ETHIOPIAN POPULATION HEALTH (and analytical lessons from California)

Presentation for Bahir Dar University School of Graduate Studies

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CONTENTS

- Objectives
- A spatial statistical tool in focus: the Geographically Weighted Regression (GWR)
- The Ethio-demography and health website
- Income Inequality and Health (lessons from California)

OBJECTIVES

1. To highlight a spatial statistics tool and show examples of its application using Ethiopia's 2016 Demographic and Health Survey (DHS) data

2. To introduce a demography and health website and solicit contributions from demographers, epidemiologists, sociologists, and geographers

3. To share experiences and best practices from my employment at the California Department of Public Health

PART I. SPATIAL STATISTICS

The research question:

Are the unweighted proportions of women's responses to DHS question V744c related to educational status?

Q. V744c: It is the respondent's opinion that a husband is justified in hitting or beating his wife when she argues with him

- **Yes**
- **No**

METHODOLOGY

- **Data source: Eth. DHS 2016**
  - **Data processing using R-programing language**
  - **Spatial statistics using geographically weighted regression (GWR) - an ArcGIS-Pro application**

R-PROGRAMMING

DHS files

```
> #Couples' recode
> DHS2016_Couple <- read.dta("D:/DHS2016/ETCR71DT/ETCR71FL.DTA")
> nrow(DHS2016_Couple)
[1] 6141
> #Household recode
> DHS2016_HHold <- read.dta("D:/DHS2016/ETHR71DT/ETHR71FL.DTA")
> nrow(DHS2016_HHold)
[1] 16650
> #Individual recode
> DHS2016_Wom <- read.dta("D:/DHS2016/ETIR71DT/ETIR71FL.DTA")
> nrow(DHS2016_Wom)
[1] 15683
> #Births recode
> DHS2016_Births <- read.dta("D:/DHS2016/ETBR71DT/ETBR71FL.DTA")
> nrow(DHS2016_Births)##41392
[1] 41392
>
```

Women's Attitude Toward Wife-beating (Eth. DHS 2016)

It is the respondent's opinion that a husband is justified in hitting or beating his wife when:

#V744A She goes out without telling him
#V744B She neglects the children
#V744C She argues with him
#V744D She refuses to have sex with him
#V744E She burns the food

#V744C She argues with him (National)

R-programing (National)

```
DHS2016_Wom <- read.dta("D:/DHS2016/ETIR71DT/ETIR71FL.DTA")
> nrow(DHS2016_Wom)
[1] 15683 (number of women - unweighted)

> summary(DHS2016_Wom$v744c)
      no                  yes                 don't know
 9839 (62.9%)        5707 (36.4%)          137 (0.7%)
```

R-programing (Regional)

```
#Regional proportions of yes/no answers to beatings if wife argues with husband
WomArgReg <- table(DHS2016_Wom$v101,DHS2016_Wom$v744c) # WomArgReg # print table
```

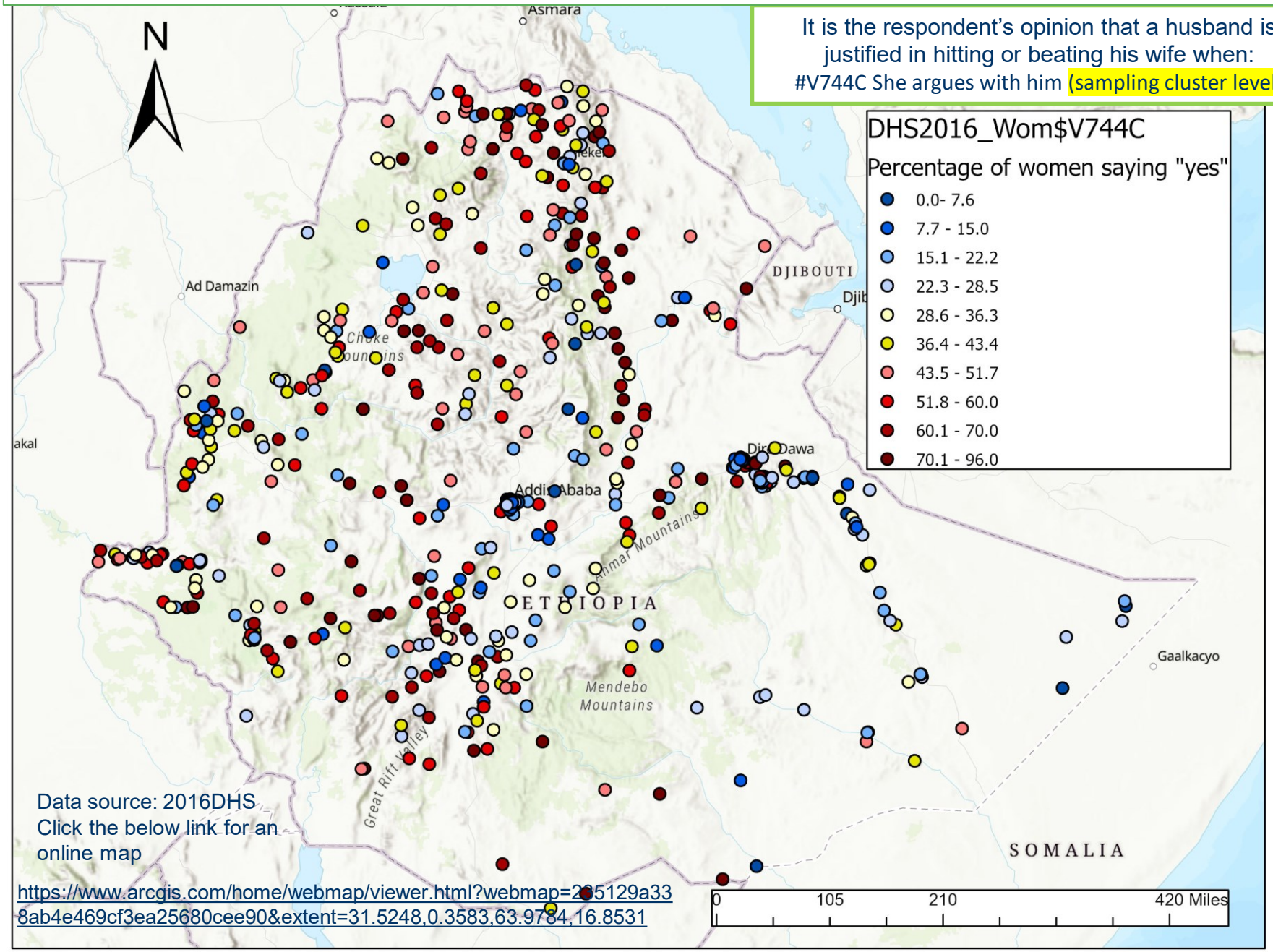
#V744C She argues with him (Regional)

Regional percentage of women who answered yes/no to a question on wife-beating over spousal arguments

Region	No	% NO	Yes	% YES	Don't l	%
Afar	531	47.1	582	51.6	15	1.3
Oromia	965	51.0	905	47.0	22	2.0
Tigray	894	53.2	783	46.4	5	0.4
SNNPR	1014	54.8	823	44.1	12	1.1
Amhara	980	57.0	725	41.7	14	1.2
Gambela	614	59.3	414	40.1	7	0.6
Benishang	725	64.4	400	35.5	1	0.1
Somali	913	65.6	446	31.5	32	2.8
Harari	654	72.2	243	27.0	9	0.8
Dire Dawa	879	77.7	239	21.1	13	1.2
Addis Aba	1670	91.6	147	7.8	7	0.6

Unweighted cluster percentages of women with a “yes” response to V744c

It is the respondent’s opinion that a husband is justified in hitting or beating his wife when:
#V744C She argues with him (sampling cluster level)



Data source: 2016DHS
Click the below link for an online map

https://www.arcgis.com/home/webmap/viewer.html?webmap=285129a338ab4e469cf3ea25680cee90&extent=31.5248,0.3583,63.9784,16.8531

SPATIAL Autocorrelation Global Moran's I

50	23	58	38
19	84	16	55
78	13	83	27
38	75	26	41

Dissimilar values
Negative

84	83	58	38
78	75	50	27
55	41	26	19
38	23	16	13

Similar values
Positive

19	83	84	13
38	55	58	26
50	41	38	75
16	78	23	75

Random pattern
No autocorrelation

Global Moran's I Summary

Moran's Index:	0.324838
Expected Index:	-0.001558
Variance:	0.000260
z-score:	20.256442
p-value:	0.000000

Dataset Information

Input Feature Class:	DHS2016_Wom$V744C
Input Field:	PCTWFBT_YE
Conceptualization:	INVERSE_DISTANCE
Distance Method:	EUCLIDEAN
Row Standardization:	True
Distance Threshold:	121760.4172 Meters
Weights Matrix File:	None
Selection Set:	False

