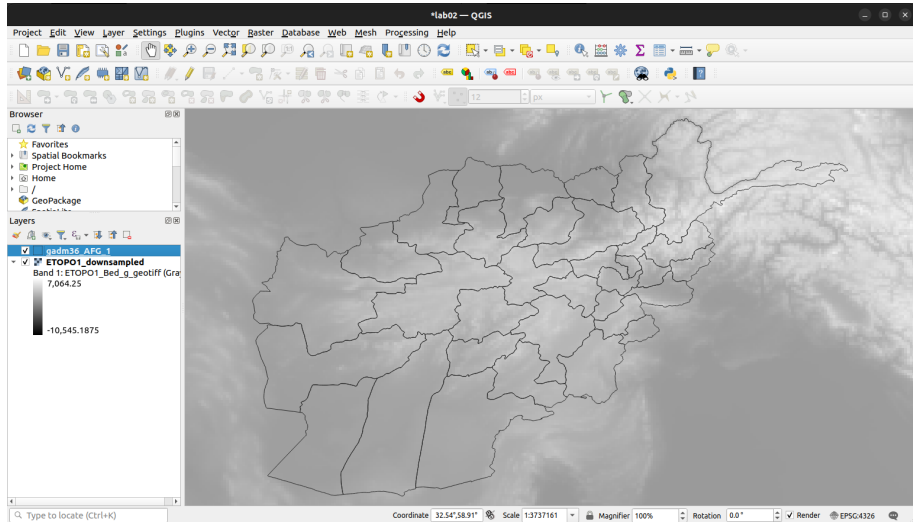
Select Fill style: No Brush



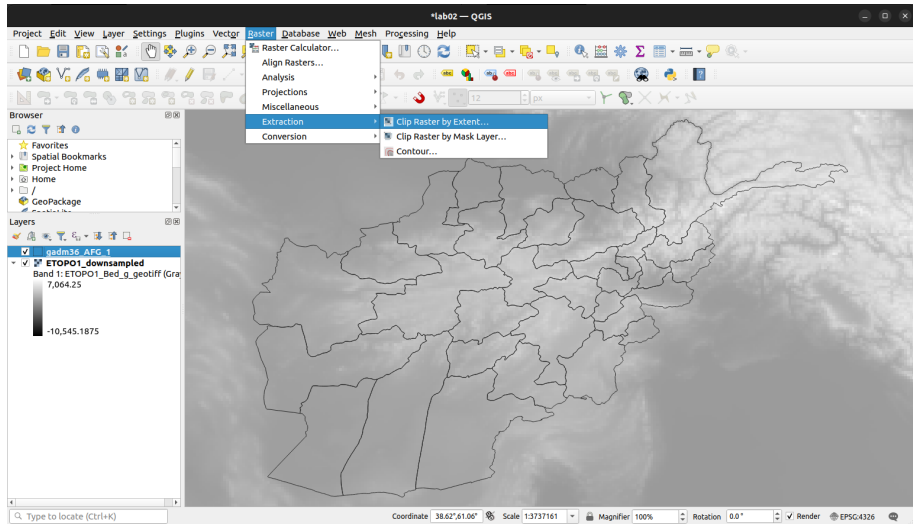
Click OK



The polygons should now be transparent, with provincial borders still visible.

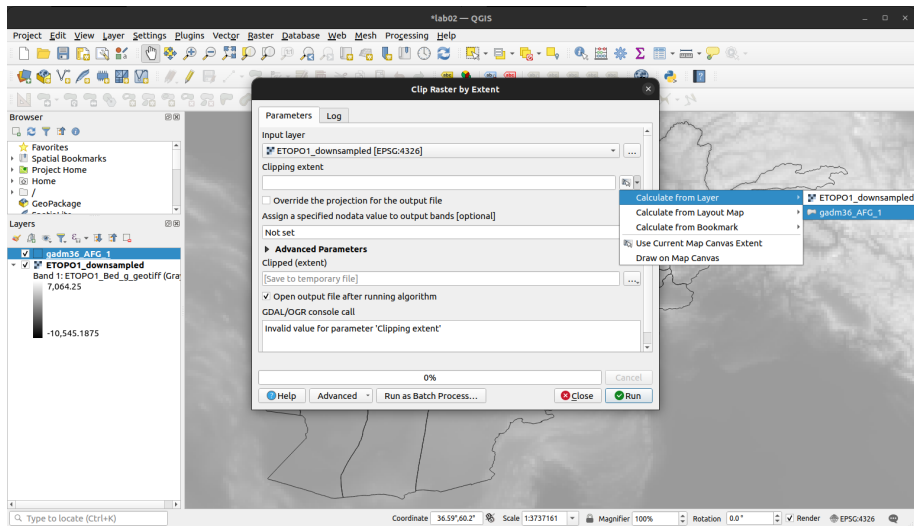


Let's drop the rest of the raster, keeping only the overlap with Afghanistan.
Clip raster: Raster → Extraction → Clip Raster by Extent...

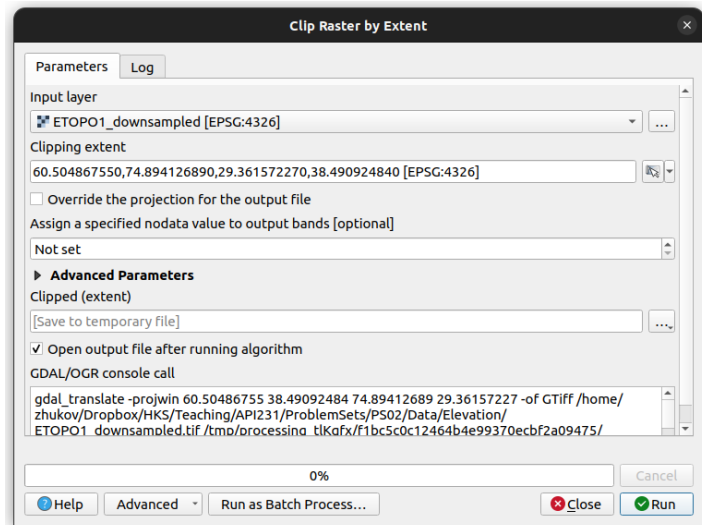


Set the Input layer as ETOPO1_downsampled.

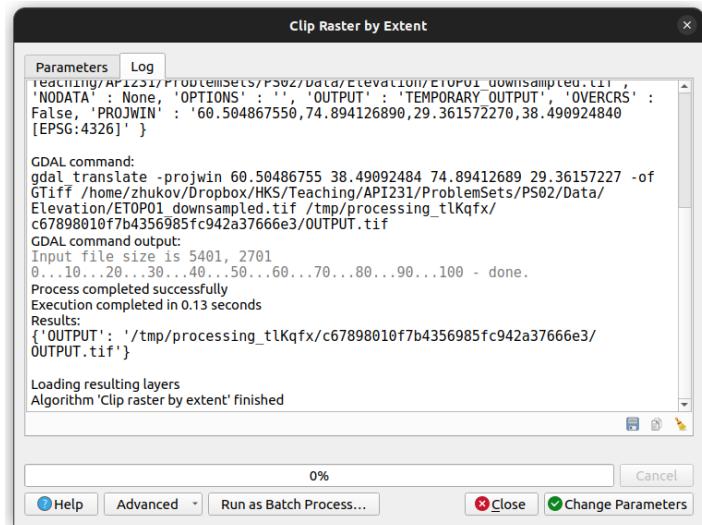
Click Clipping extent → Calculate from Layer → gadm36_AFG_1



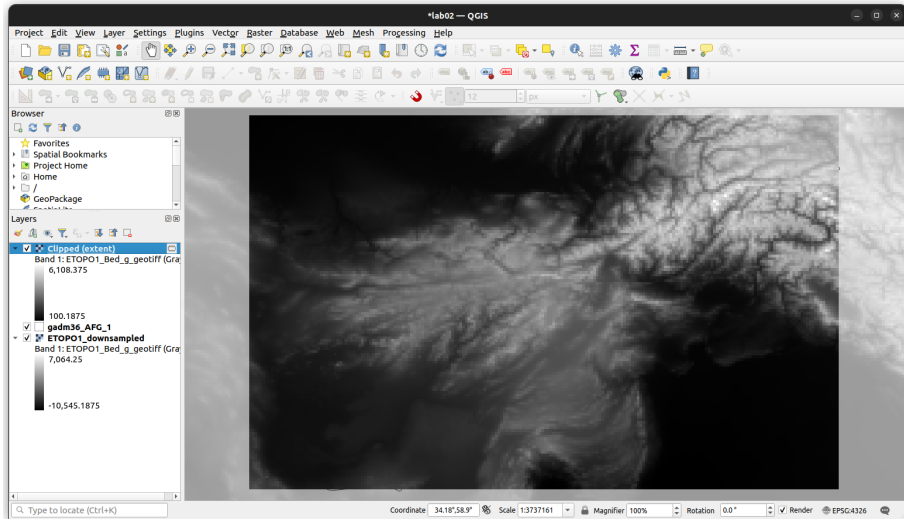
Click Run



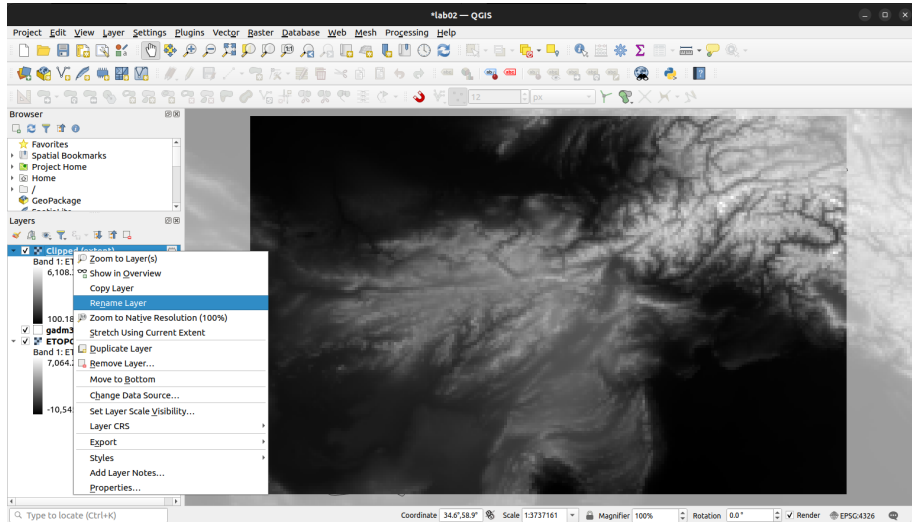
Check log to make sure there were no errors.



