

# Migration and Neighborhood in Rapidly Growing West African Cities

Arthur Getis

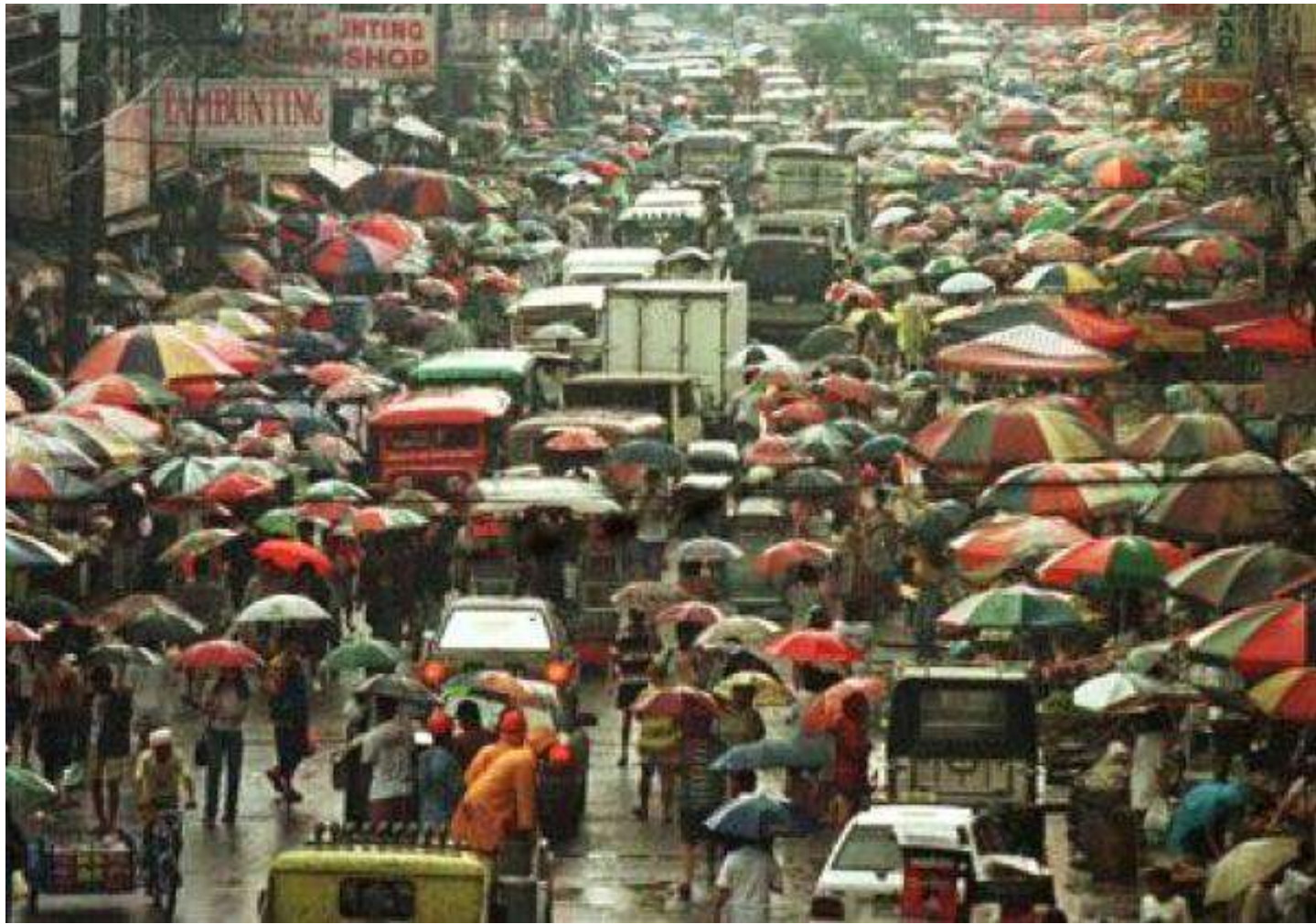
Rabat, Morocco  
October 1-2, 2012

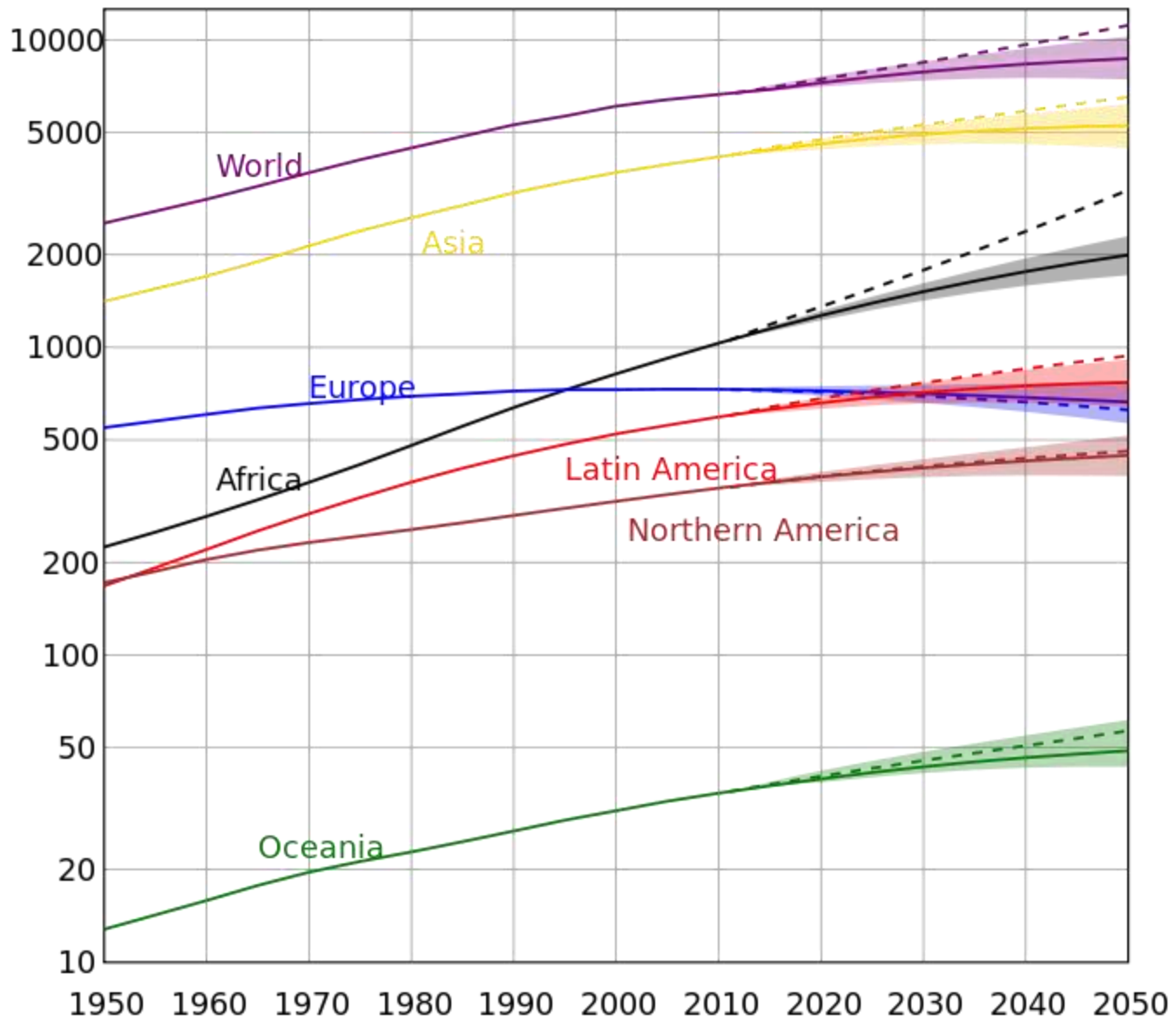


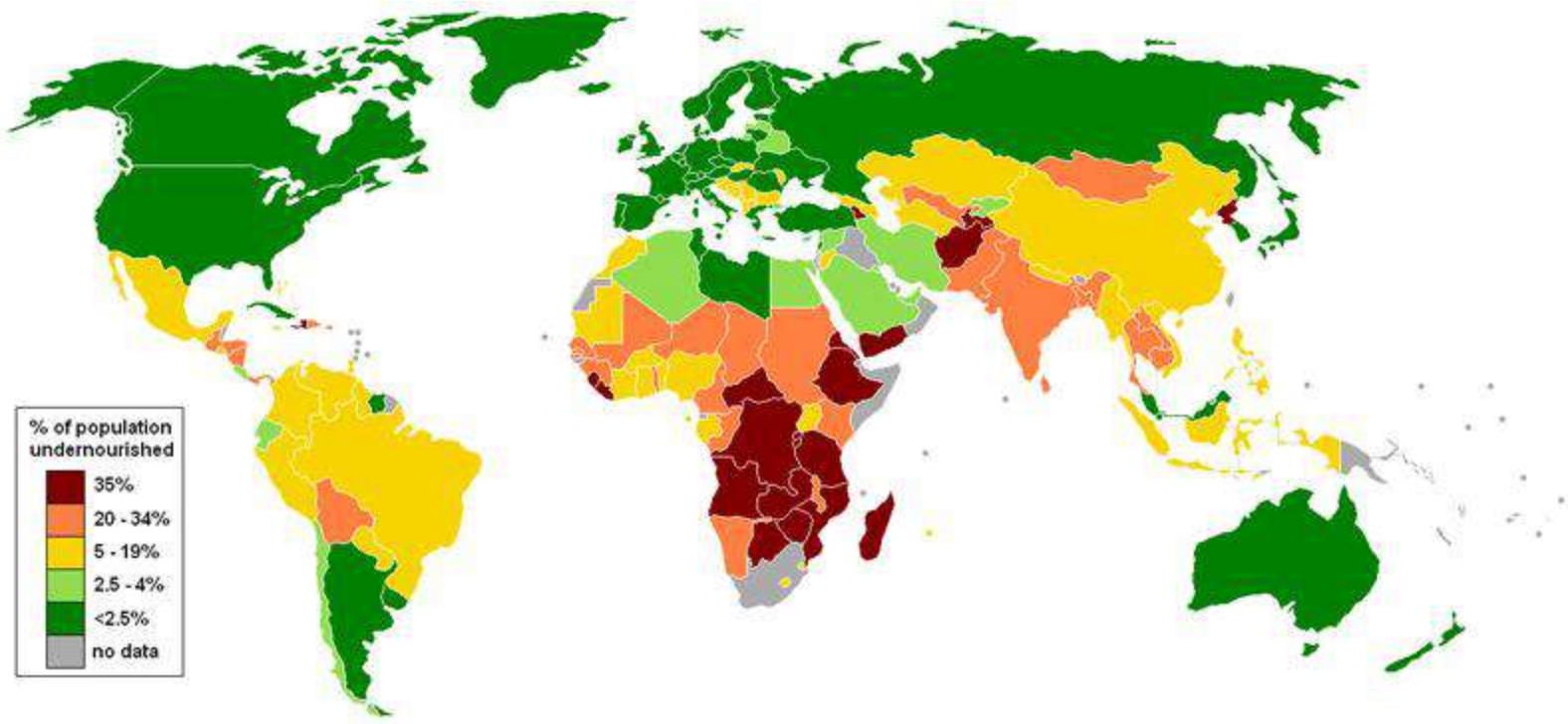






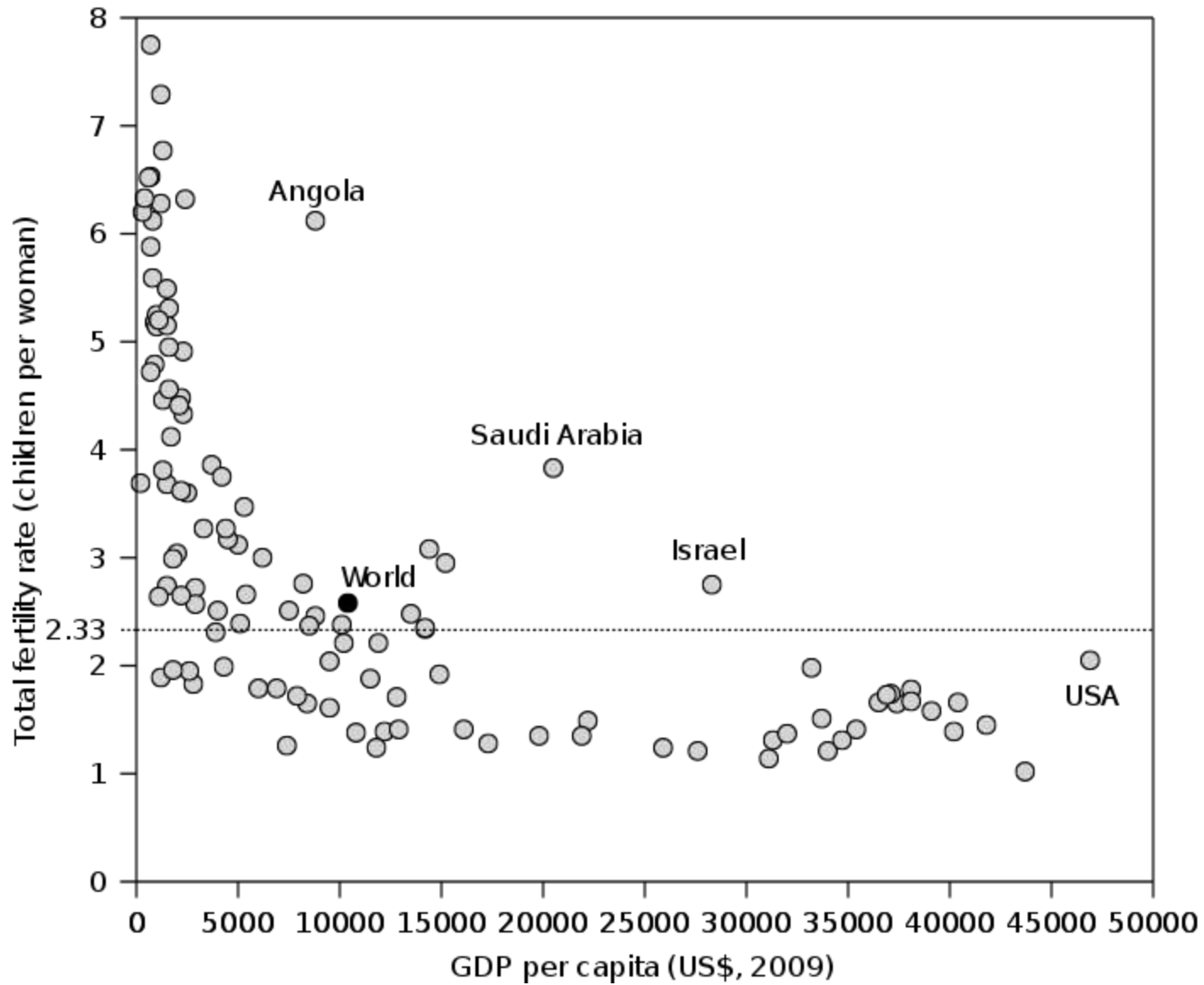














# Picture 2050 (only 38 years from now)

- 9 Billion (2 billion more than now)
- Cars, pollution, climate, health facilities, urban space, internal disequilibrium (wars, riots, stiff measures)
- The effects are already here.