Input field: Percentage of women responding "yes" to V744C

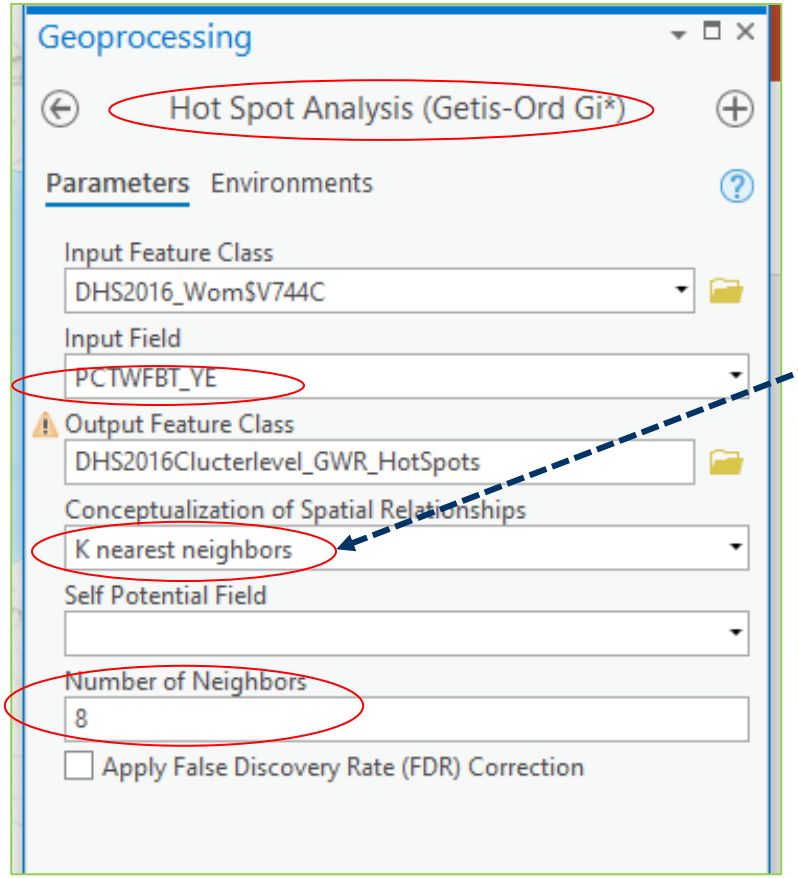
Global Moran's I Summary

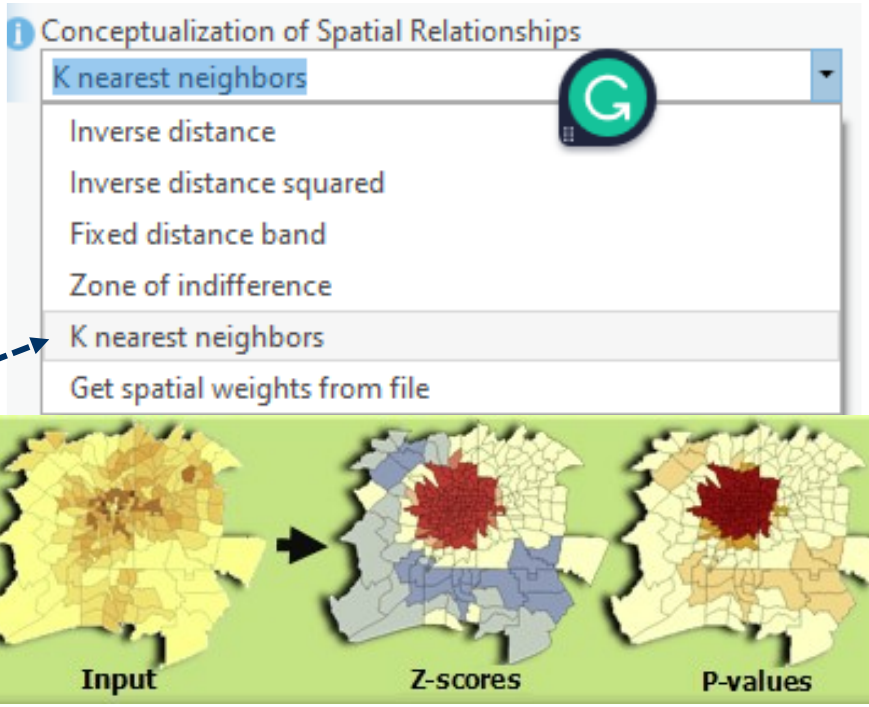
Moran's Index:	0.364077
Expected Index:	-0.001558
Variance:	0.000325
z-score:	20.282289
p-value:	0.000000

Dataset Information

Input Feature Class:	DHS2016_Wom$V744C
Input Field:	PCTWFBT_YE
Conceptualization:	K_NEAREST_NEIGHBORS
Distance Method:	EUCLIDEAN
Row Standardization:	True
Distance Threshold:	None
Weights Matrix File:	None
Selection Set:	False

Geographical **HOT-SPOT** Analysis



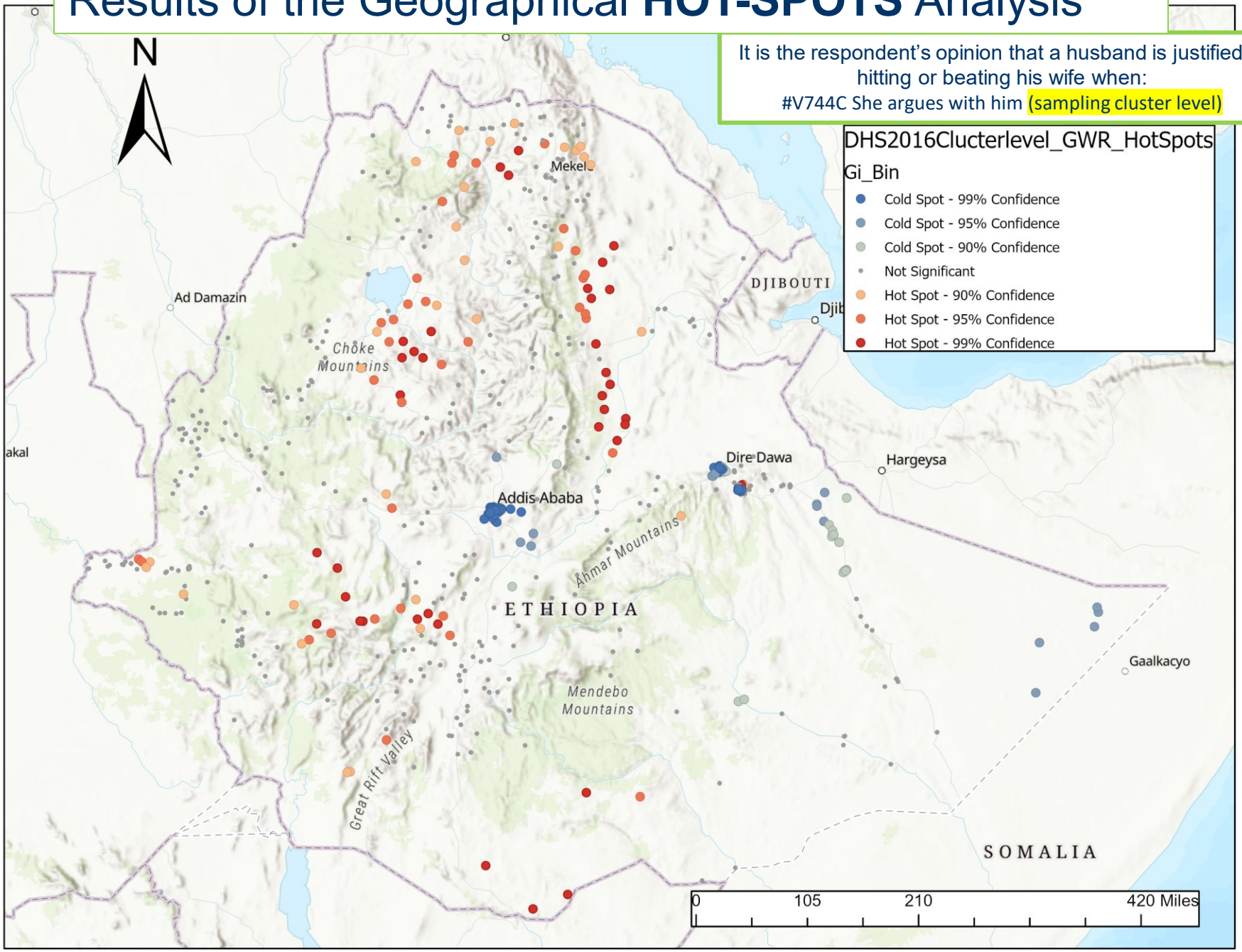


•The hot-spot tool identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots). It creates an **Output Feature Class** with a z-score, p-value, and confidence level bin field (`Gi_Bin`) for each feature in the **Input Feature Class**.

Source: https://pro.arcgis.com/en/pro-app/2.7/tool-reference/spatial-statistics/hot-spot-analysis.htm

Results of the Geographical **HOT-SPOTS** Analysis

It is the respondent's opinion that a husband is justified in hitting or beating his wife when:
#V744C She argues with him (sampling cluster level)



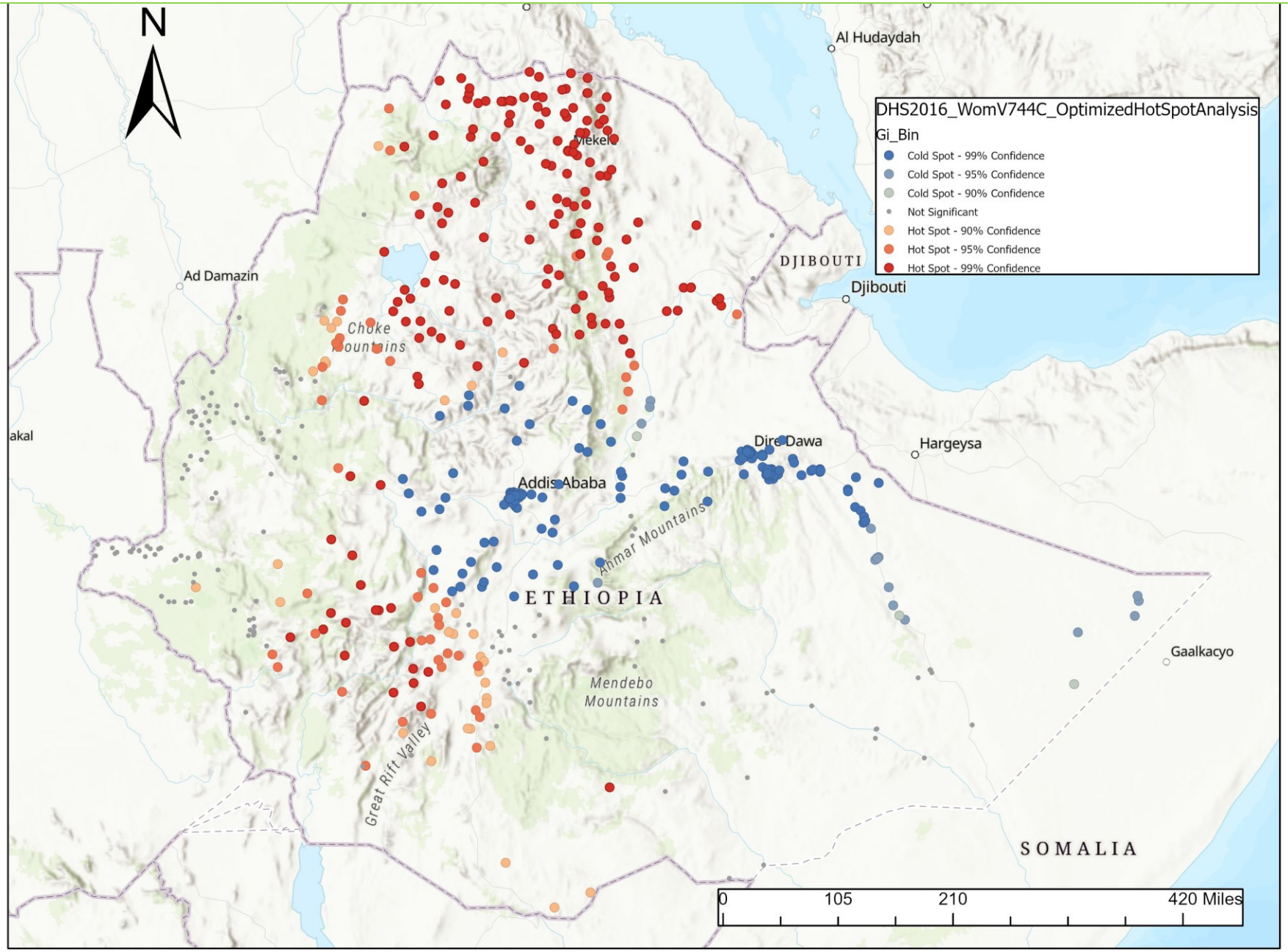
Geographical **OPTIMIZED HOT-SPOT** Analysis

"Similar to the way that the automatic setting on a digital camera will use lighting and subject versus ground readings to determine an appropriate aperture, shutter speed, and focus, the Optimized Hot Spot Analysis tool interrogates your data to obtain the settings that will yield optimal hot spot results."

Source: https://pro.arcgis.com/en/pro-app/2.7/tool-reference/spatial-statistics/how-optimized-hot-spot-analysis-works.htm

Making sure there are enough weighted features for analysis....
- There are 643 valid input features.
Evaluating the Analysis Field values....
- PCTWFBT_YE Properties:
    Min: 0.0000
    Max: 96.0000
    Mean: 37.0251
    Std. Dev.: 22.7485
Looking for locational outliers....
- There was 1 outlier location; it will not be used to compute the optimal fixed distance band.
****** Scale of Analysis ******
Looking for an optimal scale of analysis by assessing the intensity of clustering at increasing distances....
- The optimal fixed distance band is based on peak clustering found at 166072.1750 Meters
****** Hot Spot Analysis ******
Finding statistically significant clusters of high and low PCTWFBT_YE values....
- There are 497 output features statistically significant based on an FDR correction for multiple testing and spatial dependence.
- 2% of features had less than 8 neighbors based on the distance band of 166072.1750 Meters
****** Output ******
Creating output feature class: D:\EthGIS\EthioDHS_2016\Default.gdb\DHS2016_WomV744C_OptimizedHotSpotAnalysis
- Red output features represent hot spots where high PCTWFBT_YE values cluster.
- Blue output features represent cold spots where low PCTWFBT_YE values cluster.
Succeeded at Sunday, September 25, 2022 9:26:59 AM (Elapsed Time: 6.80 seconds)

Results of the Geographical **OPTIMIZED HOT-SPOT** Analysis



Looking for an explanation of the spatial pattern

What explains women's "yes" or "no" answers to the below question?