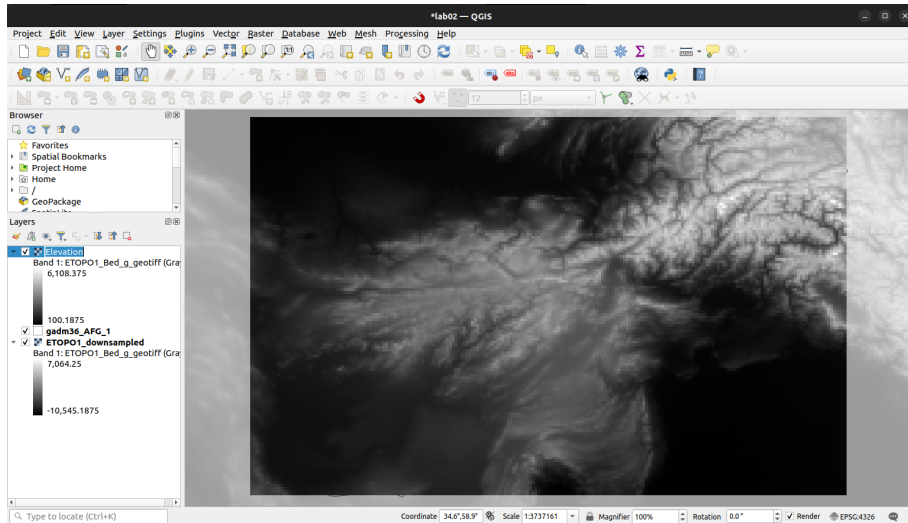
The output is a temporary raster dataset, clipped to extent of Afghanistan.



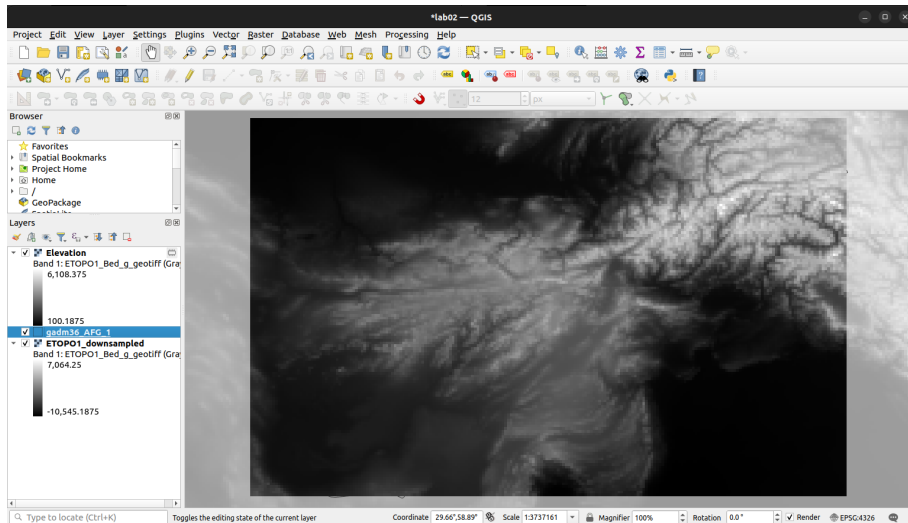
Rename the new layer to “Elevation”. Right click Clipped → Rename Layer



Change the name to Elevation

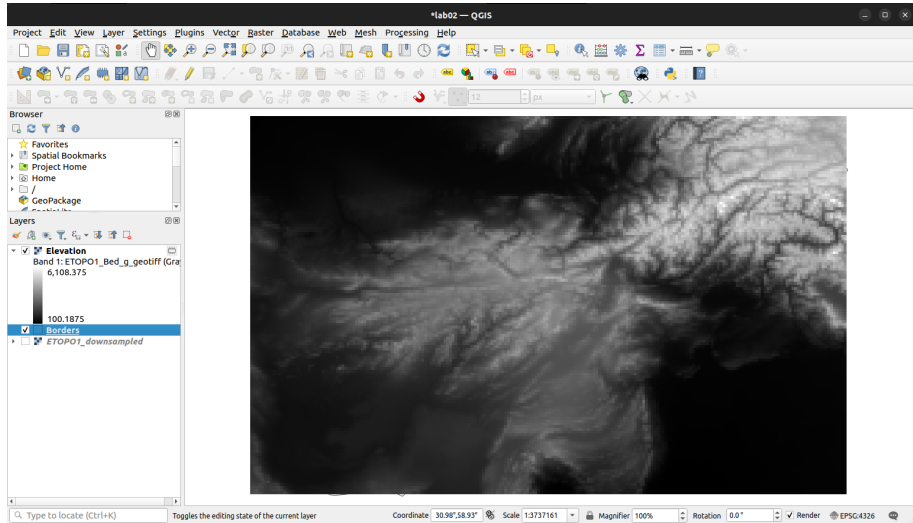


Let's do the same for gadm36_AFG_1

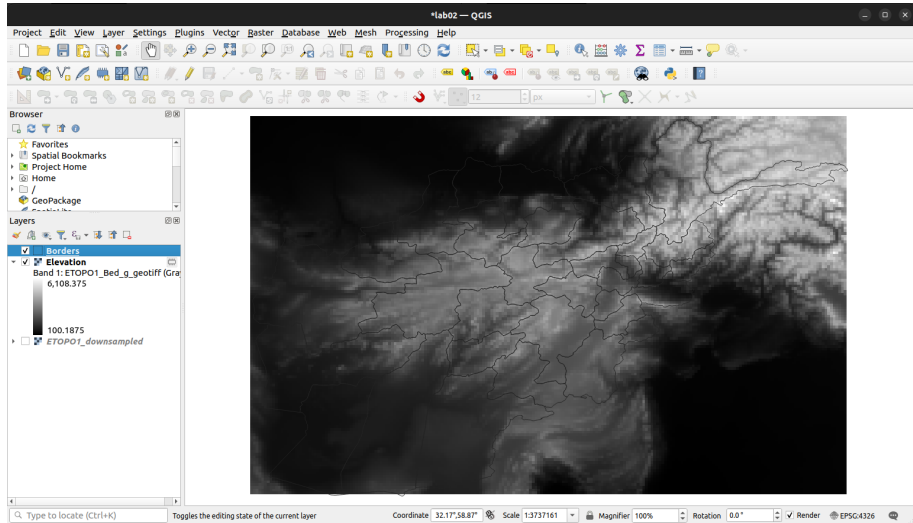


Change its name to Borders.

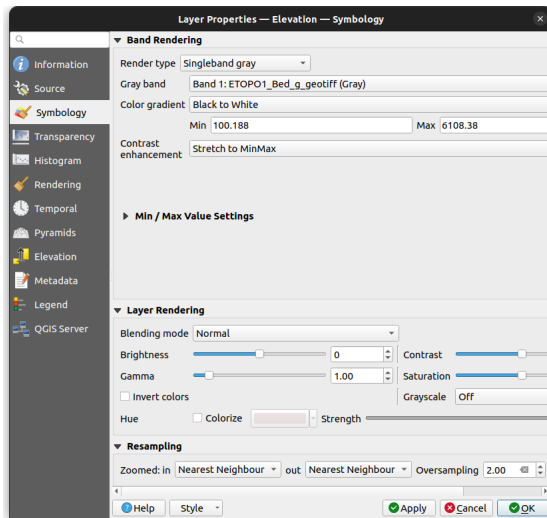
Also, un-check the box next to ETOPO1_downsampled to hide the big raster



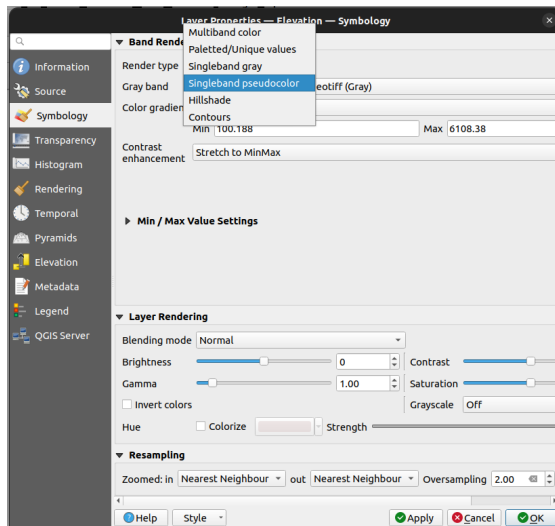
Change plot order. Drag Borders above Elevation in Layer menu.
Borders should now be (faintly) visible above elevation layer.



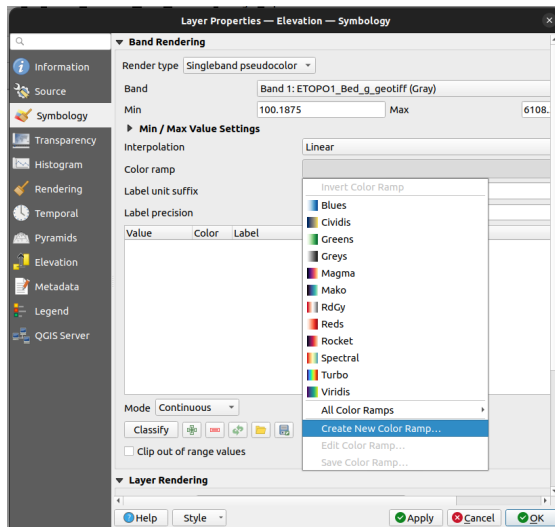
Change raster color. Right click Elevation → Properties.
Click on the menu next to Render type



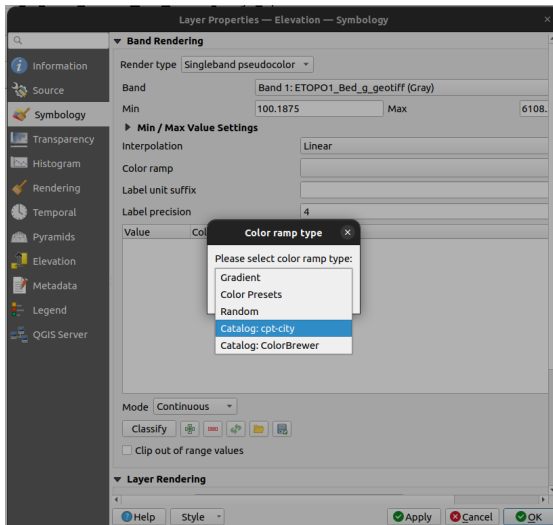
Select Render type: Singleband pseudocolor



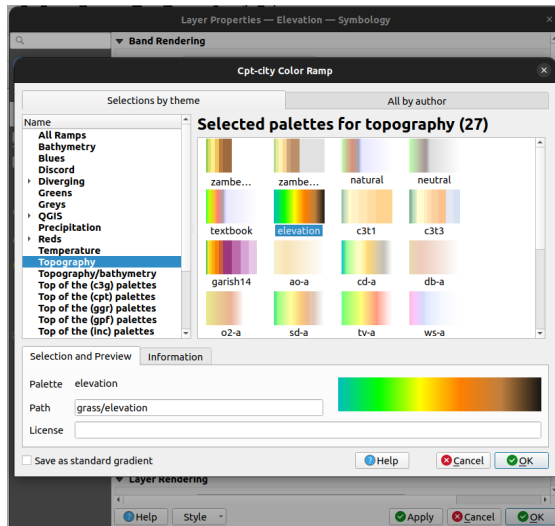
Click menu button next to Color ramp → Create New Color Ramp...