# Neighborhoods as Building Blocks for Social Research

- Conceptualization
- Motivations for delineating neighborhoods
  - Making sense of complex data
  - Spatial sampling
  - Targeted policy initiatives
- Problems with available data

# Problems with Qualitatively Delimited Neighborhoods

- Individual biases; simplified images
- Institutional biases; governance, planning, convenience
- Official neighborhoods
- Views of the world
- Agreement
- Scale

# Quantitative Approaches

- Goal: To find statistically significant spatially contiguous aggregations of spatial units
- Made possible by the development of methods for finding statistically significant spatial clusters
- The idea of local statistics

# Approaches Used in Our Studies

- Many types of neighborhoods found
- Vernacular
- Vernacular with remotely sensed and ground verification and modification (operations research methods, e.g. The Duque Method)
- Local Statistics
  - AMOEBBA (A Multidirectional Optimum Ecotope-Based Algorithm)
  - LOSH (Local Spatial Heterogeneity)



# Introduction to LOSH

- Focus on a site  $i$  having a variable value  $x$
- Consider the  $j$  surrounding places
- $G_i$  allows for tests on high or low variable values taken as a group around some site  $i$
- $H_i$  allows for tests on cluster heterogeneity and homogeneity around some site  $i$

# Uses of $H_i$

- Explore differential rates (such as disease rates within a cluster)
- Find degree of heterogeneity or homogeneity within an already delimited cluster
- Identify temporal trends in heterogeneity and homogeneity
- Identify boundaries and test for the existence of boundaries between districts
- Study the residuals of a spatial regression surrounding a site  $i$
- Define weights for generalized least squares

# Spatial Variance

- Focus and tests: On equality of spatial variance

## Literature:

- F-test, Bartlett test (requires normal distributions):  
sensitive to non-normality
- Box (1953) corrected for non-normality
- Levene (1960) replaced each observation by a scale variable e.g., an absolute deviation;  
but not georeferenced variables

# Data Analysis

- For each cell/area define the neighborhood as for the  $G$  or  $I$  statistic
- Compute the  $G$  and  $H$  statistics for each cell.
- Generate the  $G$ -map and the  $H$  map.

# Variation in region to distance $d$

We define the average of the absolute (or squared) errors to be:

$$h_1(d) = \sum_{i=1}^n |e_i(d)|^\alpha / n$$

$\alpha = 1$  (represents the mean absolute error)

$= 2$  (represents the mean variation )

For entire study area ( $n$ )

# Scaled $H_i$

- $h_1$  is the mean of absolute errors in entire study area

$$H_i(d) = \frac{\sum_j w_{ij}(d) |e_j(d)|^a}{h_1(d) \sum_j w_{ij}(d)}$$

- This scales the local area  $j$  to error values in the entire area

# The Variance of $H_i$

$K$  for number of equally weighted neighbors

$h_1$  is mean of absolute errors in entire study area

$h_2$  is mean squared residuals in entire study area

$$\text{Var}_P(H_i) = \left( \frac{1}{(n-1)Kh_1^2} \right) (h_2 - h_1^2)[n - K]$$

# Practical Test on $H_i$ for Squared Errors

- *Chi-square distribution with  $v$  degrees of freedom has mean  $v$  and variance  $2v$*

$$Z_i = 2H_i / V_i$$

- With  $2/V_i$  *df*
- *$Z$  is standard normal variate*
- *$V_i$  can be mean variance*



# CASE 1:

$p$  values for  $H_i$  for random  $x$ 's

0.85	0.18	0.42	<b>0.07</b>	0.47	0.28	0.46	0.54	0.20	0.33
0.68	<b>0.08</b>	0.37	<b>0.03</b>	0.36	0.24	0.47	0.51	0.18	0.29
0.68	<b>0.08</b>	0.21	<b>0.09</b>	0.78	0.63	0.11	<b>0.10</b>	<b>0.01</b>	0.20
0.85	0.15	0.21	<b>0.01</b>	0.32	0.14	0.24	0.29	0.43	1.00
0.74	0.20	0.42	<b>0.02</b>	0.21	0.13	0.25	0.44	0.15	0.69
0.93	0.56	0.87	<b>0.10</b>	0.13	<b>0.10</b>	0.25	0.44	0.18	0.59
0.91	0.31	0.50	0.46	0.90	0.62	0.21	0.44	0.09	0.50
0.99	0.56	0.69	0.52	0.79	0.52	0.12	0.12	<b>0.03</b>	0.32
0.88	0.28	0.68	0.52	0.91	0.96	0.44	0.14	<b>0.02</b>	0.19
0.97	0.82	0.97	0.92	0.92	0.94	0.90	0.55	0.21	0.40

- **Bold** = statistically significant at  $\leq 0.10$

## CASE 2

$p$  values for bump in  $x$ 's in middle 4x4

0.35	0.15	0.50	0.27	0.58	0.47	0.63	0.68	0.53	0.62
0.31	0.13	0.56	0.24	0.55	0.47	0.61	0.64	0.43	0.54
0.73	0.33	0.20	<b>0.06</b>	<b>0.04</b>	<b>0.05</b>	<b>0.08</b>	0.25	0.14	0.41
0.83	0.40	0.11	<b>0.09</b>	<b>0.10</b>	<b>0.14</b>	<b>0.04</b>	<b>0.08</b>	0.59	0.90
0.73	0.45	0.18	<b>0.26</b>	<b>0.45</b>	<b>0.38</b>	<b>0.01</b>	<b>0.02</b>	0.40	0.66
0.86	0.66	<b>0.07</b>	<b>0.02</b>	<b>0.38</b>	<b>0.35</b>	<b>0.20</b>	<b>0.08</b>	0.43	0.61
0.81	0.52	<b>0.03</b>	<b>0.00</b>	<b>0.08</b>	<b>0.15</b>	<b>0.05</b>	0.16	0.34	0.54
0.94	0.66	0.12	<b>0.02</b>	0.16	0.46	0.32	0.32	0.25	0.50
0.86	0.50	0.72	0.64	0.86	0.91	0.60	0.39	0.22	0.44
0.97	0.79	0.88	0.85	0.88	0.92	0.81	0.69	0.46	0.66

- **Bold** = statistically significant at  $\leq 0.10$



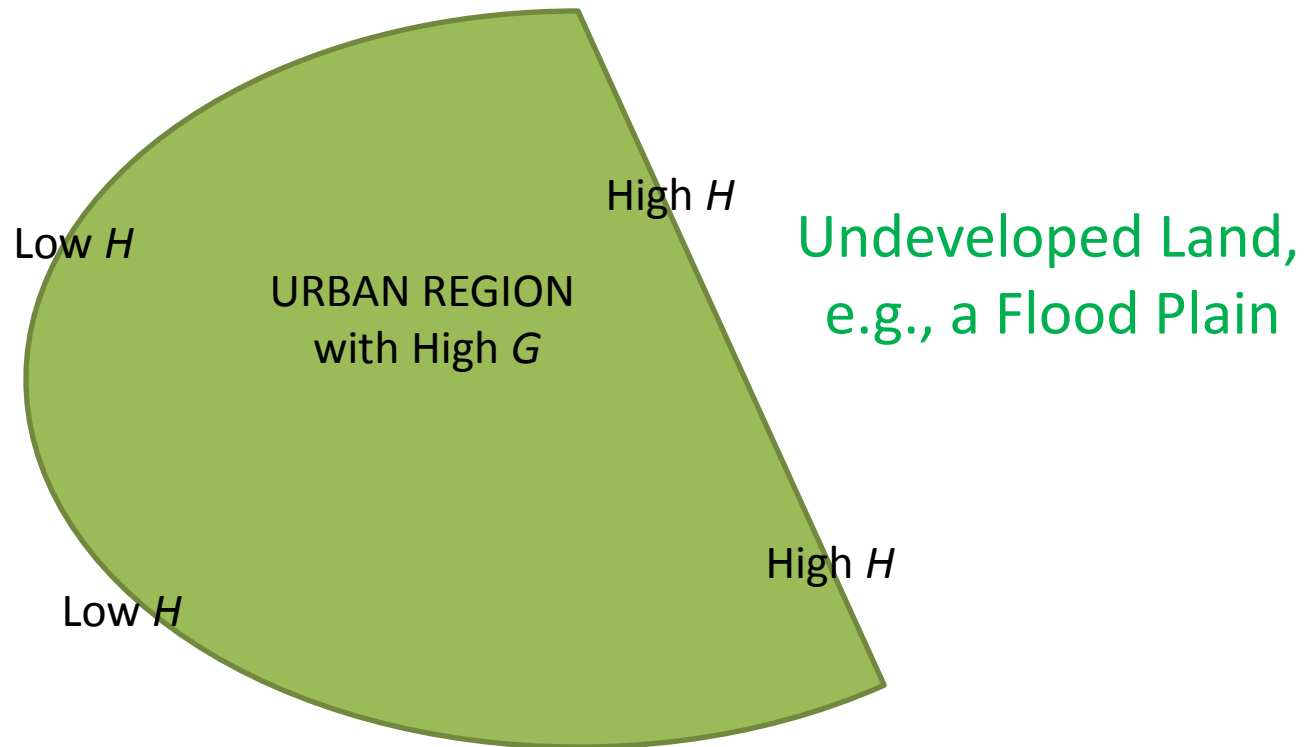
# CASE 3

$p$  values for  $H_i$  for binary (0,1) x's

0.76	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.76
0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.77
0.77	1.00	0.23	0.11	<b>0.07</b>	<b>0.07</b>	0.11	0.23	1.00	0.77
0.77	1.00	0.11	<b>0.06</b>	<b>0.07</b>	<b>0.07</b>	<b>0.06</b>	0.11	1.00	0.77
0.77	1.00	<b>0.07</b>	<b>0.07</b>	1.00	1.00	<b>0.07</b>	<b>0.07</b>	1.00	0.77
0.77	1.00	<b>0.07</b>	<b>0.07</b>	1.00	1.00	<b>0.07</b>	<b>0.07</b>	1.00	0.77
0.77	1.00	0.11	<b>0.06</b>	<b>0.07</b>	<b>0.07</b>	<b>0.06</b>	0.11	1.00	0.77
0.77	1.00	0.23	0.11	<b>0.07</b>	<b>0.07</b>	0.11	0.23	1.00	0.77
0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.77
0.76	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.76

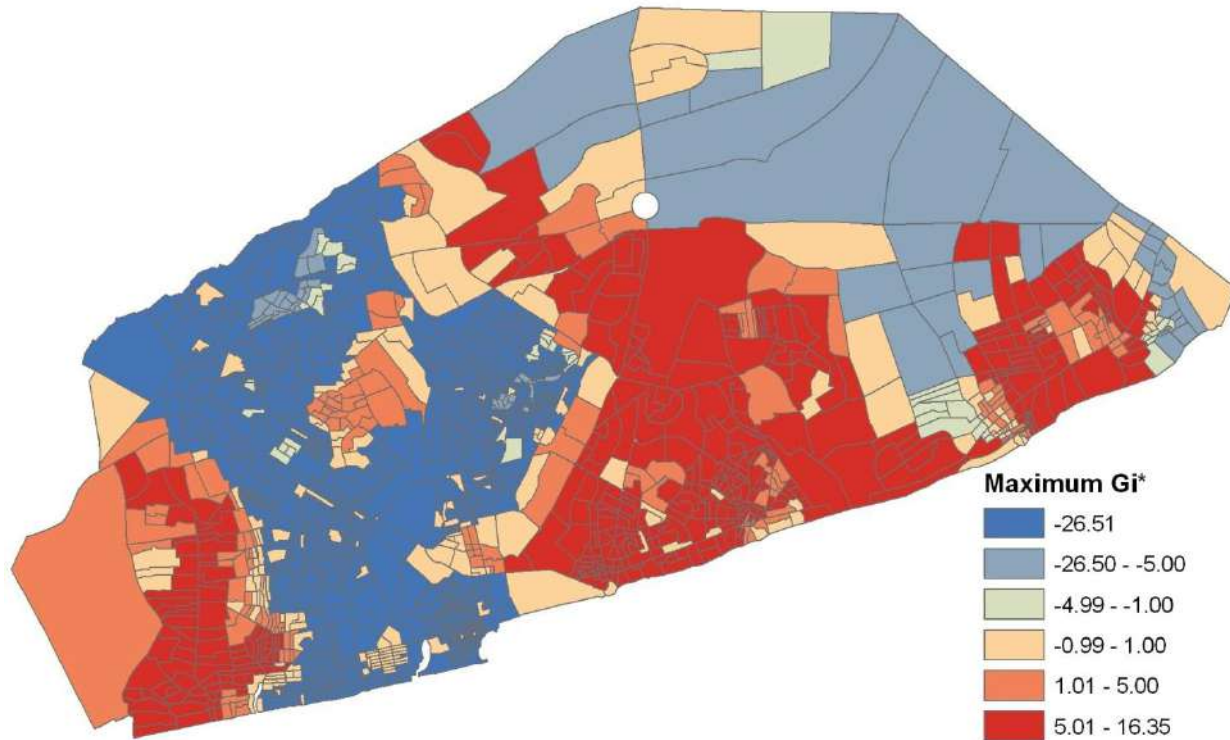
**Bold** = statistically significant at  $\leq 0.10$

