



XXVII FIG CONGRESS

11-15 SEPTEMBER 2022
Warsaw, Poland

Volunteering
for the future –
Geospatial excellence
for a better living

Alternative approaches to the perception of space in spatial analyses using GIS tools: a Polish case study

Marta Figurska, PhD

marta.figurska@uwm.edu.pl

University of Warmia and Mazury in Olsztyn, POLAND

Faculty of Geoengineering

Institute of Spatial Management and Geography

Department of Socio-Economic Geography



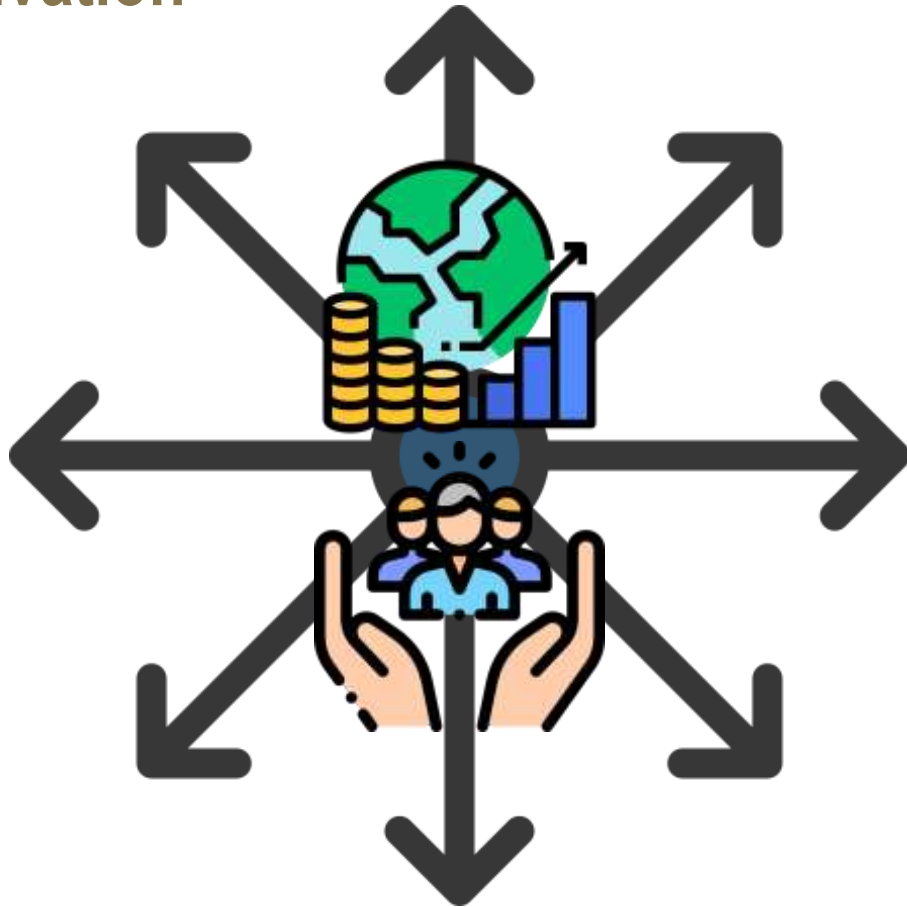
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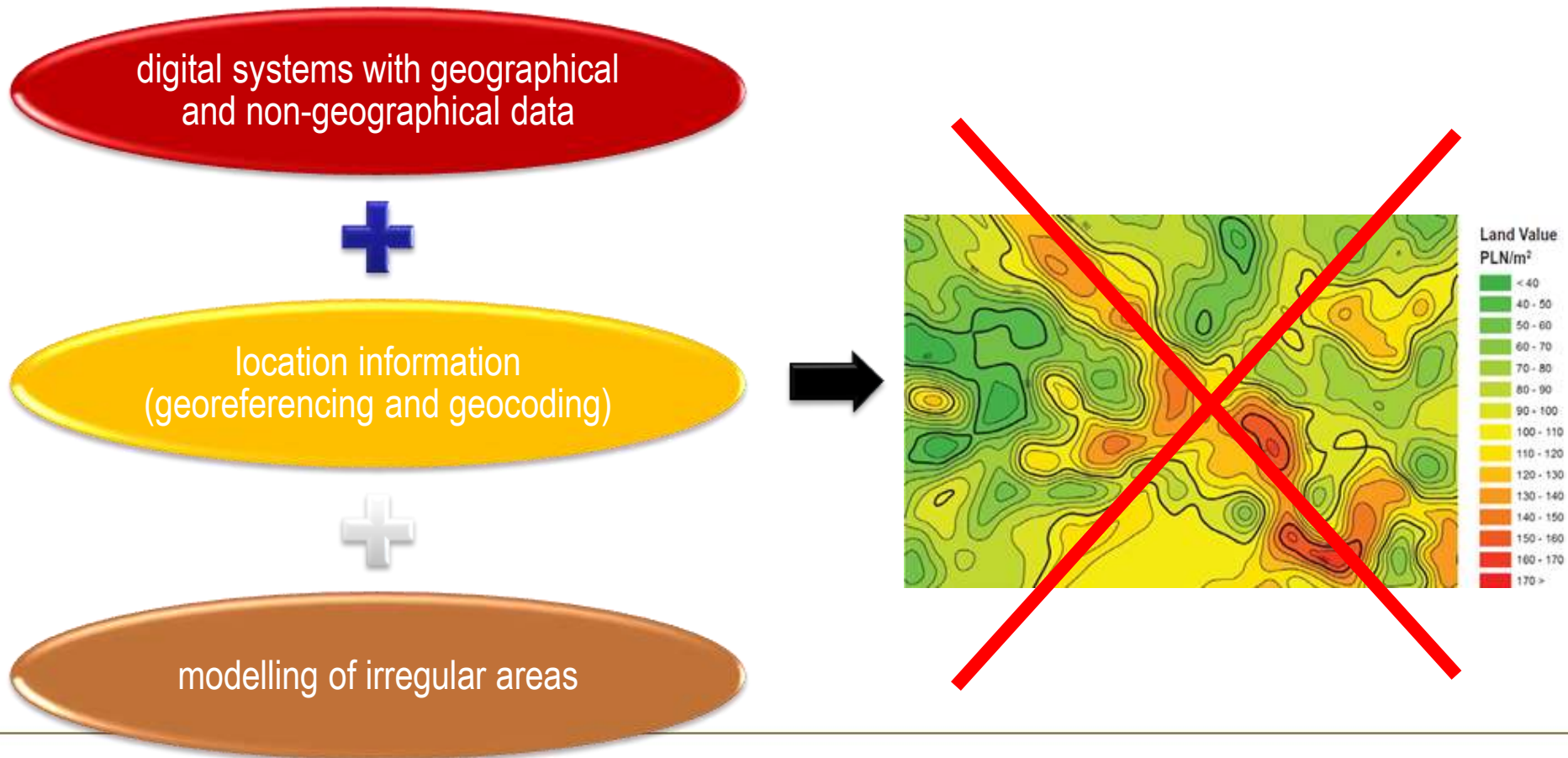