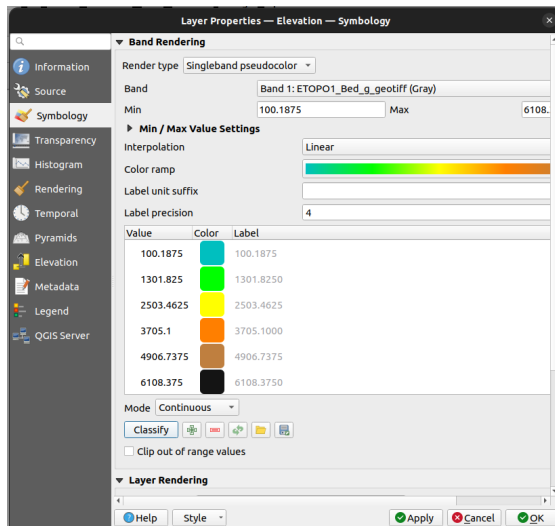
Select Catalog: cpt-city as color ramp type



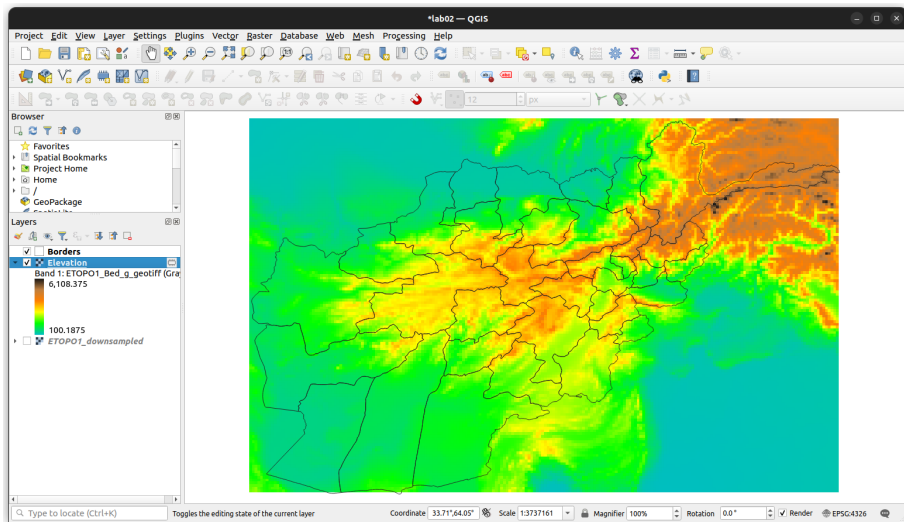
This will open a window with a lot of color themes.
Select Topography → elevation. Click OK



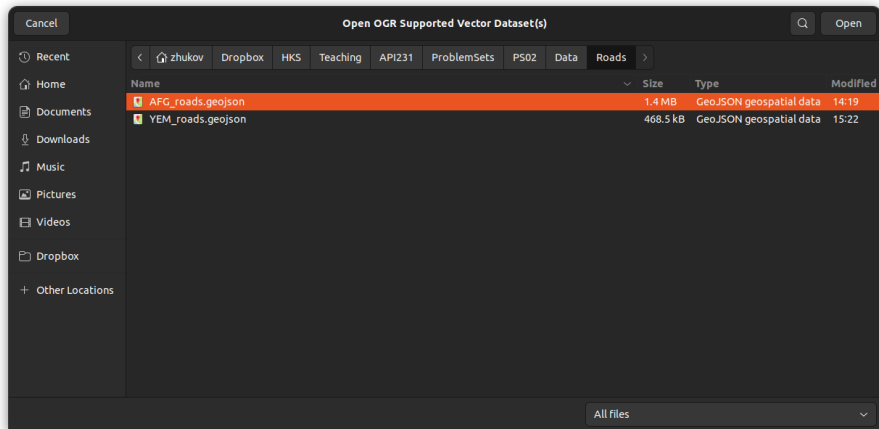
Click Classify button, then OK



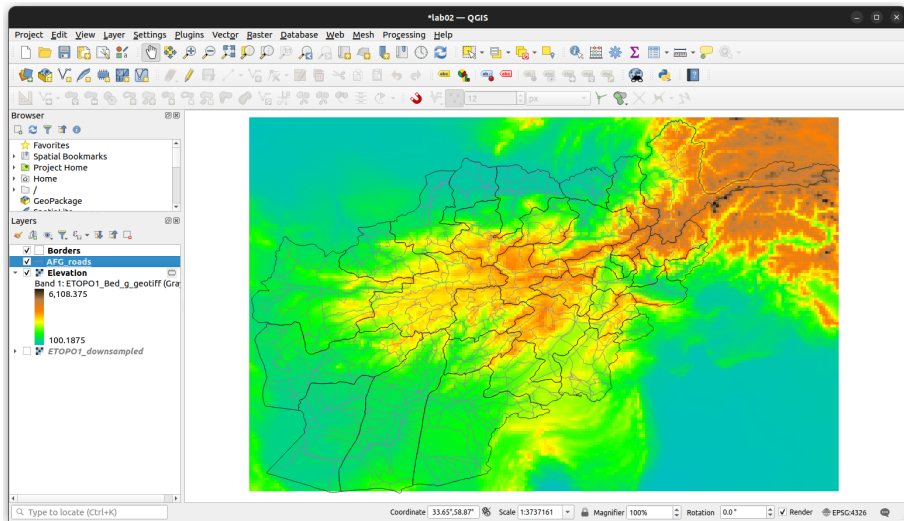
The elevation layer should now appear in blue-green-brown



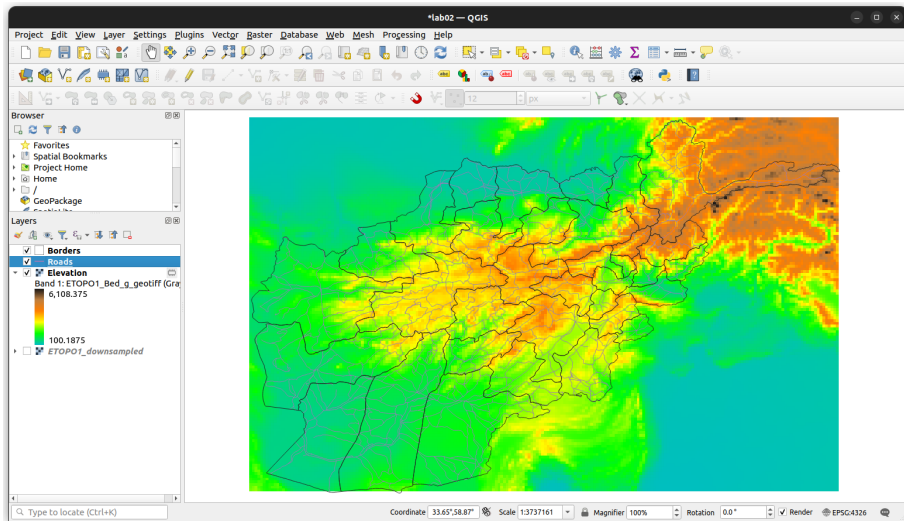
Add roads layer. Same Add Layer procedure as for borders. Open AFG_roads.geojson from Data/Roads/ folder



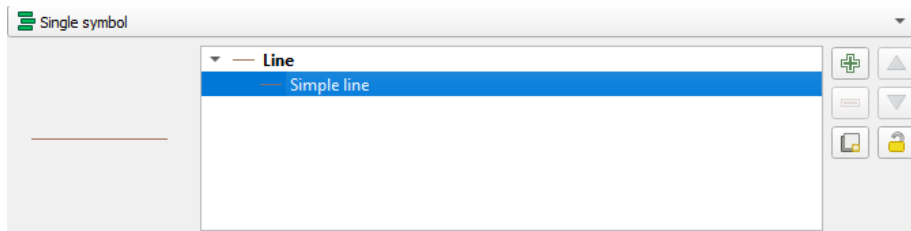
You should see the AFG_roads layer on the map



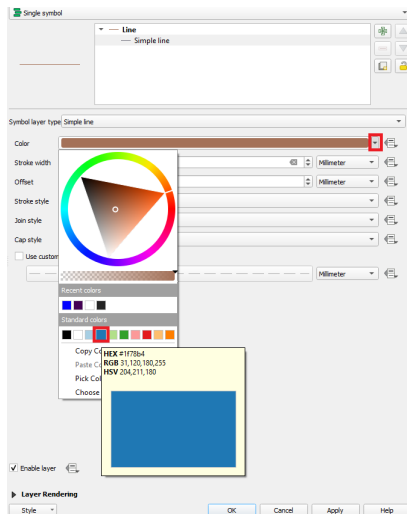
Change layer's name from AFG_roads to Roads



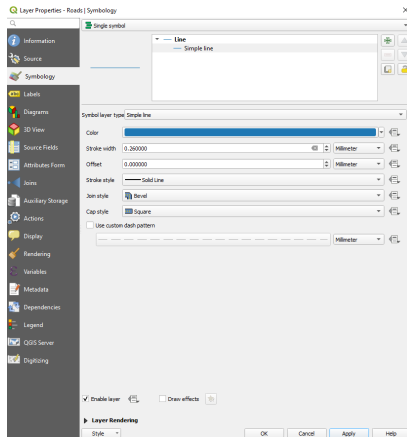
Change color to blue. Right click on Roads → Properties.
Highlight Simple line in Symbology menu



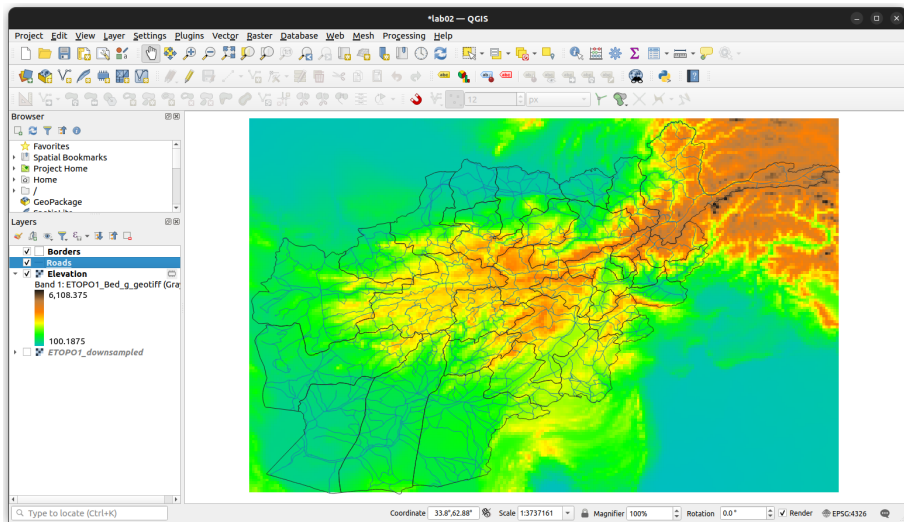
Click menu button next to Color. Select blue from Standard colors list



