Modeling and Estimating the LST using ML

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## R Markdown

myCol = terrain.colors(3)  
  
LST\_24 <- rast("2024LST.tif")  
LST\_03 <- rast("2003LST.tif")  
LST\_84 <- rast("1984LST.tif")  
  
# Converting raster data to a dataframe   
# lines of code.  
rasterdf <- function(x, aggregate = 1) {  
 resampleFactor <- aggregate  
 inputRaster <- x  
 inCols <- ncol(inputRaster)  
 inRows <- nrow(inputRaster)  
 # Compute numbers of columns and rows in the resampled raster  
 resampledRaster <- rast(ncol=(inCols / resampleFactor),  
 nrow=(inRows / resampleFactor),  
 crs = crs(inputRaster))  
 # Match to the extent of the original raster  
 ext(resampledRaster) <- ext(inputRaster)  
 # Resample data on the new raster  
 y <- resample(inputRaster,resampledRaster,method='near')  
 # Extract cell coordinates into a dataframe  
 coords <- xyFromCell(y, seq\_len(ncell(y)))  
 # Extract layer names  
 dat <- stack(values(y, dataframe = TRUE))  
 # Add names-'value' for data,'variable' for different  
 # layer names in a multilayerraster  
 names(dat) <- c('value', 'variable')  
 dat <- cbind(coords, dat)  
 dat  
}  
  
# The following code converts the LST raster to a dataframe after  
# aggregating the cell values by a factor of three.  
  
lst\_df\_24 <- rasterdf(LST\_24, aggregate = 3)  
summary(lst\_df\_24)

## x y value variable   
## Min. :434204 Min. :1310203 Min. :26.97 Band\_1:107712   
## 1st Qu.:441036 1st Qu.:1318093 1st Qu.:34.97   
## Median :447914 Median :1325983 Median :35.62   
## Mean :447914 Mean :1325983 Mean :35.63   
## 3rd Qu.:454791 3rd Qu.:1333873 3rd Qu.:36.37   
## Max. :461624 Max. :1341763 Max. :41.00   
## NA's :37089

head(lst\_df\_24)

## x y value variable  
## 1 434203.7 1341763 NA Band\_1  
## 2 434293.6 1341763 NA Band\_1  
## 3 434383.5 1341763 NA Band\_1  
## 4 434473.4 1341763 NA Band\_1  
## 5 434563.3 1341763 NA Band\_1  
## 6 434653.2 1341763 NA Band\_1

# lst\_1 <- ifel(lst\_df\_24 == 0, NA, lst)  
# lst\_1\_c <- lst\_1 \* 0.02 - 273.15  
  
A <- ggplot(data = lst\_df\_24) +  
 geom\_raster(aes(x = x,  
 y = y,  
 fill = value)) +  
 scale\_fill\_gradient(name = "Degrees C",  
 low = "blue",  
 high = "red") +  
 coord\_sf(expand = FALSE) +  
 labs(title = "LST-2024",  
 x = "longitude",  
 y = "latitude") +  
 theme(legend.position = "bottom")  
  
lst\_df\_84 <- rasterdf(LST\_84, aggregate = 3)  
summary(lst\_df\_84)

## x y value variable   
## Min. :434204 Min. :1310203 Min. :21.06 Band\_1:107712   
## 1st Qu.:441036 1st Qu.:1318093 1st Qu.:28.33   
## Median :447914 Median :1325983 Median :28.82   
## Mean :447914 Mean :1325983 Mean :28.59   
## 3rd Qu.:454791 3rd Qu.:1333873 3rd Qu.:29.14   
## Max. :461624 Max. :1341763 Max. :31.82   
## NA's :37089

lst\_df\_84%>%filter(value!="NA")%>%head()

## x y value variable  
## 1 449577.0 1341763 28.69418 Band\_1  
## 2 449487.1 1341673 28.33435 Band\_1  
## 3 449577.0 1341673 28.40637 Band\_1  
## 4 449666.9 1341673 28.79483 Band\_1  
## 5 449756.8 1341673 28.50717 Band\_1  
## 6 449846.7 1341673 28.50717 Band\_1