Motivation



- large spatial dispersion
- simultaneous high stratification
- irregular temporal variability

Motivation



Aim

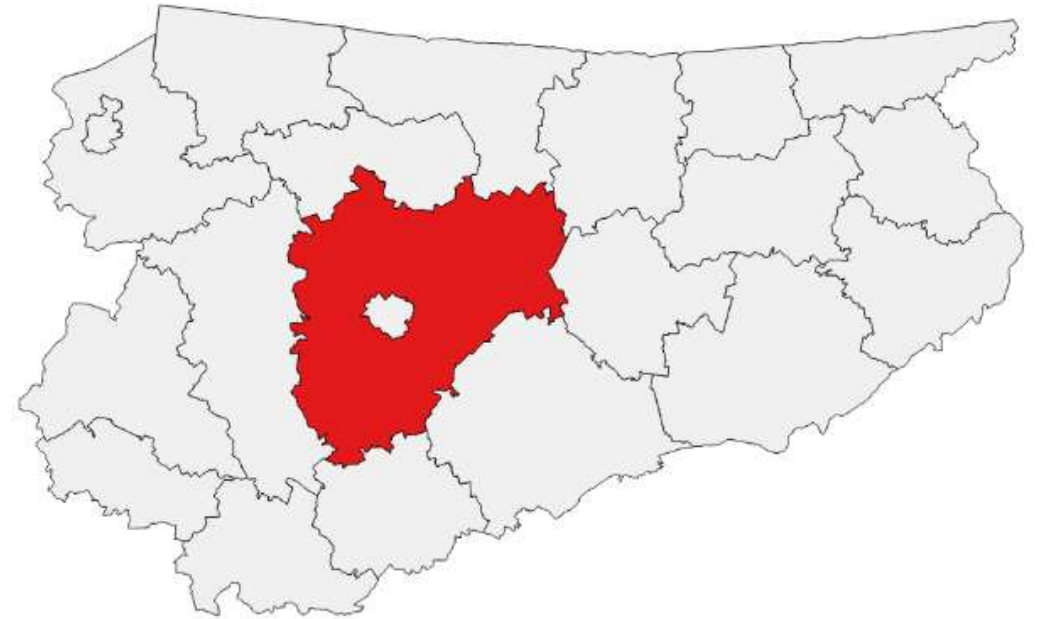
- to search among various spatial structures for proper **patterns** making it possible to define **homogeneous areas** within the examined clusters;
- to examine the utility of chosen **tessellation** methods **compared** to commonly used **interpolation** methods in geospatial analyses for land management purposes;
- to demonstrate how an application of an **irregular space partition** can enable to visualize the real world in a way similar to its factual, **heterogenic nature**, especially in the case of **dispersed data** or the lack of them, taking into account the presence of **areas of discontinuity**.

Materials



Materials

- database:
 - located in the **North-East of Poland**, in the central part of **Warmian-Masurian Voivodeship**, surrounding the area of the city of **Olsztyn**, which is the capital of the voivodeship;
 - the **largest powiat (district)** in the voivodeship (province) and one of the largest in the country (2,837 km²);
 - **forests** (41%) = part of the so-called **Green Lungs** of Poland;
 - **surface waters** (2,422 **lakes** – 5% of the area) = part of the so-called **Land of a Thousand Lakes**;



Materials

- database:
 - real estate prices from the Register of Prices and Values of the Real Estates in the **olsztyński powiat** (a local real estate market);
 - transactions of **ownership rights**;
 - **undeveloped agricultural land**;
 - **secondary** market;
 - with **natural** persons, **legal** persons, the **State** Treasury, and local **government** units as parties of the transaction;
 - between 2007 and 2017.



