Cartography M.Sc.

Refining Spatial Autocorrelation Analysis for Dasymetrically Disaggregated Spatial Data

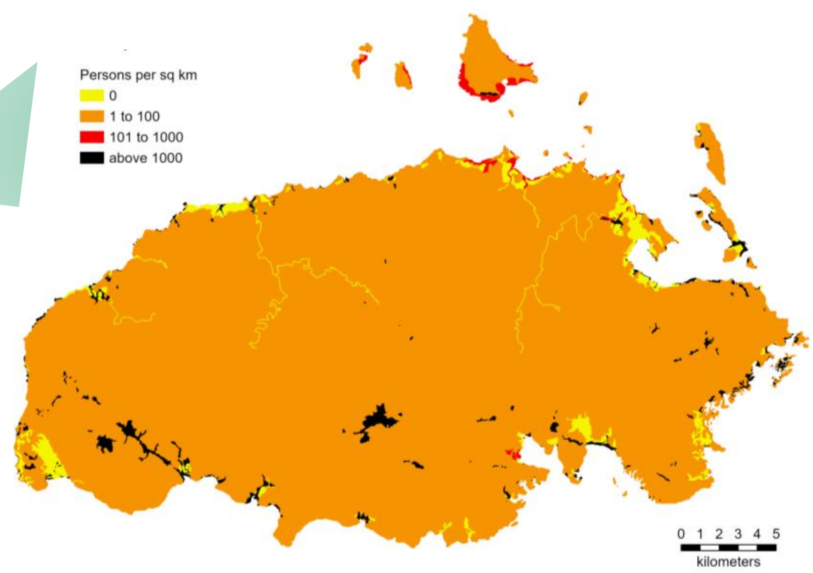
Dennis P. Dizon

Candidate, MSc Cartography

The agenda

- Introduction
  - The research problem
  - Objectives and questions
- Central concepts, related studies
- Methodology
  - Conceptual framework
  - Analysis parameters and workflow
  - Case study areas
- Results
- Discussion, conclusion

Dasymetric mapping?

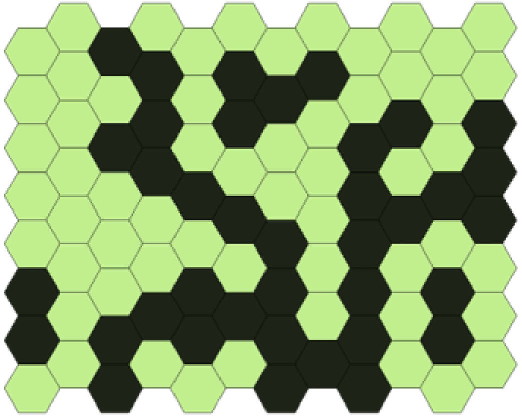


Spatial autocorrelation analysis?

Spatial outliers?

Overall pattern of values?

Spatial dispersion?

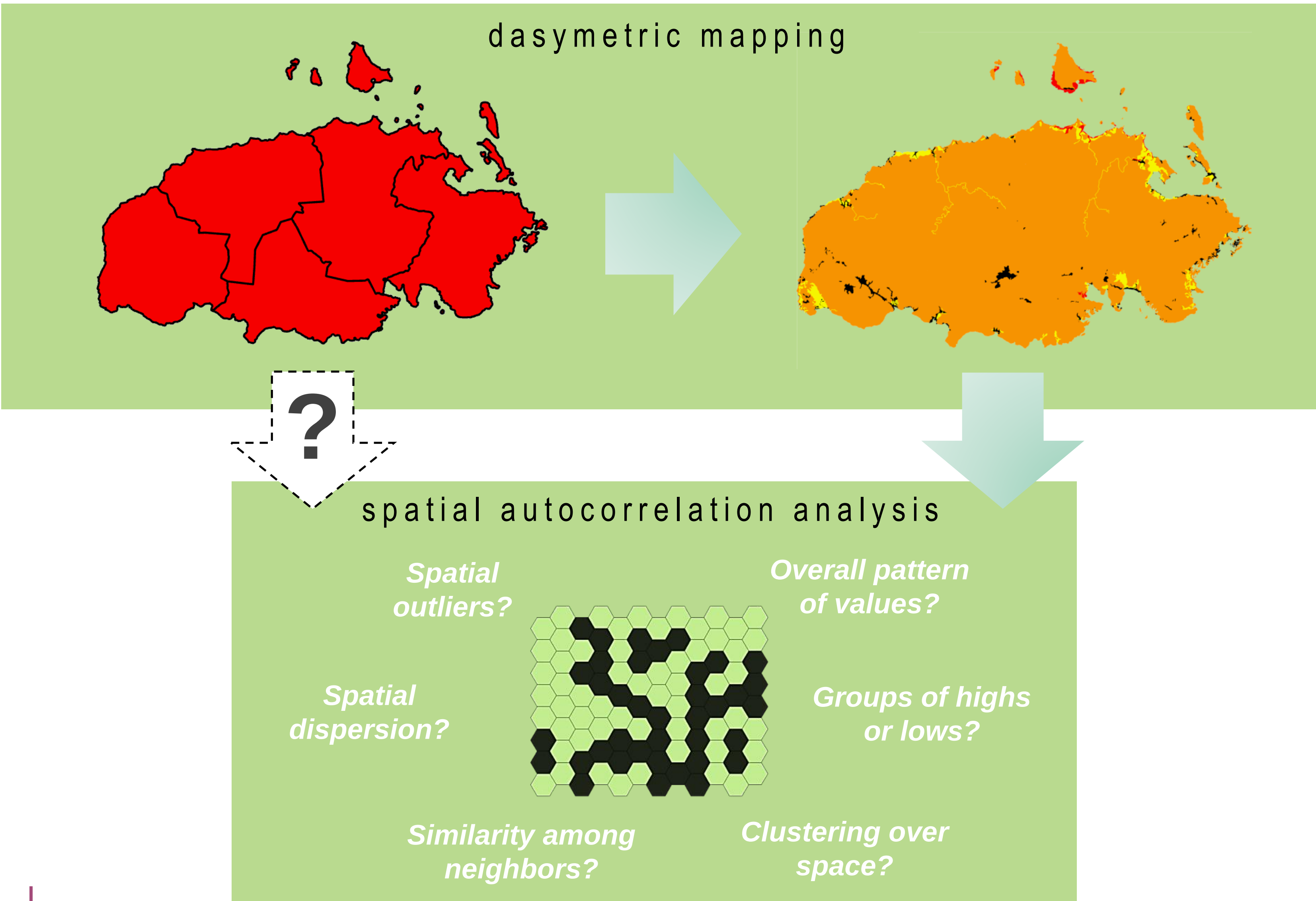


Groups of highs or lows?

Similarity among neighbors?

Clustering over space?

The research problem



Objectives and questions

What to refine?	Which **spatial autocorrelation measures** can utilize dasymetrically disaggregated spatial data?
	Which **parameter(s)** in spatial autocorrelation analysis can be modified when using dasymetrically disaggregated data?
How to refine?	What **modification(s)** in spatial autocorrelation analysis can be made when using dasymetrically disaggregated data?
Are there differences?	How do these modifications **differ from each other** in terms of results in the spatial autocorrelation analysis?
	How do the results **differ from the original** spatial autocorrelation analysis?

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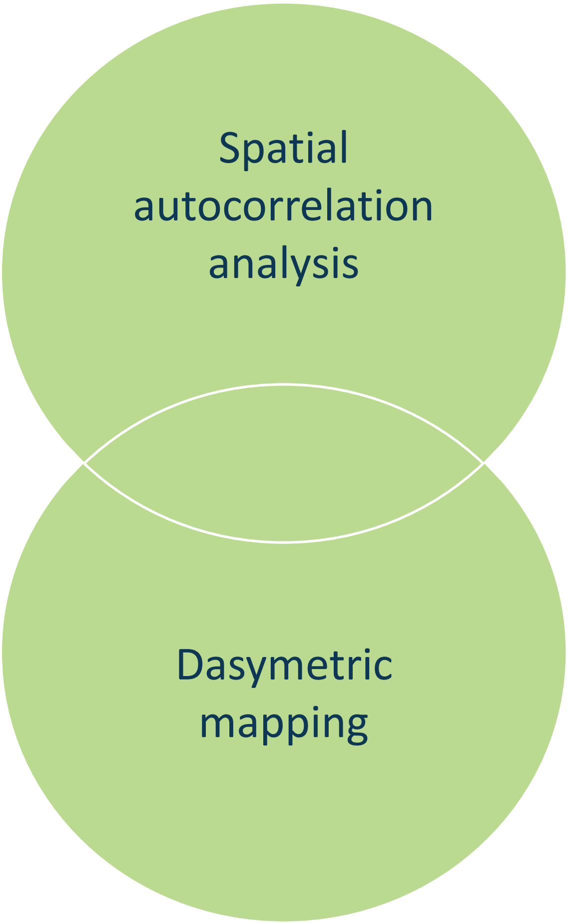
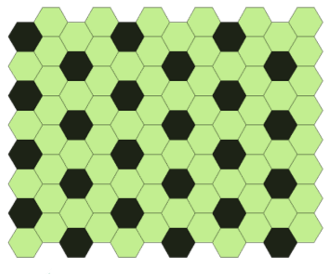
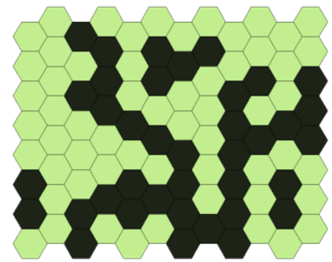
The central concepts

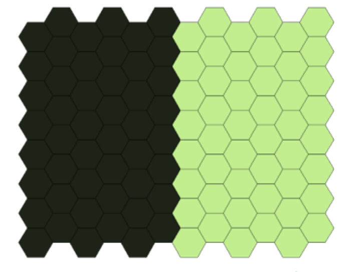


Spatial autocorrelation analysis

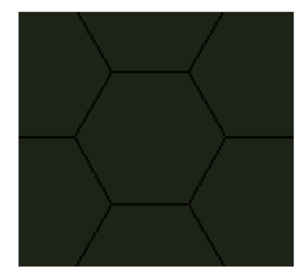
Global







Local



Spatial autocorrelation analysis

Global

$$I = \left(\frac{N}{\sum_{i=1}^{N}\sum_{j=1}^{N}\mathrm{W}}\right)\left(\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}\mathrm{W}z_i z_j}{\sum_{i=1}^{N} z_i^2}\right)$$

Global Moran's *I*

$$C = \left(\frac{N-1}{2\sum_{i=1}^{N}\sum_{j=1}^{N}\mathrm{W}}\right)\left(\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}\mathrm{W}\left(x_i - x_j\right)}{\sum_{i=1}^{N} z_i^2}\right)$$