It is the respondent's opinion that a husband is justified in hitting or beating his wife when:
#V744c She argues with him

- Urbanism appears to be a factor: case in point are the low "yes" percentages in Dire Dawa (21.1), and Harari (27.0) and the single-digit percentage in Addis Ababa (7.8)
- Urbanism could be a proxy for women's level of education
- The low "yes" percentages in the primarily rural Somali Region where less than a third (31.5%) of interviewees gave such a response, shows that such occurrences are not limited to primarily urban locations

Looking for an explanation…contd.

Terminology refresher (Multivariate and bi-variate regression)

Multivariate: dependent variable

$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + \varepsilon$

What are you trying to predict or understand?

Multivariate: explanatory variable

$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + \varepsilon$

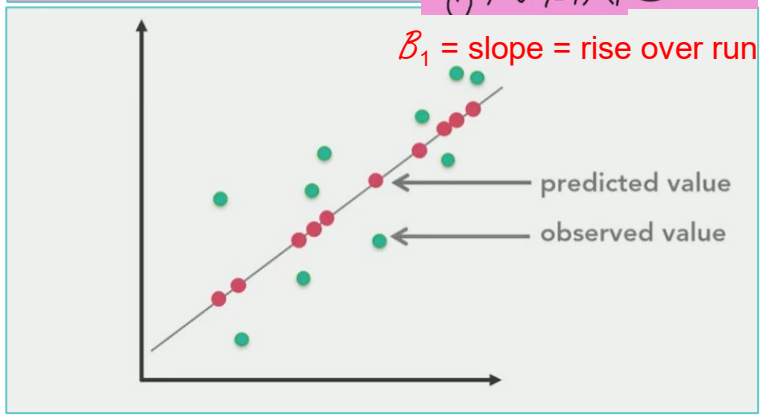
Variables you believe to cause or explain the dependent variable

Multivariate: coefficients

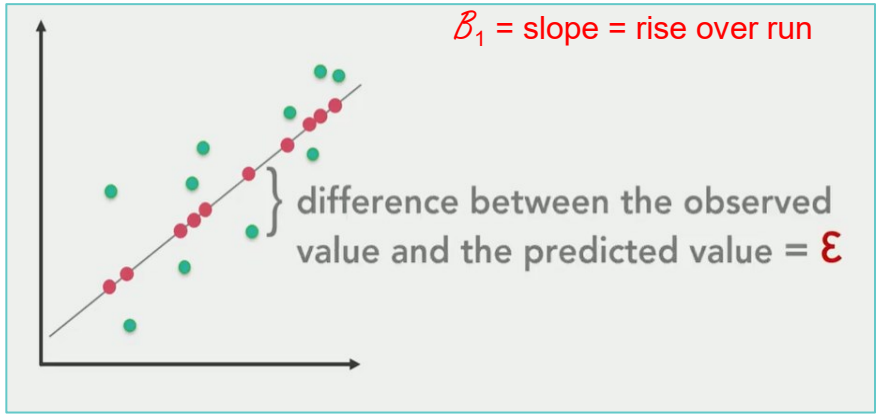
$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + \varepsilon$

Represent the strength and type of relationship that X has to y

Bi-variate: residual $y = \beta_0 + \beta_1 X_1 + \varepsilon$



Bi-variate: residual $y = \beta_0 + \beta_1 X_1 + \varepsilon$



Source: ESRI, https://www.youtube.com/watch?v=ob18SuuAJGI

Looking for an explanation…contd.

Problems with bi/multi-variate regression between V744c (y-variable) and any explanatory variables (x):

- The Morans-I statistic showed the presence of spatial autocorrelation for the dependent variable V744c – women's response to a question on wife-beating
- The presence of spatial autocorrelation creates problems with using x variables to explain y variables as it violates the assumption of the independence of y residuals*
- The main effect of such a violation is to underestimate the Error Sum of Squares (SS) thus inflating the value of the test statistic*
- This means that V744c (y) is not suitable for the ordinary least squares (OLS) regression analysis.

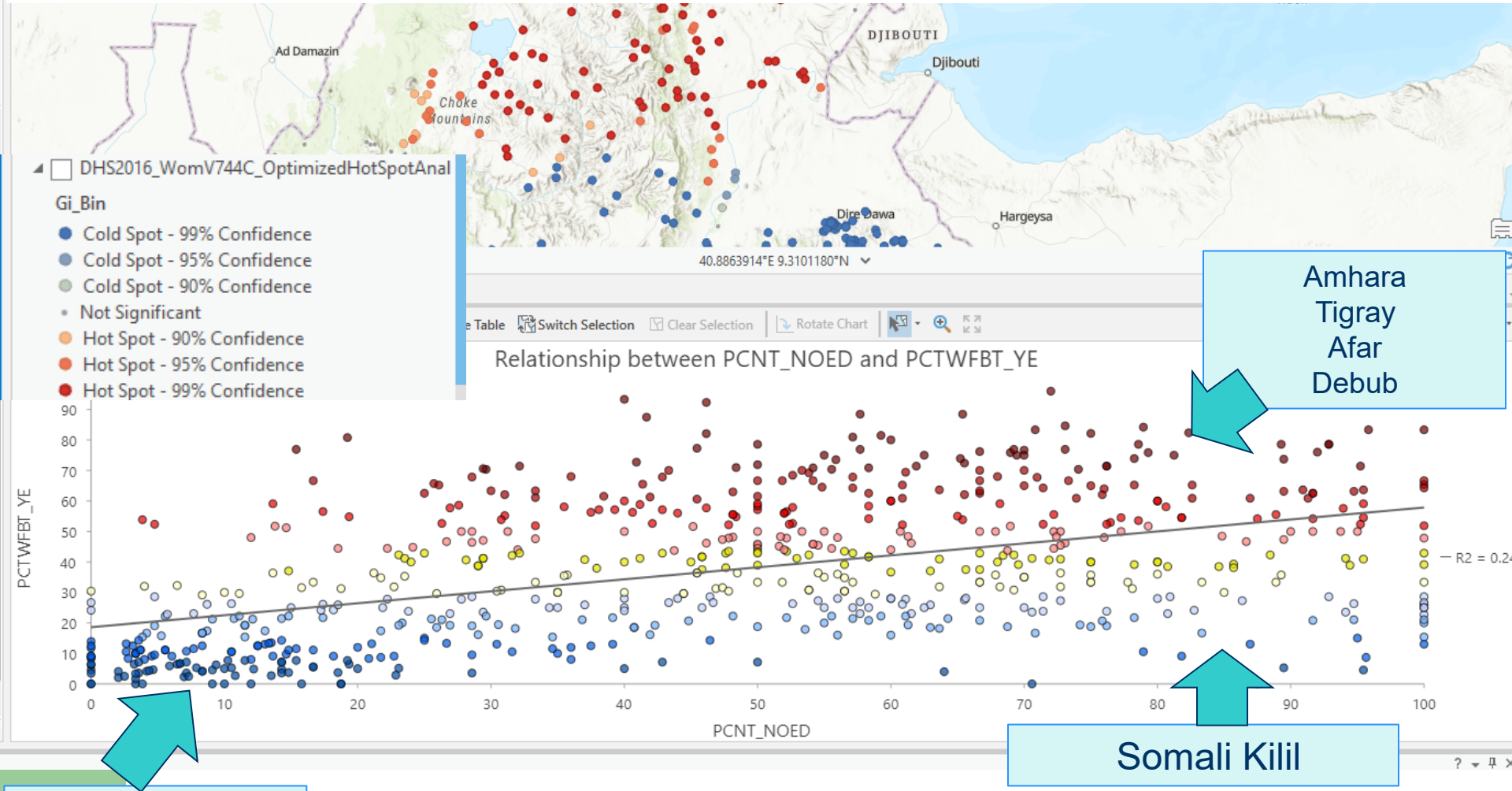
Solution

- The solution is the use of the Geographically Weighted Regression method which takes into account the presence of spatial autocorrelation and makes corrections to overcome its effects**

*Source: https://ibis.geog.ubc.ca/courses/geob479/notes/spatial_analysis/spatial_autocorrelation.htm#:~:text=If%20spatial%20autocorrelation%20is%20present,the%20value%20of%20test%20statistic

**Source: https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1538-4632.1996.tb00936.x

Looking for an explanation…contd.
Is the (y) variable suitable for ordinary least squared (OLS) regression (example: (y) versus education (x)?



Amhara
Tigray
Afar
Debub

Somali Kilil

Addis Ababa
Dire Dawa
Harari Kilil

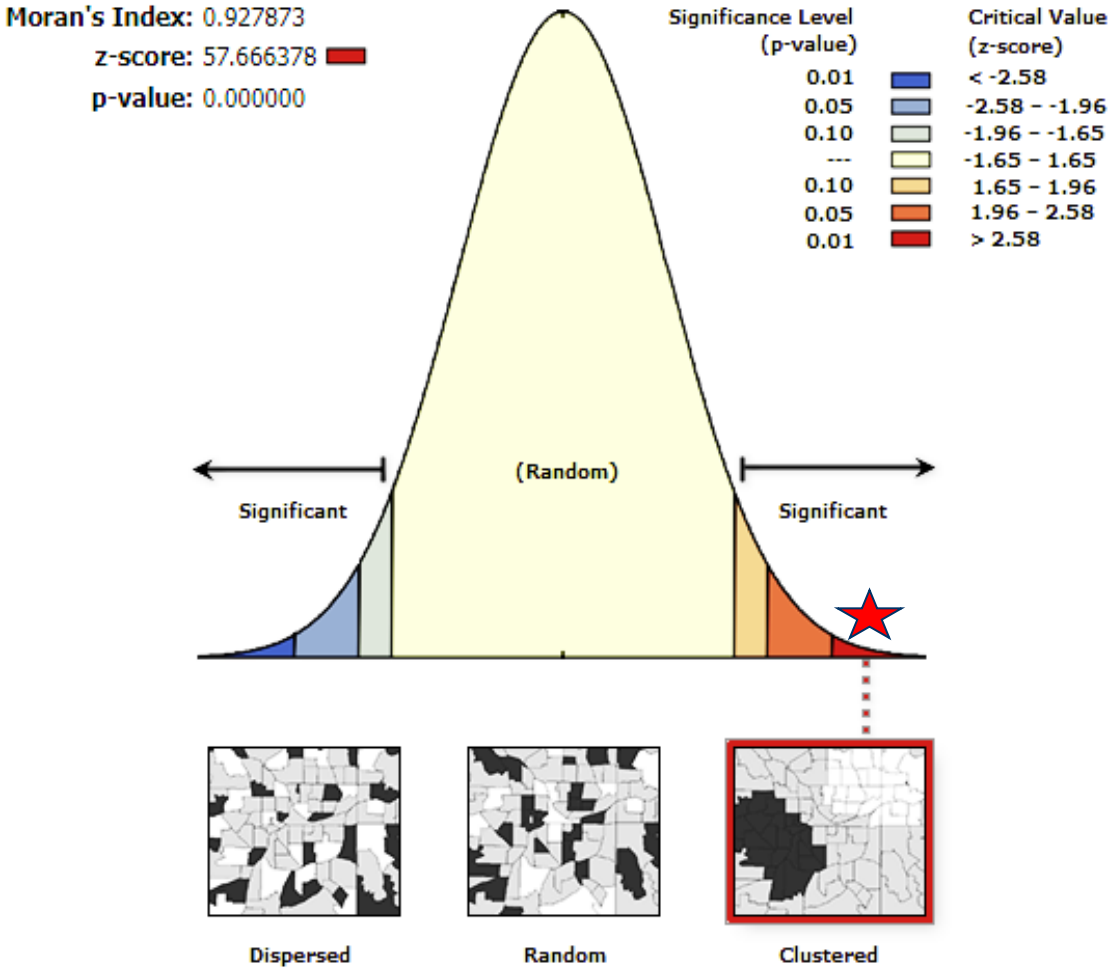
Applying the education versus V744c generalized linear regression model (GLM) to all clusters creates a **global** model and a single equation

The answer is no. The above visualization proves that it would be wrong to try and apply a single regression equation or model in the hope that it would be valid for the entire country

Looking for an explanation…contd.