# Evaluation of Boundary of Cluster Defined by High $G$

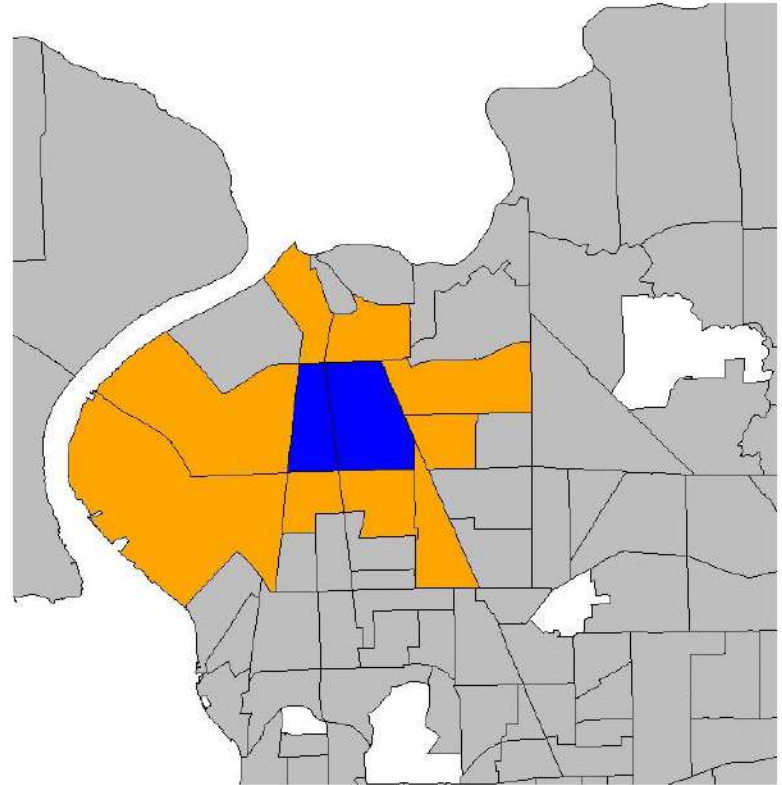


# House Quality

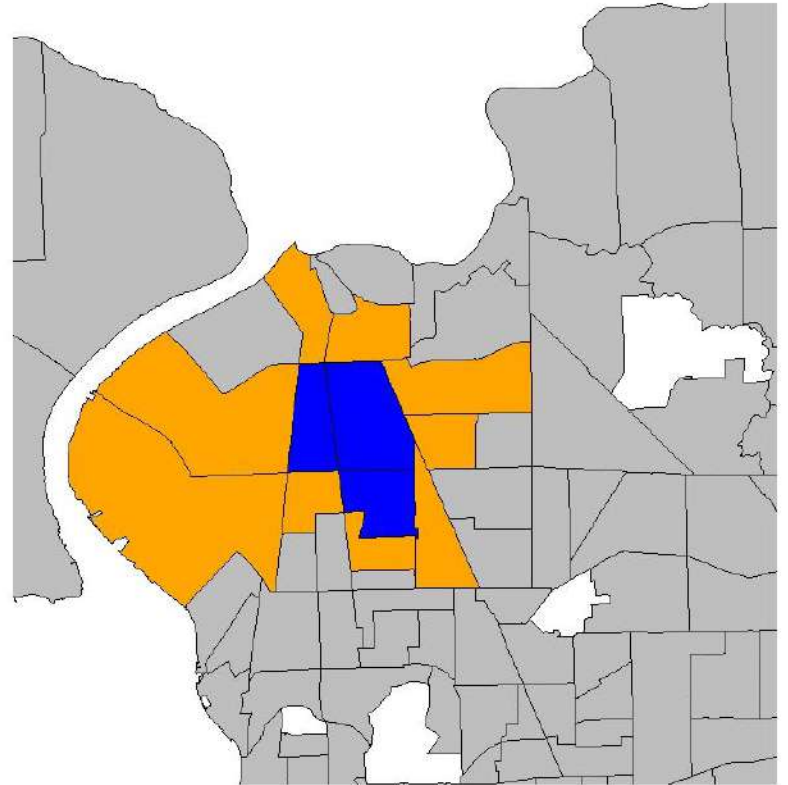
Maximum  $G_i^*$



- Step 2
- Consider contiguous census tracts
- Highest  $G_i^*$  when blue region is  $i$
- $G_i^*$  higher than in Step 1

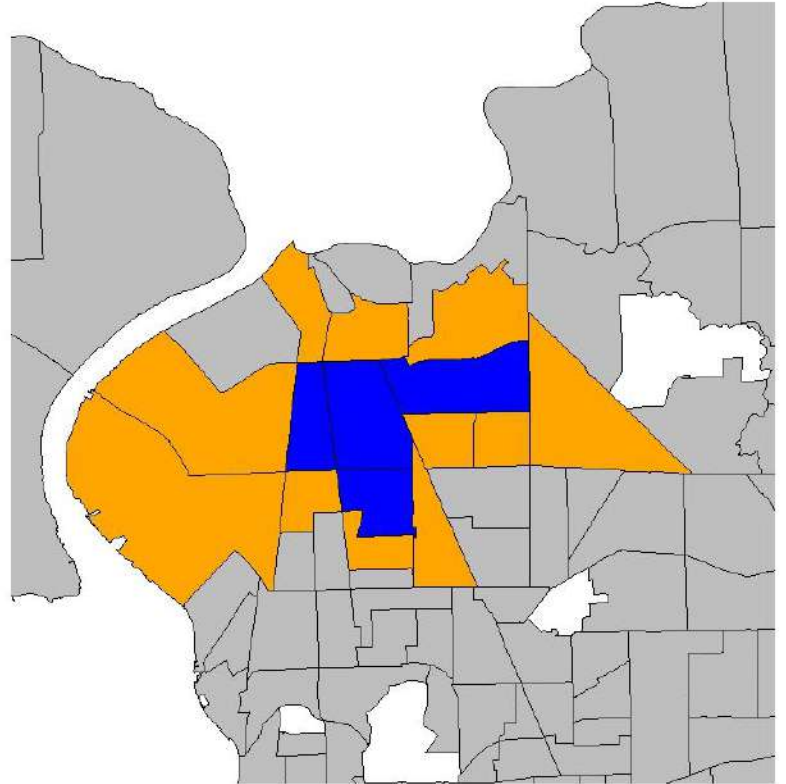


- Step 3
- $G_i^*$  still increasing (in blue)

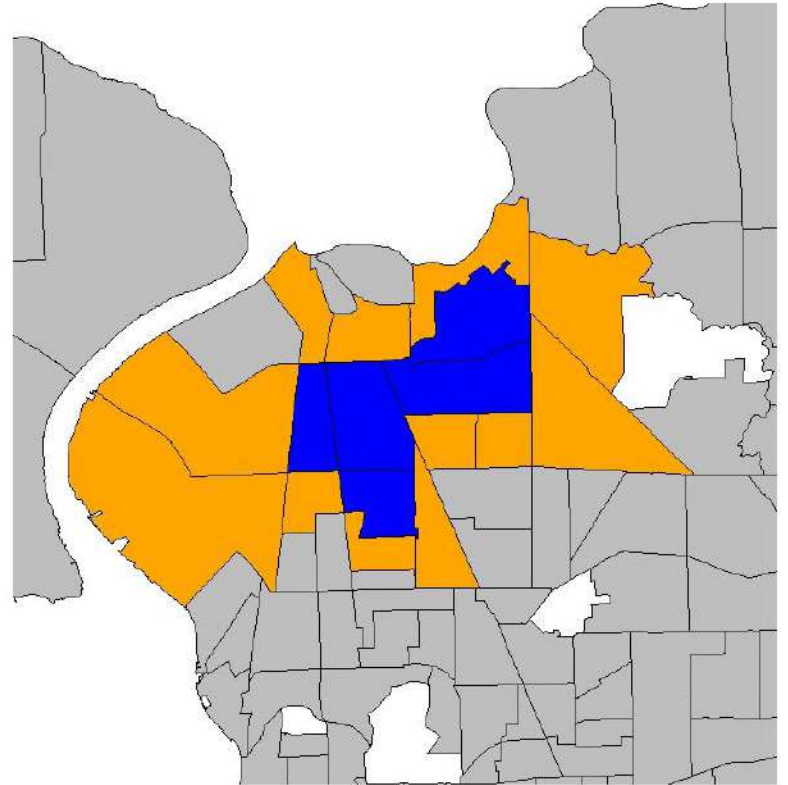




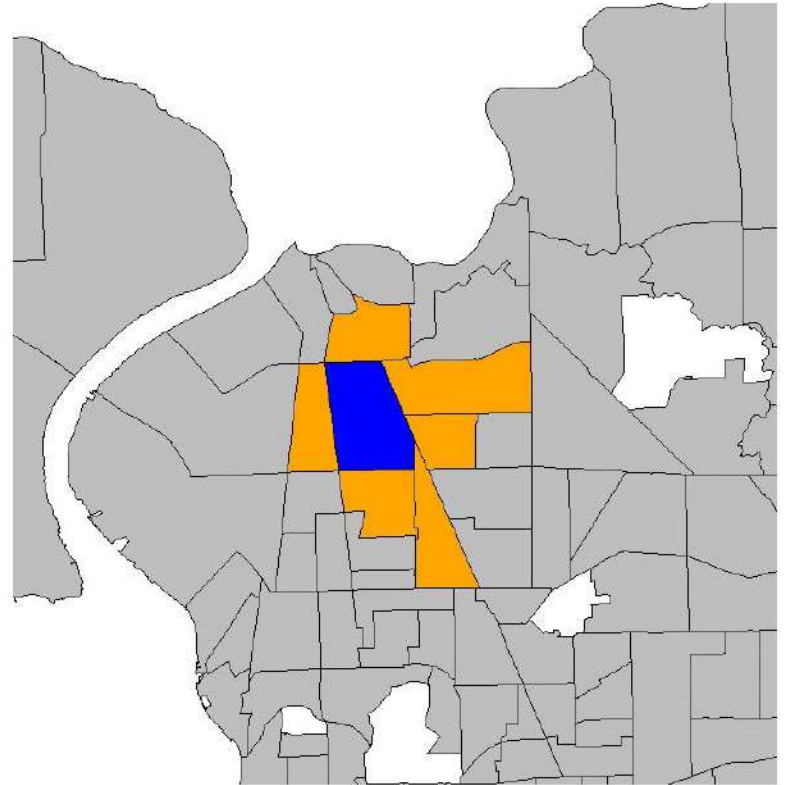
- Step 4



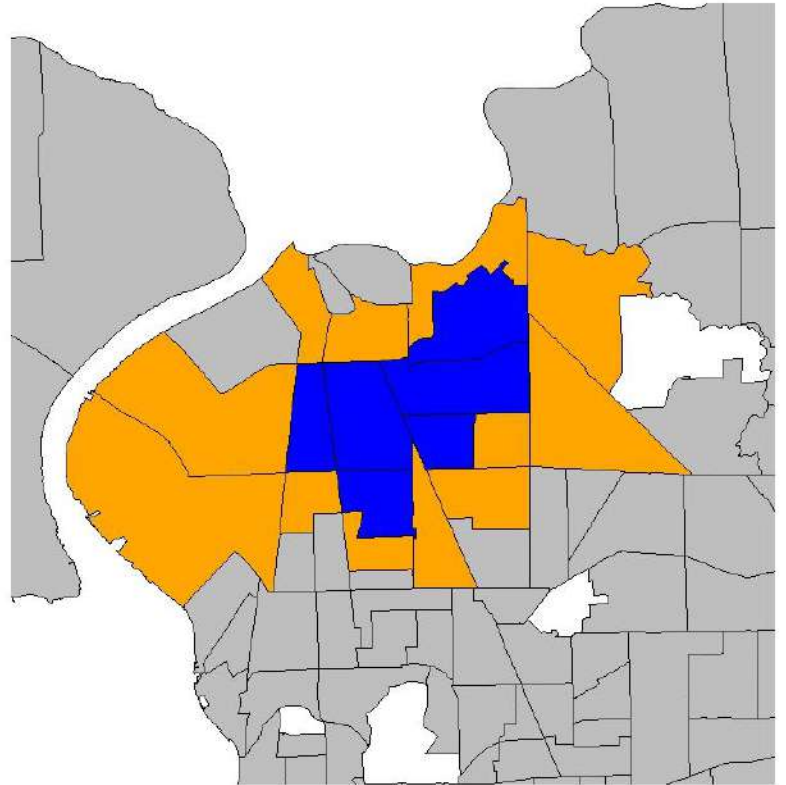
- Step 5



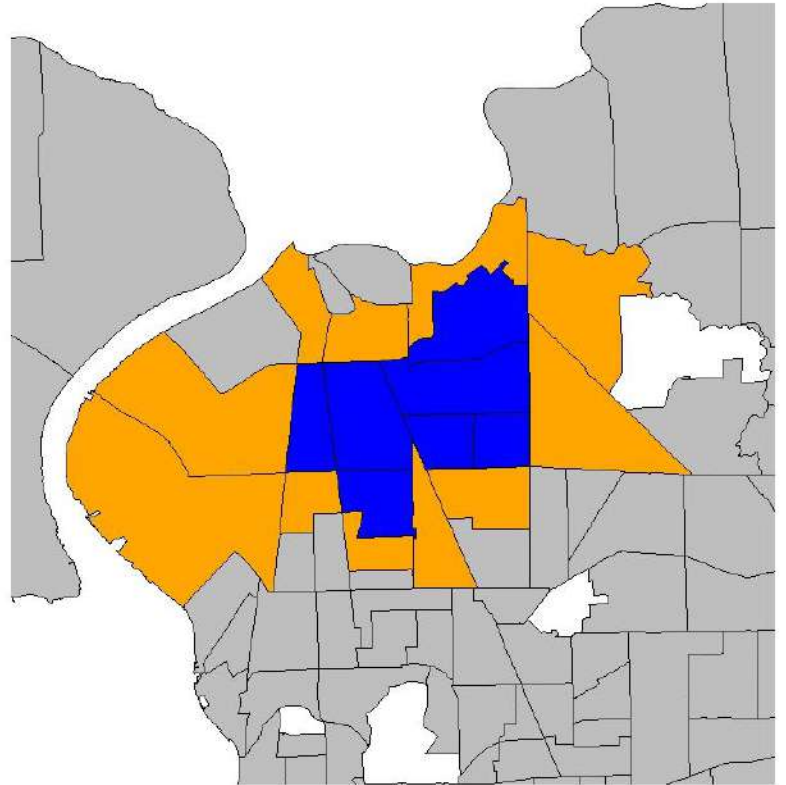
- AMOEBA
- House quality variable
- Step 1 (Maximum of Maxima  $G_i^*$ )