Geary's *C*

Local

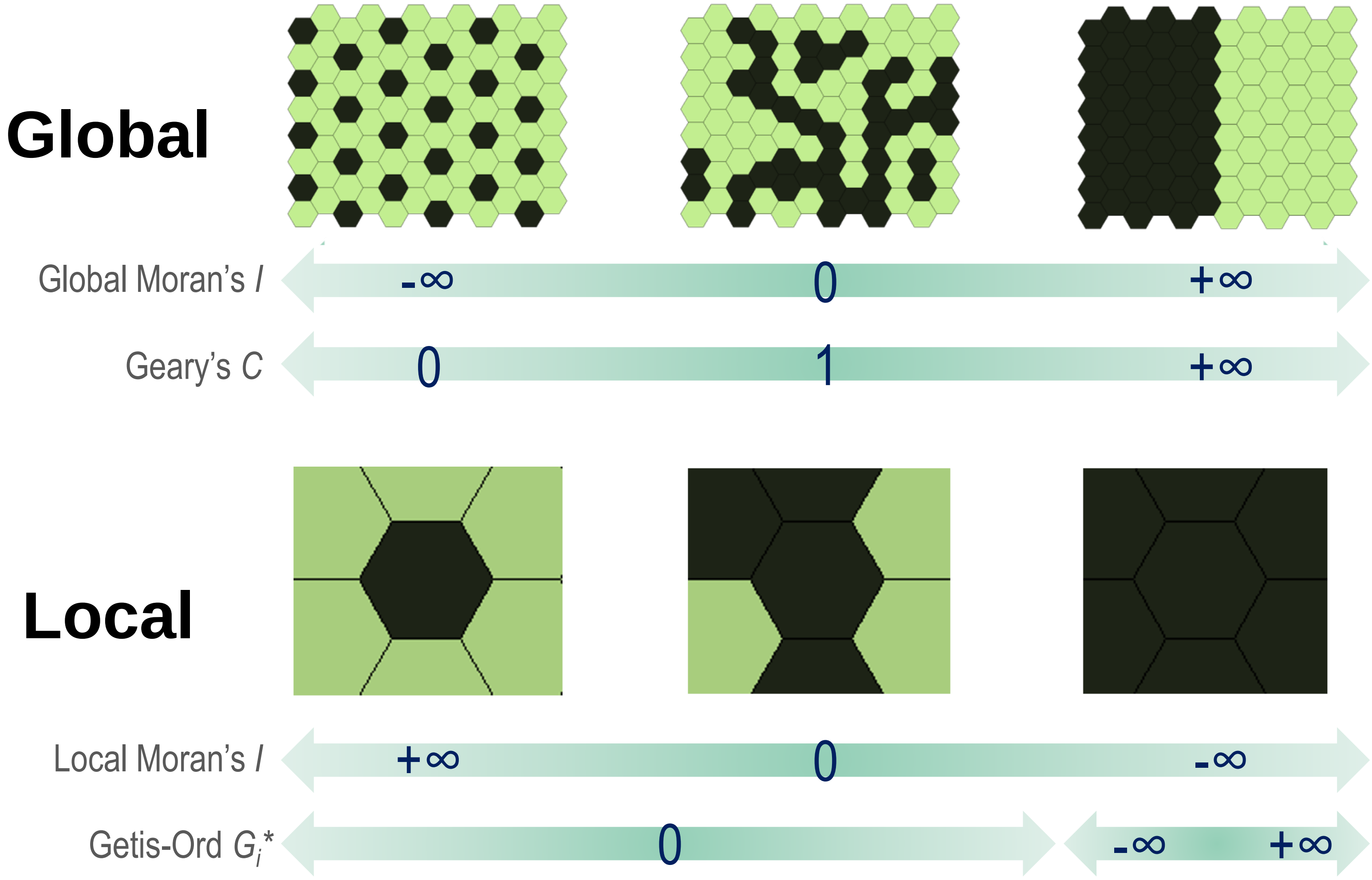
$$I_i = \left(\frac{z_i}{\sum_{i=1}^{N}\left(z_j\right)^2/N-1}\right)\left(\sum_{j=1}^{N}\mathrm{W}z_j\right)$$

Local Moran's *I*

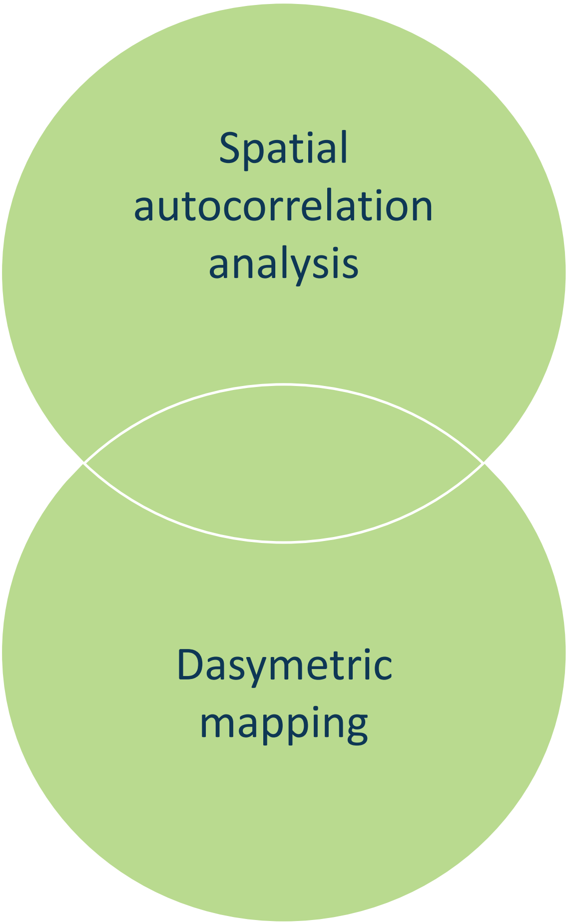
$$G_i^* = \frac{\sum_{j=1}^{N}\mathrm{W}x_j - \frac{\sum_{j=1}^{N}x_j}{N-1}\left(\sum_{j=1}^{N}\mathrm{W}\right)}{\sqrt{\left(\frac{\sum_{j=1}^{N}x_j^2}{N-1} - \frac{\sum_{j=1}^{N}x_j}{N-1}\right)\left(\frac{\left[N\sum_{j=1}^{N}\mathrm{W}^2 - \left(\sum_{j=1}^{N}\mathrm{W}\right)^2\right]}{N-1}\right)}}$$

