final

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2024-03-18

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#### **ERROR Found**

In this document, there is a recurring syntax error present in several code blocks. The error arises from the absence of the language identifier {r} within the code blocks, preventing the code from being properly interpreted as R code.

In the original document, the language identifier {r} was written like this:

# sample code

To resolve this issue, we made sure that all code blocks are preceded by the language identifier {r} to indicate that they contain R code.

# sample code

# How to Create a 3D Population Density Map in R

#### **1. Install library Packages**:

You need to install the necessary packages. Run the following commands in your R console. Try to install them one by one, it might library restarting the R-session several times.

install.packages("sf", dependencies=TRUE)  
install.packages("tmap", dependencies=TRUE)  
install.packages("mapview", dependencies=TRUE)  
install.packages("stars", dependencies=TRUE)  
install.packages("rayshader", dependencies=TRUE)  
install.packages("MetBrewer", dependencies=TRUE)  
install.packages("rayrender")  
install.packages("extrafont", dependencies=TRUE)  
install.packages("magick", dependencies=TRUE)

#### **2. Load Packages and Set Options**:

Load the library libraries and set the RGL options:

options(rgl.useNULL = FALSE)  
library(tidyverse)

## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──  
## ✔ dplyr 1.1.4 ✔ readr 2.1.5  
## ✔ forcats 1.0.0 ✔ stringr 1.5.1  
## ✔ ggplot2 3.5.0 ✔ tibble 3.2.1  
## ✔ lubridate 1.9.3 ✔ tidyr 1.3.1  
## ✔ purrr 1.0.2   
## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ dplyr::filter() masks stats::filter()  
## ✖ dplyr::lag() masks stats::lag()  
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(sf)

## Linking to GEOS 3.11.2, GDAL 3.8.2, PROJ 9.3.1; sf\_use\_s2() is TRUE

library(tmap)

## Breaking News: tmap 3.x is retiring. Please test v4, e.g. with  
## remotes::install\_github('r-tmap/tmap')

library(ggplot2)  
library(mapview)  
library(stars)

## Loading required package: abind

library(rayshader)  
library(MetBrewer)  
library(colorspace)  
library(rayrender)

##   
## Attaching package: 'rayrender'  
##   
## The following object is masked from 'package:rayshader':  
##   
## run\_documentation  
##   
## The following object is masked from 'package:ggplot2':  
##   
## arrow

library(magick)

## Linking to ImageMagick 6.9.12.98  
## Enabled features: cairo, freetype, fftw, ghostscript, heic, lcms, pango, raw, rsvg, webp  
## Disabled features: fontconfig, x11

library(extrafont)

## Registering fonts with R

#### **3. Load and Transform Data**:

You’ll need to load the population data and administrative boundaries for the Philippines, transforming them into a suitable coordinate system. The data is downloaded from Kontur Population.

# population data of Myanmar  
MM\_hex <- st\_read("data/kontur\_population\_MM\_20231101.gpkg") %>% st\_transform(3106)

## Reading layer `population' from data source   
## `C:\Users\User\Downloads\data\kontur\_population\_MM\_20231101.gpkg'   
## using driver `GPKG'  
## Simple feature collection with 212821 features and 2 fields  
## Geometry type: POLYGON  
## Dimension: XY  
## Bounding box: xmin: 10259660 ymin: 1078258 xmax: 11261570 ymax: 3303433  
## Projected CRS: WGS 84 / Pseudo-Mercator

# administrative boundaries of Myanmar  
MM\_admin <- st\_read("data/kontur\_boundaries\_MM\_20230628.gpkg") %>% st\_transform(3106)

## Reading layer `boundaries' from data source   
## `C:\Users\User\Downloads\data\kontur\_boundaries\_MM\_20230628.gpkg'   
## using driver `GPKG'  
## Simple feature collection with 488 features and 6 fields  
## Geometry type: MULTIPOLYGON  
## Dimension: XY  
## Bounding box: xmin: 92.17292 ymin: 9.526084 xmax: 101.1701 ymax: 28.54784  
## Geodetic CRS: WGS 84