The dependent variable, V744c is not suitable for ordinary least squares regression as the residuals are not randomly distributed; they are clustered

Spatial Autocorrelation Report

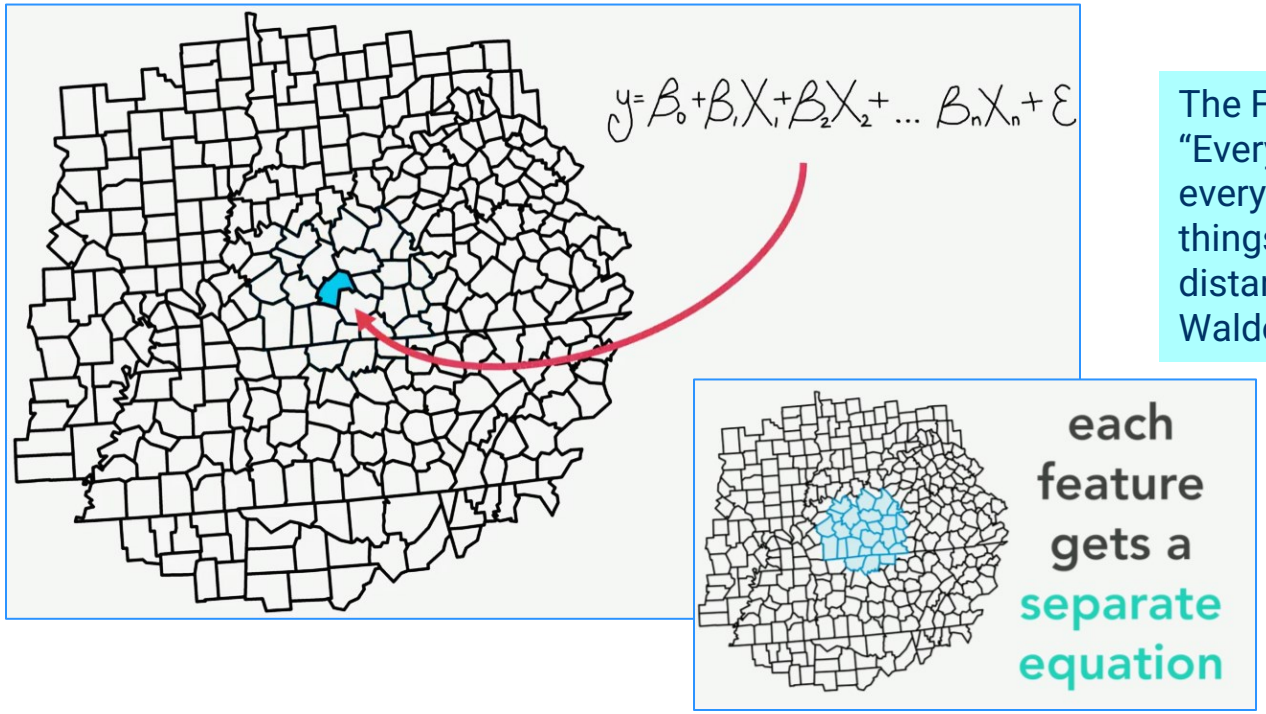


Given the z-score of 57.666378, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

The solution is a Geographically Weighted Regression - GWR

https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1538-4632.1996.tb00936.x

- With GWR, each cluster is grouped with its immediate neighbors and is given a separate equation*

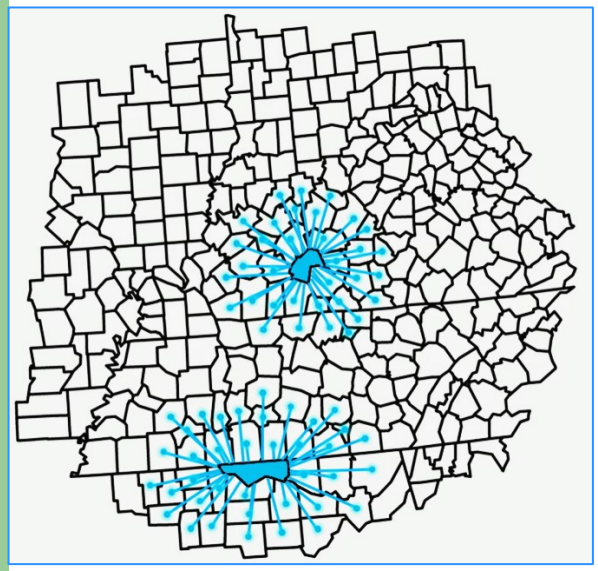


The First Law of Geography: "Everything is related to everything else, but near things are more related than distant things."
Waldo Tobler

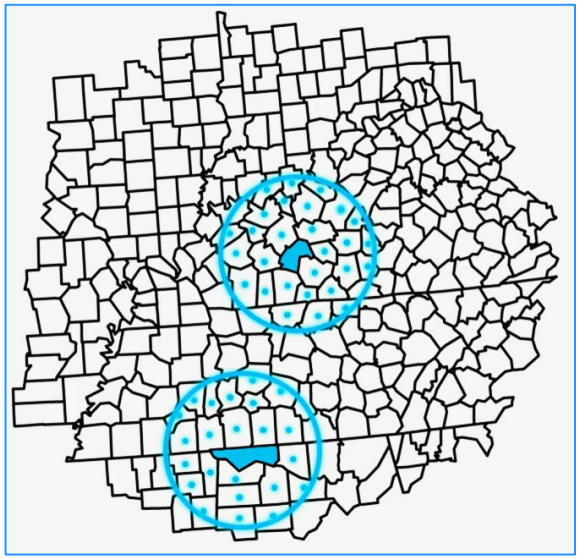
*Source: ESRI https://www.youtube.com/watch?v=ob18SuuAJGI