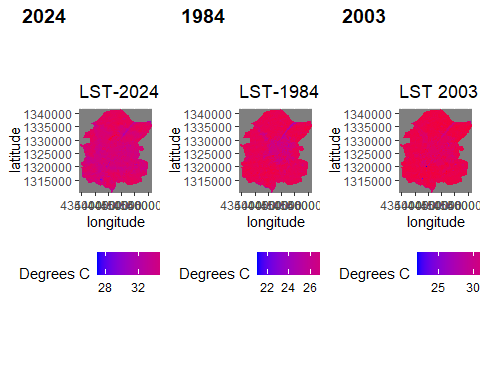
B <- ggplot(data = lst\_df\_84) +  
 geom\_raster(aes(x = x,  
 y = y,  
 fill = value)) +  
 scale\_fill\_gradient(name = "Degrees C",  
 low = "blue",  
 high = "red") +  
 coord\_sf(expand = FALSE) +  
 labs(title = "LST-1984",  
 x = "longitude",  
 y = "latitude") +  
 theme(legend.position = "bottom")  
  
lst\_df\_03 <- rasterdf(LST\_03, aggregate = 3)  
summary(lst\_df\_03)

## x y value variable   
## Min. :434204 Min. :1310203 Min. :22.08 Band\_1:107712   
## 1st Qu.:441036 1st Qu.:1318093 1st Qu.:33.70   
## Median :447914 Median :1325983 Median :34.48   
## Mean :447914 Mean :1325983 Mean :34.24   
## 3rd Qu.:454791 3rd Qu.:1333873 3rd Qu.:34.96   
## Max. :461624 Max. :1341763 Max. :38.24   
## NA's :37089

lst\_df\_84%>%filter(value!="NA")%>%head()

## x y value variable  
## 1 449577.0 1341763 28.69418 Band\_1  
## 2 449487.1 1341673 28.33435 Band\_1  
## 3 449577.0 1341673 28.40637 Band\_1  
## 4 449666.9 1341673 28.79483 Band\_1  
## 5 449756.8 1341673 28.50717 Band\_1  
## 6 449846.7 1341673 28.50717 Band\_1

C <- ggplot(data = lst\_df\_03) +  
 geom\_raster(aes(x = x,  
 y = y,  
 fill = value)) +  
 scale\_fill\_gradient(name = "Degrees C",  
 low = "blue",  
 high = "red") +  
 coord\_sf(expand = FALSE) +  
 labs(title = "LST 2003",  
 x = "longitude",  
 y = "latitude") +  
 theme(legend.position = "bottom")  
  
ggarrange(A,B,C,nrow = 1,labels = c(  
 "2024","1984","2003"  
))



# Matrix table for Markov Chain  
# source("TransProb.R")  
# source("MatDataBase.R")  
# source("GatherTransMat.R")  
  
# mat\_84324<- GatherTransMat("LST1984"=lst\_df\_84$value,"LST2003"=lst\_df\_03$value,"LST2024"=lst\_df\_24$value)  
# DriveZone<- c("LST1984","LST2003","LST2024")  
# Mat\_state<- as.matrix(mat\_84324)%>%na.omit()  
# MCZone<- new("markovchain",transitionMatrix=mat\_84324,state=c("SDR","AE","CW"))  
#   
#   
# lst\_df\_84\_new<- lst\_df\_84%>%mutate(LST= "LST1984")%>%select("value",LST)  
# lst\_df\_03\_new<- lst\_df\_03%>%mutate(LST= "LST2003")%>%select("value",LST)  
# lst\_df\_24\_new<- lst\_df\_24%>%mutate(LST= "LST2024")%>%select("value",LST)  
#   
# lst\_matrix<- rbind(lst\_df\_84\_new,lst\_df\_03\_new,lst\_df\_24\_new)%>%na.omit()  
# Dzone<- c("LST84","LST03","LST24")

## Preliminary Analysis: Modelling phase

LULC\_24 <- rast("2024\_LULC.tif")  
NDVI\_24 <- rast("2024\_NDVI.tif")  
NDBI\_24 <- rast("2024\_NDBI.tif")  
LULC\_2044 <- rast("2084\_LULC.tif")  
LULC\_2064 <- rast("2084\_LULC.tif")  
LULC\_2084 <- rast("2084\_LULC.tif")  
  