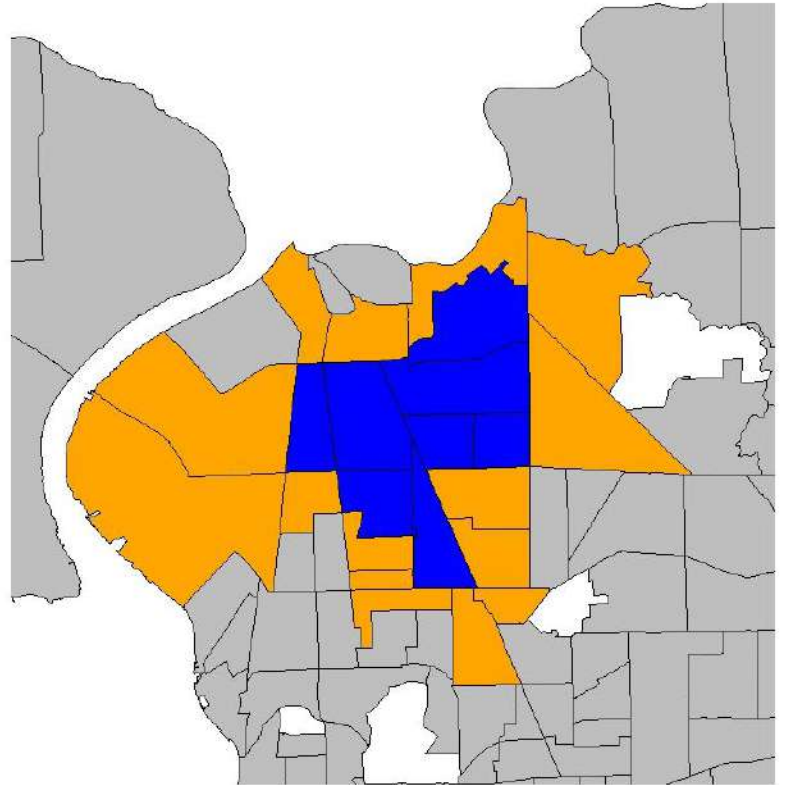
- Step 6



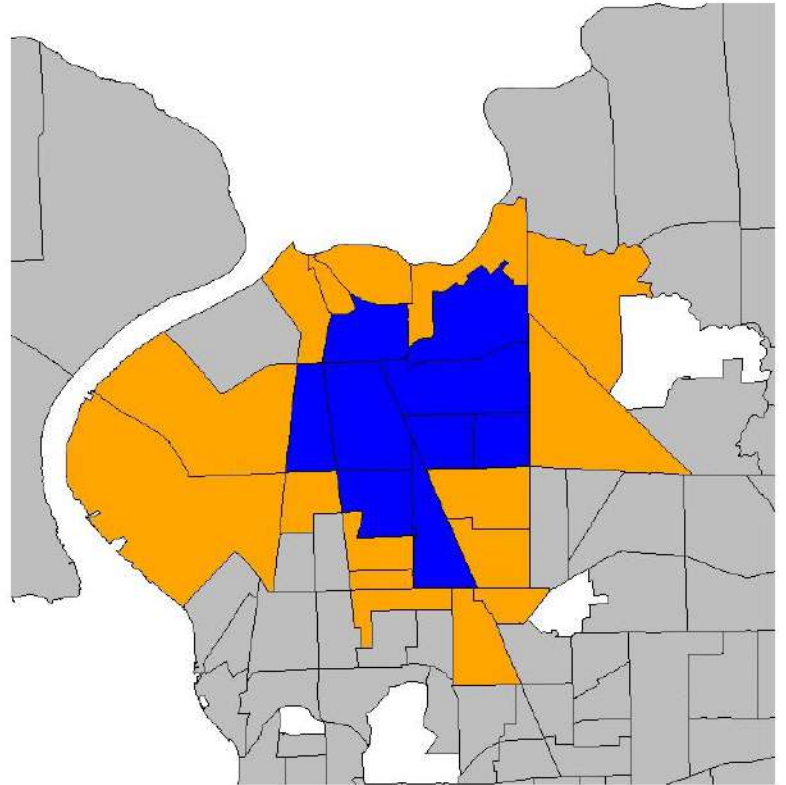
- Step 7



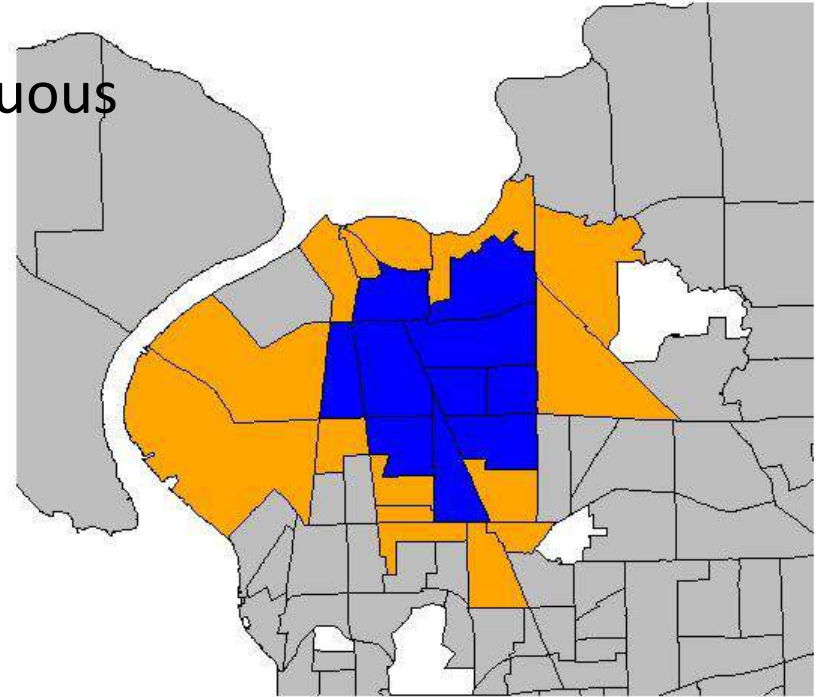
- Step 8



- Step 9



- Step 10
- Finally, by adding in other contiguous census tracts  $G_i^*$  decreases (or stays the same) instead of increasing





# Interpretations

Mean/Variance

High  $H$

Low  $H$

High  $|G|$

**Hot spot:**

**Hot Spot:**

**Heterogeneous  
local conditions**

**Homogeneous**

Low  $|G|$

Uneven local

Homogeneous

Example 1: Traditional cluster (homogeneity) = High  $G$ , Low  $H$

Example 2: High  $H$  at cluster boundary indicates  
well-defined neighborhood

# Interpretation

## **High $G_i$ , High $H_i$**

A hot spot with heterogeneous local conditions

## **High $G_i$ , Low $H_i$**

A hot spot with similar surrounding areas; the map would indicate whether the affected region is larger than the single 'cell'

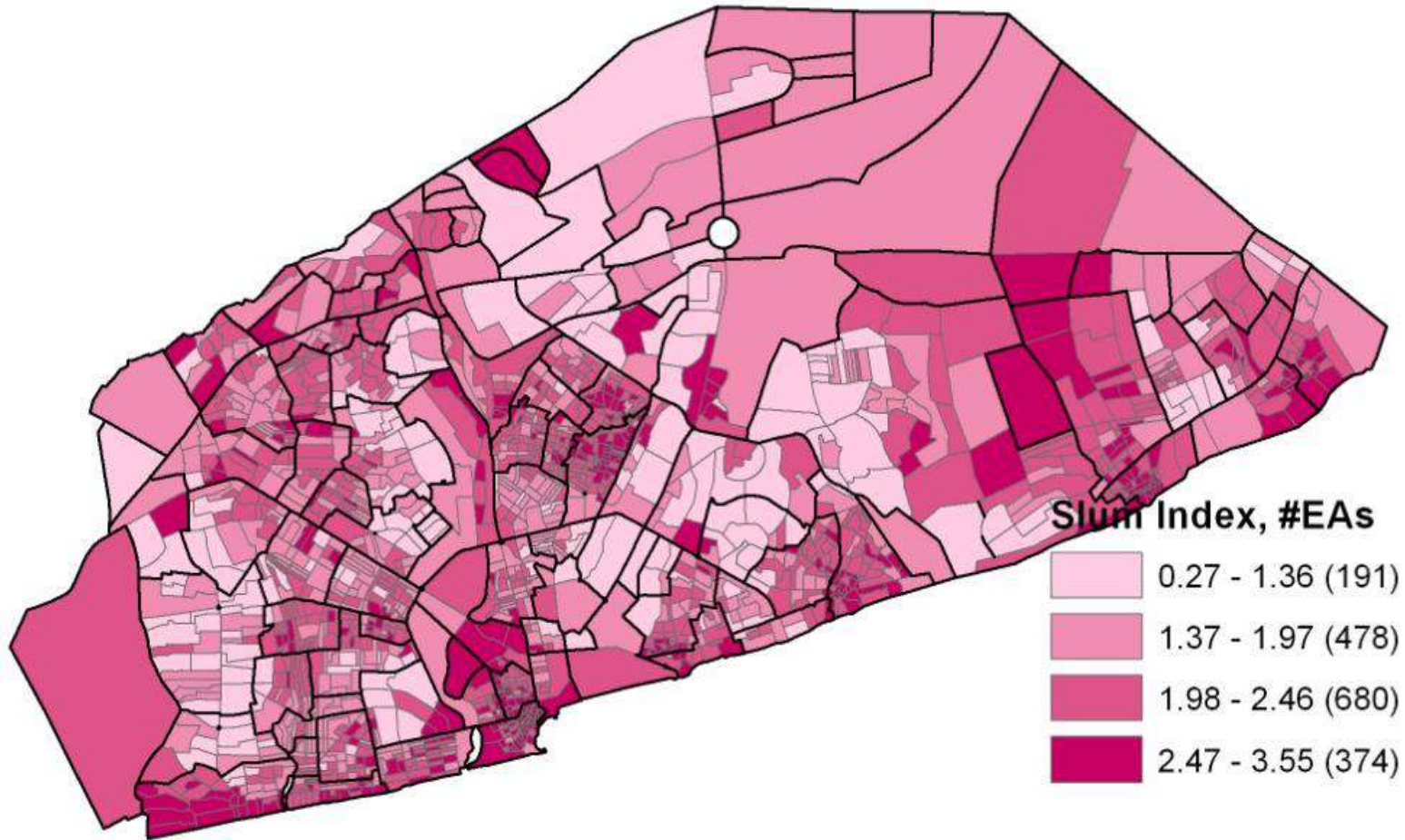
## **Low $G_i$ , High $H_i$**

Heterogeneous local conditions but at a low average level  
(an unlikely event)