GWR ….contd.
Defining local

Number of neighbors



Distance band

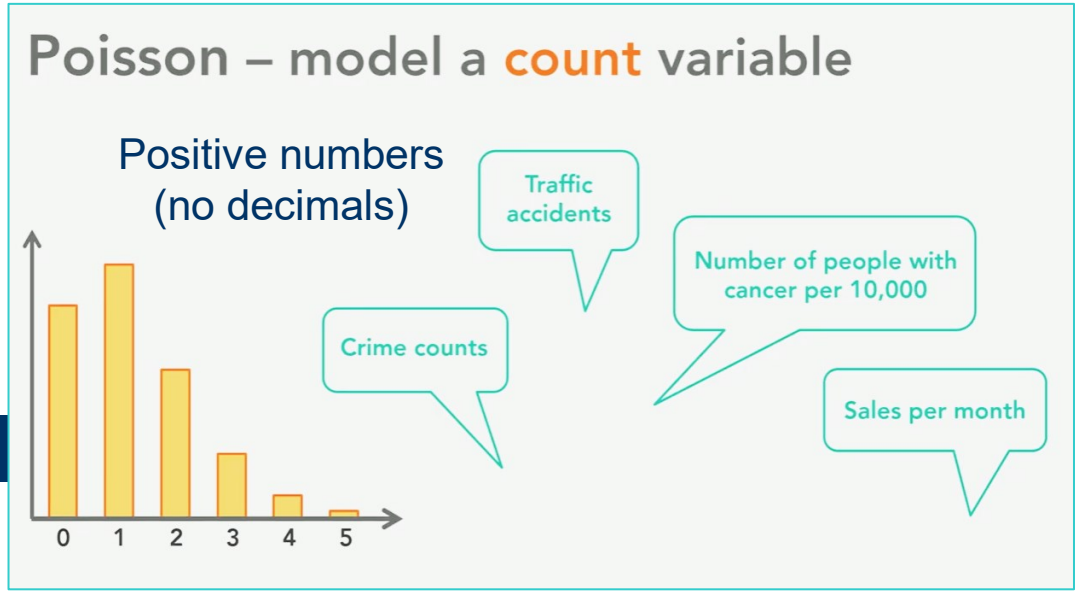


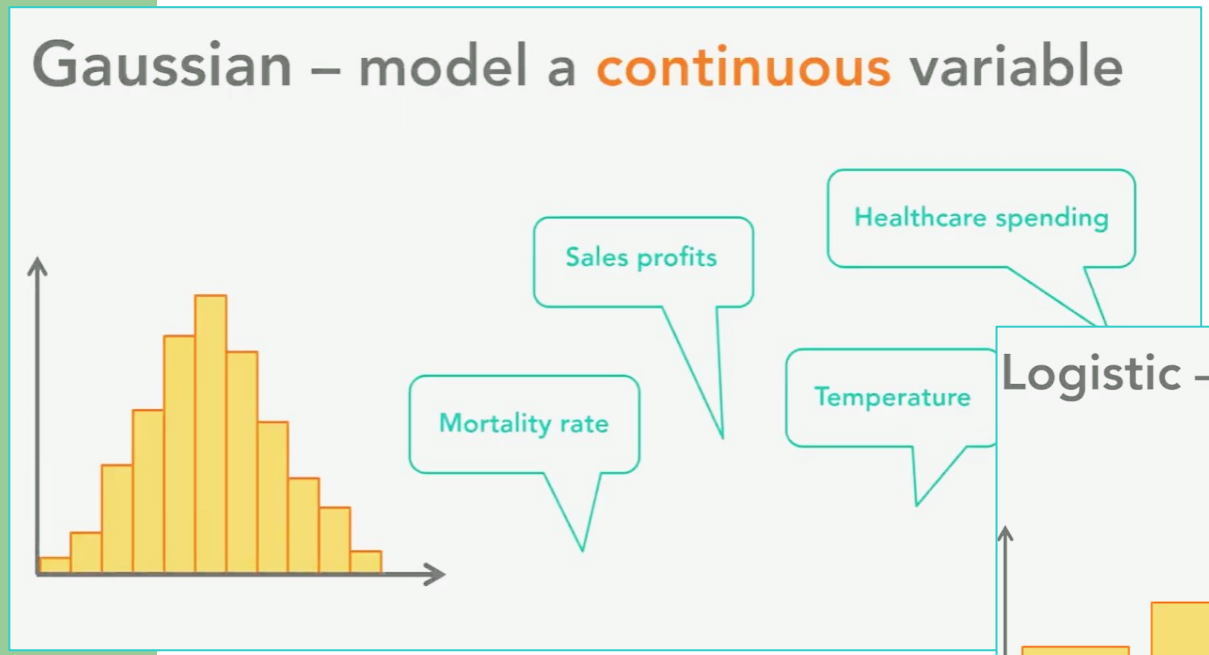
Golden search*

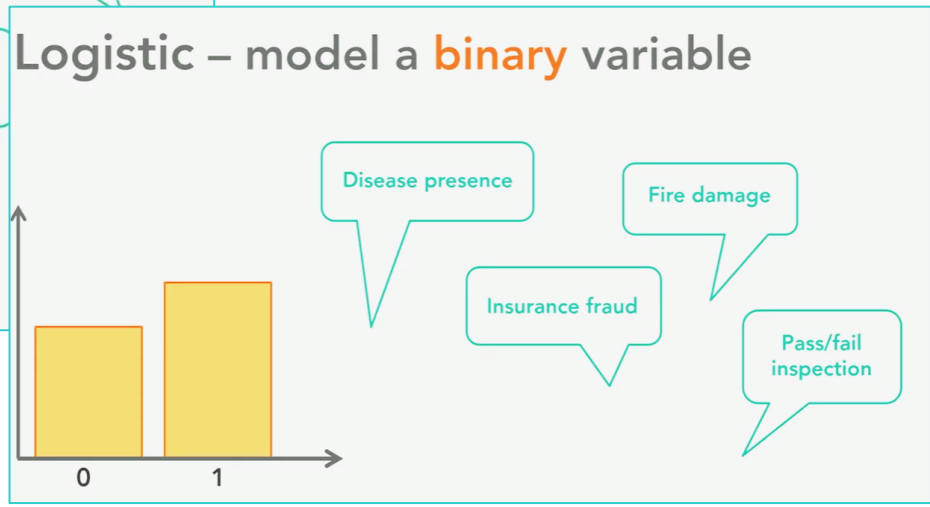
*Software finds an optimum distance by increasing distances by thirds (golden search) until the best local minima are found

Source: ESRI https://www.youtube.com/watch?v=ob18SuuAJGI

Three GWR Models (depending on your data type)

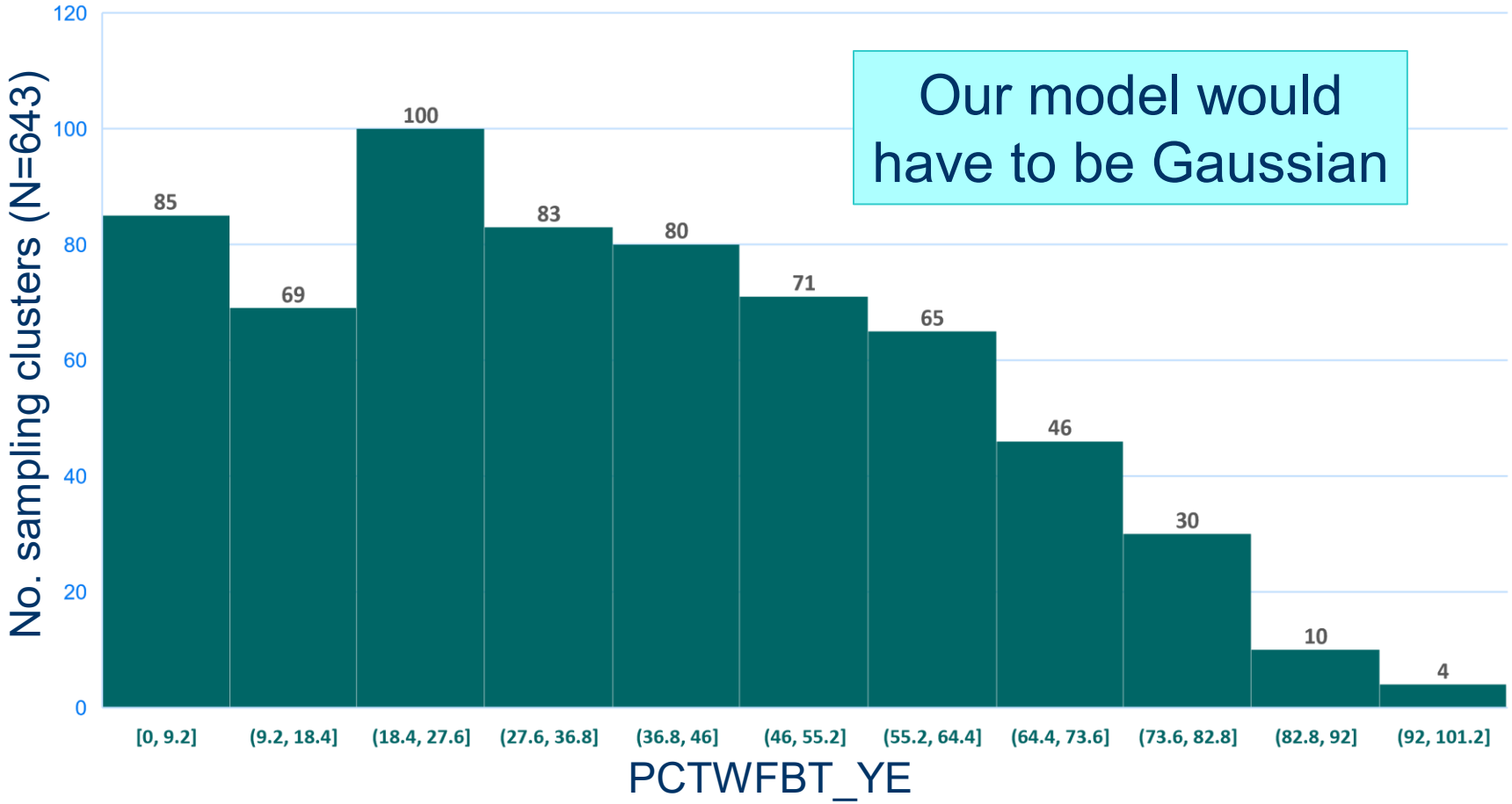




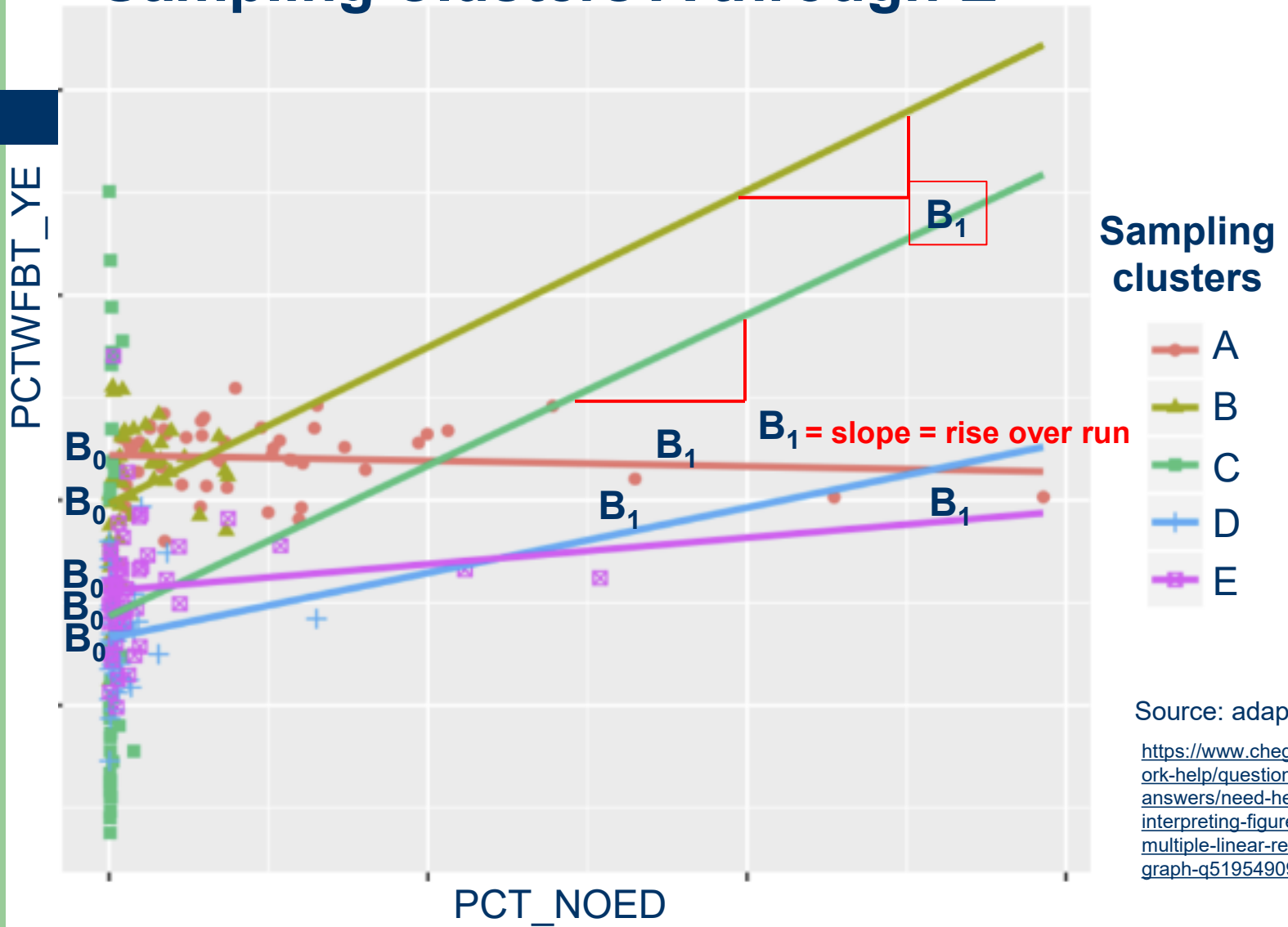


Source: ESRI https://www.youtube.com/watch?v=ob18SuuAJGI

Histogram of the Percentage of Women Responding “yes" to a Question on Wife-beating