Getis-Ord G_i*

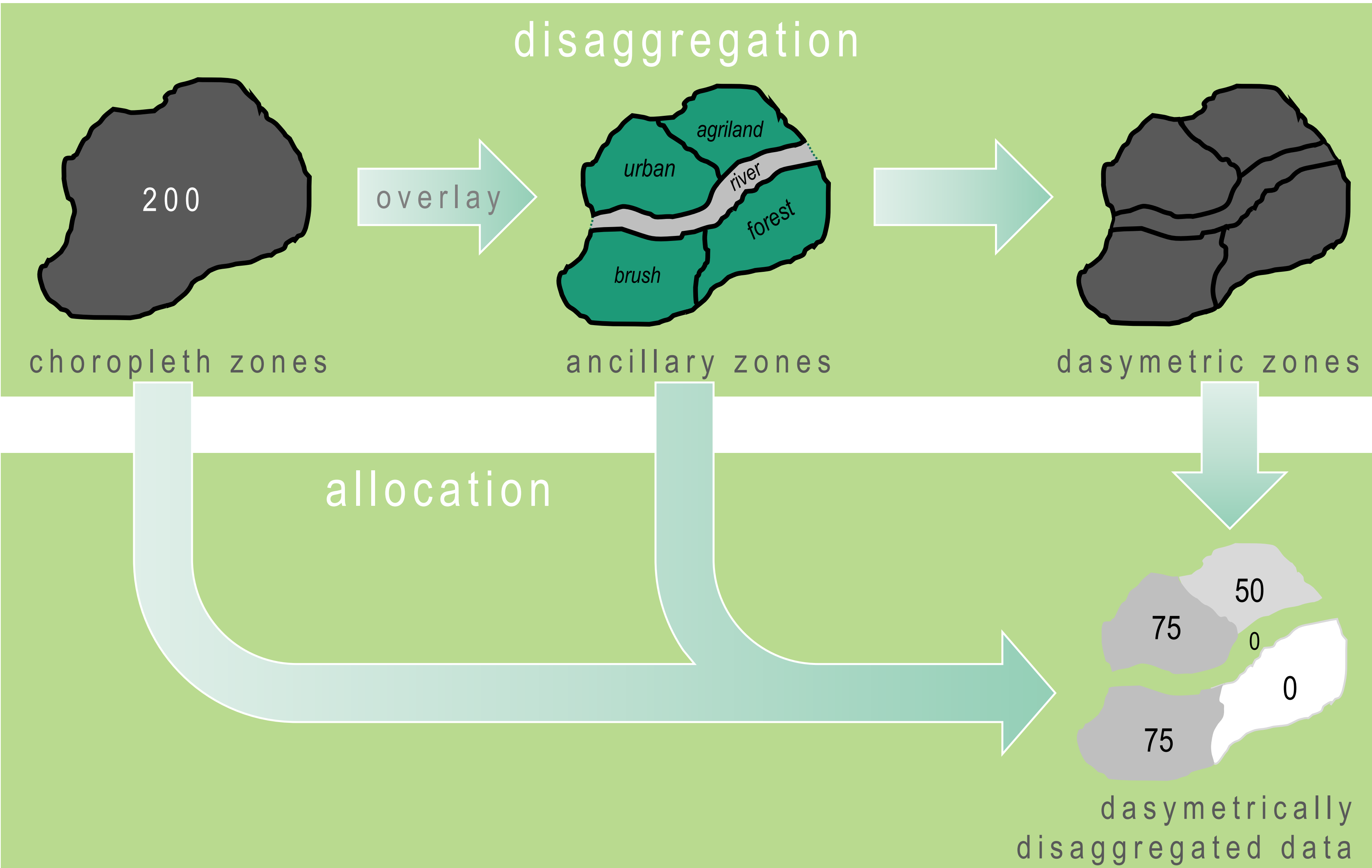
Spatial autocorrelation analysis



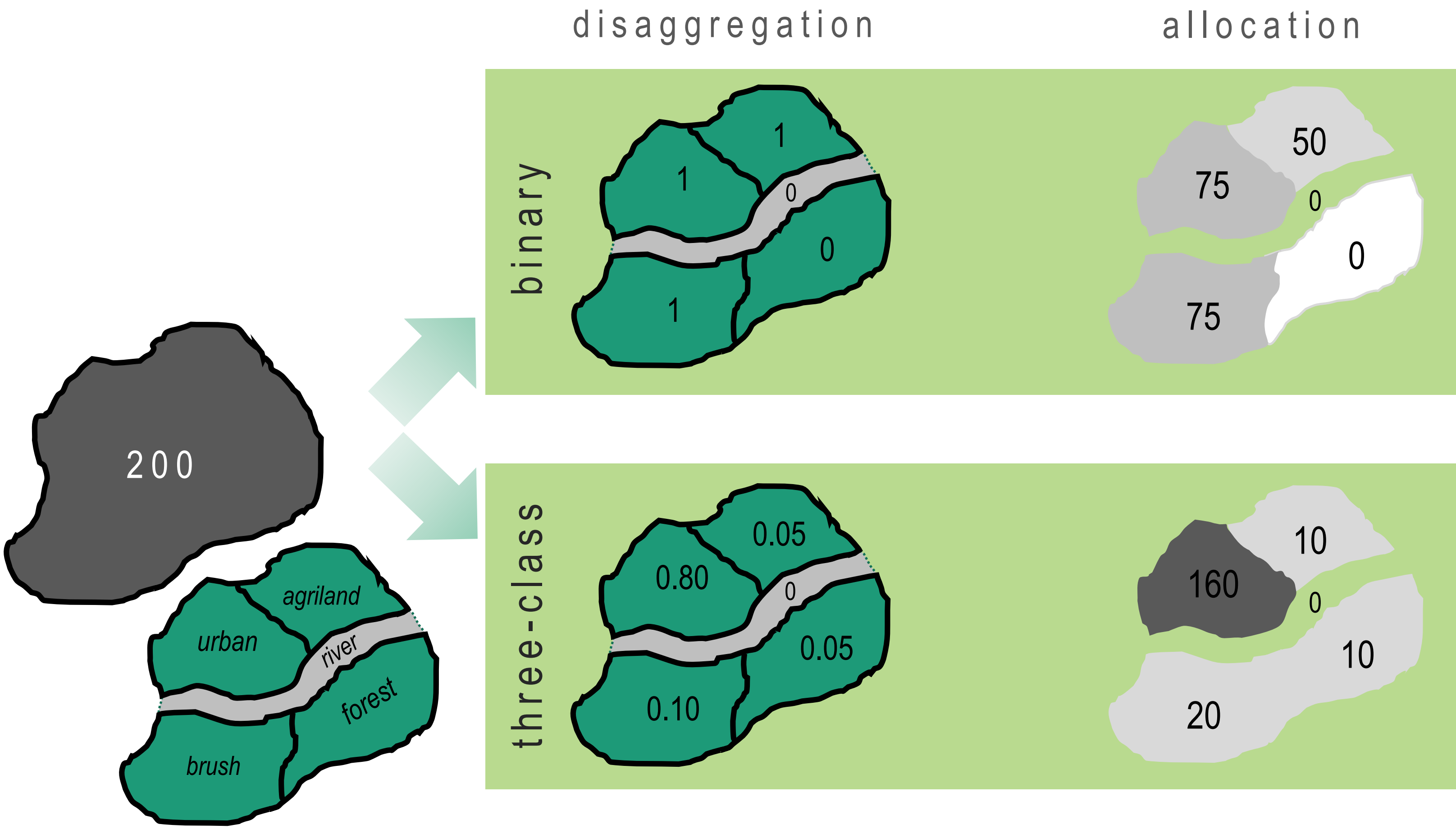
The central concepts



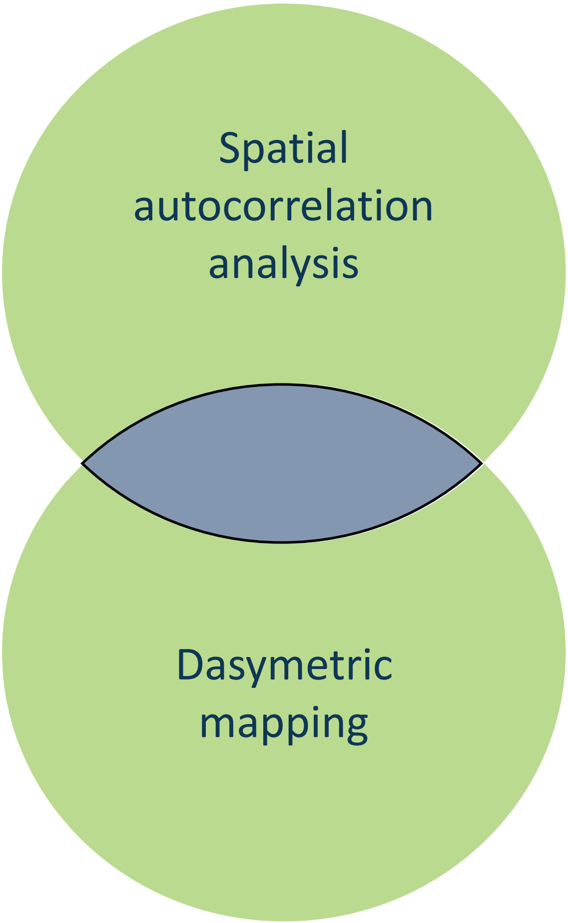
Dasymetric mapping



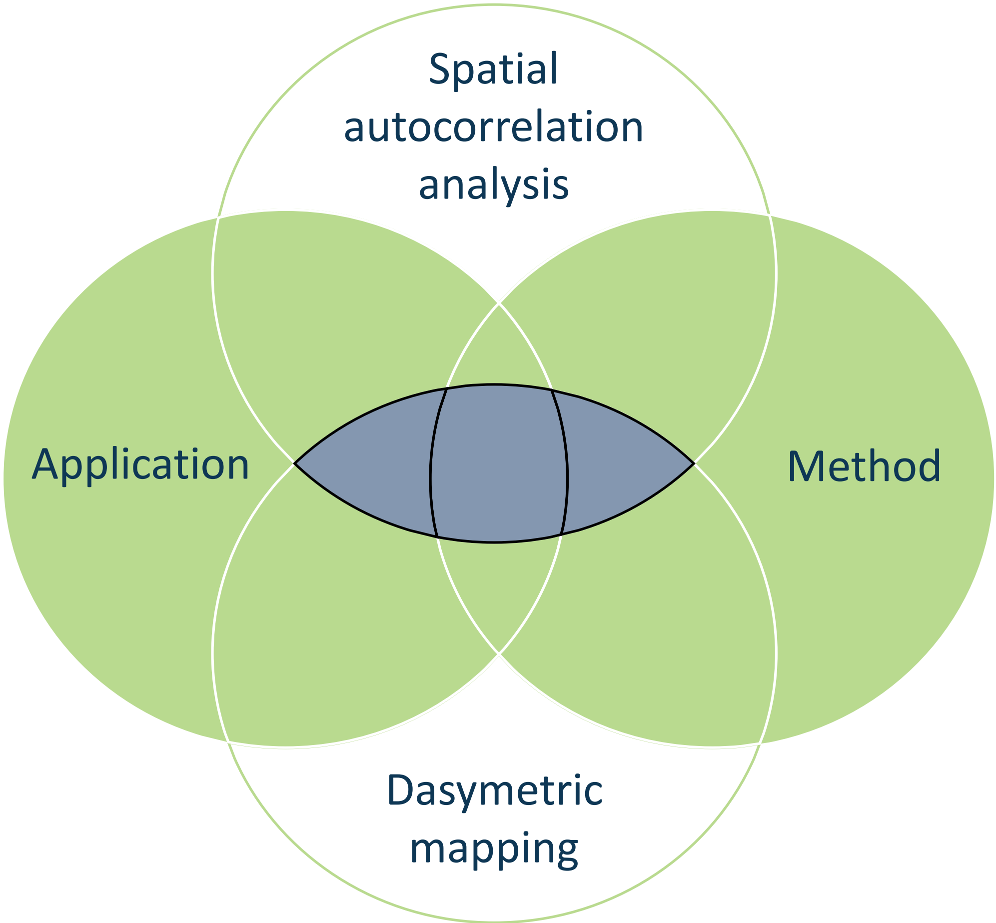
Dasymetric methods



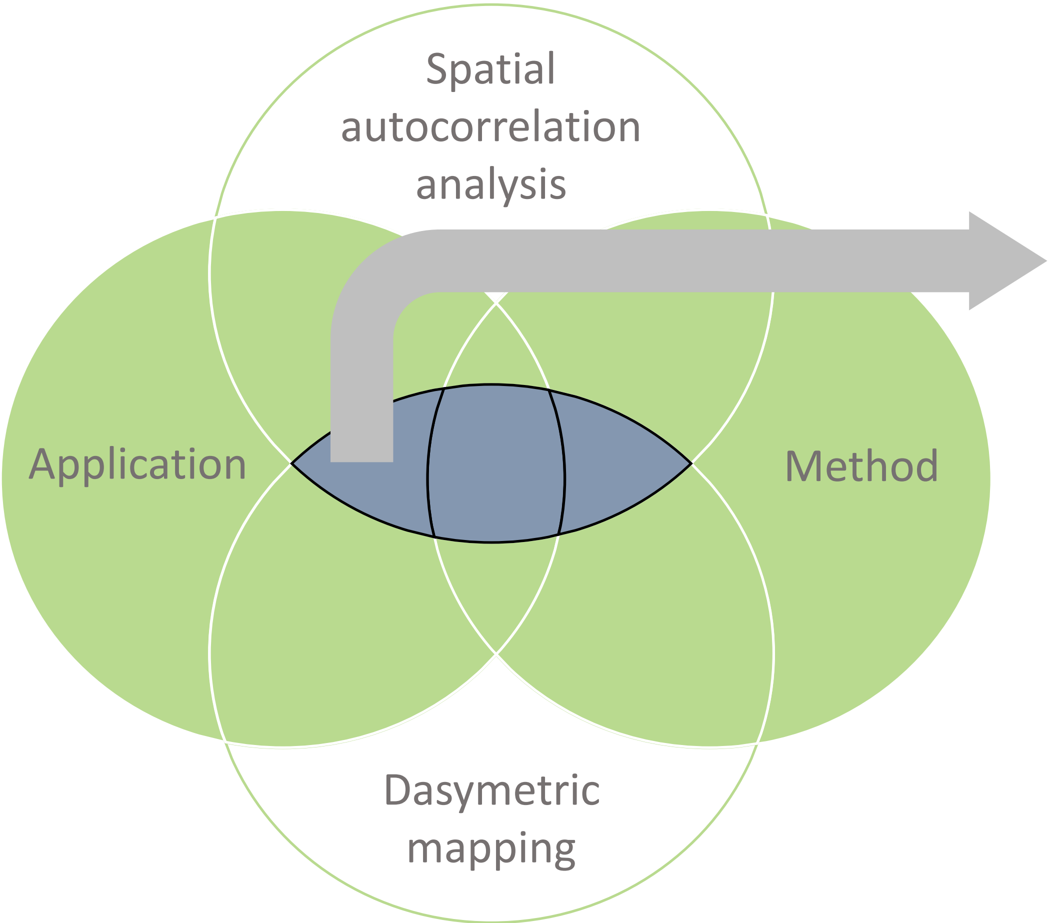
Related studies



Related studies



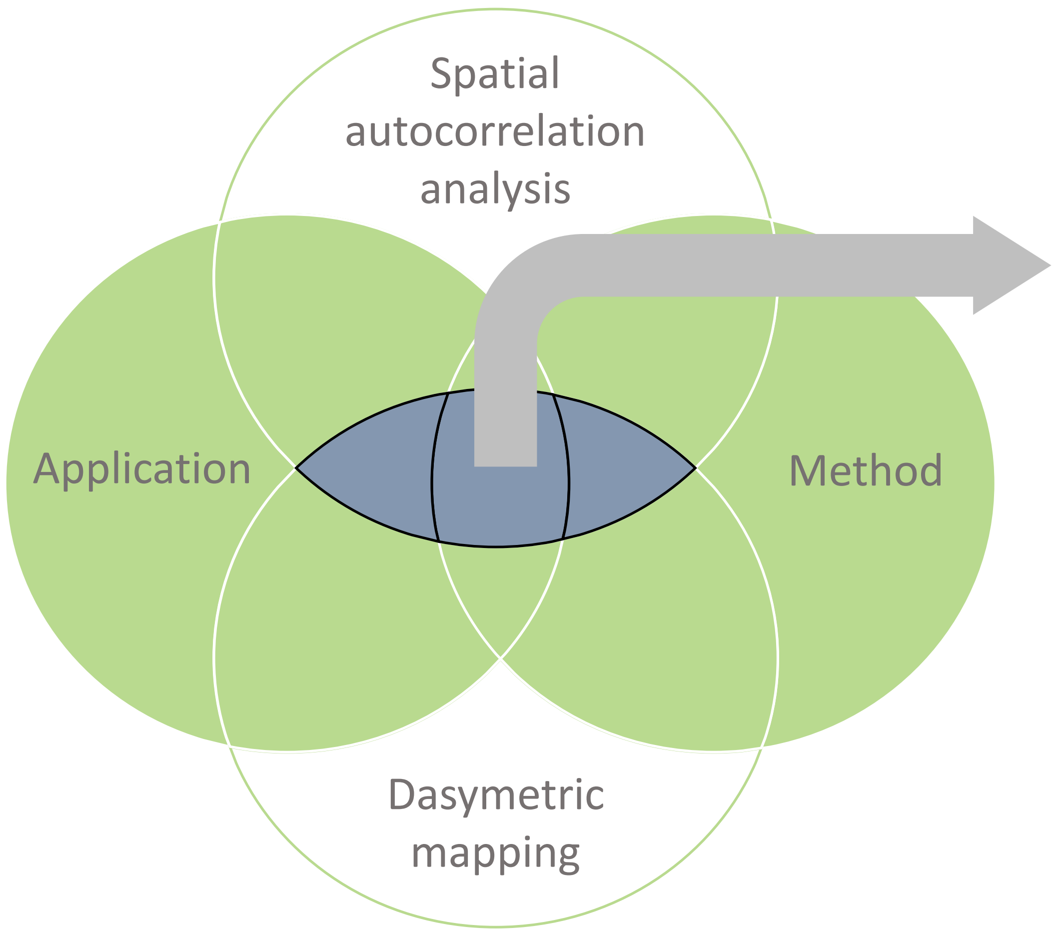
Related studies



Direct application

- Choi et al. (2011)
- Weeks (2010)

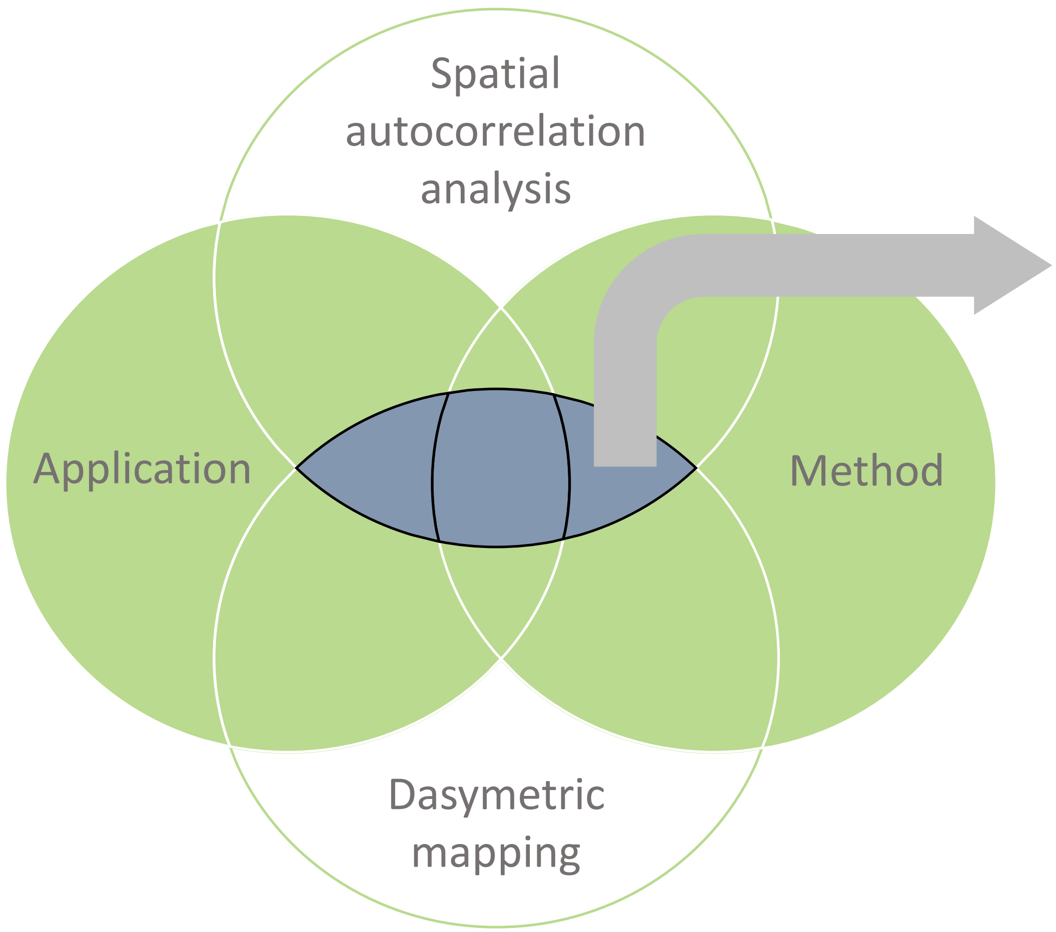
Related studies



Application to improve an existing analysis method

- Boo et al. (2015)
- Mosley (2012)
- Parenteau & Sawada (2012)
- Hu et al. (2007)

Related studies



"Analysis" of the method

- Rodrigues & Tenedorio (2016)
- Reynolds (2011)

This study falls in this area

+ Refining the analysis

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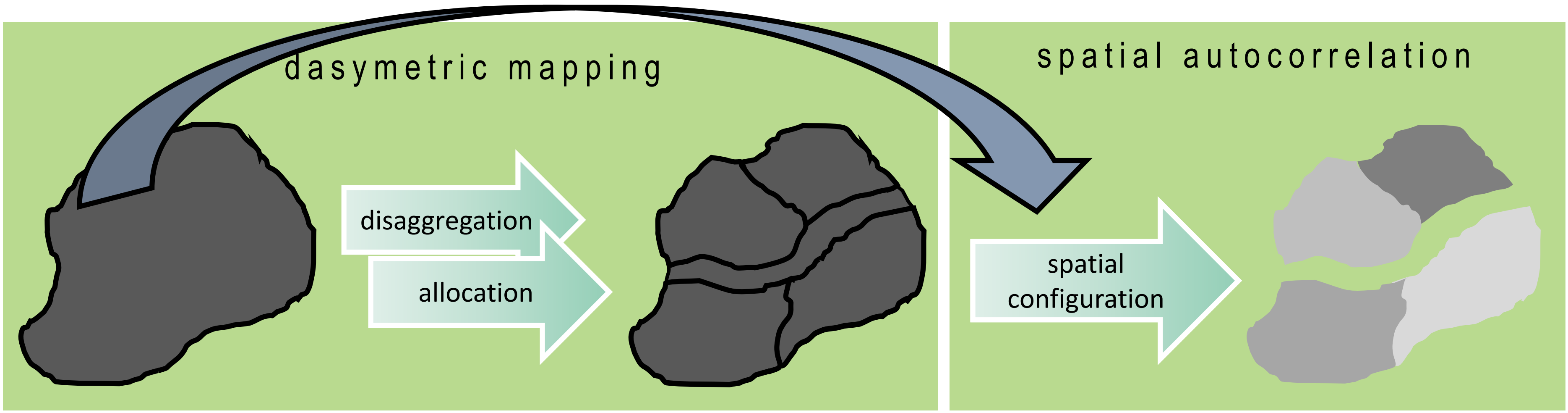
The conceptual framework



Spatial autocorrelation analysis

Global

$$I = \left(\frac{N}{\sum_{i=1}^{N}\sum_{j=1}^{N}\mathrm{W}}\right)\left(\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}\boxed{\mathrm{W}}z_i z_j}{\sum_{i=1}^{N}z_i^2}\right)$$

Global Moran's *I*

$$C = \left(\frac{N-1}{2\sum_{i=1}^{N}\sum_{j=1}^{N}\mathrm{W}}\right)\left(\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}\boxed{\mathrm{W}}(x_i - x_j)}{\sum_{i=1}^{N}z_i^2}\right)$$