#### **4. Check and Create Boundaries**:

Inspect the ‘name\_en’ column and create the boundary for the Philippines. Use the filter option to plot specific districts and divisions on the map.

distinct\_names <- MM\_admin %>% distinct(name\_en)  
print(distinct\_names)

## name\_en  
## 1 Myanmar  
## 2 <NA>  
## 3 Bago Region  
## 4 Rakhine  
## 5 Naypyitaw Union Territory  
## 6 Mon State  
## 7 Mandalay  
## 8 Magway  
## 9 Kayin State  
## 10 Kayah State  
## 11 Kachin State  
## 12 Chin  
## 13 Ayeyarwady  
## 14 Yangon  
## 15 Tanintharyi Region  
## 16 Shan State  
## 17 Sagaing Region  
## 18 Pa Laung Self-Administered Zone  
## 19 Pa'O Self-Administered Zone  
## 20 Danu Self-Administered Zone  
## 21 Naga Self-Administered Zone  
## 22 Wa Self-Administered Division  
## 23 South Shan State  
## 24 North Shan State  
## 25 East Shan State  
## 26 West Bago Region  
## 27 East Bago Region  
## 28 Wa State Southern region  
## 29 Wa State (Northern Region)  
## 30 Nam Deeg Special District  
## 31 Kyaukme District  
## 32 Kyaukpyu District  
## 33 Kyaukse District  
## 34 Labutta  
## 35 Langhko District  
## 36 Lashio District  
## 37 Laukkaing District  
## 38 Loikaw District  
## 39 Loilen District  
## 40 Magway District  
## 41 Mandalay District  
## 42 Matman District  
## 43 Maubin  
## 44 Maungdaw District  
## 45 Mawlaik District  
## 46 Mawlamyine District  
## 47 Meiktila District  
## 48 Minbu District  
## 49 Mindat District  
## 50 Mohnyin District  
## 51 Mong Hsat District  
## 52 Monywa District  
## 53 Mrauk-U District  
## 54 Mu Se District  
## 55 Myaungmya  
## 56 Myawaddy District  
## 57 Myeik District  
## 58 Myitkyina District  
## 59 Myingyan District  
## 60 Nyaung-U District  
## 61 Pakokku District  
## 62 Pathein  
## 63 Putao District  
## 64 Pyapon  
## 65 Pyay District  
## 66 Pyin Oo Lwin District  
## 67 Sagaing District  
## 68 Shwebo District  
## 69 Sittwe District  
## 70 Tachileik District  
## 71 Mong Hpayak District  
## 72 Tamu District  
## 73 Taunggyi District  
## 74 Taungoo District  
## 75 Thandwe District  
## 76 Thaton District  
## 77 Tharrawaddy District  
## 78 Thayet District  
## 79 Yamethin District  
## 80 Yinmabin District  
## 81 Bago District  
## 82 Bawlakhe District  
## 83 Bhamo District  
## 84 Dawei District  
## 85 Falam District  
## 86 Gangaw District  
## 87 Hakha District  
## 88 Hinthada  
## 89 Kawthoung District  
## 90 Yangon South  
## 91 Pangkham Special District  
## 92 Kengtung District  
## 93 Yangon West  
## 94 Yangon East  
## 95 Hkamti District  
## 96 Yangon North  
## 97 Hopang District  
## 98 Dekkhina District  
## 99 Ottara District  
## 100 Hpa-An District  
## 101 Kanbalu District  
## 102 Hpapun District  
## 103 Kale District  
## 104 Mong Mit District  
## 105 Katha District  
## 106 Kawkareik District  
## 107 Mōung Nēng County  
## 108 Mongpauk County  
## 109 