30.037 transactions



*.TXT → *.XLSX



18.838 transactions

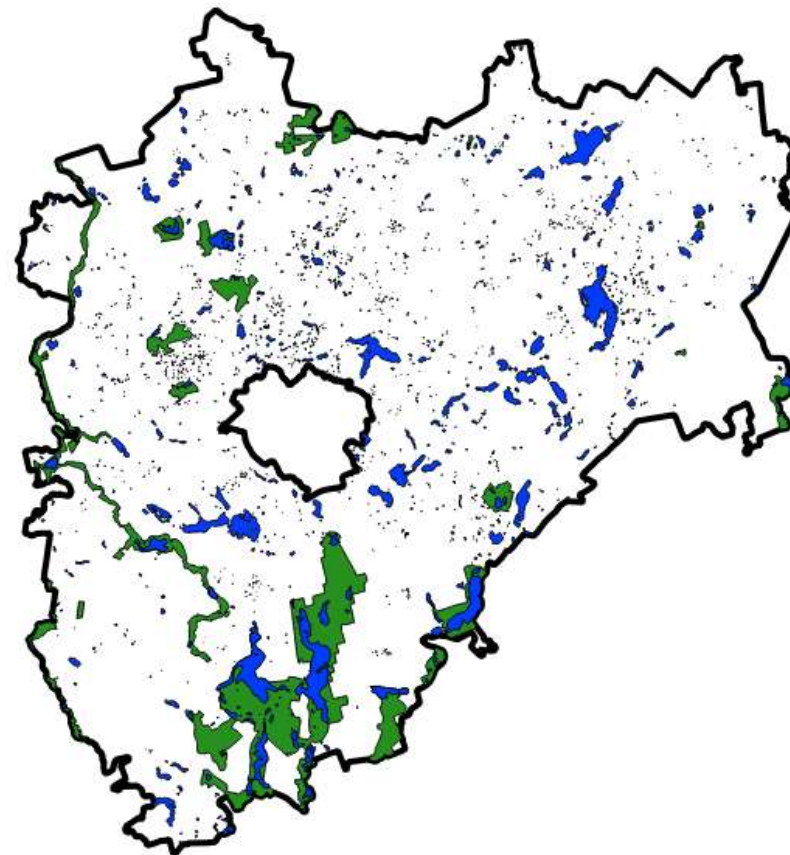