Geary's *C*

Local

$$I_i = \left(\frac{z_i}{\sum_{i=1}^{N}(z_j)^2/N-1}\right)\left(\sum_{j=1}^{N}\boxed{\mathrm{W}}z_j\right)$$

Local Moran's *I*

$$G_i^* = \frac{\sum_{j=1}^{N}\boxed{\mathrm{W}}x_j - \frac{\sum_{j=1}^{N}x_j}{N-1}\left(\sum_{j=1}^{N}\mathrm{W}\right)}{\sqrt{\left(\frac{\sum_{j=1}^{N}x_j^2}{N-1} - \frac{\sum_{j=1}^{N}x_j}{N-1}\right)\left(\frac{\left[N\sum_{j=1}^{N}\mathrm{W}^2 - \left(\sum_{j=1}^{N}\mathrm{W}\right)^2\right]}{N-1}\right)}}$$

Getis-Ord G_i*

Spatial weight matrices

$$I = \left(\frac{N}{\sum_{i=1}^{N}\sum_{j=1}^{N} \mathrm{W}}\right)\left(\frac{\sum_{i=1}^{N}\sum_{j=1}^{N} \boxed{\mathrm{W}} z_i z_j}{\sum_{i=1}^{N} z_i^2}\right)$$

$$\begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

contiguity

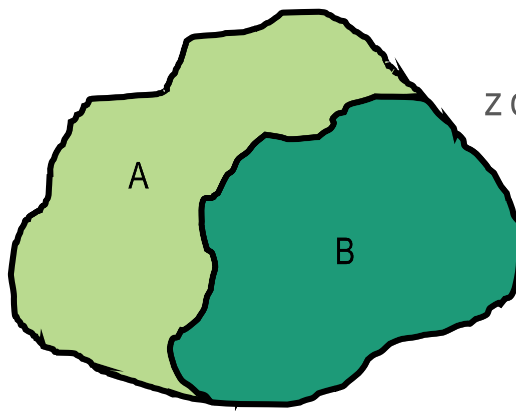
$$\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

nearest neighbors

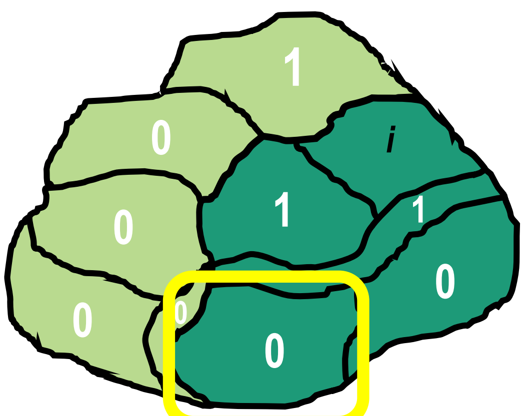
$$\begin{bmatrix} 0 & 0{,}004 & 0{,}010 & 0 & 0{,}003 & 0 \\ 0{,}004 & 0 & 0{,}004 & 0{,}005 & 0{,}002 & 0{,}002 \\ 0{,}010 & 0{,}004 & 0 & 0 & 0 & 0{,}003 \\ 0 & 0{,}005 & 0 & 0 & 0{,}003 & 0{,}007 \\ 0{,}003 & 0{,}002 & 0 & 0{,}003 & 0 & 0{,}007 \\ 0 & 0{,}002 & 0{,}003 & 0{,}007 & 0{,}007 & 0 \end{bmatrix}$$