Mongmaoe County  
## 110 Yinmabin Township  
## 111 Ywangan Township  
## 112 Zabuthiri Township  
## 113 Zalun  
## 114 Zeyarthiri Township  
## 115 Zigon Township  
## 116 Pinlebu Township  
## 117 Pinlaung Township  
## 118 Pindaya Township  
## 119 Phyu  
## 120 Pekon Township  
## 121 Paungde Township  
## 122 Paungbyin Township  
## 123 Paung Township  
## 124 Pauktaw Township  
## 125 Paukkaung Township  
## 126 Pauk Township  
## 127 Patheingyi Township  
## 128 Pantanaw  
## 129 Pangwaun Township  
## 130 Pangsang Township  
## 131 Paletwa Township  
## 132 Pale Township  
## 133 Palaw Township  
## 134 Pakokku Township  
## 135 Ahlone  
## 136 Amarapura Township  
## 137 Ann Township  
## 138 Aunglan Township  
## 139 Aungmyethazan Township  
## 140 Ayadaw Township  
## 141 Bago Township  
## 142 Bahan  
## 143 Banmauk Township  
## 144 Bawlakhe Township  
## 145 Bhamo Township  
## 146 Bilin Township  
## 147 Bogale  
## 148 Bokpyin Township  
## 149 Budalin Township  
## 150 Buthidaung Township  
## 151 Chanayethazan Township  
## 152 Chanmyathazi Township  
## 153 Chauk Township  
## 154 Chaung-U Township  
## 155 Chaungzon Township  
## 156 Chipwi Township  
## 157 Cocokyun  
## 158 Dagon  
## 159 Daik-U Township  
## 160 Dala  
## 161 Danubyu  
## 162 Dawbon  
## 163 Dawei Township  
## 164 Dedaye  
## 165 Dekkhinathiri Township  
## 166 Demoso Township  
## 167 Einme  
## 168 Falam Township  
## 169 Gangaw Township  
## 170 Gwa Township  
## 171 Gyobingauk Township  
## 172 Hakha Township  
## 173 Hkamti Township  
## 174 Hlaing  
## 175 Hlaingbwe Township  
## 176 Hlaingtharya (East)  
## 177 Hlegu  
## 178 Hmawbi  
## 179 Homalin Township  
## 180 Hopang  
## 181 Hopong Township  
## 182 Hpa-An Township  
## 183 Hpakant Township  
## 184 Hpasawng Township  
## 185 Hpruso Township  
## 186 Hsenwi Township  
## 187 Hsi Hseng Township  
## 188 Hsipaw Township  
## 189 Htantabin Township  
## 190 Htantabin  
## 191 Indaw Township  
## 192 Ingapu  
## 193 Injangyang Township  
## 194 Insein  
## 195 Kalaw Township  
## 196 Kalay Township  
## 197 Kalewa Township  
## 198 Kamaryut  
## 199 Kamma Township  
## 200 Kanbalu Township  
## 201 Kangyidaunt  
## 202 Kani Township  
## 203 Kanpetlet Township  
## 204 Katha Township  
## 205 Kawa Township  
## 206 Kawhmu  
## 207 Kawkareik Township  
## 208 Kawlin Township  
## 209 Kawthoung Township  
## 210 Kayan  
## 211 Kengtung Township  
## 212 Kawnglanghpu Township  
## 213 Khin-U Township  
## 214 Konkyan  
## 215 Kungyangon  
## 216 Kunhing Township  
## 217 Kunlong Township  
## 218 Kutkai Township  
## 219 Kyaiklat  
## 220 Kyaikmaraw Township  
## 221 Kyaikto Township  
## 222 Kyainseikgyi Township  
## 223 Kyangin  
## 224 Kyaukkyi Township  
## 225 Kyaukme Township  
## 226 Kyaukpadaung Township  
## 227 Kyaukpyu Township  
## 228 Kyaukse Township  
## 229 Kyauktada  
## 230 Kyauktaga Township  
## 231 