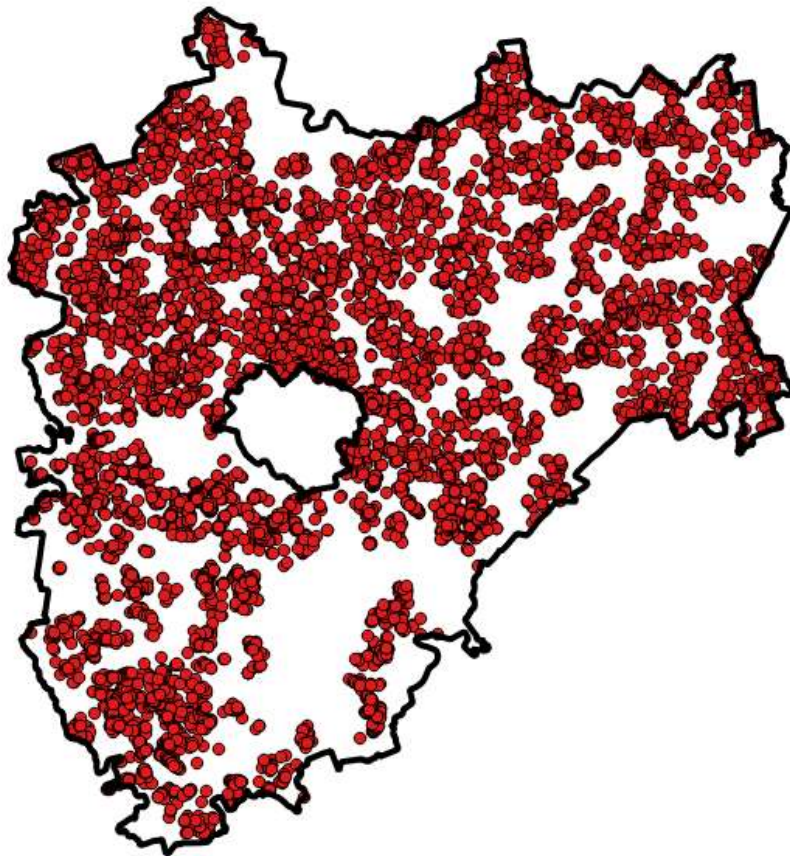


Matlab + QGIS



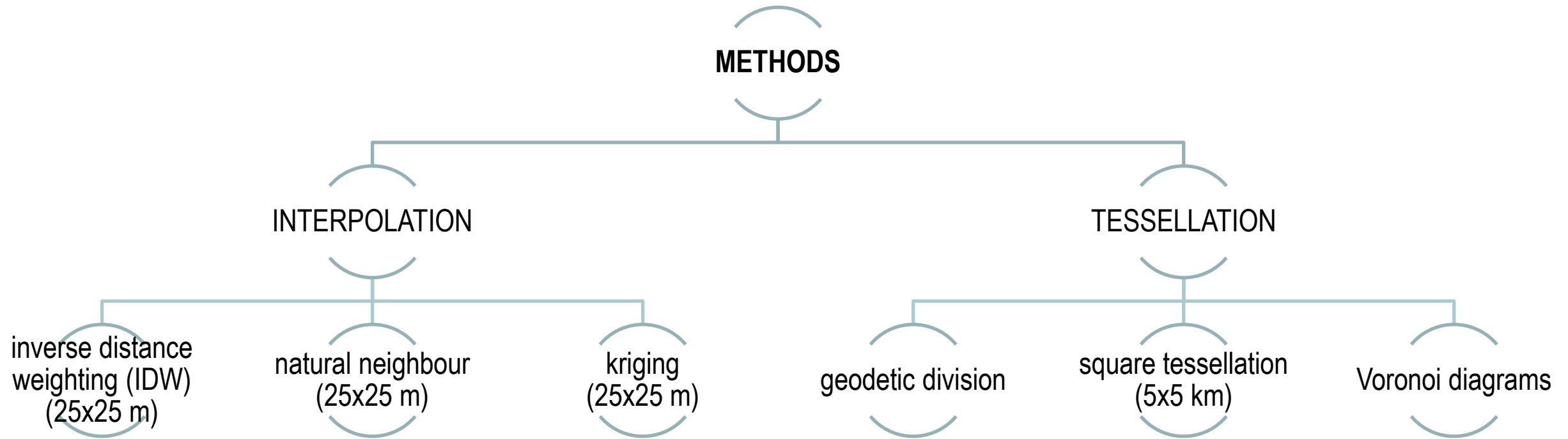
9.973 transactions
(10.849 land parcels)