distance

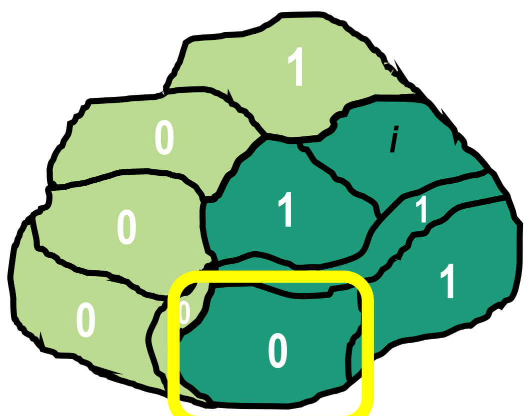
Spatial weight matrices



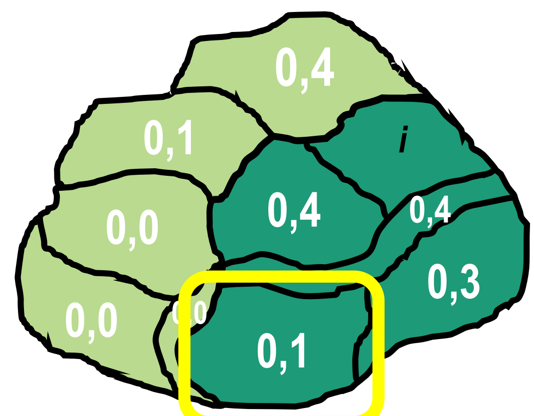
choroplethic
zones (A and B)



contiguity



nearest neighbors
(k = 4)



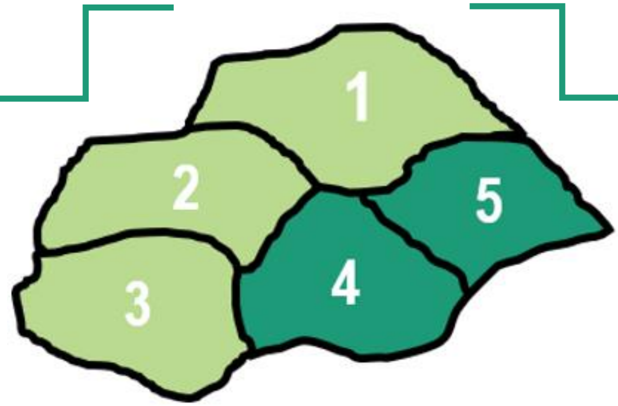
distance

A revised spatial weight matrix

$$W_D = p_S W_S + p_C W_C$$

spatial priority

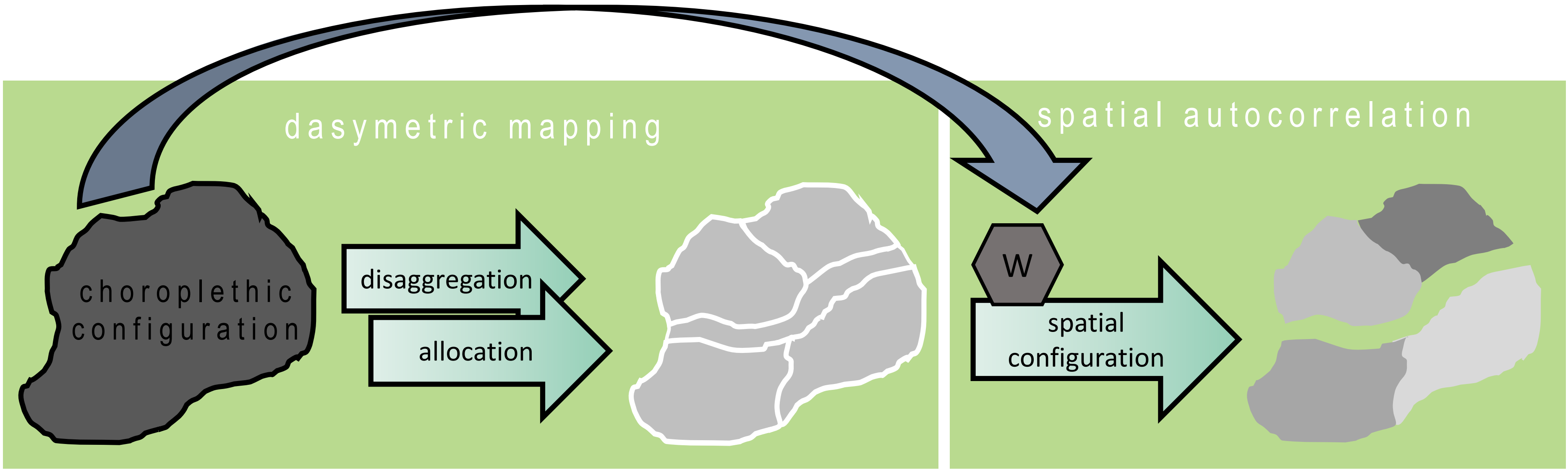
choroplethic priority



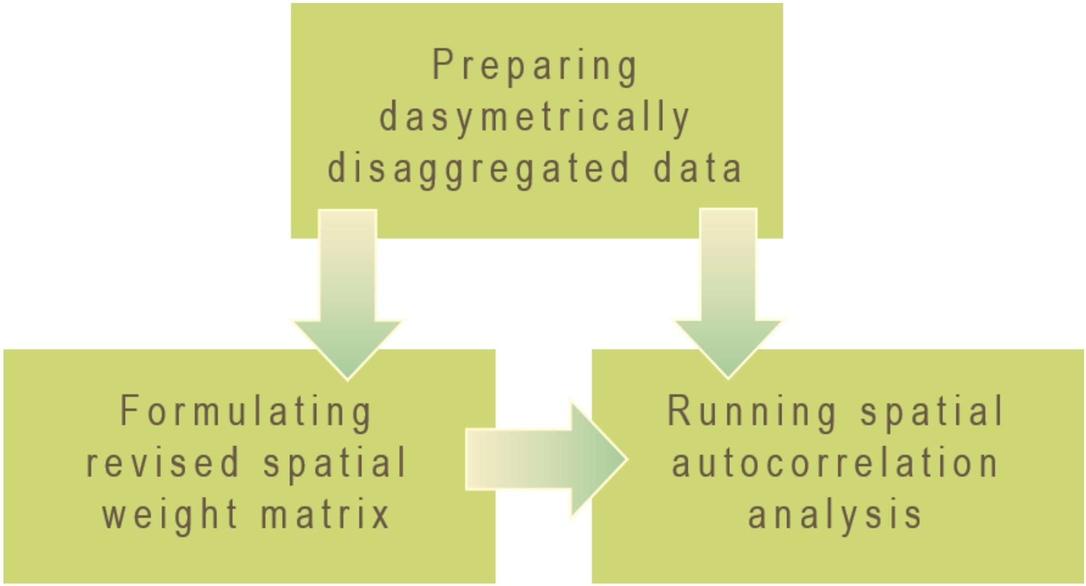
$$W_D = 0.70 W_S + 0.30 W_C$$

$$[0.7] * \underbrace{\begin{bmatrix} 0 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 & 0 \end{bmatrix}}_{W_S} + [0.3] * \underbrace{\begin{bmatrix} 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}}_{W_C} = \underbrace{\begin{bmatrix} 0 & 1 & 0,3 & 0,7 & 0,7 \\ 1 & 0 & 1 & 0,7 & 0 \\ 0,3 & 1 & 0 & 0,7 & 0 \\ 0,7 & 0,7 & 0,7 & 0 & 1 \\ 0,7 & 0 & 0 & 1 & 0 \end{bmatrix}}_{W_D}$$

The conceptual framework



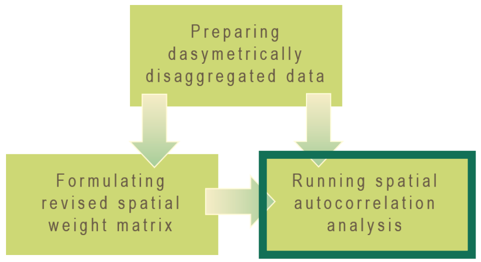
Analysis workflow



Analysis parameters

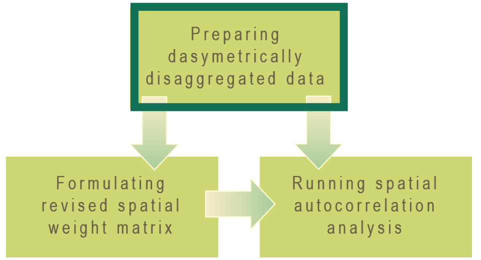
Spatial weight matrices		
Revised	W_{D1}	$W_{D1} = 0.70W_S + 0.30W_C$
	W_{D2}	$W_{D2} = 0.50W_S + 0.50W_C$
	W_{D3}	$W_{D3} = 0.30W_S + 0.70W_C$

Analysis parameters



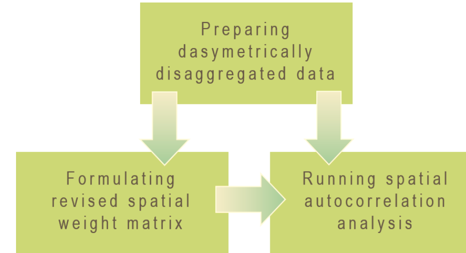
Spatial weight matrices		**Spatial autocorrelation measures**			
		Global		Local	
		Global Moran's *I*	Geary's *C*	Local Moran's *I*	Getis-Ord G_i*
Revised	W_{D1}				
	W_{D2}				
	W_{D3}				

Analysis parameters



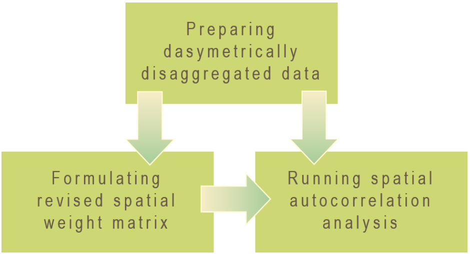
Spatial weight matrices		Spatial autocorrelation measures							
		Global				Local			
		Global Moran's I		Geary's C		Local Moran's I		Getis-Ord G_i*	
Revised	W_{D1}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D2}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D3}	binary	3-class	binary	3-class	binary	3-class	binary	3-class

Analysis parameters



Spatial weight matrices		Spatial autocorrelation measures							
		Global				Local			
		Global Moran's *I*		Geary's *C*		Local Moran's *I*		Getis-Ord G_i^*	
Revised	W_{D1}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D2}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D3}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
Conventional	W_S	binary	3-class	binary	3-class	binary	3-class	binary	3-class
		Dasymetric mapping methods							