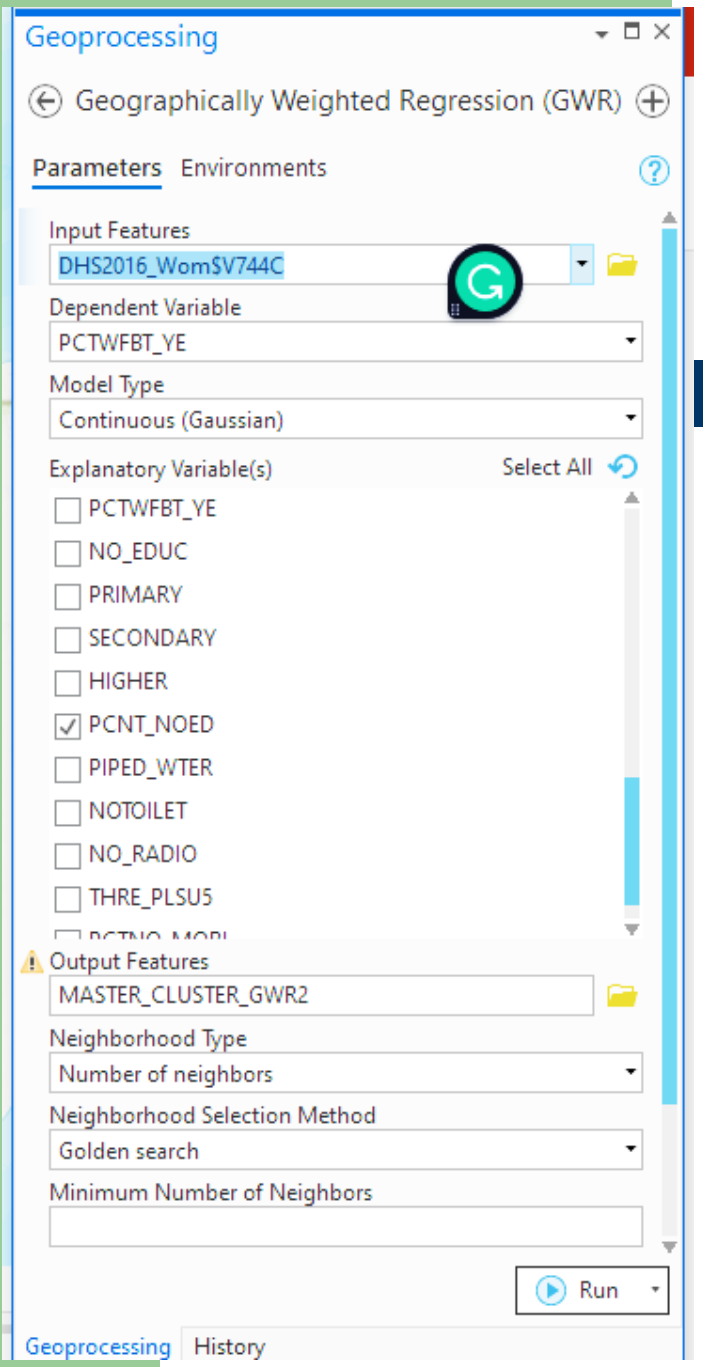


Bi-variate B_0, B_1 plots for Hypothetical Sampling Clusters A through E



Source: adapted from

https://www.chegg.com/homework-help/questions-and-answers/need-help-interpreting-figure-made-multiple-linear-regression-graph-q51954909



GWR ….contd.

Results

v744C (y) vs. education (x)

WARNING 110306: The final model didn't have the lowest AICc encountered in the Golden Search Results.
WARNING 110259: At least one local regression had very limited variation after applying the weights. Use caution when interpreting the results.

-------- Analysis Details -------
Number of Features: 643
Dependent Variable: PCTWFBT_YE
Explanatory Variables: PCNT_NOED
Number of Neighbors: 72

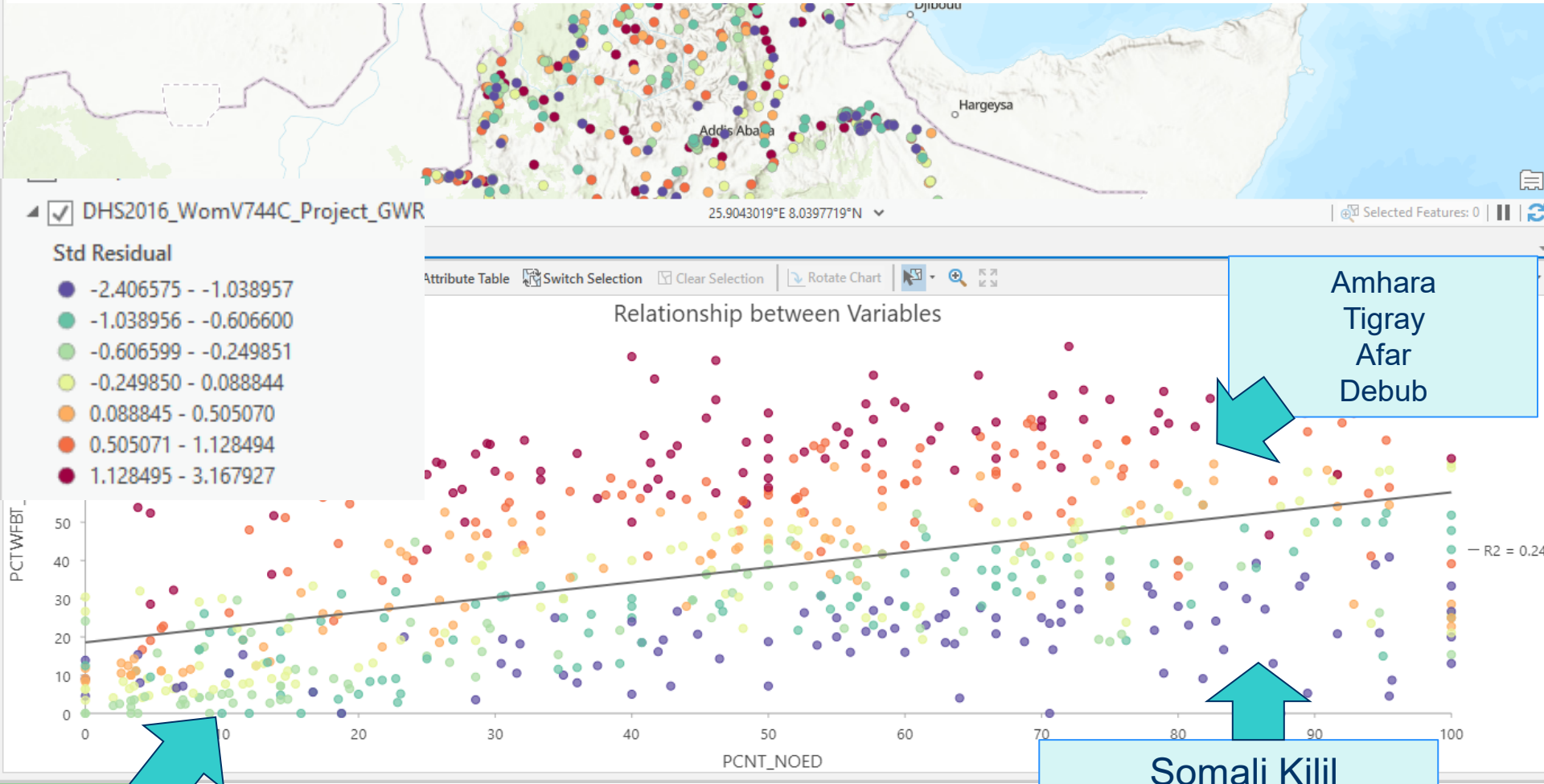
---------- Model Diagnostics ----------
R2: 0.5123
AdjR2: 0.4585
AICc: 5489.8314
Sigma-Squared: 280.1931
Sigma-Squared MLE: 252.3868
Effective Degrees of Freedom: 579.1888

Succeeded at Friday, September 23, 2022 7:26:15 AM (Elapsed Time: 6.19 seconds)

-- Golden Search Results

#Neighbors	AICc
30	5514.0940
643	5667.8465
264	5548.8335
409	5569.4515
175	5524.7560
119	5500.4482
85	5491.6356
64	5492.1195
98	5493.9578
77	5489.8220
72	5489.8314

Did the Geographically Weighted Regression method correct the ordinary least squared (OLS) regression problems associated with spatial autocorrelation of the (y) variable?



Amhara
Tigray
Afar
Debub

Somali Kilil

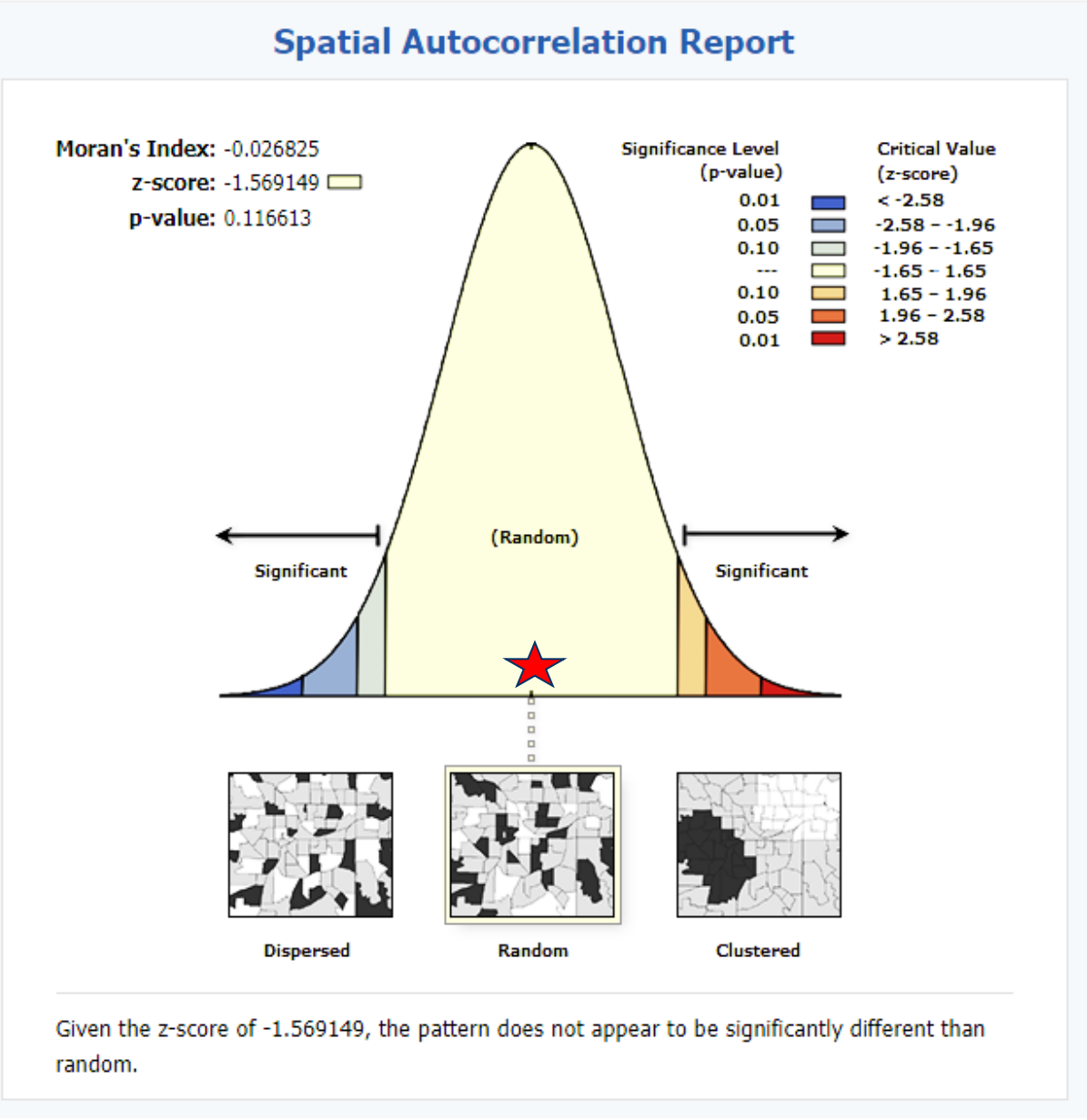
Addis Ababa
Dire Dawa
Harari Kilil

Applying the education versus V744c geographically weighted regression model (GWR) to all clusters creates individualized **local** models for each sampling cluster based on how its (x)(y) values relate to (x)(y) values in neighboring clusters