Kyauktan  
## 232 Kyauktaw Township  
## 233 Kyaunggon  
## 234 Kyeemyindaing  
## 235 Kyethi Township  
## 236 Kyonpyaw  
## 237 Kyunhla Township  
## 238 Kyunsu Township  
## 239 Lahe Township  
## 240 Lai-Hka Township  
## 241 Langhko Township  
## 242 Lanmadaw  
## 243 Lashio Township  
## 244 Latha  
## 245 Laukkaing  
## 246 Launglon Township  
## 247 Lawksawk Township  
## 248 Leshi Township  
## 249 Lemyethna  
## 250 Letpadan Township  
## 251 Lewe Township  
## 252 Loikaw Township  
## 253 Loilem Township  
## 254 Mabein Township  
## 255 Machanbaw Township  
## 256 Madaya Township  
## 257 Magway Township  
## 258 Maha Aungmye Township  
## 259 Mahlaing Township  
## 260 Mansi Township  
## 261 Mantong Township  
## 262 Matman  
## 263 Matupi Township  
## 264 Maungdaw Township  
## 265 Mawkmai Township  
## 266 Mawlaik Township  
## 267 Mawlamyine  
## 268 Mawlamyinegyun  
## 269 Mayangone  
## 270 Meiktila Township  
## 271 Mese Township  
## 272 Minbu Township  
## 273 Minbya Township  
## 274 Mindat Township  
## 275 Mindon Township  
## 276 Mingala Taungnyunt  
## 277 Mingin Township  
## 278 Minhla Township  
## 279 Mogaung Township  
## 280 Mogok Township  
## 281 Mohnyin Township  
## 282 Momauk Township  
## 283 Mong Hpayak Township  
## 284 Mong Hsat Township  
## 285 Mong Hsu Township  
## 286 Mong Kung Township  
## 287 Mong Khet Township  
## 288 Mong La Township  
## 289 Mongmao Township  
## 290 Mong Mit Township  
## 291 Mong Nai Township  
## 292 Mong Pan Township  
## 293 Mong Ping Township  
## 294 Mong Ton Township  
## 295 Mongyai Township  
## 296 Mong Yang Township  
## 297 Mong Yawng Township  
## 298 Monyo Township  
## 299 Monywa Township  
## 300 Ponnagyun Township  
## 301 Mudon Township  
## 302 Manaung Township  
## 303 Muse Township  
## 304 Myaing Township  
## 305 Myanaung  
## 306 Myaung Township  
## 307 Myebon Township  
## 308 Myeik Township  
## 309 Myingyan Township  
## 310 Myinmu Township  
## 311 Myitkyina Township  
## 312 Myittha Township  
## 313 Myothit Township  
## 314 Namhkam Township  
## 315 Namhsan Township  
## 316 Namtu Township  
## 317 Nansang Township  
## 318 Nanyun Township  
## 319 Narphan Township  
## 320 Natmauk Township  
## 321 Natogyi Township  
## 322 Nattalin Township  
## 323 Nawnghkio Township  
## 324 Nawngmun Township  
## 325 Ngape Township  
## 326 Ngapudaw  
## 327 Ngazun Township  
## 328 North Okkalapa  
## 329 Nyaung-U Township  
## 330 Nyaungdon  
## 331 Nyaunglebin Township  
## 332 Nyaungshwe Township  
## 333 Okpho Township  
## 334 Oktwin Township  
## 335 Ottarathiri Township  
## 336 Pabedan  
## 337 Pandaung Township  
## 338 South Okkalapa  
## 339 Thingangyun  
## 340 Pazundaung  
## 341 Botahtaung  
## 342 Dagon Seikkan  
## 343 South Dagon  
## 344 East Dagon  
## 345 North Dagon  
## 346 Mrauk-U Township  
## 347 Putao Township  
## 348 Pwintbyu Township  
## 349 