library(dplyr)  
lst\_df\_24\_NAomit<- lst\_df\_24%>%filter(value!="NA")  
lst\_lon\_lat<- lst\_df\_24%>%filter(value!="NA")%>%dplyr::select(x,y)  
lulc\_24\_merg<-terra::extract(LULC\_24,lst\_lon\_lat)%>%dplyr::select(Value\_1)  
NDVI\_24\_merg<-terra::extract(NDVI\_24,lst\_lon\_lat)%>%dplyr::select(Band\_1)  
NDBI\_24\_merg<- terra::extract(NDBI\_24,lst\_lon\_lat)%>%dplyr::select("2024\_NDBI")  
current\_lst\_24<- cbind(lst\_df\_24\_NAomit,lulc\_24\_merg,NDVI\_24\_merg,NDBI\_24\_merg)  
# names(current\_lst\_24)<- c("lon","lat","LST","variable","LULC","NDVI","NDBI")  
  
current\_lst\_24\_naomit<- current\_lst\_24%>% na.omit(Value\_1)  
current\_lst\_24\_naomit$Value\_1<-as.numeric(current\_lst\_24\_naomit$Value\_1)  
  
  
current\_lst\_24\_logistM\_1<- lm(value~Value\_1+Band\_1+current\_lst\_24\_naomit$"2024\_NDBI",data=current\_lst\_24\_naomit)  
current\_lst\_24\_logistM\_2<- lm(value~Band\_1,data=current\_lst\_24\_naomit)  
current\_lst\_24\_logistM\_3<- lm(value~current\_lst\_24\_naomit$Value\_1,data=current\_lst\_24\_naomit)  
summary(current\_lst\_24\_logistM\_1)

##   
## Call:  
## lm(formula = value ~ Value\_1 + Band\_1 + current\_lst\_24\_naomit$"2024\_NDBI",   
## data = current\_lst\_24\_naomit)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -8.5351 -0.4489 0.0530 0.5122 5.1244   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 34.370064 0.011954 2875.284 < 2e-16 \*\*\*  
## Value\_1 0.345194 0.003411 101.210 < 2e-16 \*\*\*  
## Band\_1 -0.687839 0.115699 -5.945 2.78e-09 \*\*\*  
## current\_lst\_24\_naomit$"2024\_NDBI" 8.784863 0.126801 69.280 < 2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.7886 on 70568 degrees of freedom  
## Multiple R-squared: 0.3781, Adjusted R-squared: 0.3781   
## F-statistic: 1.43e+04 on 3 and 70568 DF, p-value: < 2.2e-16

summary(current\_lst\_24\_logistM\_2)

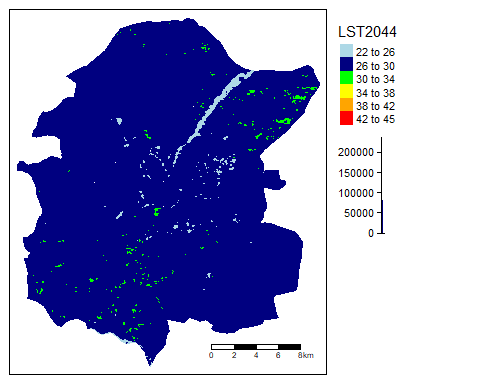
##   
## Call:  
## lm(formula = value ~ Band\_1, data = current\_lst\_24\_naomit)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -8.3252 -0.5958 0.0399 0.6902 5.6545   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 35.18834 0.01013 3472.98 <2e-16 \*\*\*  
## Band\_1 4.40384 0.09363 47.04 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.9847 on 70570 degrees of freedom  
## Multiple R-squared: 0.0304, Adjusted R-squared: 0.03038   
## F-statistic: 2212 on 1 and 70570 DF, p-value: < 2.2e-16

summary(current\_lst\_24\_logistM\_3)

##   
## Call:  
## lm(formula = value ~ current\_lst\_24\_naomit$Value\_1, data = current\_lst\_24\_naomit)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -8.0754 -0.4442 0.0717 0.5418 5.1545   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 34.643045 0.006450 5371.2 <2e-16 \*\*\*  
## current\_lst\_24\_naomit$Value\_1 0.401118 0.002285 175.5 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.8343 on 70570 degrees of freedom  
## Multiple R-squared: 0.3039, Adjusted R-squared: 0.3039   
## F-statistic: 3.081e+04 on 1 and 70570 DF, p-value: < 2.2e-16