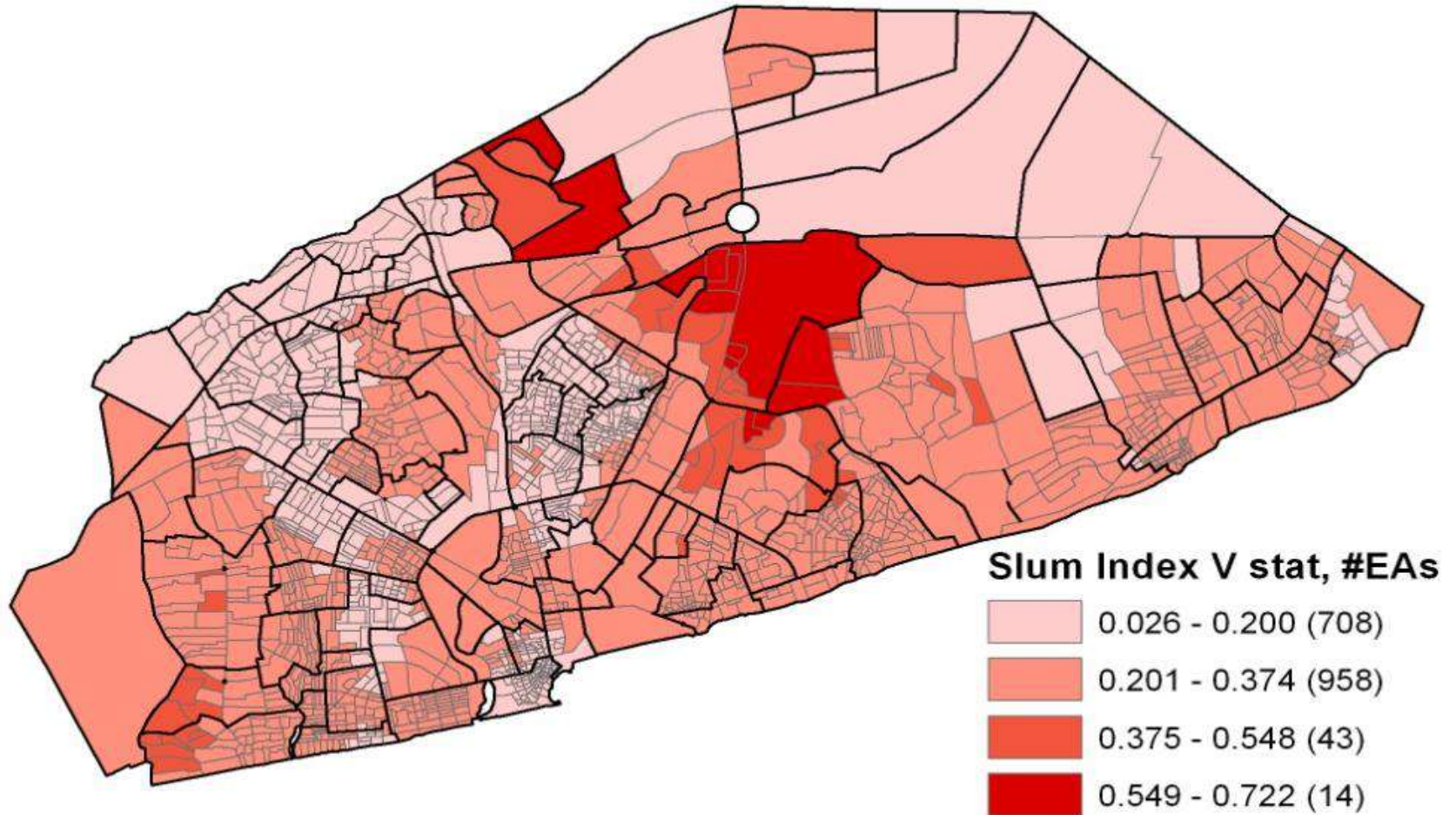
## **Low $G_i$ , Low $H_i$**

Homogeneous local conditions and a low average level

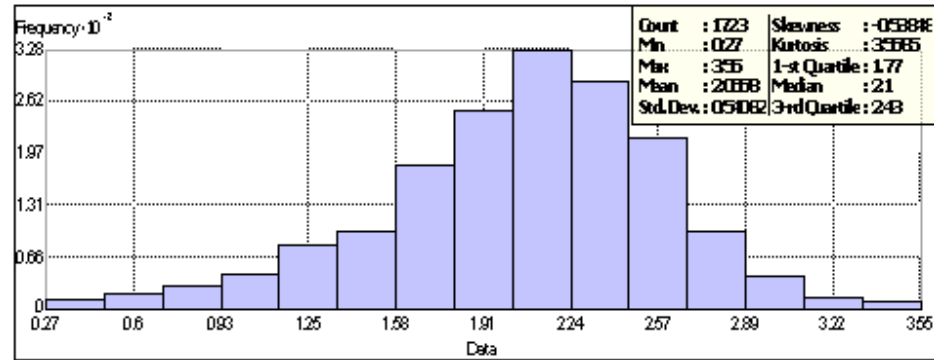
# Slum Index



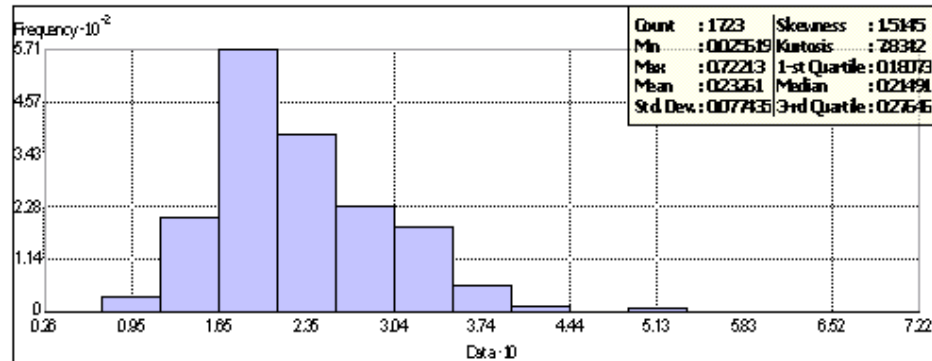
# *Hi* for Slum Index



# Slum Index and *Hi* Frequency Distributions

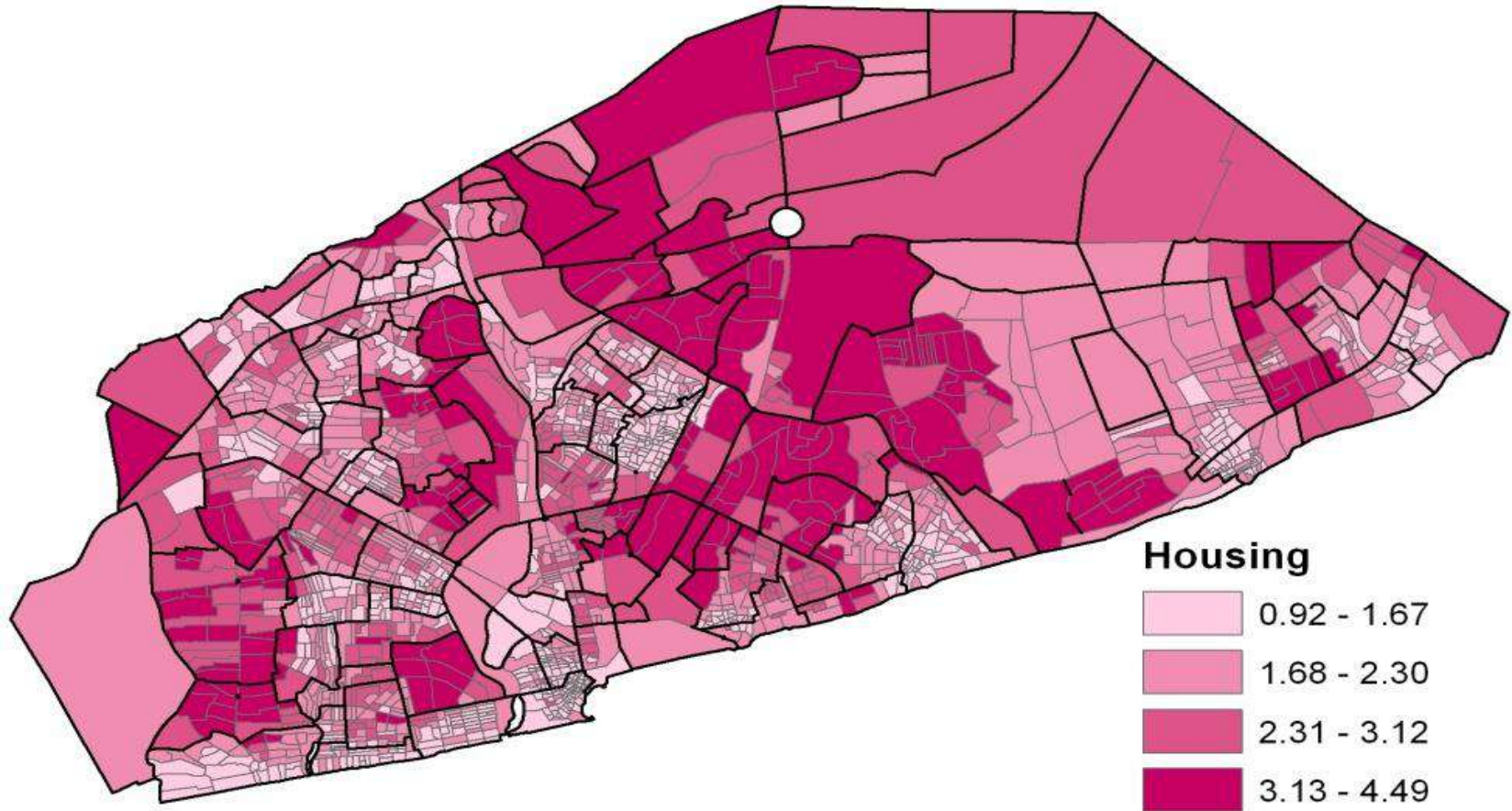


Data Source: Attribute: Slum

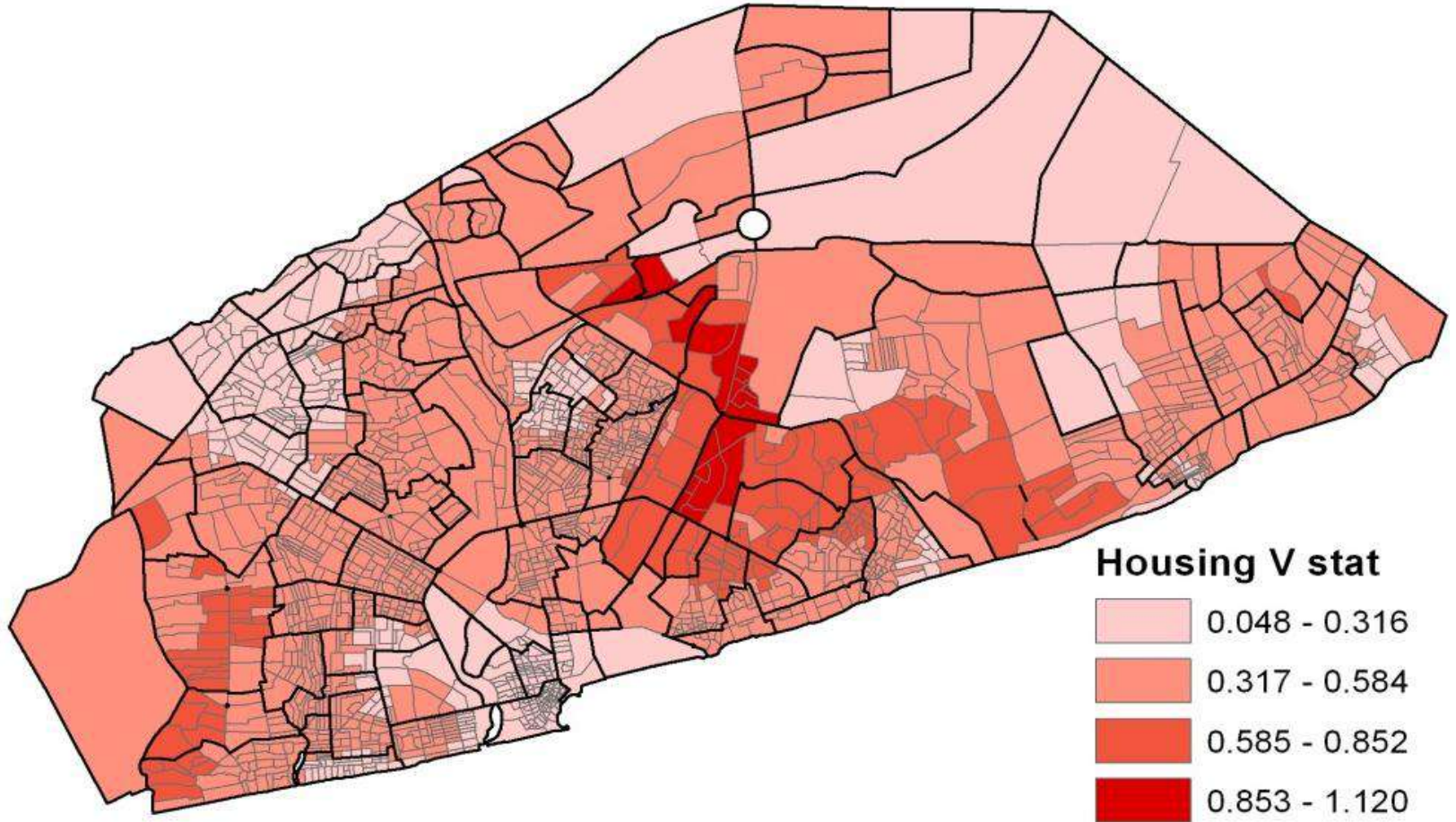


Data Source: Attribute: result

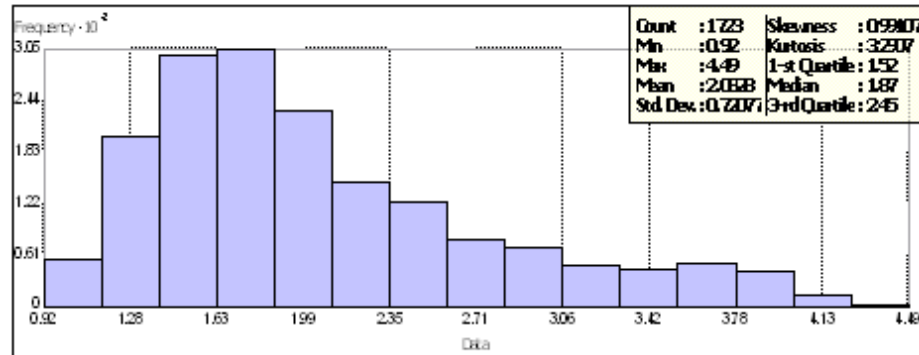
# Housing Quality



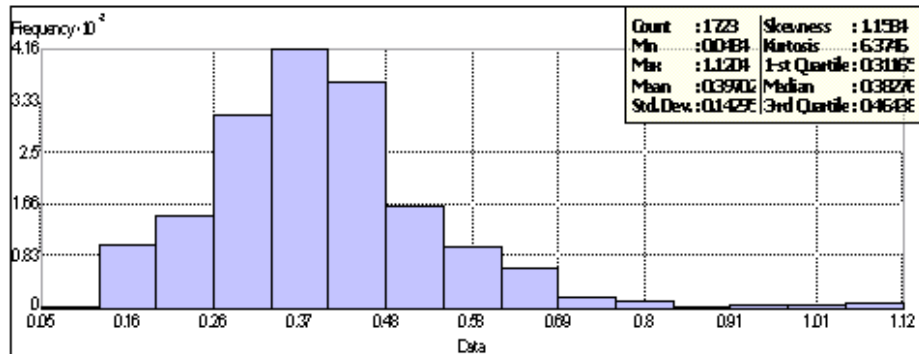