Analysis parameters



Raw counts

Spatial weight matrices		Spatial autocorrelation measures							
		Global				Local			
		Global Moran's I		Geary's C		Local Moran's I		Getis-Ord G_i^*	
Revised	W_{D1}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D2}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D3}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
Conventional	W_S	binary	3-class	binary	3-class	binary	3-class	binary	3-class

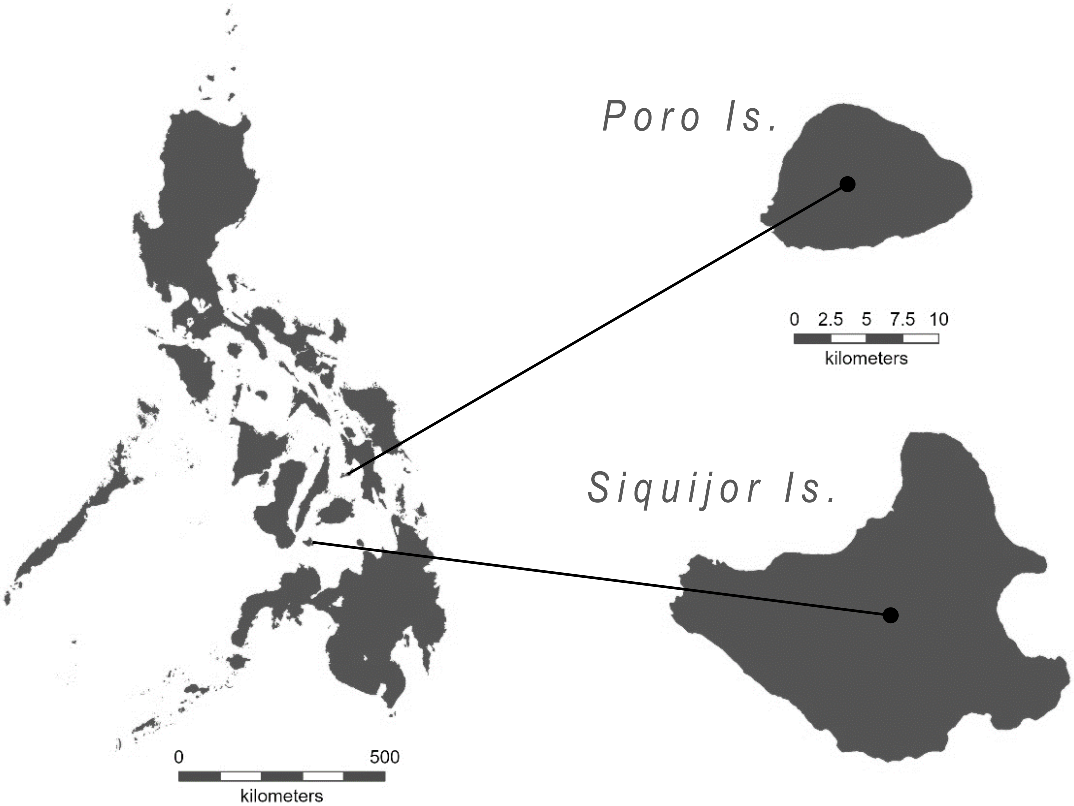
Dasymetric mapping methods

Densities

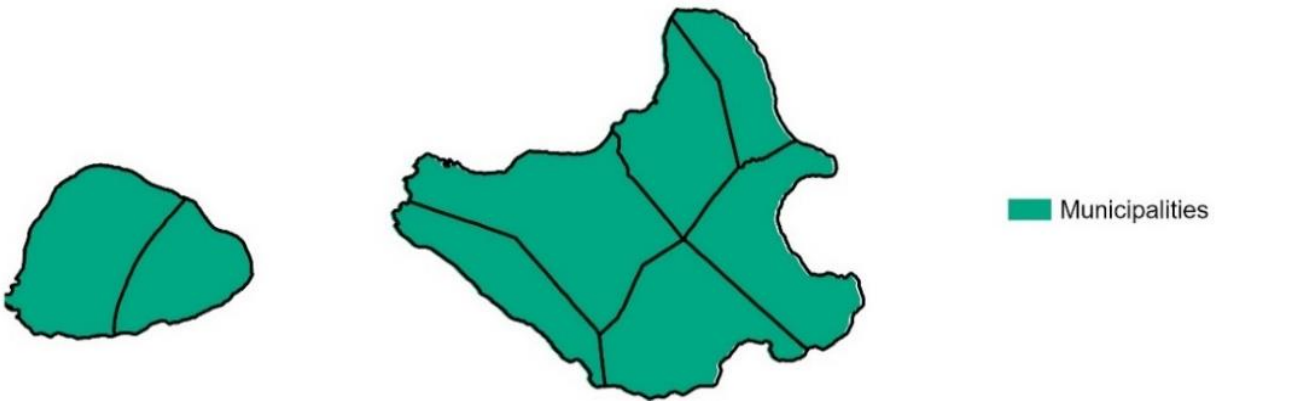
Spatial weight matrices		Spatial autocorrelation measures							
		Global				Local			
		Global Moran's I		Geary's C		Local Moran's I		Getis-Ord G_i^*	
Revised	W_{D1}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D2}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
	W_{D3}	binary	3-class	binary	3-class	binary	3-class	binary	3-class
Conventional	W_S	binary	3-class	binary	3-class	binary	3-class	binary	3-class

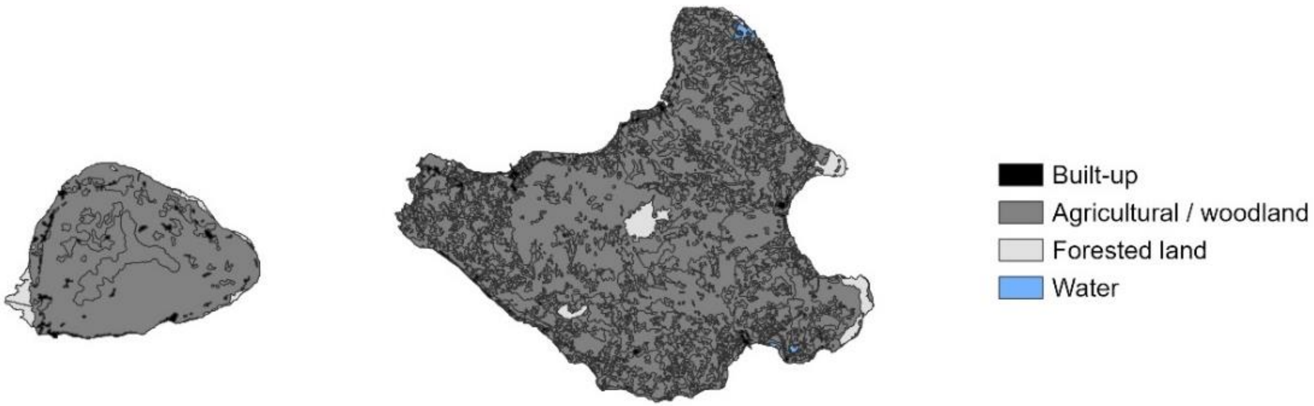
Dasymetric mapping methods

Case study areas



Case study areas





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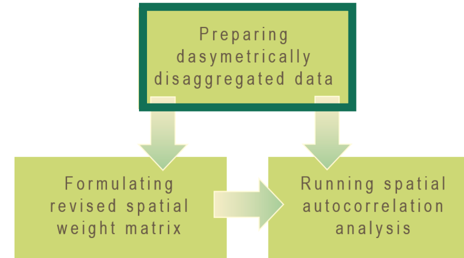
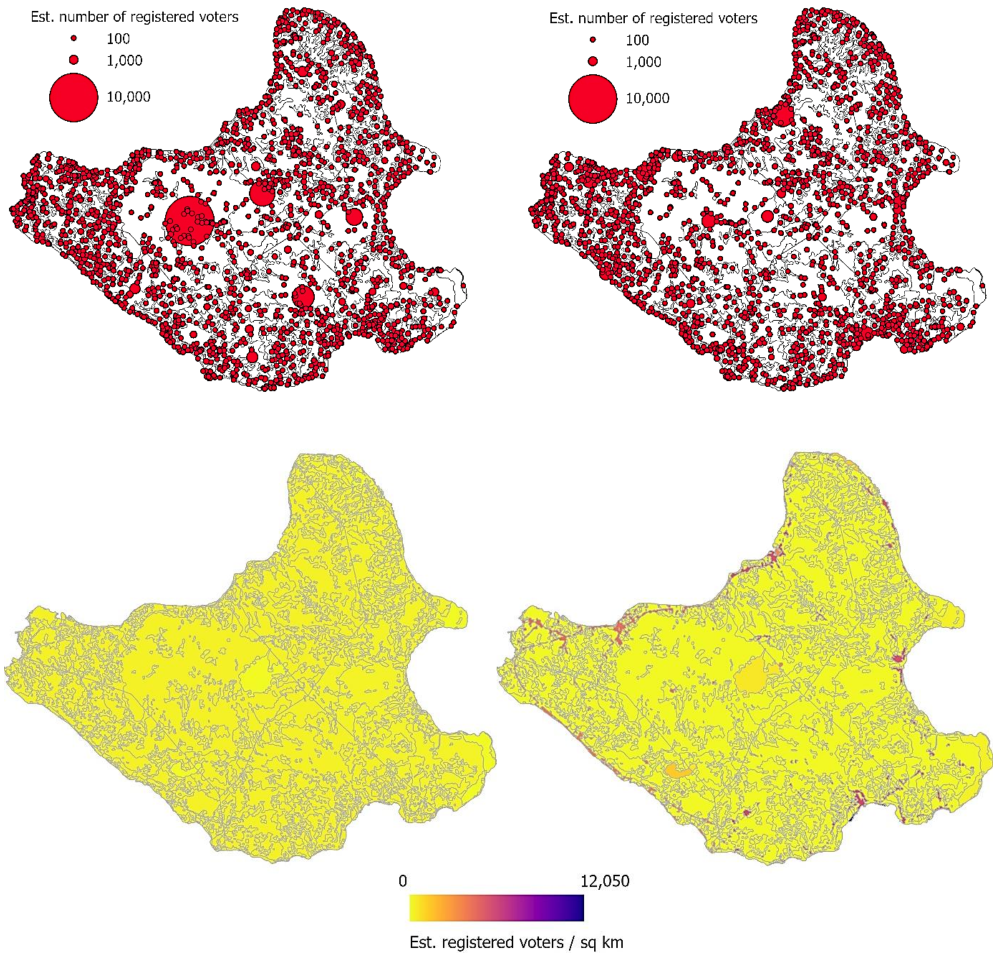
Dasymetric disaggregation