Materials



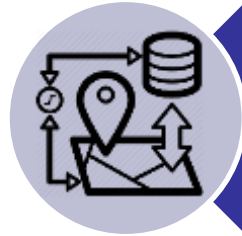
Distribution of analysed real estates (on the left)
and location of water reservoirs (blue) and green areas (green) (on the right) in the olsztyński powiat.

Methods



Methods

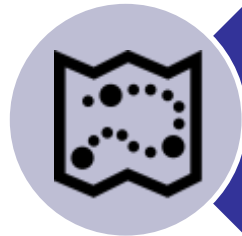
TESSELLATION



method of **spatial analyses**

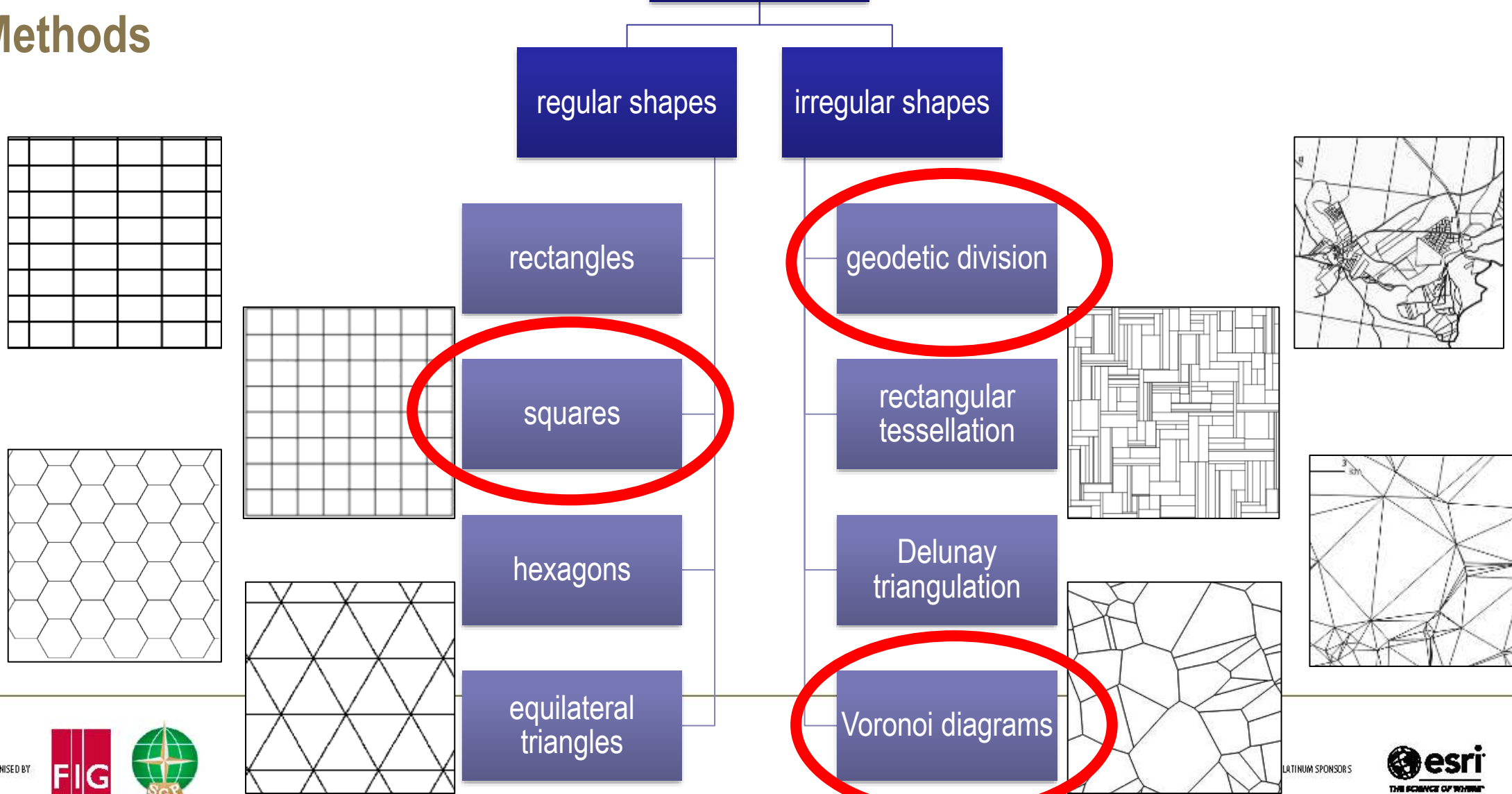


division of a selected area
or **space**



data processing using **point
integration**

Methods

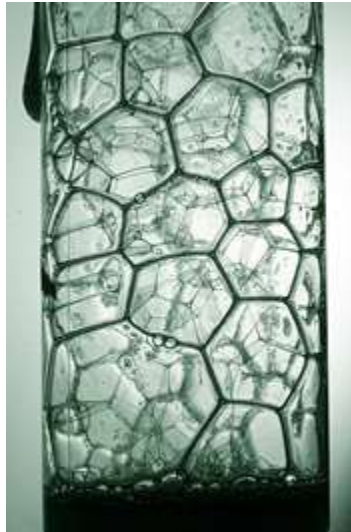


Methods

VORONOI DIAGRAMS

- based on the **nearest neighbour method** (regarding **spatial connections** of points with their **neighbourhood**)
- quantitative measures of the **homogeneity** of a **heterogeneous phenomenon** on the basis of its **local clusters**
- **avoiding** excessive **smoothing** or **generalisation** of data