# *Hi* for Housing Quality



# Housing Quality and *Hi* Frequency Distributions



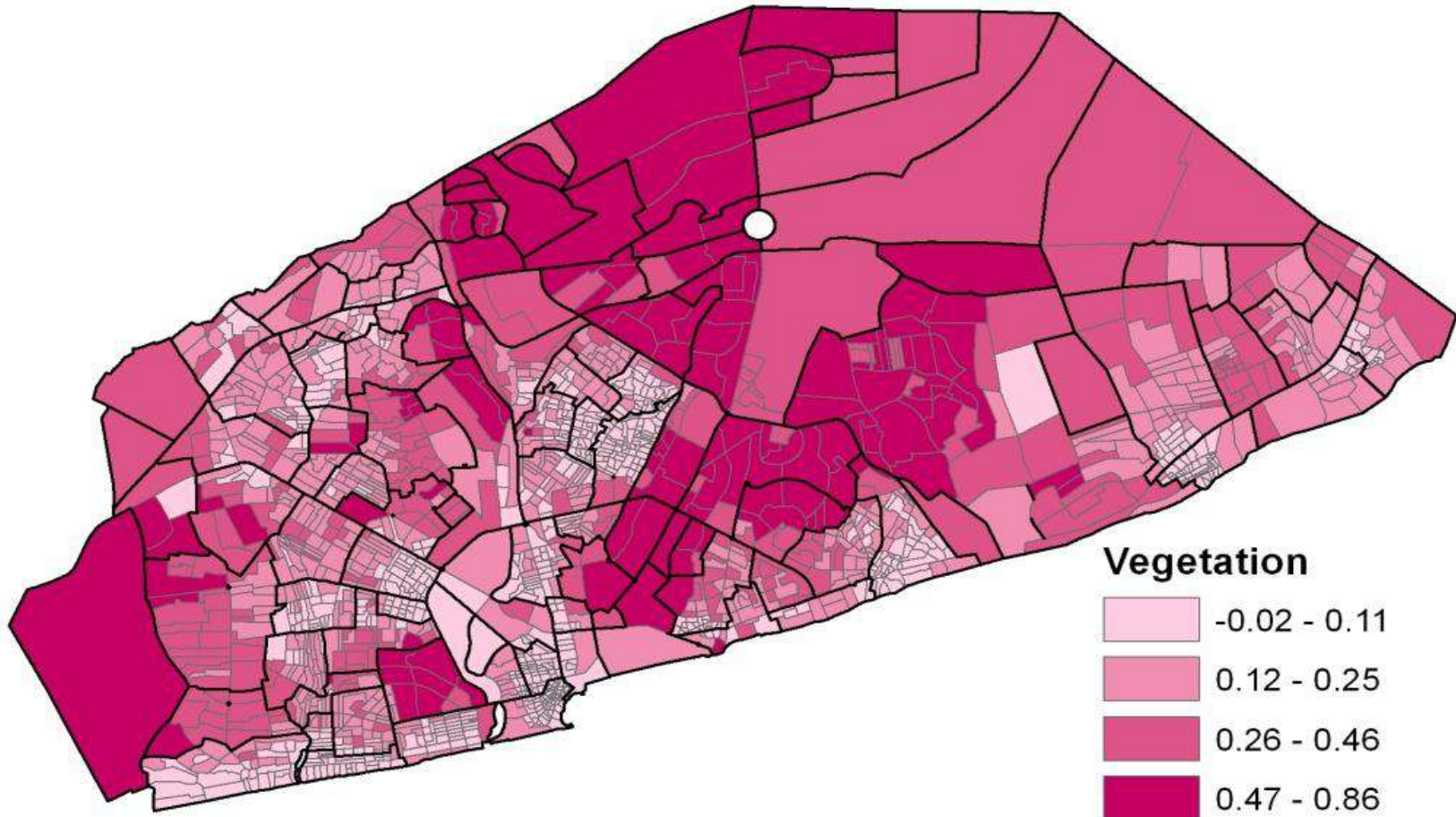
Data Source: Attribute: Housing



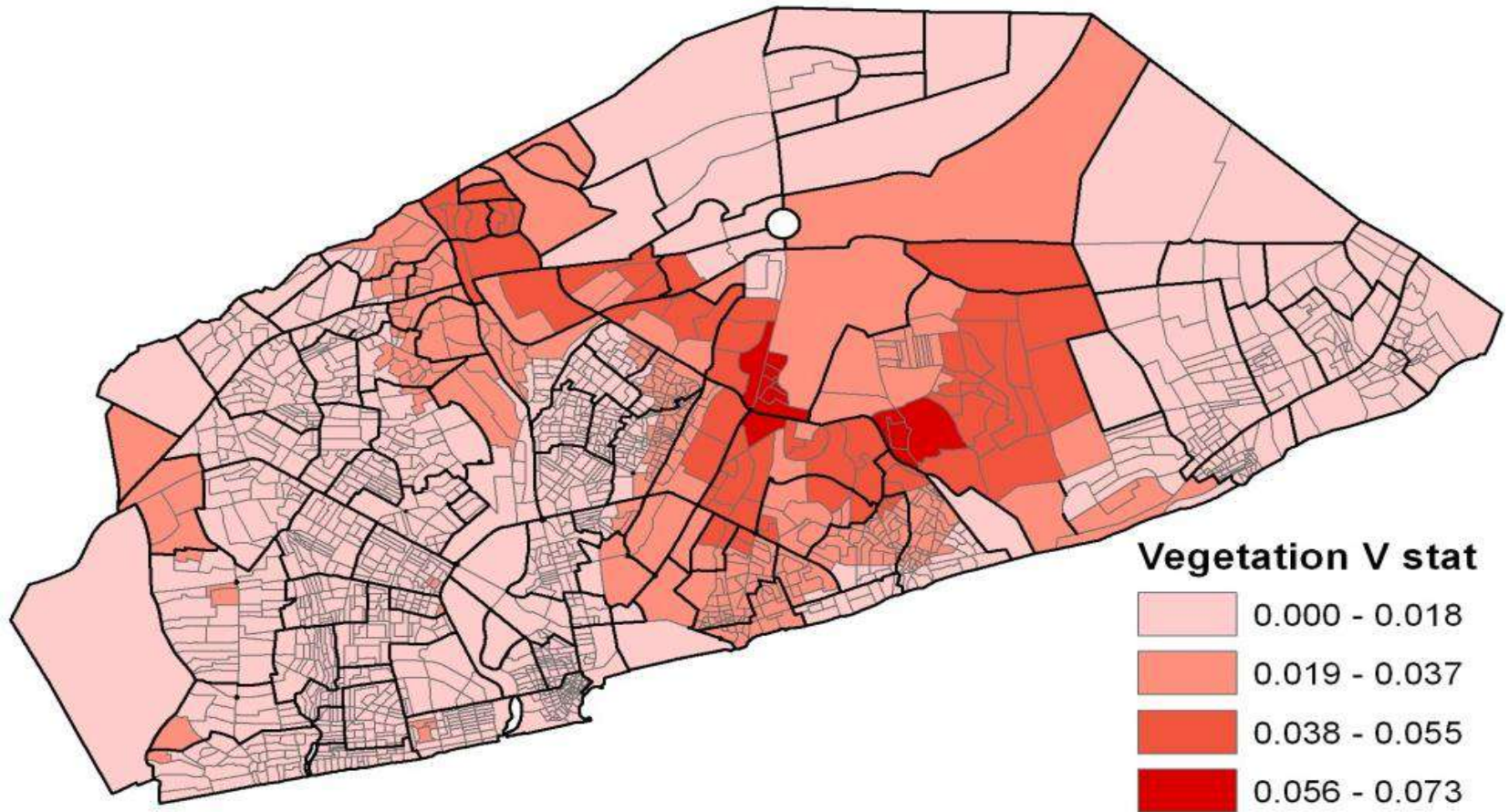
Data Source: Attribute: result



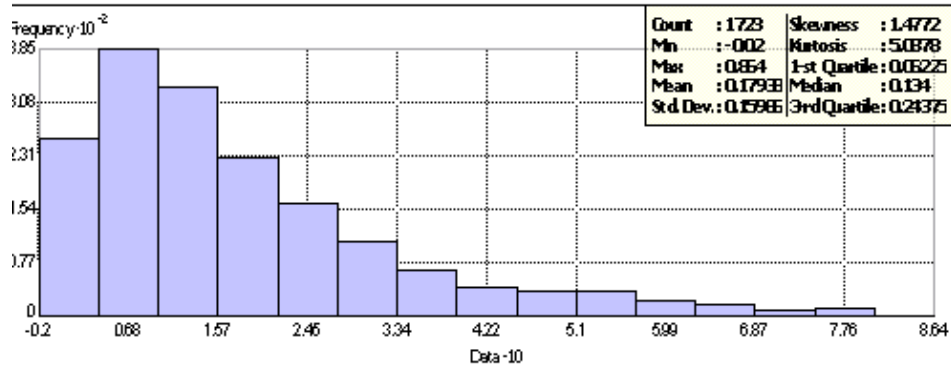
# Remotely Sensed Vegetation Values



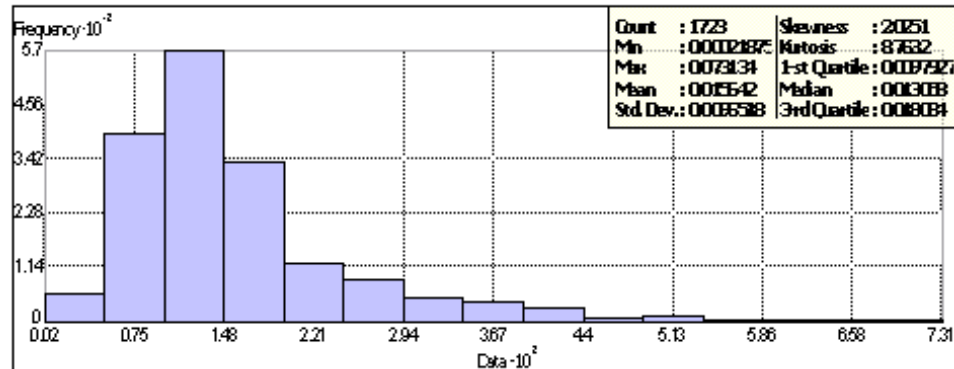
# *Hi* for Remotely Sensed Vegetation



# Vegetation and *Hi* Distributions

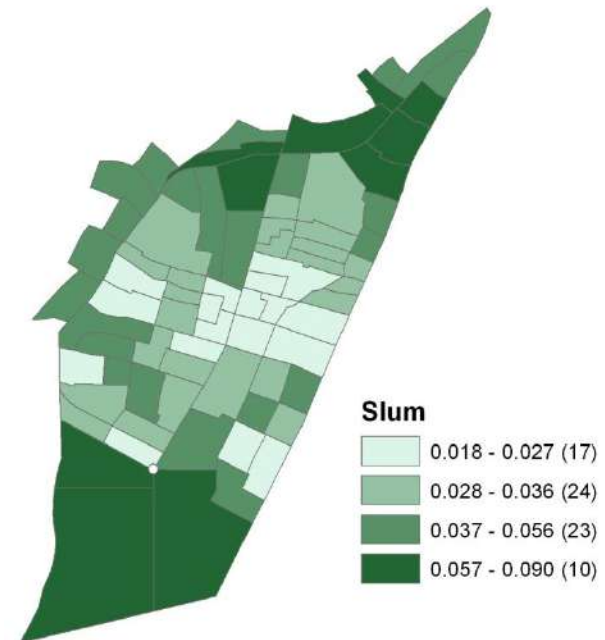
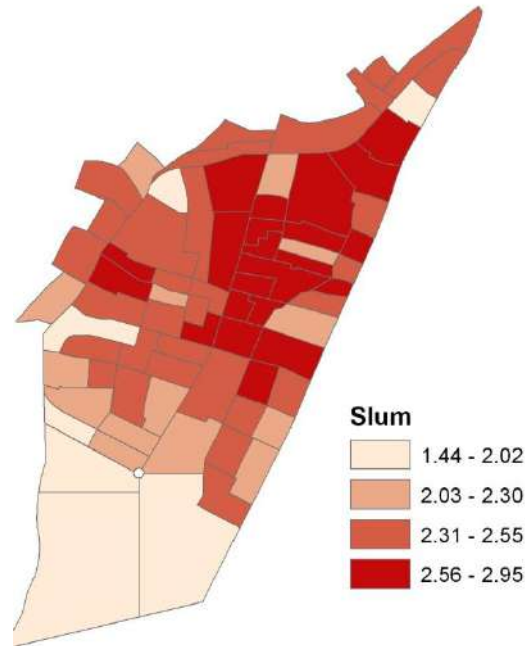
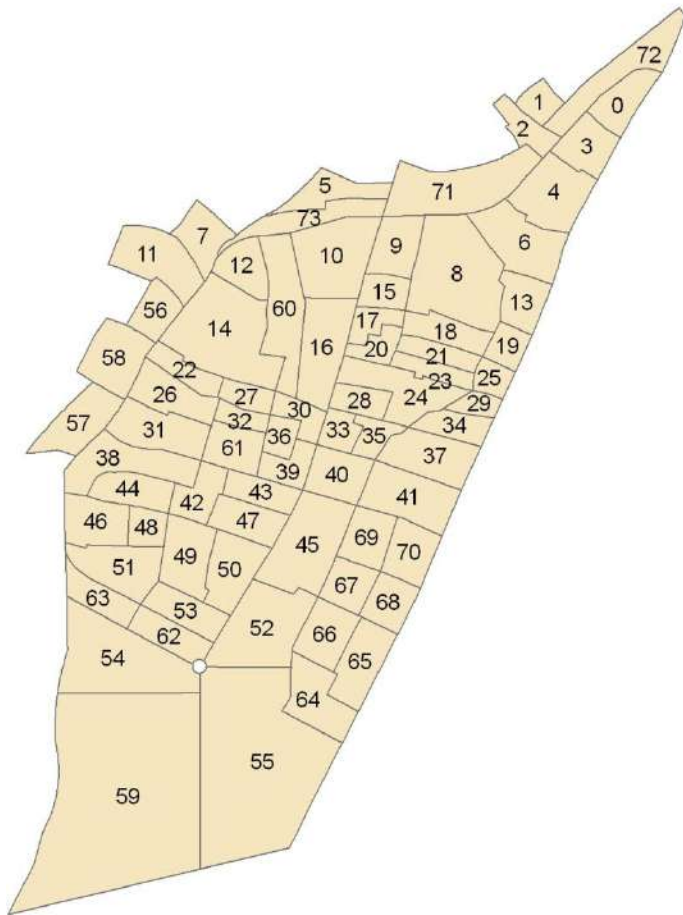