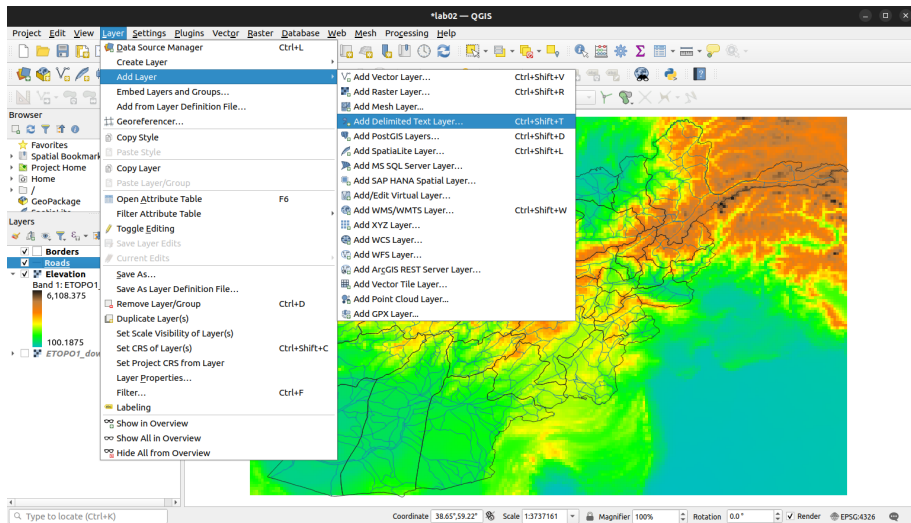
Click Apply or OK



The roads should appear in blue



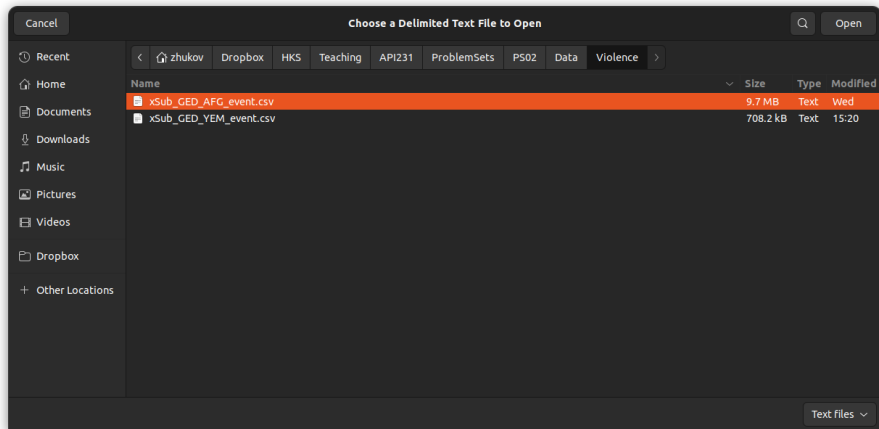
Add violence data. Layer → Add Layer → Add Delimited Text Layer...



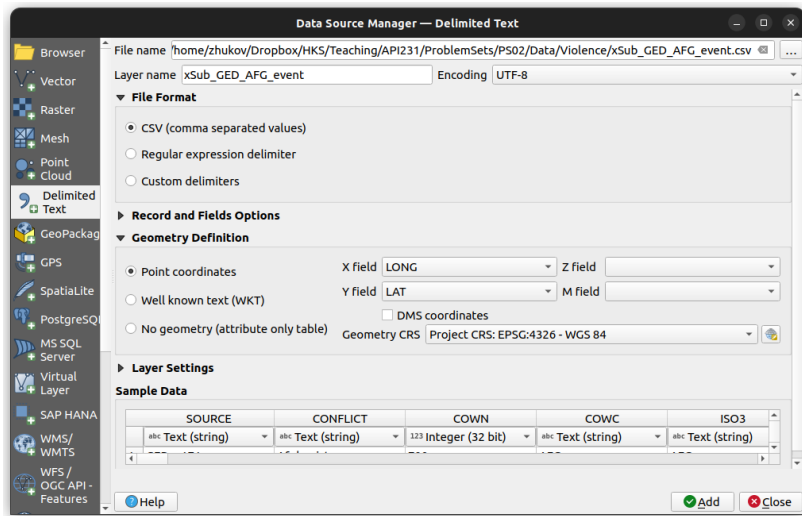
Click ... button next to File name dialog

File name 

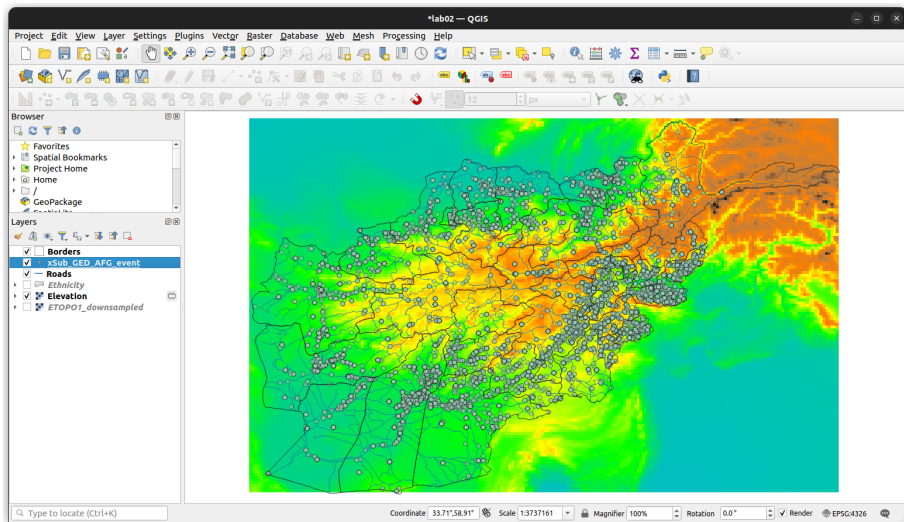
Navigate to `xSub_GED_AFG_event.csv` in `Data/Violence/` menu.
Click `Open`



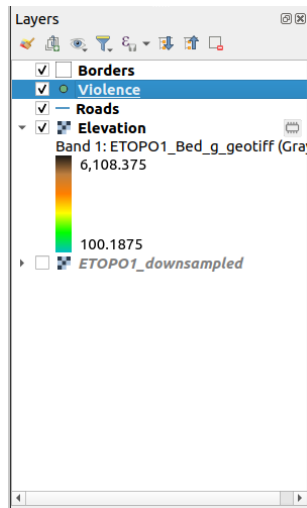
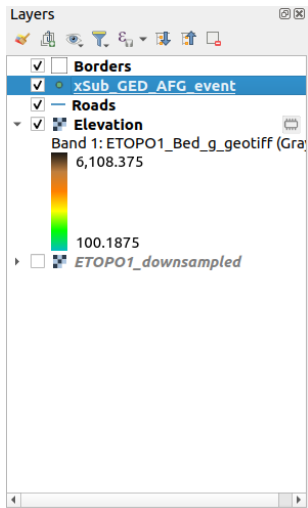
Under Geometry Definition, set X field = LONG and Y field = LAT.
Click Add



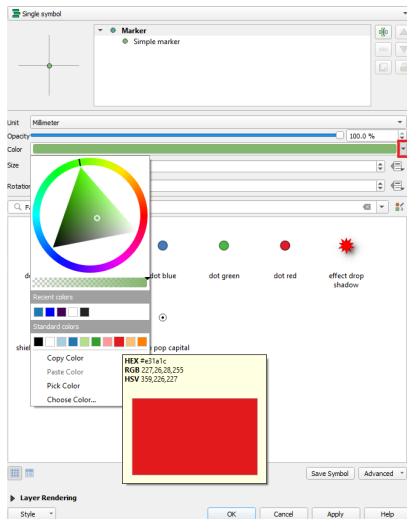
You should now see about 30,000 violent events on the map



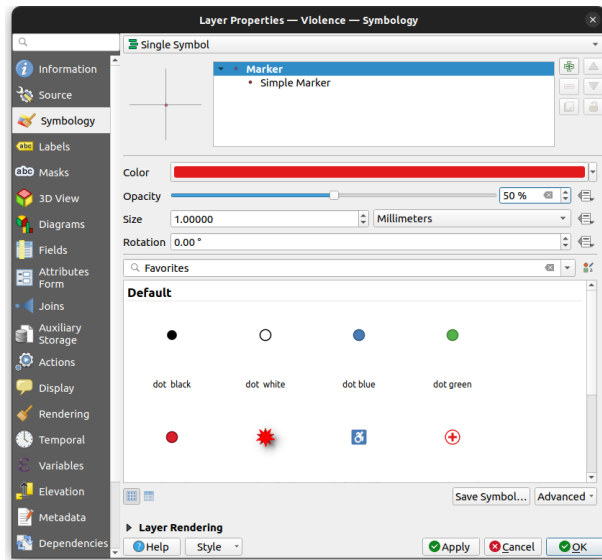
Change layer's name to Violence



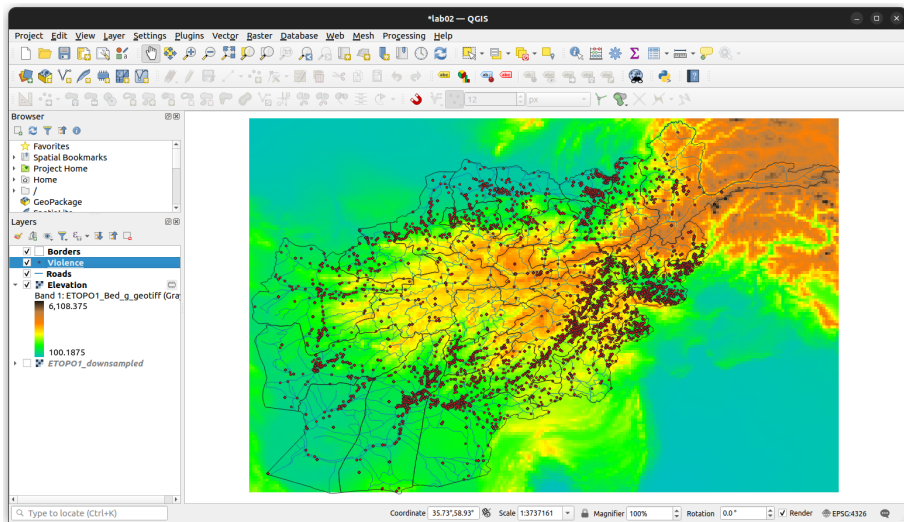
Change layer's color. Right click → Properties. Click menu button next to Color. Select red color in Standard colors