Pyawbwe Township  
## 350 Pyay Township  
## 351 Pyigyidagun Township  
## 352 Pyinmana Township  
## 353 Pyinoolwin Township  
## 354 Ramree Township  
## 355 Rathedaung Township  
## 356 Sagaing Township  
## 357 Salin Township  
## 358 Salingyi Township  
## 359 Sanchaung  
## 360 Saw Township  
## 361 Seikgyikanaungto  
## 362 Seikphyu Township  
## 363 Shadaw Township  
## 364 Shwebo Township  
## 365 Shwedaung Township  
## 366 Shwegu Township  
## 367 Shwegyin Township  
## 368 Shwepyithar  
## 369 Sidoktaya Township  
## 370 Sinbaungwe Township  
## 371 Singu Township  
## 372 Sintgaing Township  
## 373 Sittwe Township  
## 374 Sumprabum Township  
## 375 Tabayin Township  
## 376 Tada-U Township  
## 377 Taikkyi  
## 378 Tamwe  
## 379 Tanai Township  
## 380 Tangyan Township  
## 381 Tanintharyi Township  
## 382 Tatkon Township  
## 383 Taungdwingyi Township  
## 384 Taunggyi Township  
## 385 Taungoo Township  
## 386 Taungtha Township  
## 387 Taze Township  
## 388 Tedim Township  
## 389 Thabaung  
## 390 Thabeikkyin Township  
## 391 Thaketa  
## 392 Thanatpin Township  
## 393 Thanbyuzayat Township  
## 394 Thandaunggyi Township  
## 395 Thandwe Township  
## 396 Thanlyin  
## 397 Thantlang Township  
## 398 Thaton Township  
## 399 Tharrawaddy Township  
## 400 Thayet Township  
## 401 Thayetchaung Township  
## 402 Thazi Township  
## 403 Thegon Township  
## 404 Thongwa  
## 405 Tigyaing Township  
## 406 Tilin Township  
## 407 Tonzang Township  
## 408 Toungup Township  
## 409 Hsawlaw Township  
## 410 Twantay  
## 411 Waingmaw  
## 412 Wakema  
## 413 Waw Township  
## 414 Wetlet Township  
## 415 Wundwin Township  
## 416 Wuntho Township  
## 417 Yamethin Township  
## 418 Yankin  
## 419 Ye  
## 420 Ye-U Township  
## 421 Yebyu Township  
## 422 Yedashe Township  
## 423 Yegyi  
## 424 Yenangyaung  
## 425 Yesagyo Township  
## 426 Great Coco Island  
## 427 Hlaingtharya (West)  
## 428 Pobbathiri Township  
## 429 Narwee  
## 430 Kaung Ming Sang District  
## 431 Banwai District  
## 432 Man Doun District  
## 433 Mansiang District  
## 434 Yawnglin District  
## 435 Nar Kawng District  
## 436 Noung Kied District  
## 437 Nam Hkan Wu District  
## 438 Panyang District  
## 439 Hkun Mar  
## 440 Mongpauk District  
## 441 Hotao District  
## 442 Longtan  
## 443 Monghpen Economic Development Zone  
## 444 Namhpai District  
## 445 Mong Ning District  
## 446 Yiang Chen  
## 447 Yingpan District  
## 448 Lianhe District  
## 449 Glong Ba District  
## 450 San Chi Ward  
## 451 Htein Thit Ward  
## 452 Byaw Taw Wa Ward  
## 453 Sin Seik Ward  
## 454 Kyauk Maw Ward  
## 455 Pein Hne Taw Ward  
## 456 Ka Nyon Ward  
## 457 Za Yit Ward  
## 458 Bon Maw Ward  
## 459 Kyet Sa Pyin Ward  
## 460 Daung Ngu Ward  
## 461 Thin Baw Seik Ward  
## 462 Ah Nauk Myo Twin Ward  
## 463 Ta Laing Htein Ward  
## 464 Oe Loke Ward  
## 465 Kaing Daw Kwin