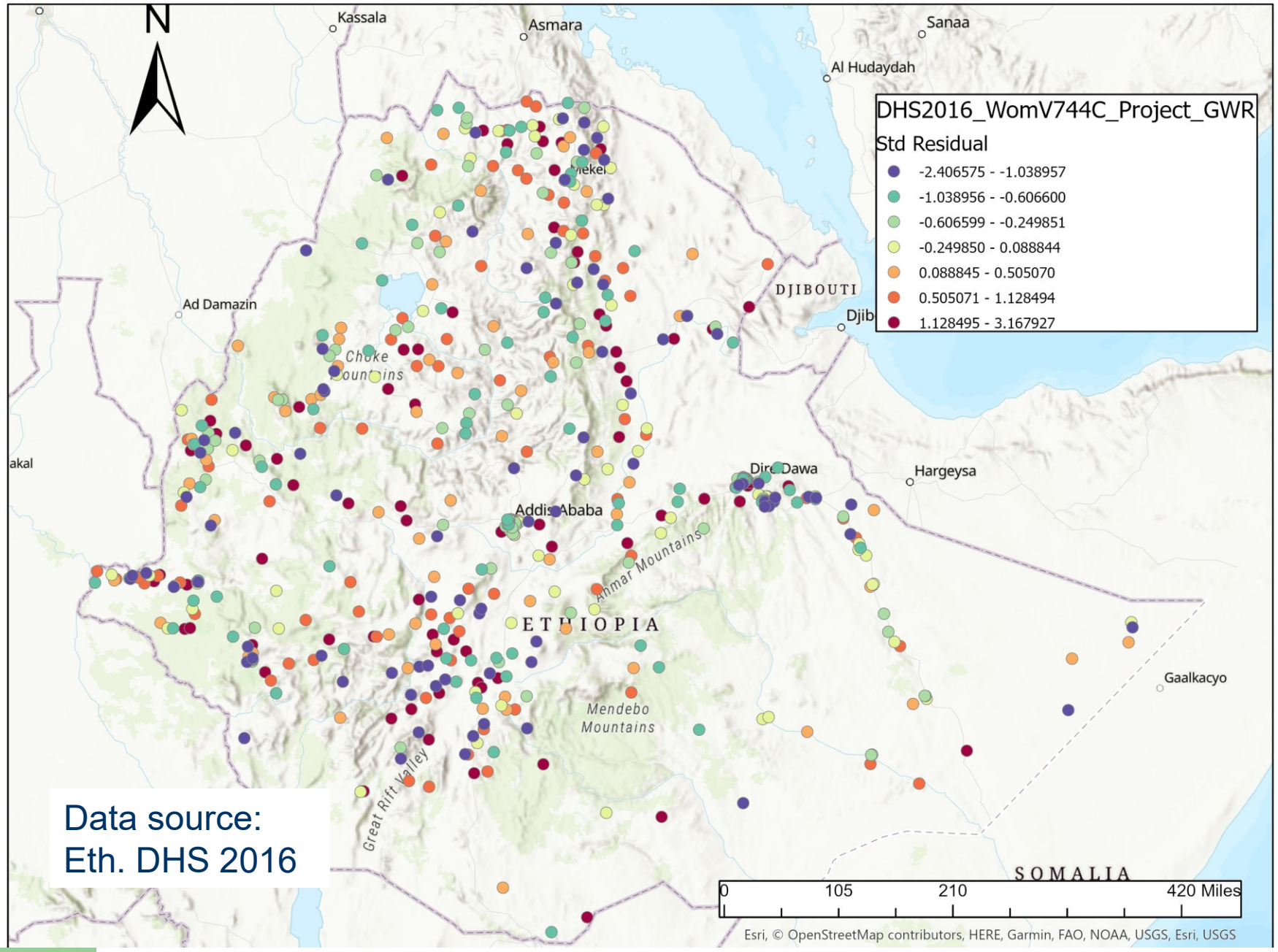
Yes. Geographically Weighted Regression corrected the ordinary least squared (OLS) regression problems associated with spatial autocorrelation of the (y) variable

GWR ….contd.

Proof that the assumption of independent residuals was not violated

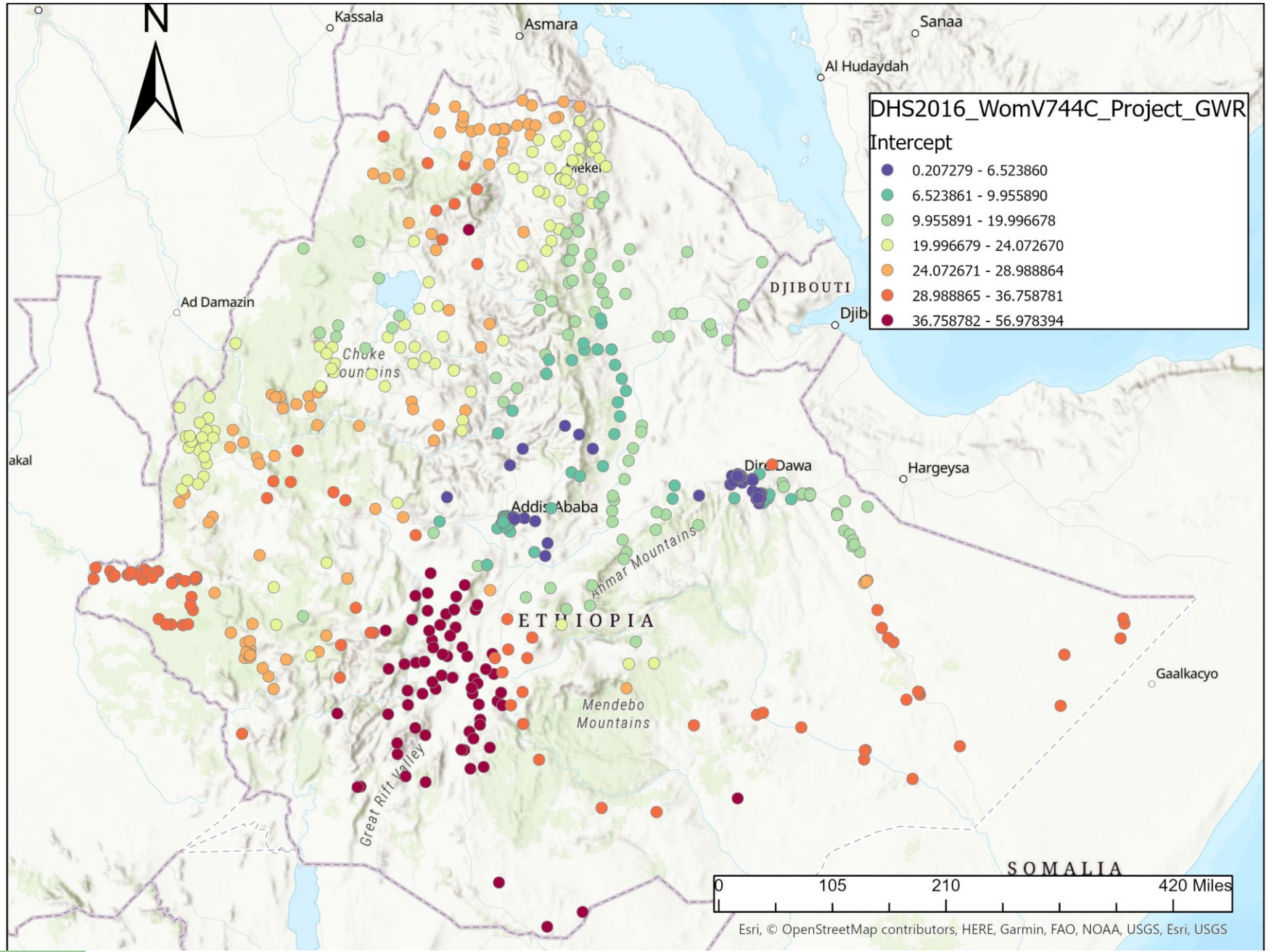


Standardized Residuals ($\mathfrak{E}$), Geographically Weighted Regression with Women's Response on Wife-beating as (y) variable and education as (x) variable