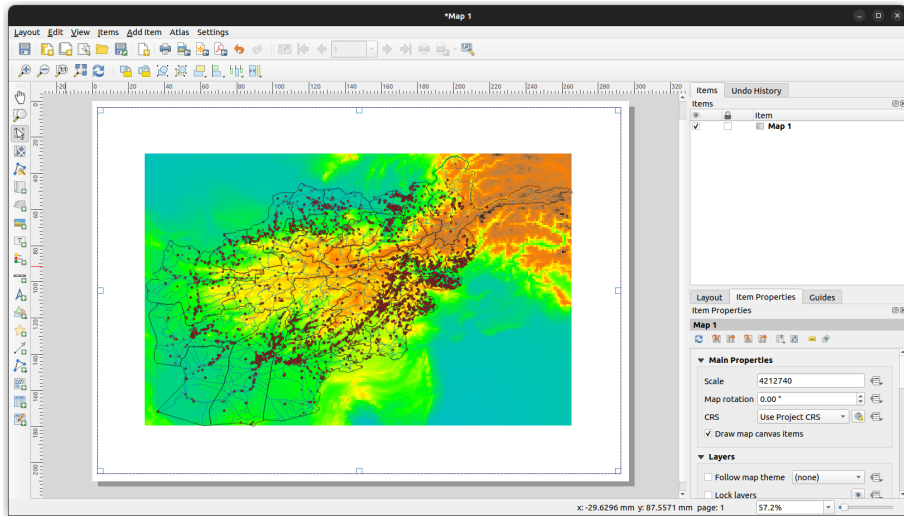
Make points smaller and translucent. Set $\text{Opacity} = 50\%$ and $\text{Size} = 1.0$



The points should now be smaller and redder.

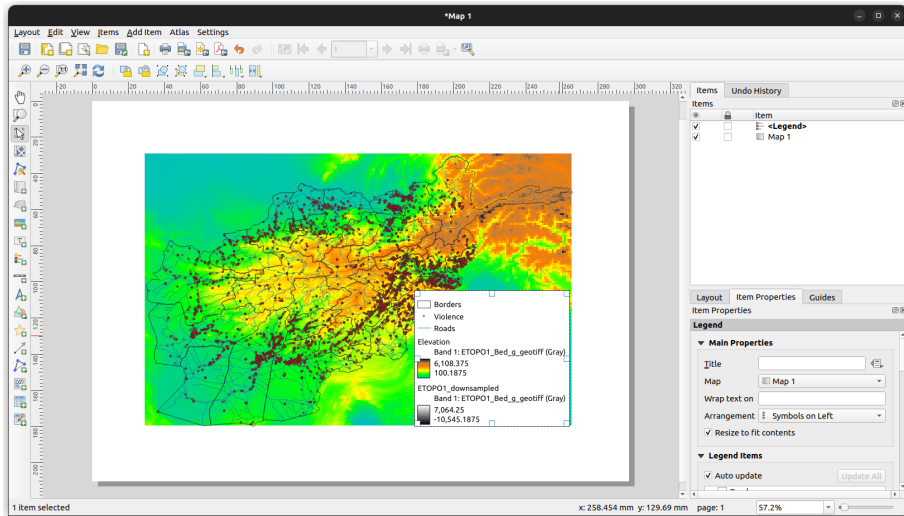


Export the map to image. Project → New Print Layout.
Place map on layout, with Add Item → Add Map

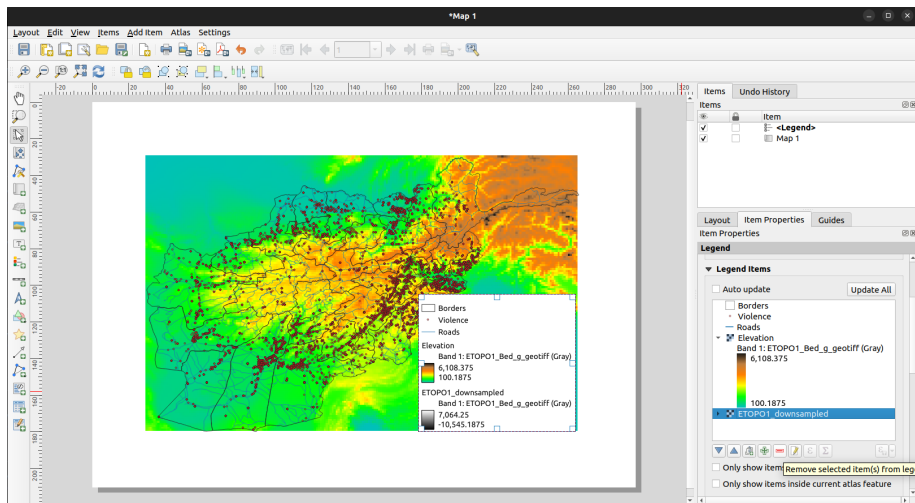


Add legend with Add Item → Add Legend.

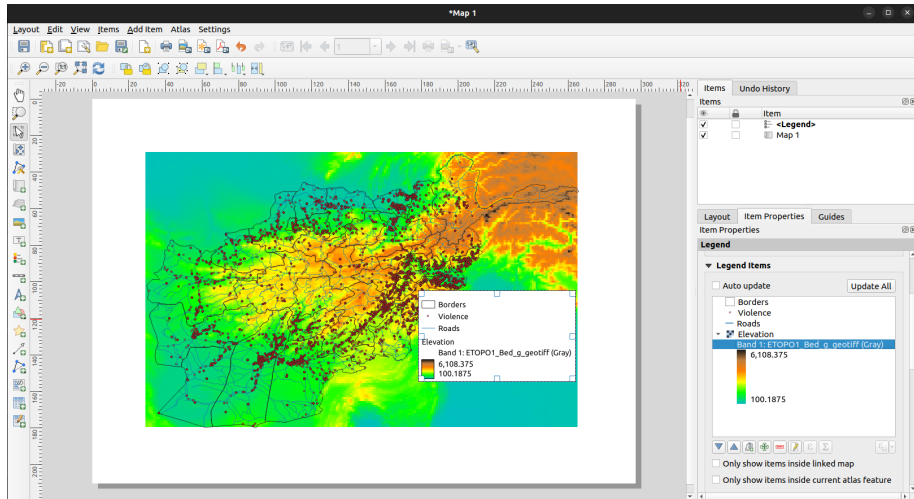
The legend includes an item we need to remove (ETOP01_downsampled)



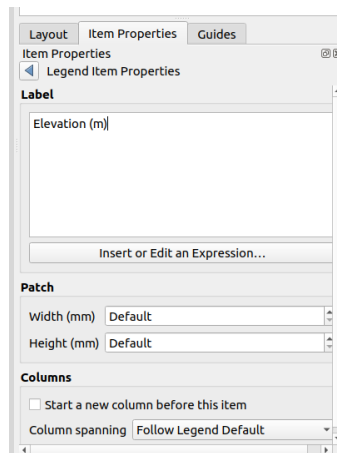
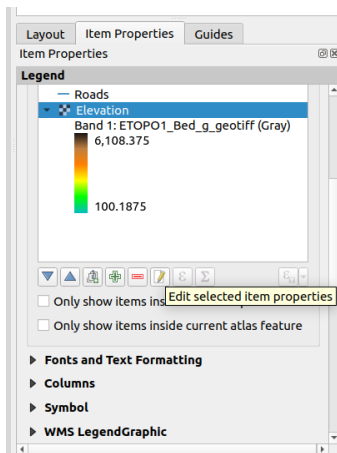
To remove this item, highlight the legend, go to Item Properties. Un-check the Auto update box under Legend Items. Highlight ETOP01_downsampled and click on the red “—” button to remove it



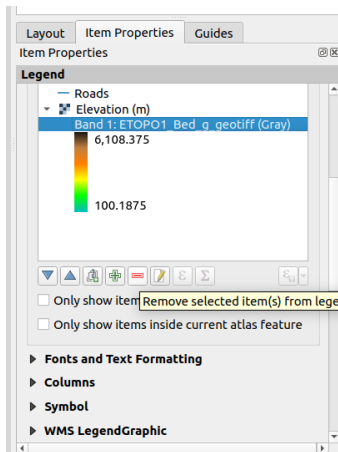
The ETOP01_downsampled item should now disappear from the legend.



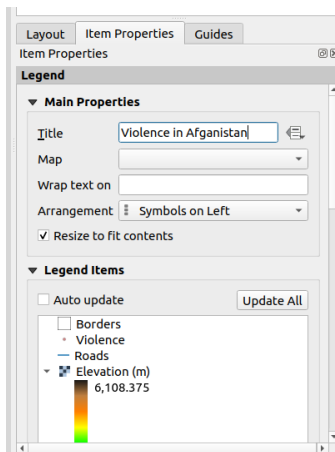
Edit layers' names in legend. Highlight **Elevation** and click on the **Edit** button (pencil and paper icon). Change text to “Elevation (m)”



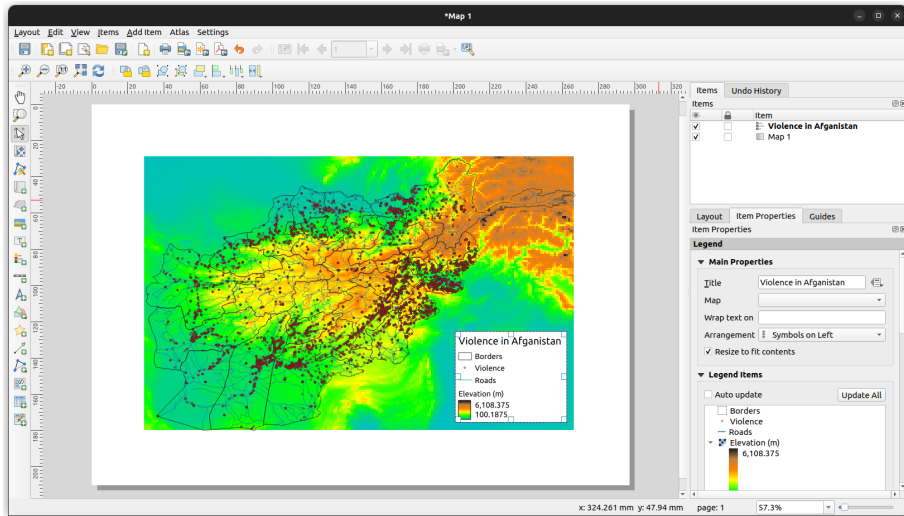
Let's also remove the band information from the legend. Highlight Band 1: ETOPO1_Bed_g_geotiff (Gray), click the “-” button to remove it.