# Creating BD Boundary  
MM\_boundary <- MM\_admin %>%  
 st\_geometry %>%  
 st\_union %>%  
 st\_sf %>%  
 st\_make\_valid()

#### **5. Plot Boundaries for Verification**:

Visualize the hex data and boundaries to ensure accuracy.

names(MM\_hex)

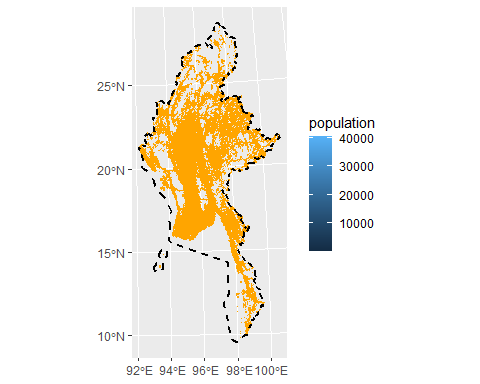
## [1] "h3" "population" "geom"

## Revision No. 1

Upon reviewing the original code, we found that the representation of the boundary lines in the plot lacked clarity and distinction. To address this, we revised the code to enhance the styling of the boundary lines in the plot.

We added the linetype and linewidth parameters in the geom\_sf function to include boundary lines in the plot.

library(ggplot2)  
  
ggplot(MM\_hex) +  
 geom\_sf(aes(fill = population),  
 color = "orange",  
 linewidth = 0) +  
 geom\_sf(  
 data = MM\_boundary,  
 fill = NA,  
 color = "black",  
   
 # additional code for boundary lines  
   
 linetype = "dashed",  
 linewidth = .8  
 )



#### **6. Calculate Aspect Ratio**:

Determine the aspect ratio for the map based on the bounding box of the boundary.

# setting the ph boundary as a bounding box  
bbox <- st\_bbox(MM\_boundary)  
  
# finding the aspect ratio  
bottom\_left <- st\_point(c(bbox[["xmin"]], bbox[["ymin"]])) %>%  
 st\_sfc(crs = 3106)  
bottom\_right <- st\_point(c(bbox[["xmax"]], bbox[["ymin"]])) %>%  
 st\_sfc(crs = 3106)  
top\_left <- st\_point(c(bbox[["xmin"]], bbox[["ymax"]])) %>%  
 st\_sfc(crs = 3106)  
top\_right <- st\_point(c(bbox[["xmin"]], bbox[["ymax"]])) %>%  
 st\_sfc(crs = 3106)  
  
width <- st\_distance(bottom\_left, bottom\_right)  
height <- st\_distance(bottom\_left, top\_left)  
  
if(width > height) {  
 w\_ratio = 1  
 h\_ratio = height / width  
} else {  
 h\_ratio = 1.1  
 w\_ratio = width / height  
}

#### 7. **Rasterize Population Data**:

Convert the population data into a raster format suitable for 3D rendering.

* For interactively checking the 3D plot setting the size low will help render in real time.
* To improve the quality of the 3D image when saving, change the settings to a higher resolution.

# convert to raster to convert to matrix  
size = 3500  
  
pop\_raster <- st\_rasterize(  
 MM\_hex,  
 nx = floor(size \* w\_ratio) %>% as.numeric(),  
 ny = floor(size \* h\_ratio) %>% as.numeric()  
)  
  
pop\_matrix <- matrix(pop\_raster$population,  
 nrow = floor(size \* w\_ratio),  
 ncol = floor(size \* h\_ratio))

#### **8. Define Color Palette**:

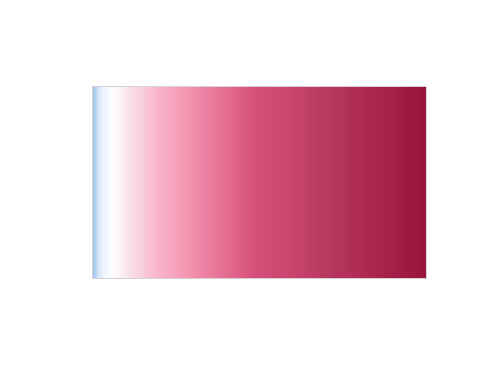
Select a color palette from the MetBrewer or RColorBrewer library and customize it for your map.