Data Source: Attribute: HybridVeg

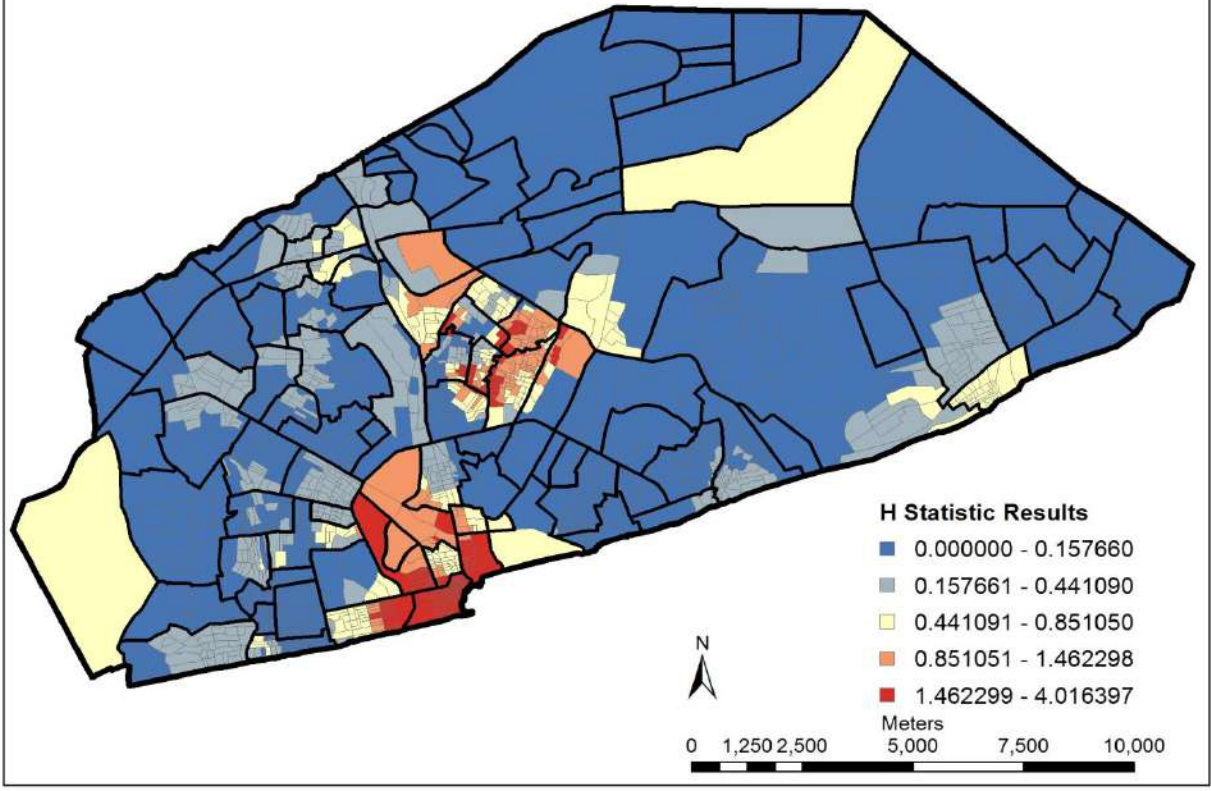


Data Source: Attribute: result

# Example Vernacular Neighborhood: Nima



### H Statistic Results for all MaxGi Combinations



# Closing Comments and Suggestions

LOSH:

- Identifies transitional regions
- Directs attention toward boundary demarcation
- Shows degree of heterogeneity/homogeneity within clusters
- Suggestion 1: Use as a further test on residuals of regression for identifying spatial outliers
- Suggestion 2: Use for tests on coefficients in GWR



Figure 7 - Slum Sum: Amoeba-clustered EAs at the 95% Confidence Level





Figure 8 - Chest Pain: Amoeba-clustered EAs at the 95% Confidence Level



Figure 9 - Illiteracy

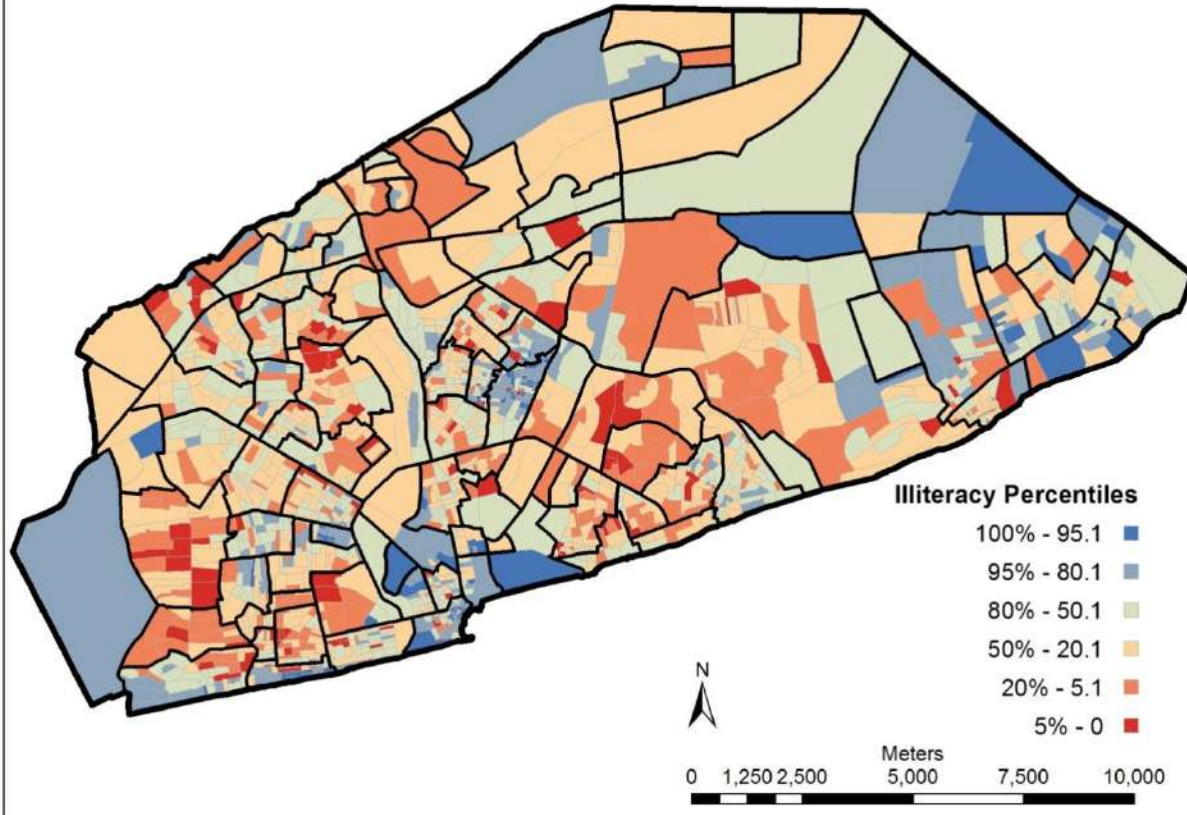


Figure 10 - The Intersection of Amoeba-clustered EAs from Figures 7 & 8

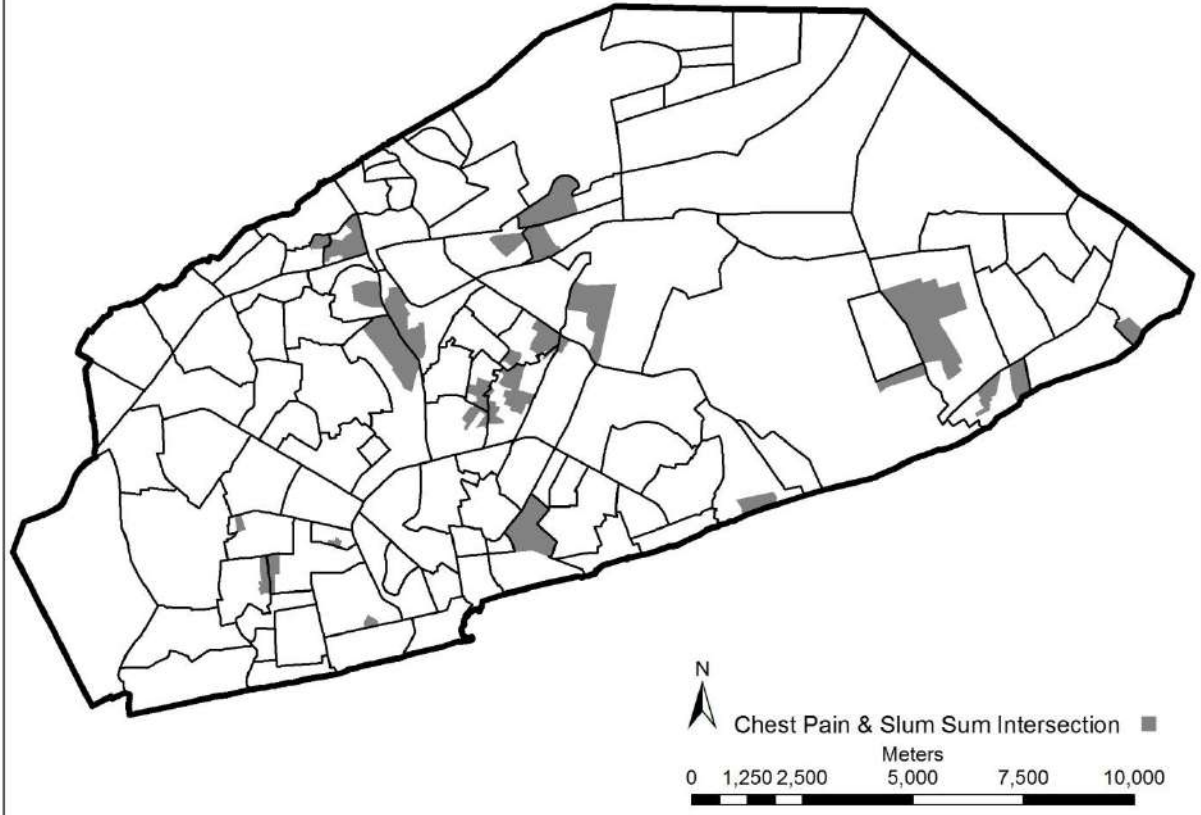


Figure 11 -  
Illiteracy rates in the intersection of Amoeba-clustered EAs from Figures 7 & 8

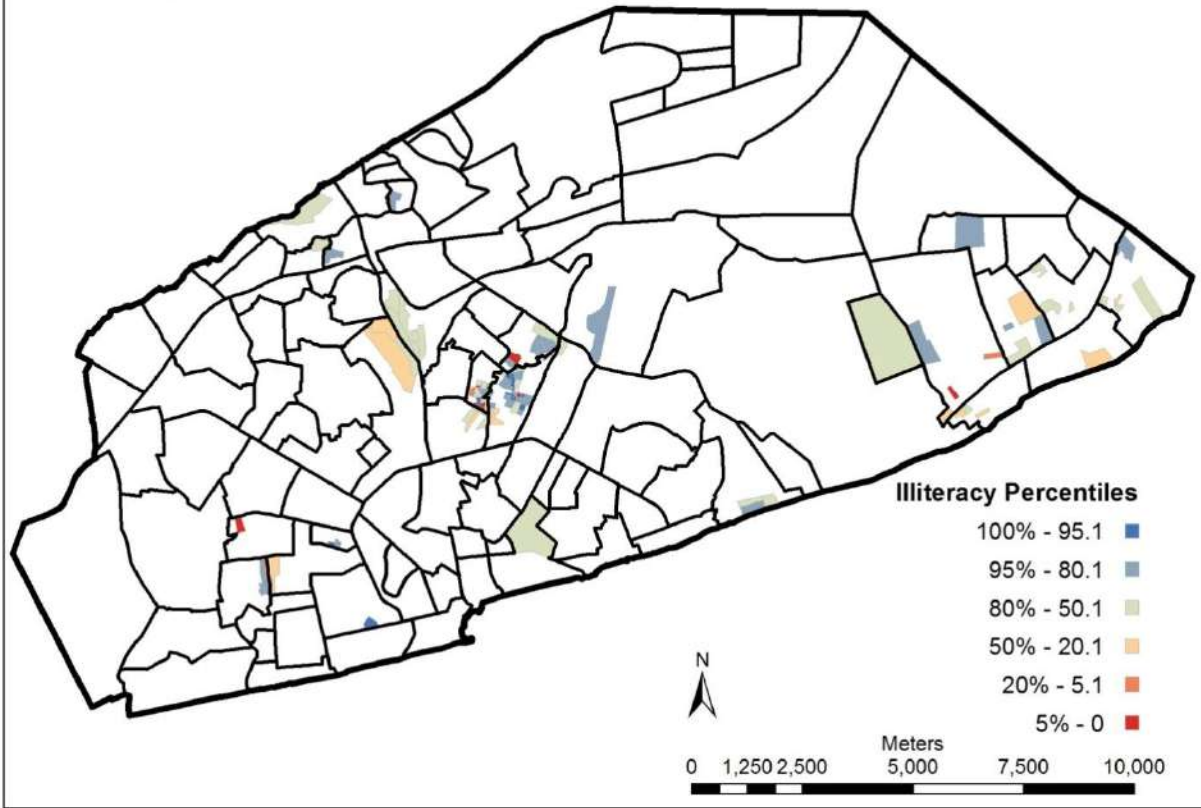
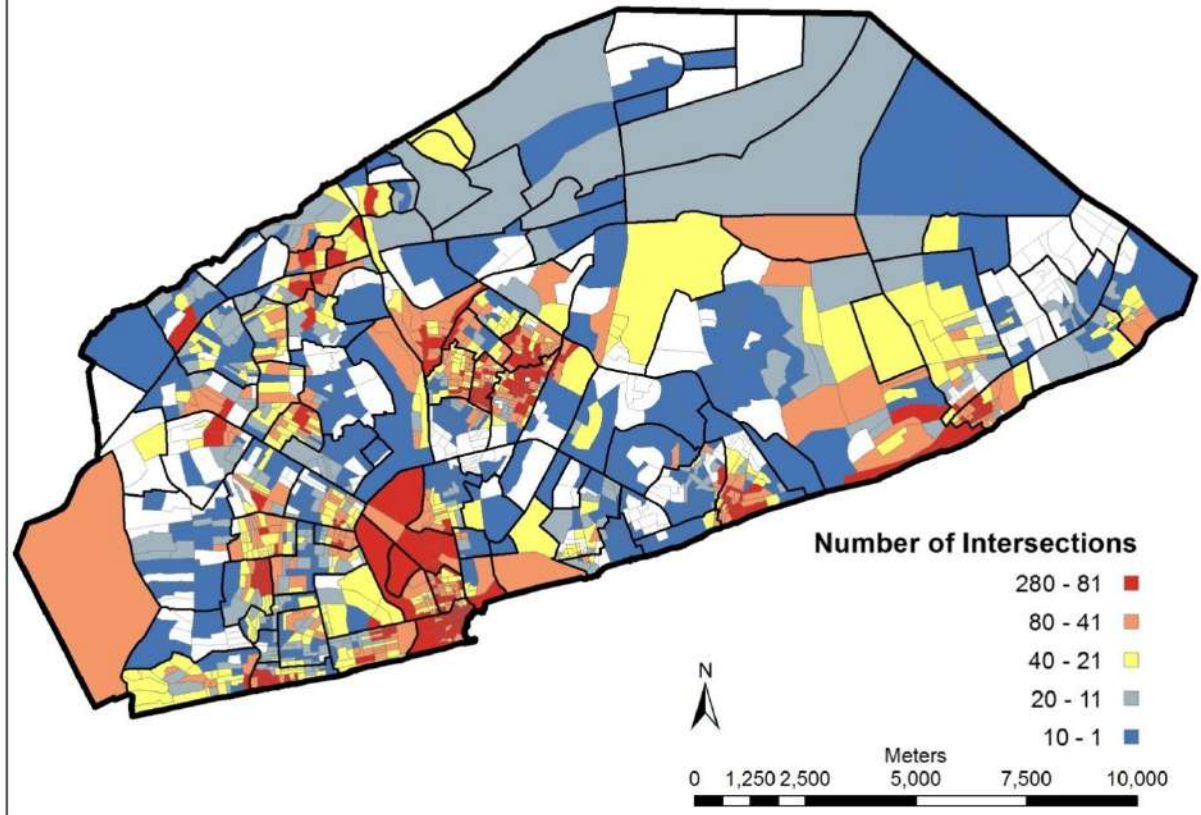
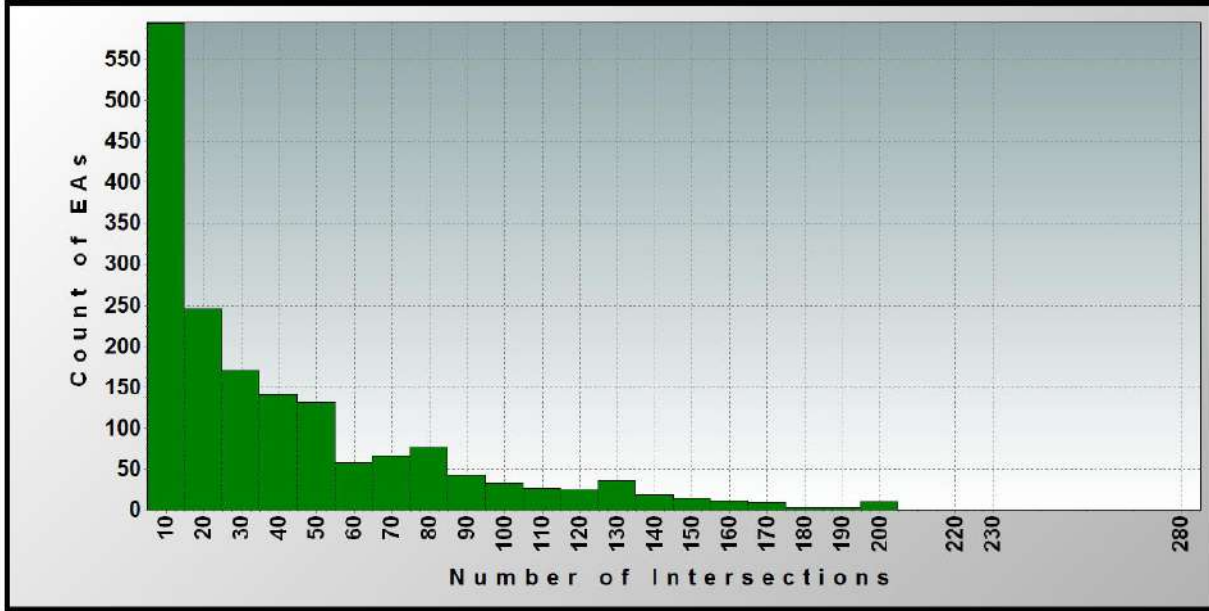