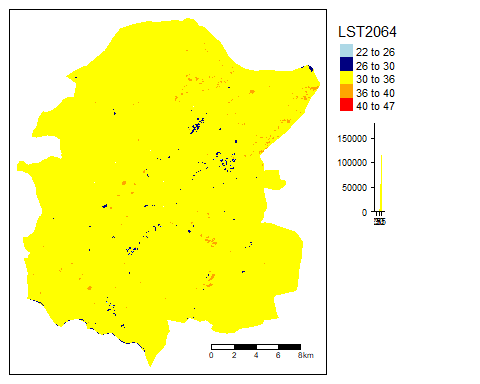
# sss1<- predict(LULC\_24,current\_lst\_24\_logistM,type="response")  
#   
# lulc\_64\_merg<-terra::extract(LULC\_2044,lst\_lon\_lat)  
# lulc\_084\_merg<-terra::extract(LULC\_2064,lst\_lon\_lat)  
# lulc\_44\_merg<-terra::extract(LULC\_2084,lst\_lon\_lat)  
# Pred\_2044\_using24<- predict(current\_lst\_24\_logistM,lulc\_44\_merg,type="response")  
# Pred\_2064\_using24<- predict(current\_lst\_24\_logistM,lulc\_64\_merg,type="response")  
# Pred\_2084\_using24<- predict(current\_lst\_24\_logistM,lulc\_084\_merg,type="response")  
# plot(sss1)  
# plot(LST\_24)  
# head(current\_lst\_24\_naomit)  
  
tm\_A<- tmap::tm\_shape(LST\_84)+  
tmap::tm\_raster(title="LST2044",  
breaks = c(22,26,30,34,38,42,45),  
# labels = C(22-26,26-30,30-34,34-38,38-42,42-45),  
palette = c("lightblue","navyblue","green","yellow","orange","red"),  
legend.hist = T) +  
tmap::tm\_layout(legend.outside = TRUE)+  
tmap::tm\_scale\_bar(position=c("right", "bottom"))  
  
tm\_A

## Warning: Values have found that are less than the lowest break

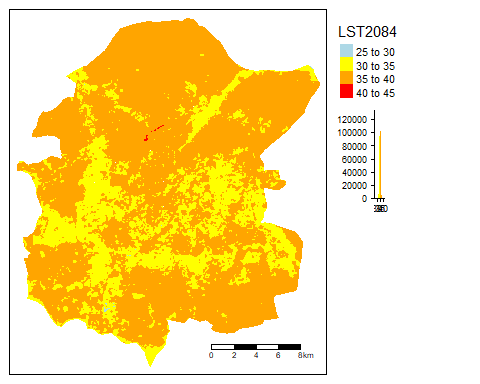


tm\_B<- tmap::tm\_shape(LST\_03)+  
tmap::tm\_raster(title="LST2064",  
style = "fixed",  
breaks = c(22,26,30,36,40,47),  
# labels = C(22-26,26-30,30-34,34-38,38-42,42-45),  
palette = c("lightblue","navyblue","yellow","orange","red"),  
legend.hist = T) +  
tmap::tm\_layout(legend.outside = TRUE)+  
tmap::tm\_scale\_bar(position=c("right", "bottom"))  
  
tm\_B

## Warning: Values have found that are less than the lowest break



tm\_C<- tmap::tm\_shape(LST\_24)+  
tmap::tm\_raster(title="LST2084",  
style = "fixed",  
breaks = c(25,30,35,40,45),  
# labels = C(22-26,26-30,30-34,34-38),  
palette = c("lightblue","yellow","orange","red"),  
legend.hist = T) +  
tmap::tm\_layout(legend.outside = TRUE)+  
tmap::tm\_scale\_bar(position=c("right", "bottom"))  
  
tm\_C



# install.packages(c('neuralnet','keras','tensorflow'),dependencies = T)  
  
cr<-rcorr(as.matrix(current\_lst\_24\_naomit[,5:7]))  
cr$r

## Value\_1 Band\_1 2024\_NDBI  
## Value\_1 1.0000000 0.5802790 0.3374899  
## Band\_1 0.5802790 1.0000000 -0.2684692  
## 2024\_NDBI 0.3374899 -0.2684692 1.0000000

# model = neuralnet(  
# value~Band\_1+current\_lst\_24\_naomit$"2024\_NDBI",data=current\_lst\_24\_naomit,  
# hidden=c(4,2),  
# linear.output = FALSE  
# )  
#   
# sss<- predict(NDVI\_24,model,type="response")  
# plot(sss)

# library(tiff)  
# library(leaflet)  
# library(tmap)  
# library(tmaptools)