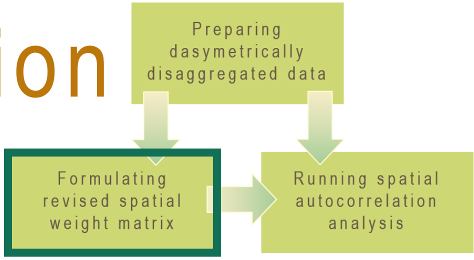


Raw counts

Densities

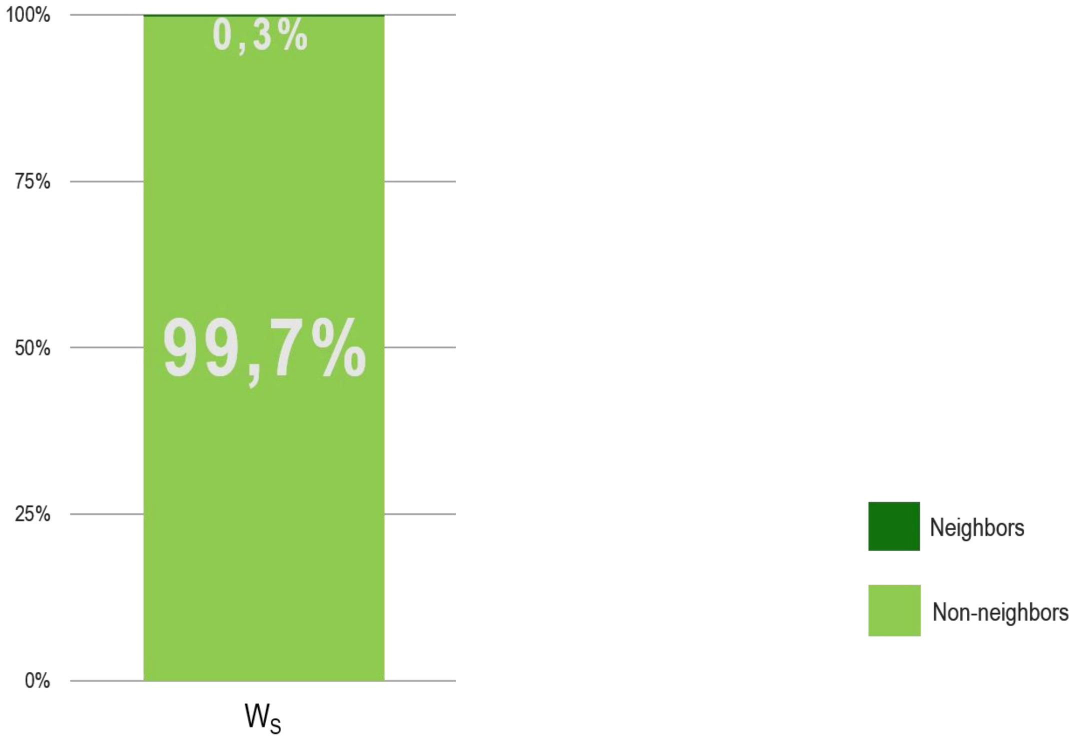


Spatial weight matrix construction

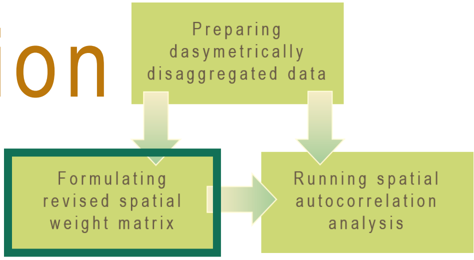


No. of dasymetric zones: 1 885

No. of matrix elements: $1\ 885^2 = 3\ 553\ 225$



Spatial weight matrix construction



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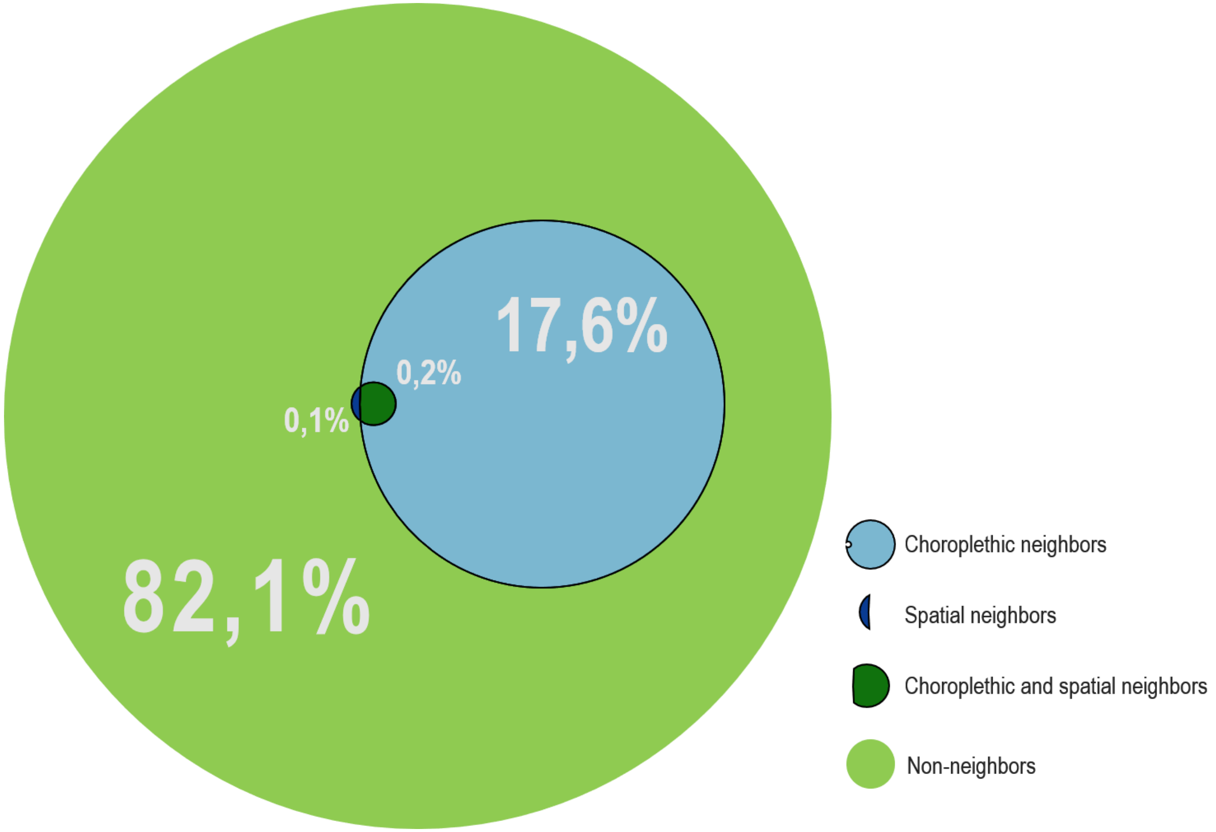
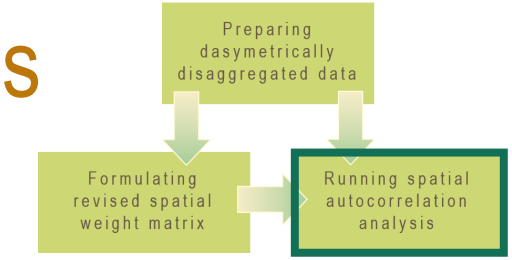
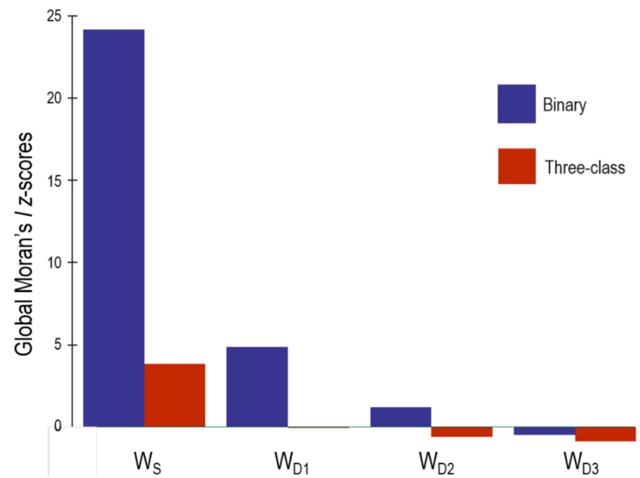