## Revision No. 2

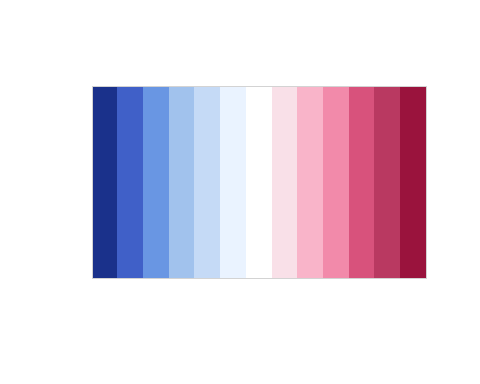
n the original code, the color palette was generated with a bias of 4.5. While the colors in the palette seemed fitting for our visualization, we found that the transitions between colors were not as distinct as we had hoped. To address this issue, we decided to change the bias from 4 to 4.5.

This adjustment creates a color palette with more distinct boundaries between colors and less smooth transitions compared to the original palette. We expect that this change will lead to a perceptible difference in the appearance of the generated color palette, resulting in a better presentation of the population density of our chosen country.

# Create color palette from MetBrewer Library  
color <- MetBrewer::met.brewer(name="Benedictus", direction = -1)  
  
tx <- grDevices::colorRampPalette(color, bias = 4)(256) # new bias  
swatchplot(tx)



swatchplot(color)



#### **9. Render 3D Map**:

Use Rayshader to create a 3D representation of the population density.

## Revision No. 3

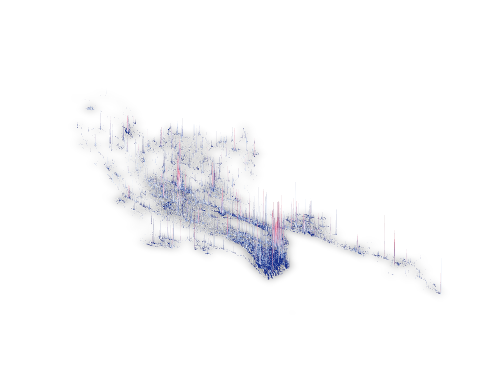
In the original code, the fov parameter was included in the plot\_3d function. When we included it, we noticed that it affected the rendering process of the 3D plot. Removing the FOV parameter allowed the rendering process to proceed without the specific FOV setting. We made this decision to optimize rendering efficiency, considering that specifying a FOV may increase computational complexity or rendering time.

Although the FOV parameter was removed, the plot\_3d function still produces a reasonable output. The default angle leaves us satisfied, and we believe that the inclusion of the FOV parameter does not significantly affect the overall presentation of our input

# Close any existing 3D plot before plotting another  
rgl::close3d()  
  
pop\_matrix %>%  
 height\_shade(texture = tx) %>%  
 plot\_3d(heightmap = pop\_matrix,  
 zscale = 70,   
 solid = FALSE,  
 shadowdepth = 0,  
 )  
render\_camera(theta = -50, phi = 50, zoom = .7,)  
  
# To interactively view the 3D plot  
rgl::rglwidget()

## Google Chrome was not found. Try setting the `CHROMOTE\_CHROME` environment variable to the executable of a Chromium-based browser, such as Google Chrome, Chromium or Brave.

## Warning in snapshot3d(scene = x, width = width, height = height): webshot =  
## TRUE requires the webshot2 package and Chrome browser; using rgl.snapshot()  
## instead



#### **10. Render in high-quality and Save Image**:

Fine-tune the camera angle and render a high-quality image of the 3D map.

## Revision No. 4

In this current chunk of code, multiple lines of code were originally turned into comments, rendering them inexecutable. We resolved this issue by removing the ‘#’ symbols to revert them back to executable code.

However, after running this chunk multiple times, we encountered issues generating high-quality files due to incompatible parameter values. The original code produced unsuccessful outputs, such as all-black output, all-black output with white dots, or a white dimension with a black base. These issues stemmed from using **lightcolor = c("white", "white")** instead of **lightcolor = c(pop\_matrix[2], color)**, which caused the 3D population density map to not display any color.