Figure 12 - Number of E and H Intersections per Enumeration Area

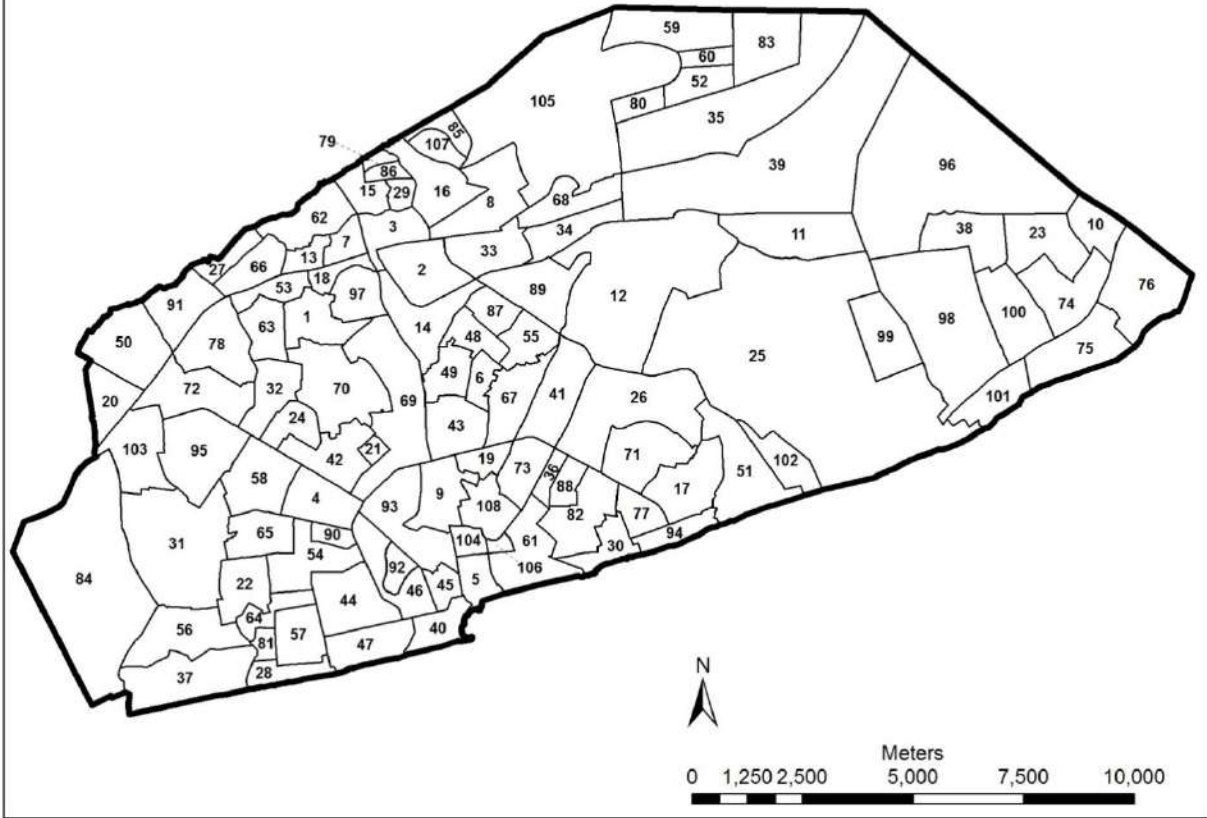




ASUO  
AFF CHEMISTS GHANA



Figure 1a - Field Modified Vernacular Neighborhoods





# Vernacular Neighborhoods of Accra, Ghana

Vernacular = locally understood

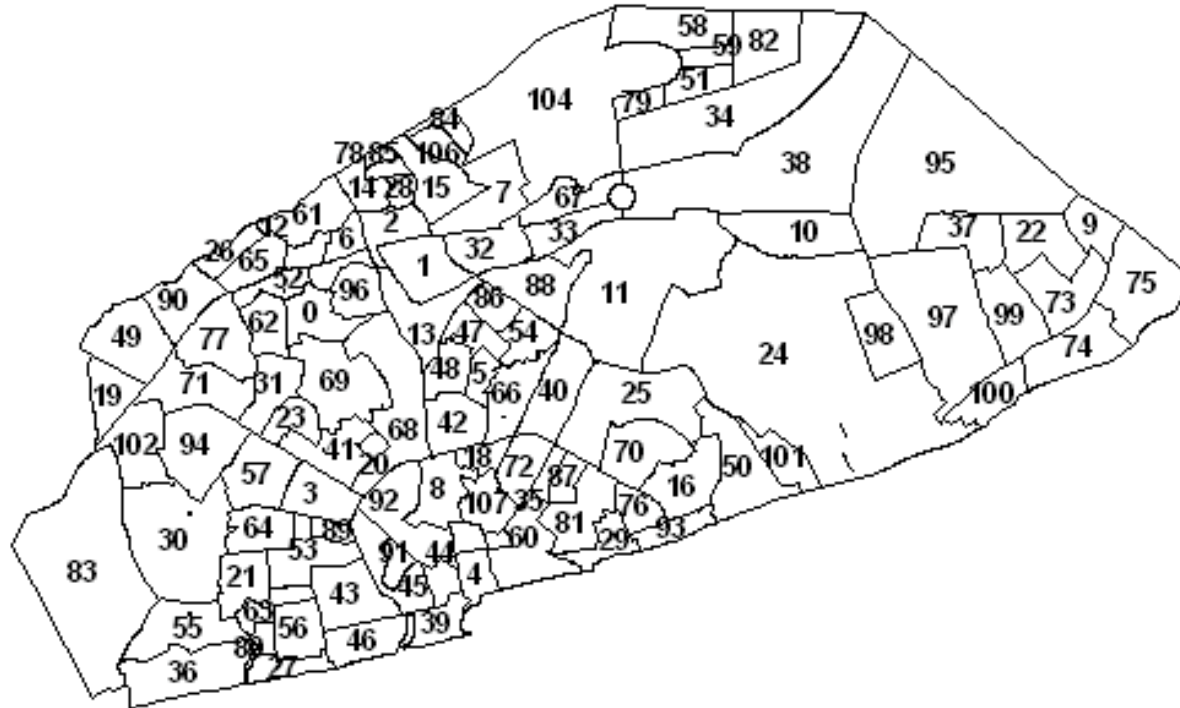


Figure 1b - Field Modified Vernacular Neighborhoods

Number	Name	Number	Name	Number	Name
1	Abeka	39	Industrial Area	77	Nyanbia Estates
2	Abelemkpe	40	Jamestown	78	Official Town
3	Abofu	41	Kanda Estate	79	Okoman
4	Abossey Okai	42	Kaneshie	80	Okponglo
5	Accra Central	43	Kokomlemlé	81	Old Damsoman
6	Accra New Town	44	Korle Bu Hospital	82	Osu
7	Achimota	45	Korle Dudor	83	Otinshie
8	Achimota Forest	46	Korle Lagoon Area	84	Pambros Salt Ponds
9	Adabraka	47	KorleGonno	85	Papao
10	Addogonno	48	Kotobabi	86	Parakuo Estate
11	Airport Hills Residential Area	49	Kpehe	87	Pig Farm
12	Airport Residential Area	50	Kwashie	88	Ringway Estate
13	Akweteyman	51	La	89	Roman Ridge
14	Alajo	52	La Bawalshie	90	Sabon Zongo
15	Algoboshie	53	Lapaz	91	Santa Maria
16	Anumle	54	Lartebiokorshi	92	Sodom & Gomorah
17	Apapa	55	Mamobi	93	South Industrial Area
18	Apenkwa	56	Mamponse	94	South La Estate
19	Asylum Down	57	Mamprobi	95	South Ordokor
20	Awoshie	58	Mataheko	96	Spintex Road
21	Awudome Estate	59	Medina Estates	97	Tesano
22	Banana Inn	60	Mepeasm	98	Teshie
23	Buade	61	Ministries	99	Teshie Manheam
24	Bubiashie	62	New Achimota	100	Teshie Nungua Estates
25	Burma Camp	63	New Fadama	101	Teshie Old Town
26	Cantonments	64	New Mamprobi	102	Trade Center
27	Chantan	65	New Russia	103	Tsabaa
28	Chorkor	66	Niiboye Town	104	Tudu
29	Christian Village	67	Nima	105	University Of Ghana
30	Christianborg	68	North Dzorwulu Residential Area	106	Victoriaborg West legon Residential
31	Dansoman Estate	69	North Industrial Area	107	West Ridge
32	Darkuman	70	North kaneshie		
33	Dzorwulu Residential Area East Dzorwulu Residential Area	71	North labone Estate		
34	East Legon Residential	72	North Ordokor		
35	East Ridge	73	North Ridge		
36	Gbegbeyise	74	Nungua		
37	Greda Estates	75	Nungua Old Town		
38		76	Nungua Salem		

Figure 1b - Field Modified Vernacular Neighborhoods

Number	Name	Number	Name	Number	Name
1	Abeka	39	Industrial Area	77	Nyanbia Estates
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13	Akweteyman	51	La	89	Roman Ridge
14	Alajo	52	La Bawalshie	90	Sabon Zongo
15	Algoboshie	53	Lapaz	91	Santa Maria
16	Anumle	54	Lartebiokorshi	92	Sodom & Gomorah
17	Apapa	55	Mamobi	93	South Industrial Area
18	Apenkwa	56	Mamponse	94	South La Estate
19	Asylum Down	57	Mamprobi	95	South Ordokor
20	Awoshie	58	Mataheko	96	Spintex Road
21	Awudome Estate	59	Medina Estates	97	Tesano
22	Banana Inn	60	Mepeasm	98	Teshie
23	Buade	61	Ministries	99	Teshie Manheam
24	Bubiashie	62	New Achimota	100	Teshie Nungua Estates
25	Burma Camp	63	New Fadama	101	Teshie Old Town
26	Cantonments	64	New Mamprobi	102	Trade Center
27	Chantan	65	New Russia	103	Tsabaa
28	Chorkor	66	Niiboye Town	104	Tudu
29	Christian Village	67	Nima	105	University Of Ghana
30	Christianborg	68	North Dzorwulu Residential Area	106	Victoriaborg West legon Residential
31	Dansoman Estate	69	North Industrial Area	107	West Ridge
32	Darkuman	70	North kaneshie		
33	Dzorwulu Residential Area East Dzorwulu Residential Area	71	North labone Estate		
34	East Legon Residential	72	North Ordokor		
35	East Ridge	73	North Ridge		
36	Gbegbeyise	74	Nungua		
37	Greda Estates	75	Nungua Old Town		
38		76	Nungua Salem		

Figure 2 - Enumeration Area Centroids



Figure 3 - GPS Derived Locations of WHSA-II Survey Participants



Figure 4 - Theoretical K-Functions