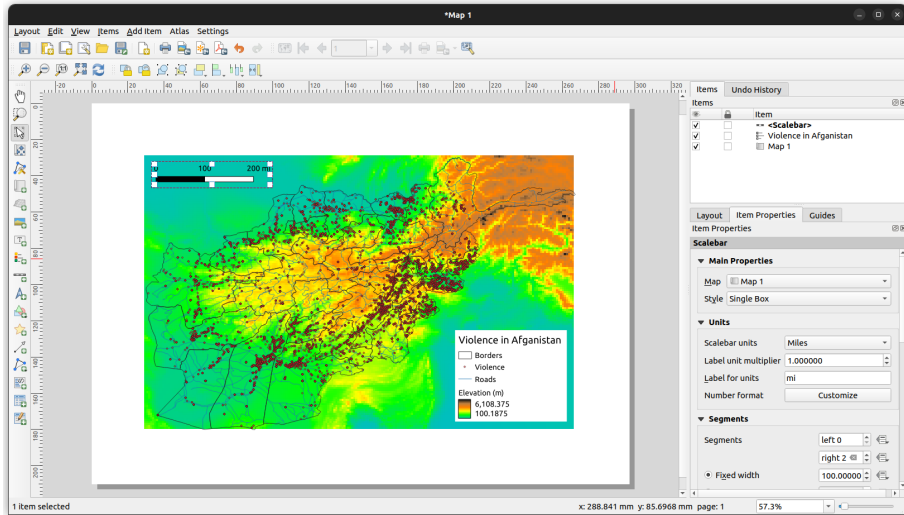
Change legend Title to “Violence in Afghanistan” in Item Properties



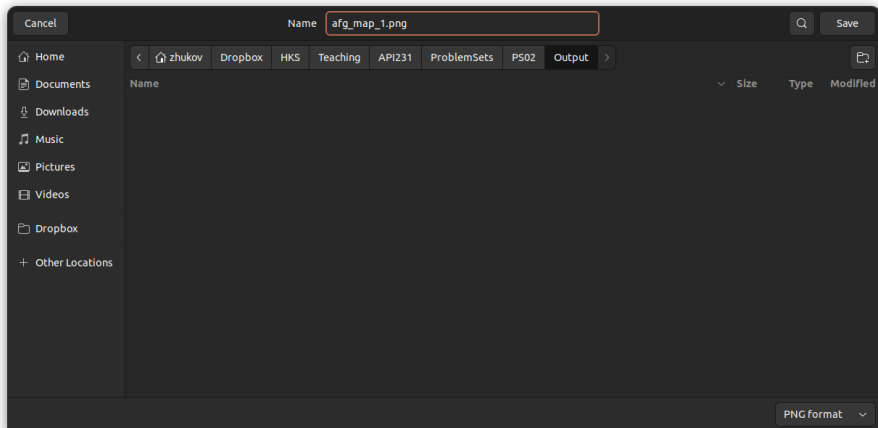
The legend should now look something like this



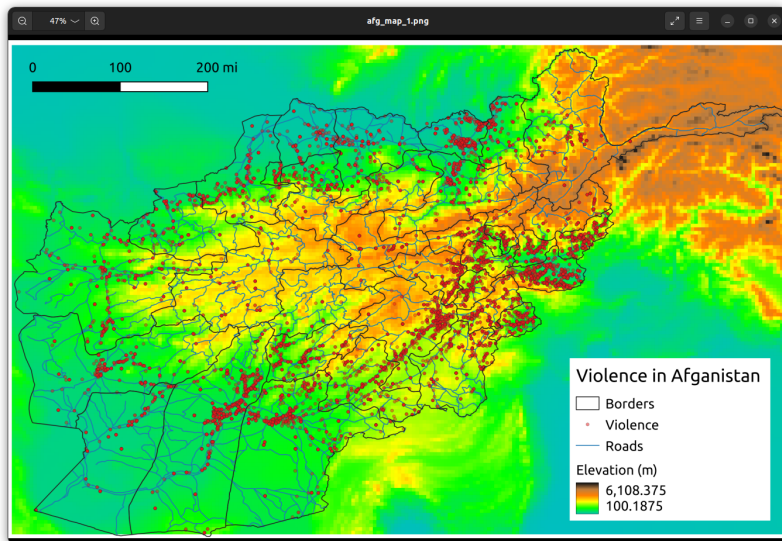
Add scale bar. Change Scalebar units to Miles



Export to file. Layout menu → Export as Image.... Name it afg_map_1.png

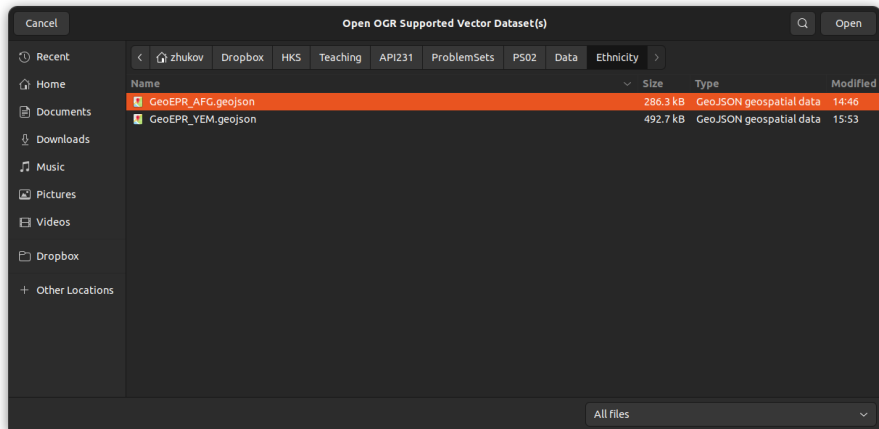


The output file should look like this.

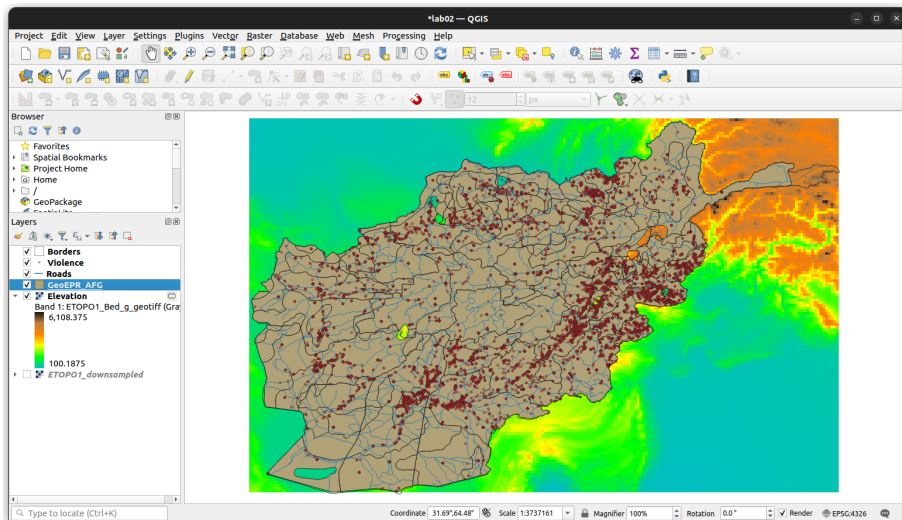


Map 2

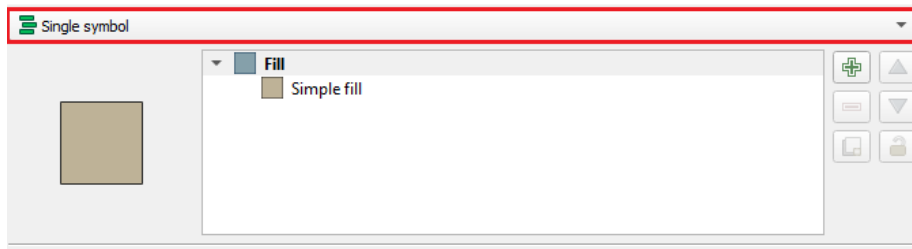
Load ethnicity data. Add (as vector layer) GeoEPR_AFG.geojson from Data/Ethnicity/ folder



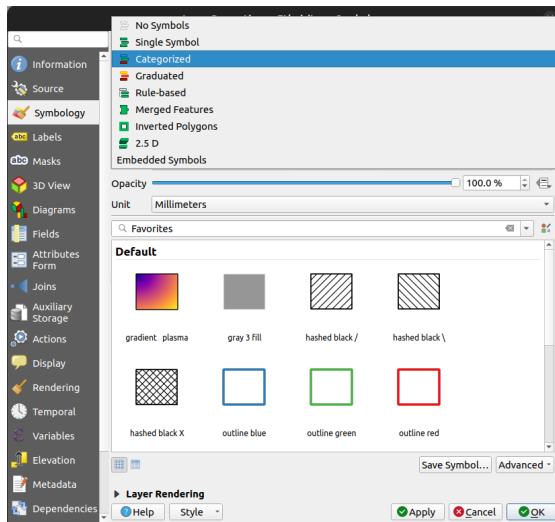
Load ethnicity data. Add (as vector layer) GeoEPR_AFG.geojson from Data/Ethnicity/ folder. This will add a new polygon layer to the map. Change its name from GeoEPR_AFG to Ethnicity



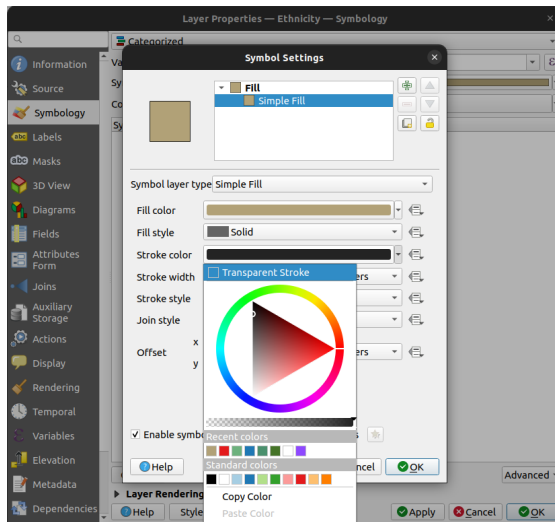
Open the layer's Properties. Click on Single symbol in Symbology menu



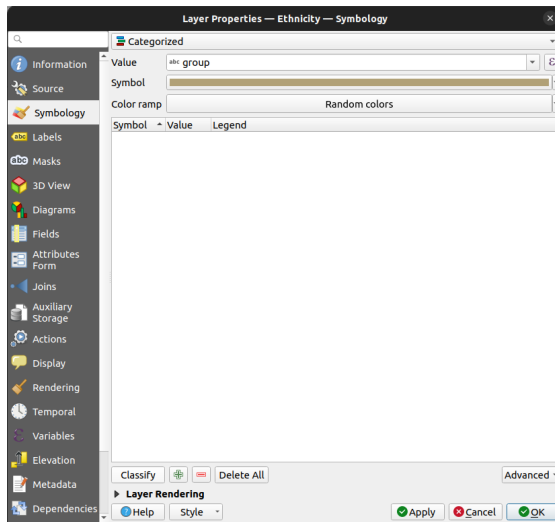
Change symbol type from Single symbol to Categorized