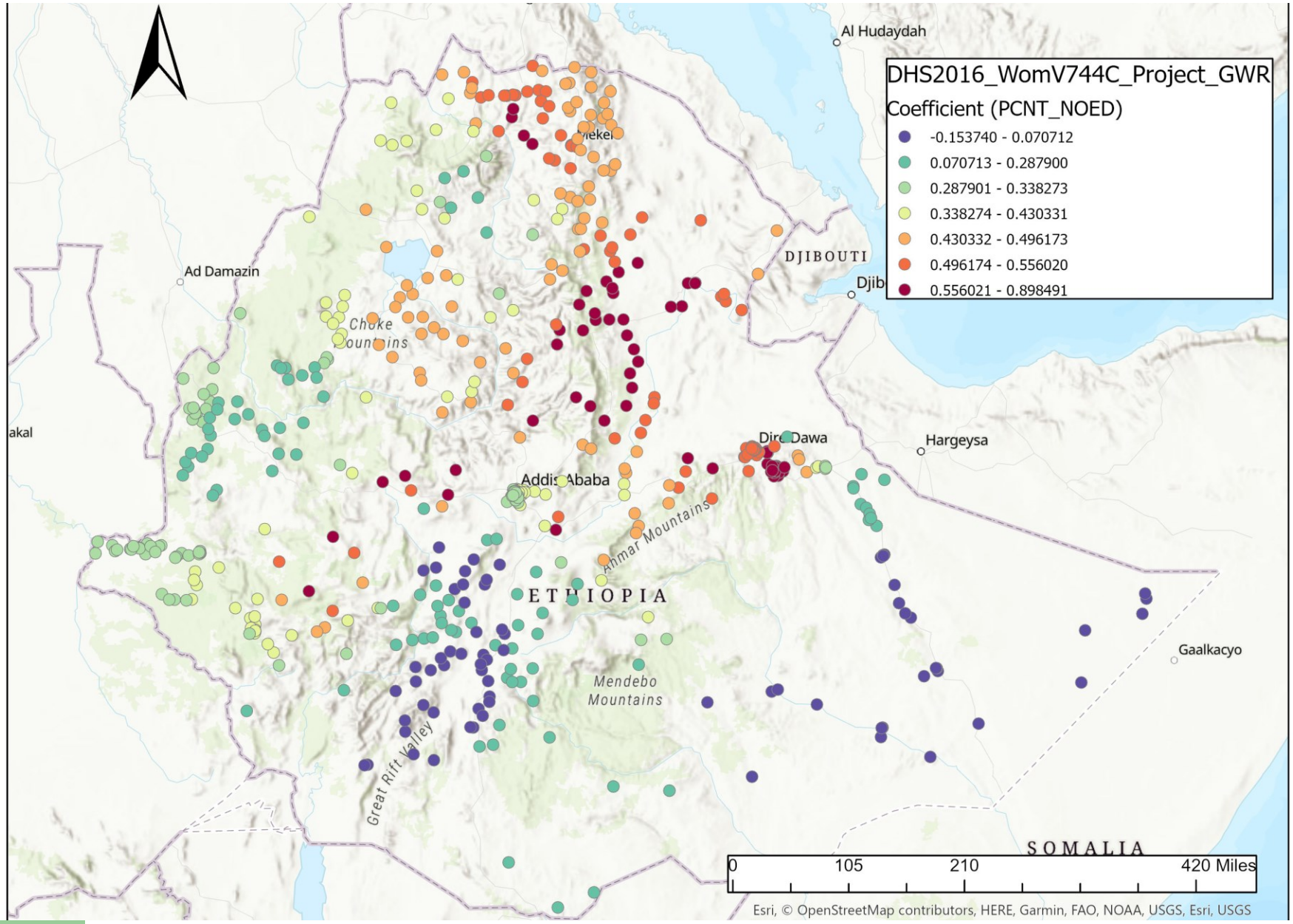


Data source:
Eth. DHS 2016

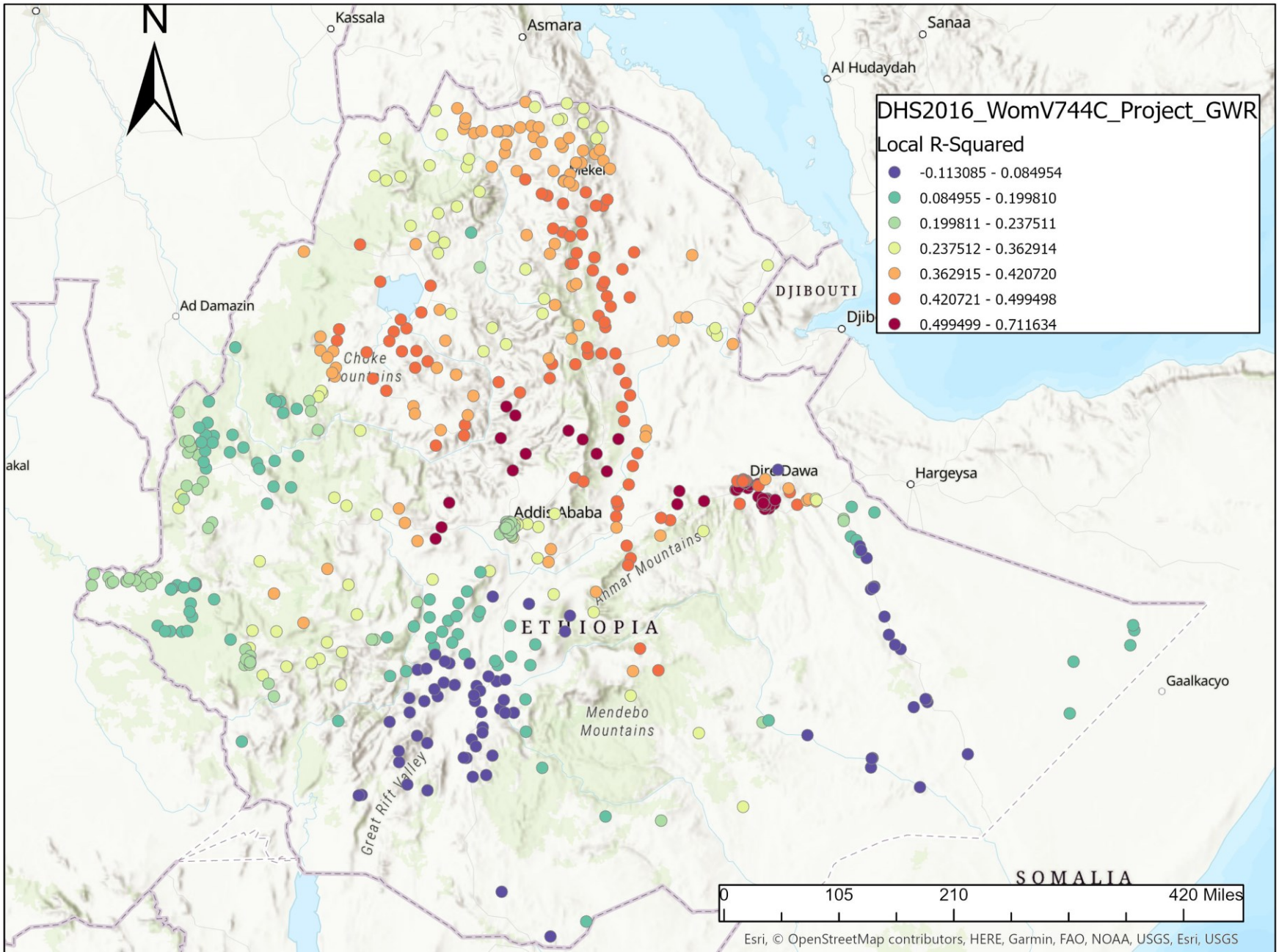
Intercept (β_0), Geographically Weighted Regression with Women's Response on Wife-beating as (y) variable and education as (x) variable



Beta Coefficient ($\mathcal{B}_1$), Geographically Weighted Regression with Women's Response on Wife-beating as (y) variable and education as (x) variable



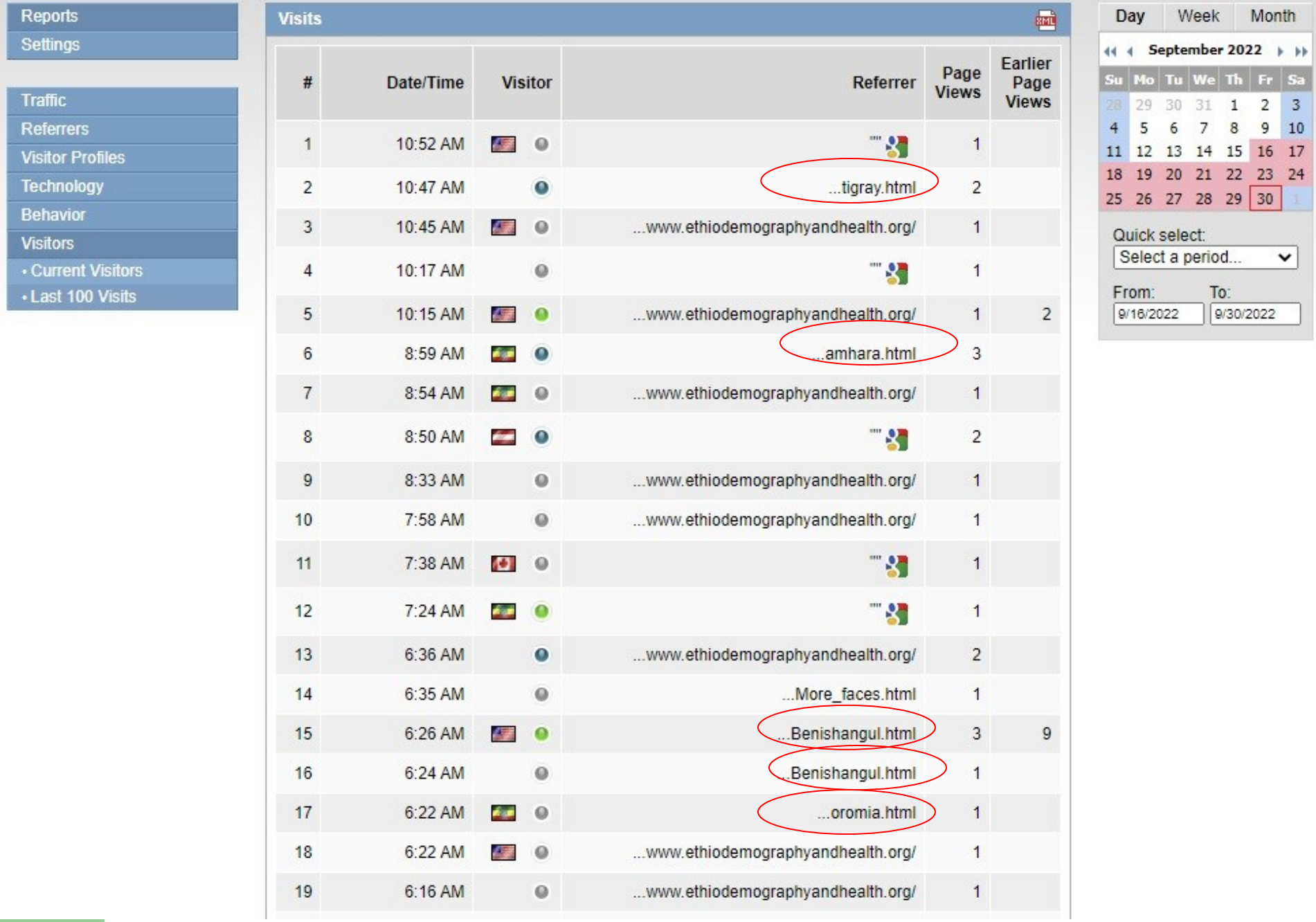
Local R-Squared, Geographically Weighted Regression with Women's Response on Wife-beating as (y) variable and education as (x) variable



PART I: SUMMARY

- Place-based ordinary least squared (OLS) regression analyses produce global results for all locations in the study by neglecting the role of geographical distance and the resulting autocorrelation of values from nearby locations
- As near things are more related than distance things, such negligence results in biased statistical estimations
- Using the geographically weighted regression method (GWR) corrects the traditional methodological flaws by producing local results for all locations in the study
- This presentation has provided evidence by testing for the presence of spatial autocorrelation in unweighted proportions of women responding to a question on wife-beating
- Nationally, a “no education” status explained 46% of the variability in the percentage of women responding “yes” to a question on wife-beating (V744c) but this varied locally from 0 to a high of 71%.
- Other explanatory variables, for example, the DHS Wealth Index, could have been included in the analysis but were omitted due to the risk of multicollinearity
- Results obtained in this analysis call for policy interventions aimed at protecting women against spousal abuse to be framed with local (not national or regional) sets of preventative measures in mind

PART II. ETHIO-DEMOGRAPHY-AND-HEALTH



#	Date/Time	Visitor	Referrer	Page Views	Earlier Page Views
1	10:52 AM		""	1	
2	10:47 AM		...tigray.html	2	
3	10:45 AM		...www.ethiodemographyandhealth.org/	1	
4	10:17 AM		""	1	
5	10:15 AM		...www.ethiodemographyandhealth.org/	1	2
6	8:59 AM		...amhara.html	3	
7	8:54 AM		...www.ethiodemographyandhealth.org/	1	
8	8:50 AM		""	2	
9	8:33 AM		...www.ethiodemographyandhealth.org/	1	
10	7:58 AM		...www.ethiodemographyandhealth.org/	1	
11	7:38 AM		""	1	
12	7:24 AM		""	1	
13	6:36 AM		...www.ethiodemographyandhealth.org/	2	
14	6:35 AM		...More_faces.html	1	
15	6:26 AM		...Benishangul.html	3	9
16	6:24 AM		...Benishangul.html	1	
17	6:22 AM		...oromia.html	1	
18	6:22 AM		...www.ethiodemographyandhealth.org/	1	
19	6:16 AM		...www.ethiodemographyandhealth.org/	1	

PART II. DATA DASHBOARDS AND MAPS ON ETHIO-DEMOGRAPHY-AND-HEALTH WEBSITE

Demography and health

https://ethiodemography.maps.arcgis.com/apps/opsdashboard/index.html#/e485f88663af4304992f9980324bd69a

Health care institutions

https://ethiodemography.maps.arcgis.com/home/webmap/viewer.html?webmap=8e3f3e3a6c6c47acbc5da3192d1ef041&extent=33.5072,4.7111,41.6206,9.2193

COVID-19

https://ethiodemography.maps.arcgis.com/apps/dashboards/a612bb3e59174cc8920b4b416705d3f3

http://www.ethiodemographyandhealth.org/Aynalem_Adugna_COVID_19_in_Ethiopia_PDF.pdf

My proposal for an Ethiopian population journal

Ethiopian Journal of Population Studies (ethiojps.org)

PART III. INCOME INEQUALITY AND HEALTH
Lessons from California

Income inequality and health: Story Map and dashboard

https://storymaps.arcgis.com/stories/84fcd9cce18f498b8ac5861b95add64a