To address this, we added **sample\_method = "sobol"** to achieve a more even coverage of space compared to purely random sequences.

We also made changes to the parameters in the **render\_highquality** function to resolve these issues. Refer to the comments in the code for the specific changes made.

By incorporating these clarifications, the explanation becomes more accessible and understandable for readers who may not be familiar with the code or its context.

Sz# Define the output file path using the glue package  
outfile <- glue::glue("C:/Users/HP PAVILION/Documents/data/MM\_MAP[5].png")  
  
{  
 # Record the start time of the execution  
 start\_time <- Sys.time()  
   
 # Print the start time in cyan color  
 cat(crayon::cyan(start\_time), "\n")  
   
 if(!file.exists(outfile)) {  
 png::writePNG(matrix(1), target = outfile)  
 }  
   
 render\_highquality(  
 filename = outfile,  
 interactive = FALSE,   
 lightdirection = 100, # originally 50,  
 lightaltitude = c(70, 90), # originally c(30,80)  
 lightcolor = c(pop\_matrix[2], color), # originally c("white", "white")  
 lightintensity = c(600, 100),  
 samples = 450, # originally 550  
 sample\_method = "sobol",  
 width = 1080, # originally 1980  
 height = 920 # originally 1180  
 )  
   
 # Record the end time of the execution  
 end\_time <- Sys.time()  
   
 # Calculate the difference between start and end time  
 diff <- end\_time - start\_time  
   
 # Print the execution time in cyan color  
 cat(crayon::cyan(diff), "\n")  
}

#### **11. Annotate the image**

You can add names and more details about your generated visualization.

## Revision No. 5

We slightly enhanced the original code by revising these original lines:

install.packages("showtext") library(showtext) install.packages("extrafont") library(extrafont) font\_import(pattern = "Philosopher")

We transformed it into a code where it checks whether each package is already installed before attempting to install it. This prevents unnecessary installation processes, saving time and system resources.

While we changed some of the values for font customization, not much were really revised. Some of the original parts of the code were still used in this chunk. Any other changes made were not intently for a different effect but just for preferences in customization.

# Check if packages are installed, and install if necessary  
if (!requireNamespace("showtext", quietly = TRUE)) {  
 install.packages("showtext")  
}  
if (!requireNamespace("extrafont", quietly = TRUE)) {  
 install.packages("extrafont")  
}  
if (!requireNamespace("magick", quietly = TRUE)) {  
 install.packages("magick")  
}  
  
# Load required packages  
library(showtext)  
library(extrafont)  
library(magick)  
  
# Import fonts  
font\_import(pattern = "Philosopher")  
  
  
  
# Automatically enable font support  
showtext\_auto()  
  
# Load Google font  
font\_add\_google("Philosopher", regular = "400", bold = "700")  
  
# Read the SVG image  
pop\_raster <- image\_read("C:/Users/HP PAVILION/Documents/data/MM\_MAP[3].png")  
  
# Define text color  
  
text\_color <- "#1e466e" # Adjust as needed  
text1\_color <- "#376795"   
  
# Annotate the image  
pop\_raster %>%  
 image\_annotate("Myanmar",  
 gravity = "northeast",  
 location = "+50+50",  
 color = text\_color,  
 size = 150,  
 font = "Philosopher",  
 weight = 800,  
 degrees = 0) %>%  
   
 image\_annotate("POPULATION DENSITY MAP",  
 gravity = "northeast",  
 location = "+50+230",  
 color = text\_color,  
 size = 30,  
 font = "Philosopher",  
 weight = 500,  
 degrees = 0) %>%  
   
 image\_annotate("Visualization by: Culanggo | Felisilda | Casiño | Abainza \nData @ Kontur Population 2023",  
 gravity = "southwest",  
 location = "+20+20",  
 color = alpha(text1\_color, .8),  
 font = "Philosopher",  
 size = 22,  
 degrees = 0) %>%  
   
 image\_write("C:/Users/HP PAVILION/Documents/data/MM\_MAP[3](ANNOTATED).png", format = "png", quality = 100)