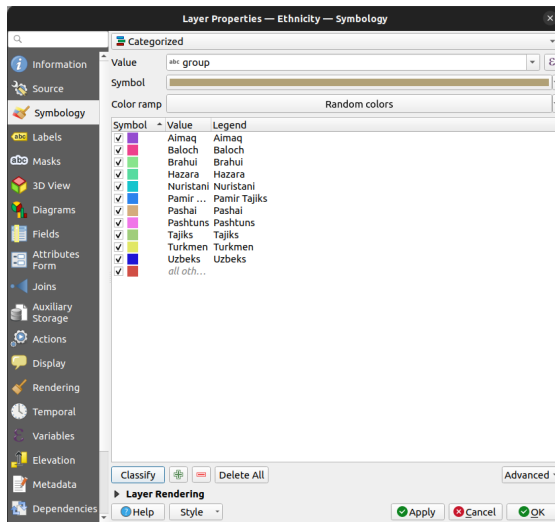
Make polygon boundaries transparent. Click on menu button next to Stroke color → check Transparent Stroke box



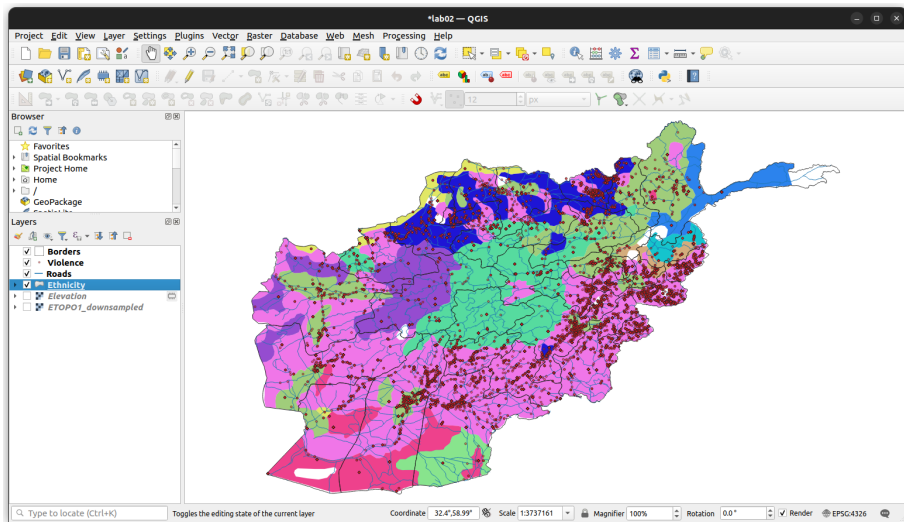
Select Value = group



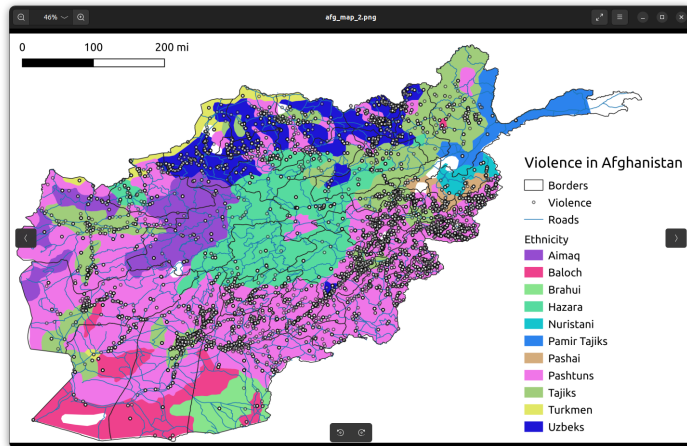
Click on Classify button, then Apply or OK



Each ethnic group's polygon should appear as a different color



Create a new map layout and export it as `afg_map_2.png`. You can do it



Problem Set 2

Your assignment (if using QGIS):

- create the same kind of “violence and ethnicity” map for Yemen
- use these files:
 - GeoEPR_YEM.geojson
 - xSub_GED_YEM_event.csv
 - gadm36_YEM_1.geojson
- follow the same steps as for “Map 2” above
- name it yem_map_2.png
- upload map to Canvas (by next Wednesday)

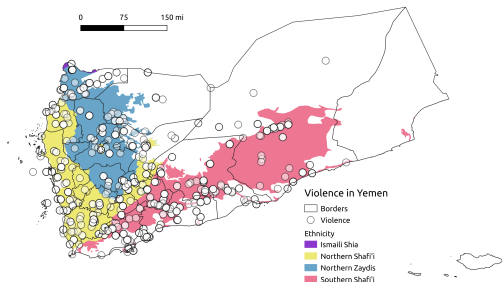


Figure 7: Can you make this map?

R

Loading R packages

To implement these steps in R, we will be using two packages:

- `sf` ("simple features", to handle spatial vector data)
- `terra` (to handle raster data, like Elevation)

```
library(sf)
library(terra) # NEW!
```

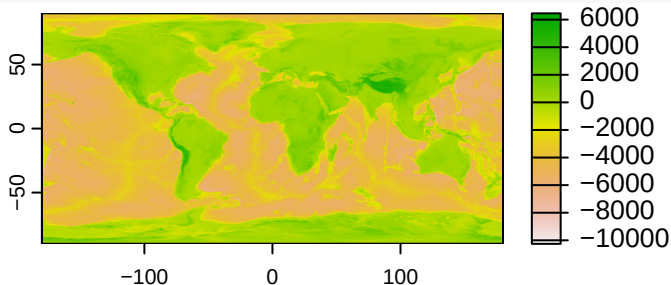
NOTE: The code to produce Map 1 and Map 2 in R is in `ps02_demo.R` on RStudio Cloud, and in `PS02.zip` (posted on Canvas).

Map 1

Loading spatial data

Let's load the *elevation raster* into R, using the `rast()` command from `terra`:

```
elevation_global = terra::rast("Data/Elevation/ETOP01_downsampled.tif")  
plot(elevation_global)
```



Let's load the *provincial boundaries* and *roads* into R, using `sf::read_sf()`:

```
borders = sf::read_sf("Data/Borders/gadm36_AFG_1.geojson")  
roads = sf::read_sf("Data/Roads/AFG_roads.geojson")  
plot(borders["geometry"])  
plot(roads["geometry"])
```

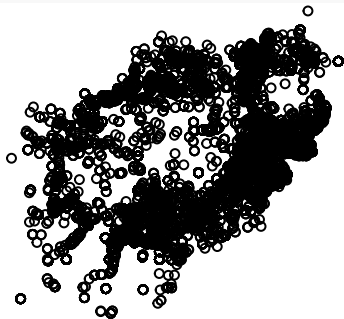


Let's load the *violence data* into R, using `read.csv()`:

```
violence = read.csv("Data/Violence/xSub_GED_AFG_event.csv")
```

To convert this table into a spatial object, we will use the `sf::st_as_sf()` command, specifying columns corresponding to geographic coordinates (LONG, LAT), and copying the CRS from the borders object:

```
violence = sf::st_as_sf(violence, coords=c("LONG", "LAT"))  
sf::st_crs(violence) = sf::st_crs(borders)  
plot(violence["geometry"])
```



Clipping the raster to Afghanistan's extent

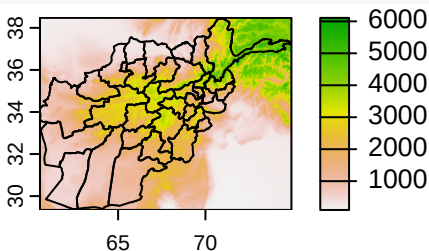
R's equivalent of QGIS's Clip Raster by Extent... command is the following:

1. Create a rectangular polygon corresponding to the extent of the borders
 - `sf::st_bbox()` finds the spatial extent of a layer
 - `sf::st_as_sfc()` converts the extent object into a polygon

```
extent_afg = sf::st_as_sfc(sf::st_bbox(borders))
```

2. Crop the raster by this new polygon, using `terra::crop()`

```
elevation = terra::crop(elevation_global, extent_afg)  
plot(elevation); plot(borders["geometry"], add=TRUE)
```



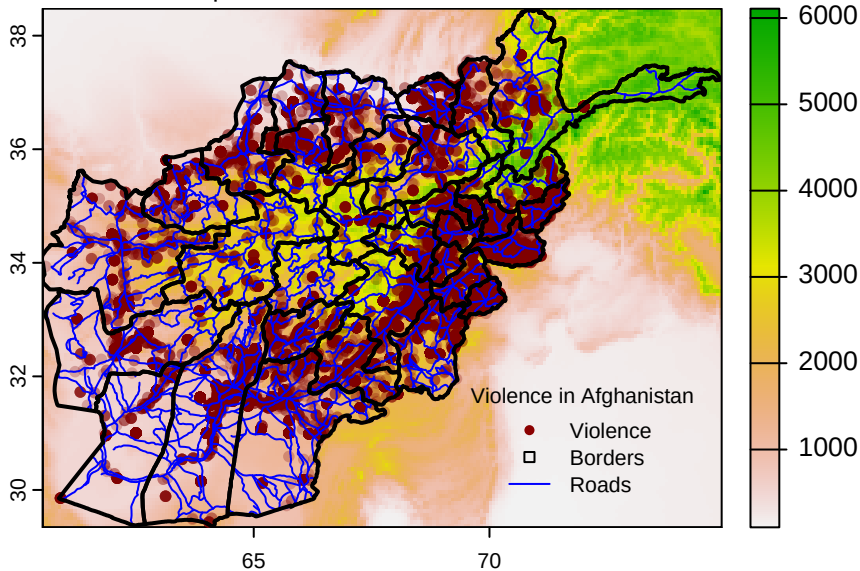
Plotting Map 1

To create the map, we will execute the following commands in sequence:

- set margins, `par()`
- draw elevation layer, `plot()` (note different syntax for rasters vs. vectors)
- add violence (translucent dark red points)
- add borders, roads (adjusting thickness, color)
- add `legend()` (specify x and y coordinates for top-left corner of legend)

```
par(mar=c(2,2,.5,.5))
plot(elevation)
plot(violence["geometry"],
plot(borders["geometry"],add=T,lwd=2)
plot(roads["geometry"],add=T,col="blue")
  col=rgb(red = .5,green = 0,blue = 0,alpha = .25),pch=16, add=T)
legend(x=70.5,y=31.5,legend=c("Violence","Borders","Roads"),
  pch=c(16,0,NA),lwd=c(NA,NA,1),col=c("darkred","black","blue"),
  title="Violence in Afghanistan",bty="n")
```