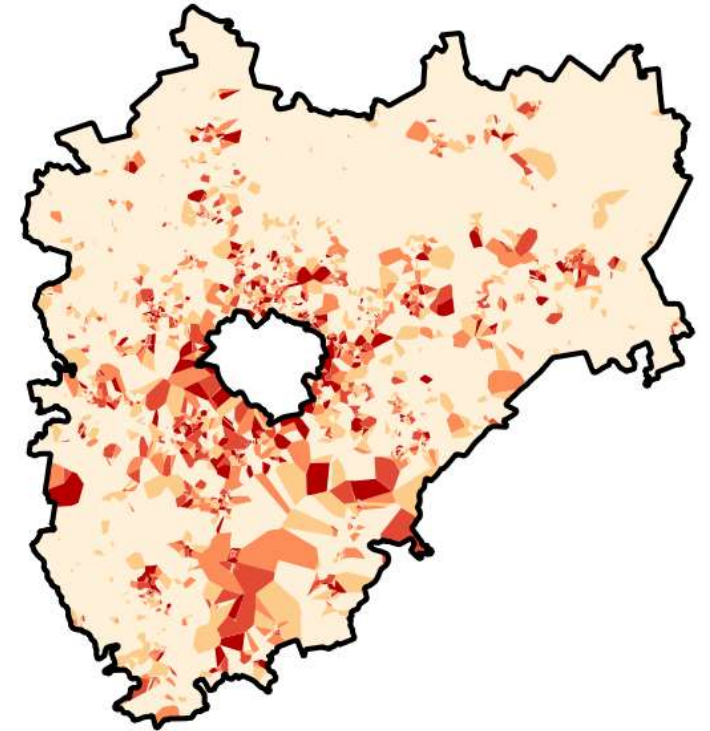
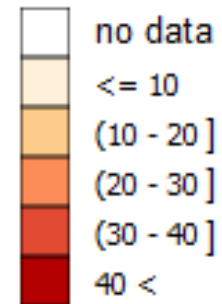
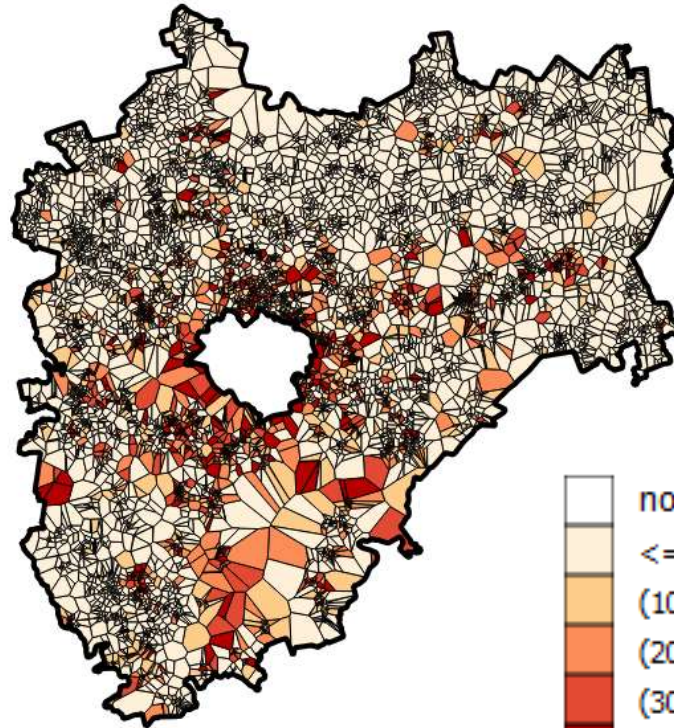
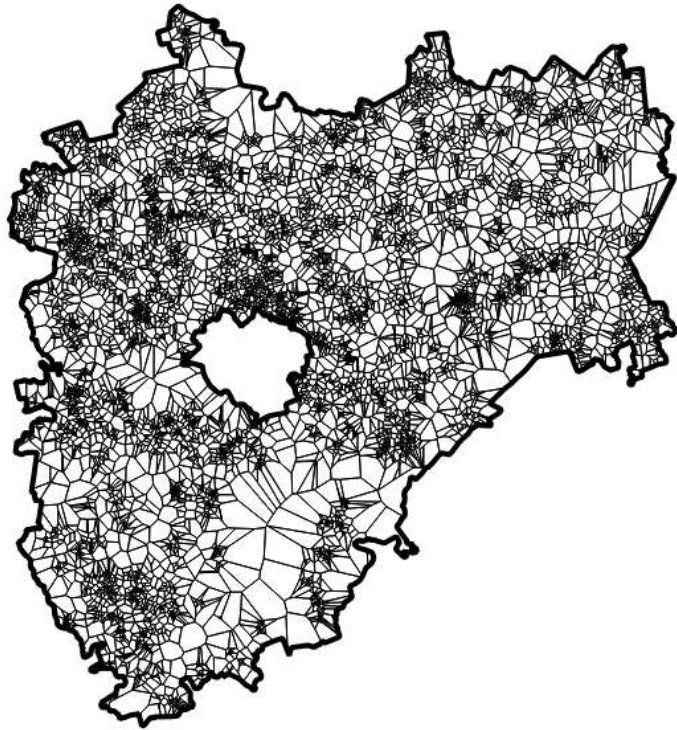
Methods