Spatial autocorrelation analysis

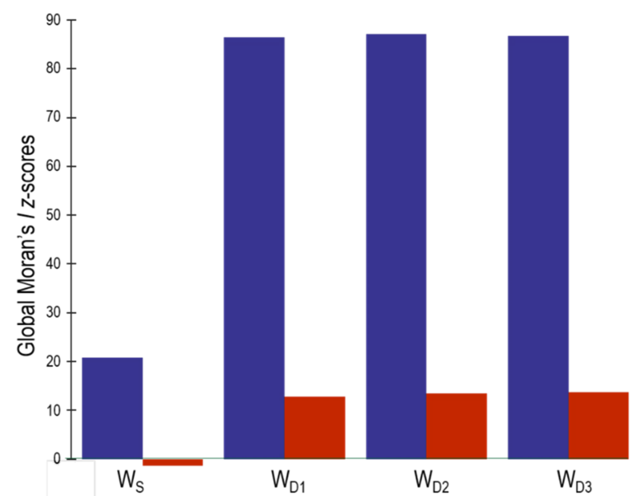


Global Moran's *I*

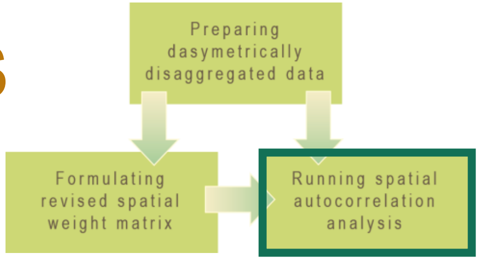
Raw counts



Densities

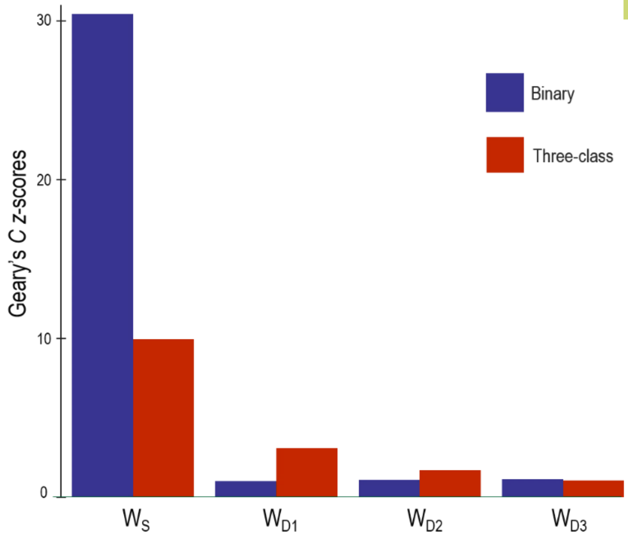


Spatial autocorrelation analysis

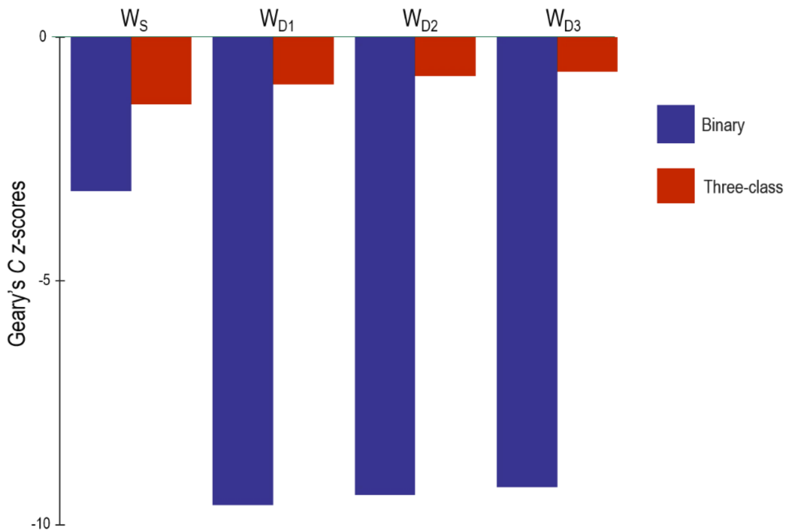


Geary's *C*

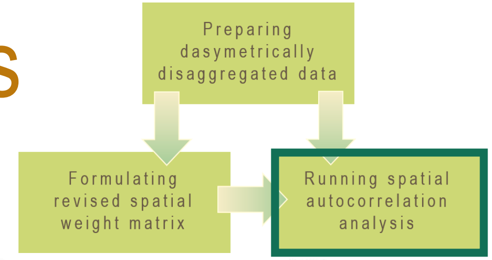
Raw counts



Densities



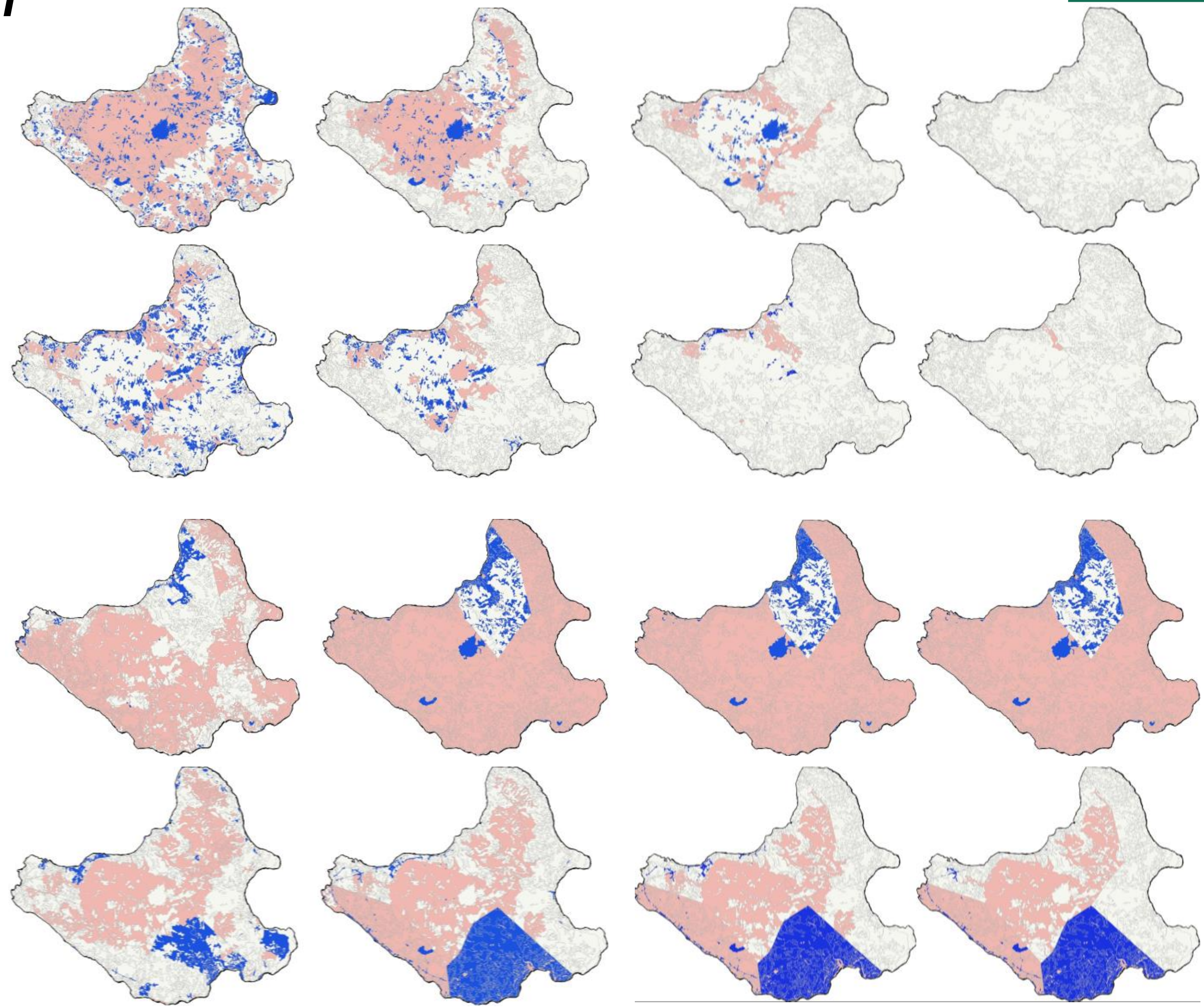
Spatial autocorrelation analysis



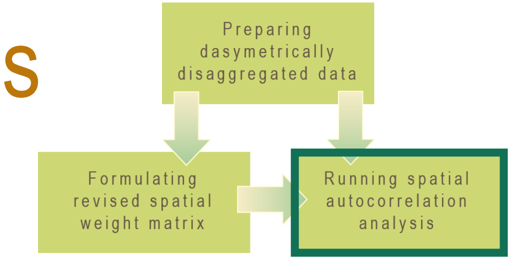
Local Moran's *I*

Raw counts

Densities



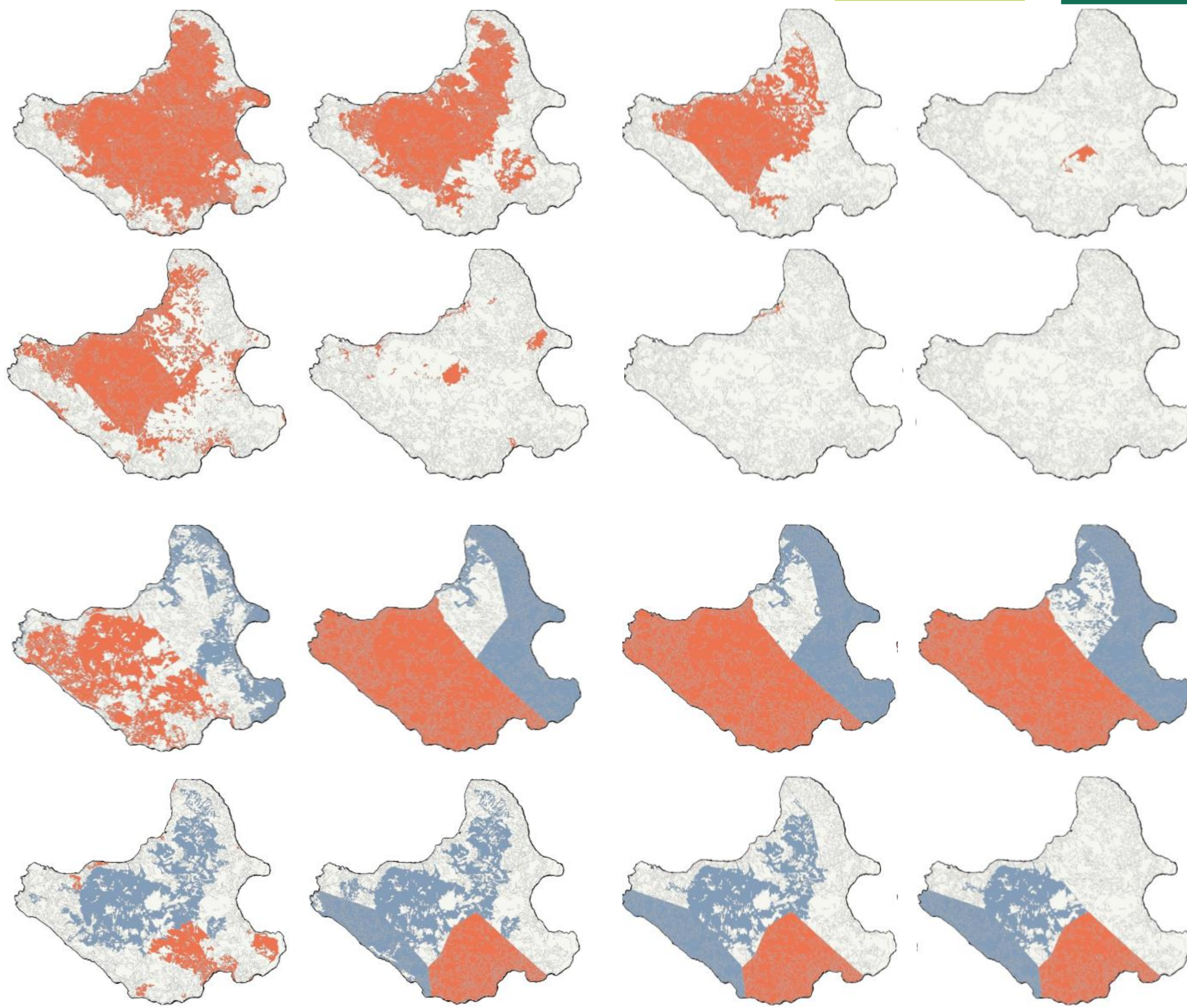
Spatial autocorrelation analysis



Getis-Ord G_i*

Raw counts

Densities



Let’s talk about...

- Introduction
  - The research problem
  - Objectives and questions
- Central concepts, related studies
- Methodology
  - Conceptual framework
  - Analysis parameters and workflow
  - Case study areas
- Results
- Discussion, conclusion

Objectives and questions

What to refine?

Which **spatial autocorrelation measures** can utilize dasymetrically disaggregated spatial data?

Which **parameter(s)** in spatial autocorrelation analysis can be modified when using dasymetrically disaggregated data?

- ***All*** global and local spatial autocorrelation measures
  - Global Moran's *I*
  - Geary's *C*
  - Local Moran's *I*
  - Getis-Ord G_i*
- The spatial weight matrix

Objectives and questions

How to refine?	What **modification(s)** in spatial autocorrelation analysis can be made when using dasymetrically disaggregated data?

- A ***priority-based*** spatial weight assignment method
  - Spatial weights are jointly based on their ***spatial and choroplethic configurations***, and;
  - Relative weighting of the two configurations

Objectives and questions

Are there differences?	How do these modifications **differ from each other** in terms of results in the spatial autocorrelation analysis?
	How do the results **differ from the original** spatial autocorrelation analysis?

- With increasing choroplethic priority, the refined method gives ***two*** effects:
  - A ***dampening effect*** – spatial autocorrelation decreases
  - An ***amplifying effect*** – spatial autocorrelation increases

- Two aspects
  - An increase in degree of neighborhood of the spatial data
  - An increase/decrease in degree of detected spatial autocorrelation

Cartography M.Sc.

Refining Spatial Autocorrelation Analysis for Dasymetrically Disaggregated Spatial Data

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