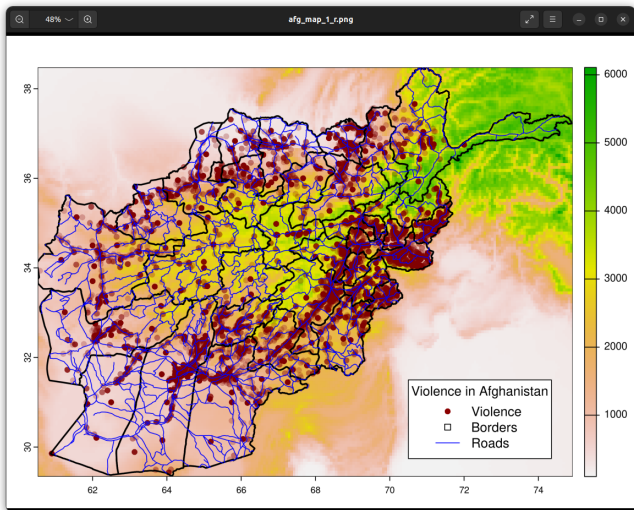
Here's what the plot should look like:



Exporting Map 1 to image file

To save the map, we will use the `png()` and `dev.off()` commands, as in PS01:

```
png("Output/afg_map_1_r.png",width = 8,height = 6,  
    units = "in",res = 300)  
par(mar=c(2,2,.5,.5))  
plot(elevation)  
plot(violence["geometry"],  
plot(borders["geometry"],add=T,lwd=2)  
plot(roads["geometry"],add=T,col="blue")  
    col=rgb(red = .5,green = 0,blue = 0,alpha = .25),pch=16, add=T)  
legend(x=70.5,y=31.5,legend=c("Violence","Borders","Roads"),  
    pch=c(16,0,NA),lwd=c(NA,NA,1),col=c("darkred","black","blue"),  
    title="Violence in Afghanistan",bty="n")  
dev.off()
```



The output file should look like this.

Map 2

Loading ethnicity data

Let's load the *ethnic settlements data* into R, using `sf::read_sf()`:

```
ethnicity = sf::read_sf("Data/Ethnicity/GeoEPR_AFG.geojson")  
plot(ethnicity["geometry"])
```

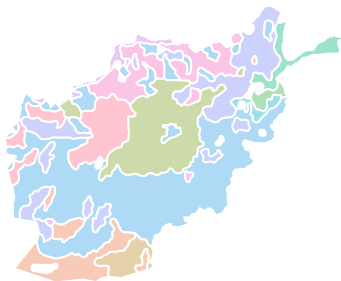


Plotting Map 2

Let's begin by creating a vector of colors, corresponding to the group column:

```
groups = as.factor(ethnicity$group)
n = length(unique(groups))
cols = hcl.colors(n,palette="Pastel 1")[groups]
plot(ethnicity["group"],col=cols,border="white")
```

group



To see what other color palettes are available in `hcl.colors()`, see `hcl.pals()`:

`hcl.pals()`

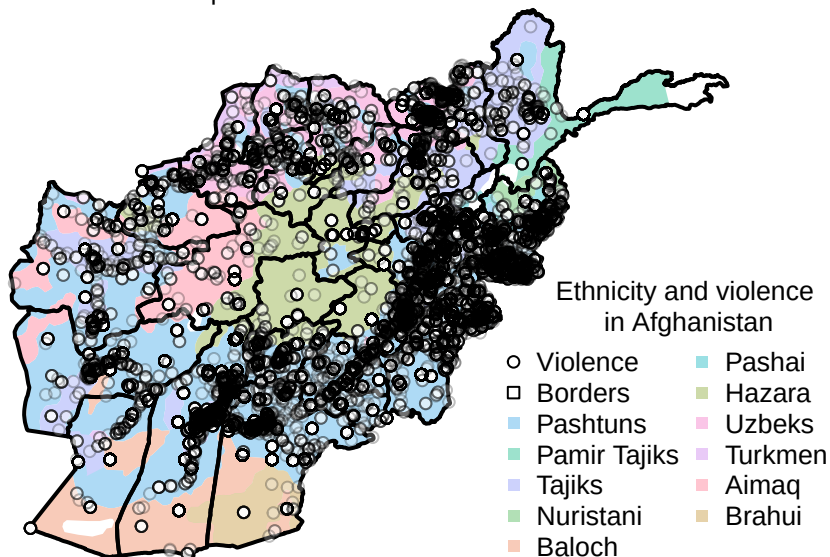
```
## [1] "Pastel 1"      "Dark 2"      "Dark 3"      "Set 2"
## [5] "Set 3"        "Warm"        "Cold"        "Harmonic"
## [9] "Dynamic"      "Grays"       "Light Grays" "Blues 2"
## [13] "Blues 3"      "Purples 2"   "Purples 3"   "Reds 2"
## [17] "Reds 3"       "Greens 2"    "Greens 3"    "Oslo"
## [21] "Purple-Blue"  "Red-Purple"  "Red-Blue"    "Purple-Orange"
## [25] "Purple-Yellow" "Blue-Yellow" "Green-Yellow" "Red-Yellow"
## [29] "Heat"         "Heat 2"      "Terrain"     "Terrain 2"
## [33] "Viridis"      "Plasma"      "Inferno"     "Rocket"
## [37] "Mako"         "Dark Mint"   "Mint"        "BluGrn"
## [41] "Teal"         "TealGrn"     "Emrld"       "BluYl"
## [45] "ag_GrnYl"     "Peach"       "PinkYl"      "Burg"
## [49] "BurgYl"       "RedOr"       "OrYel"       "Purp"
## [53] "PurpOr"       "Sunset"      "Magenta"     "SunsetDark"
## [57] "ag_Sunset"    "BrwnYl"      "YlOrRd"      "YlOrBr"
## [61] "OrRd"         "Oranges"     "YlGn"        "YlGnBu"
## [65] "Reds"         "RdPu"        "PuRd"        "Purples"
## [69] "PuBuGn"       "PuBu"        "Greens"      "BuGn"
## [73] "GnBu"         "BuPu"        "Blues"       "Lajolla"
## [77] "Turku"        "Hawaii"      "Batlow"      "Blue-Red"
## [81] "Blue-Red 2"   "Blue-Red 3"  "Red-Green"   "Purple-Green"
## [85] "Purple-Brown" "Green-Brown" "Blue-Yellow 2" "Blue-Yellow 3"
## [89] "Green-Orange" "Cyan-Magenta" "Tropic"      "Broc"
## [93] "Cork"         "Vik"         "Berlin"      "Lisbon"
## [97] "Tofino"       "ArmyRose"    "Earth"       "Fall"
## [101] "Geyser"       "TealRose"    "Temps"       "PuOr"
## [105] "RdBu"         "RdGy"        "PiYG"        "PRGn"
## [109] "BrBG"         "RdYlBu"      "RdYlGn"      "Spectral"
## [113] "Zissou 1"     "Cividis"     "Roma"
```

To create the map, we will use the same commands as above, with some differences:

- set margins to zero
- include option `reset=FALSE` when plotting the ethnicity layer
- add violence data twice (white points + black outlines)
- add `legend()` (including the vector of group colors)

```
par(mar=c(0,0,0,0))
plot(ethnicity["group"],col=cols,border=NA,reset=FALSE,main="")
plot(borders["geometry"],add=T,lwd=2)
# Add violence (white points + black outlines)
plot(violence["geometry"],col=rgb(1,1,1,alpha = .25),pch=16,add=T)
plot(violence["geometry"],col=rgb(0,0,0,alpha = .25),pch=1,add=T)
# Add legend
legend("bottomright",bty="n",ncol=2,
      legend=c("Violence","Borders",as.character(groups)),
      col=c("black","black",cols),pch=c(1,0,rep(15,length(cols))),
      cex=.8,title="Ethnicity and violence\n in Afghanistan"
    )
```

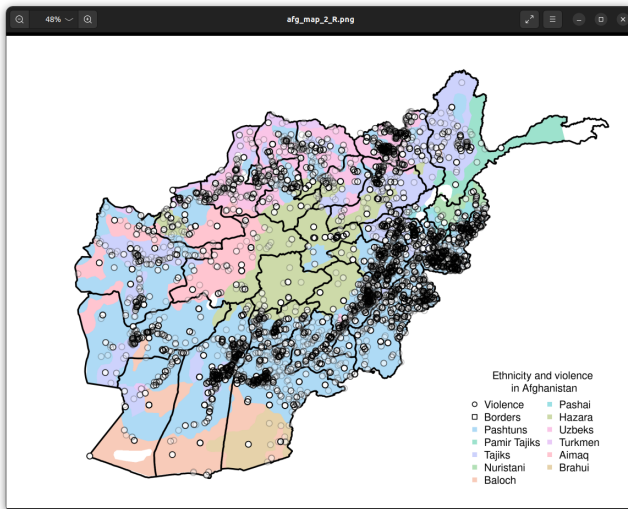
Here's what the plot should look like:



Exporting Map 2 to image file

Using the `png()` and `dev.off()` commands as bookends:

```
png("Output/afg_map_2_r.png",width = 8,height = 6,  
    units = "in",res = 300)  
par(mar=c(0,0,0,0))  
plot(ethnicity["group"],col=cols,border=NA,reset=FALSE,main="")  
plot(borders["geometry"],add=T,lwd=2)  
# Add violence (white points + black outlines)  
plot(violence["geometry"],col=rgb(1,1,1,alpha = .25),pch=16,add=T)  
plot(violence["geometry"],col=rgb(0,0,0,alpha = .25),pch=1,add=T)  
# Add legend  
legend("bottomright",bty="n",ncol=2,  
    legend=c("Violence","Borders",as.character(groups)),  
    col=c("black","black",cols),pch=c(1,0,rep(15,length(cols))),  
    cex=.8,title="Ethnicity and violence\n in Afghanistan")  
dev.off()
```



The output file should look like this.

Problem Set 2

Your assignment (if using R):

- create the same kind of “violence and ethnicity” map for Yemen
- use these files:
 - GeoEPR_YEM.geojson
 - xSub_GED_YEM_event.csv
 - gadm36_YEM_1.geojson
- follow the same steps as for “Map 2” here
- name it `yem_map_2_r.png`
- upload map to Canvas
(by next Wednesday)

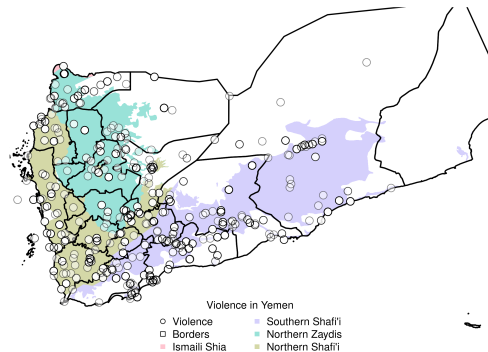


Figure 8: Can you make this map?