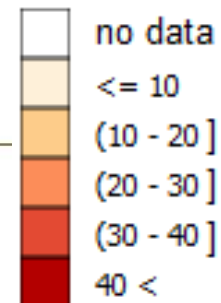
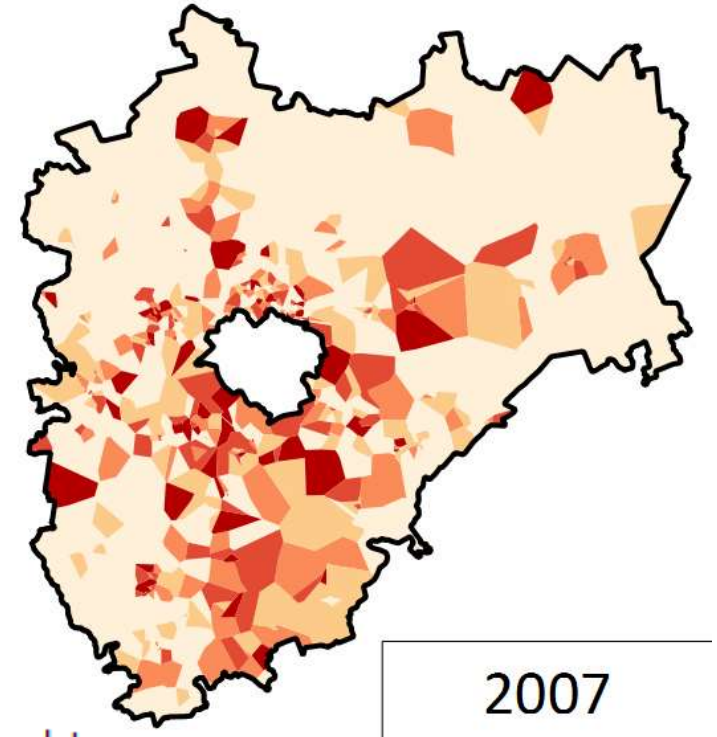
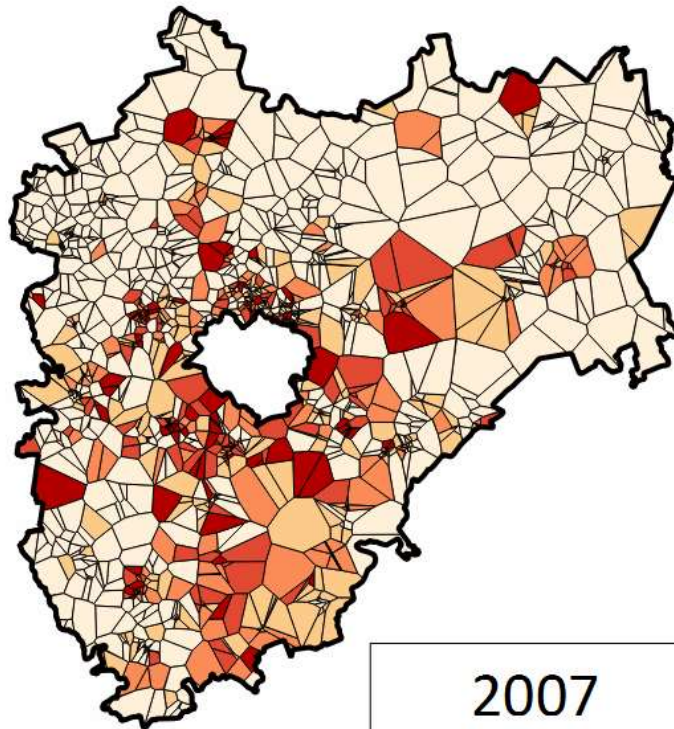
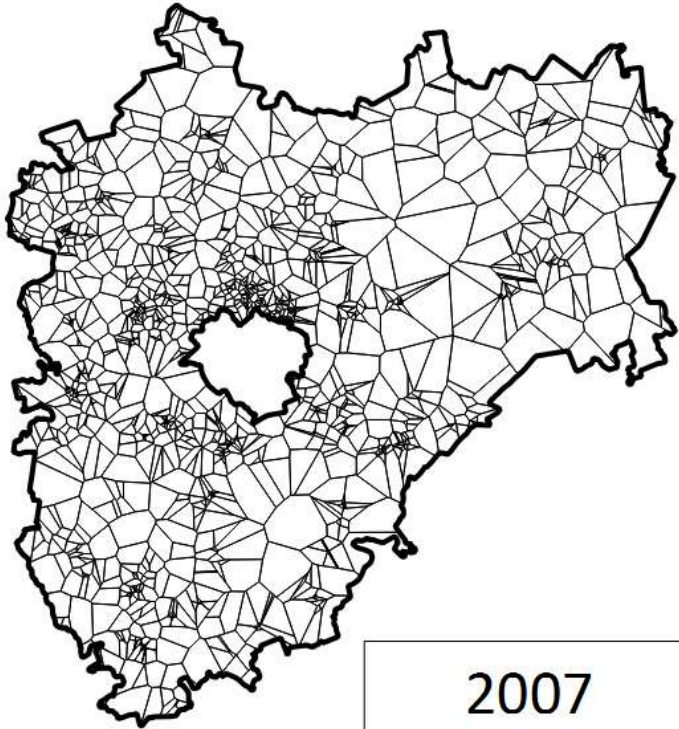
VORONOI DIAGRAMS



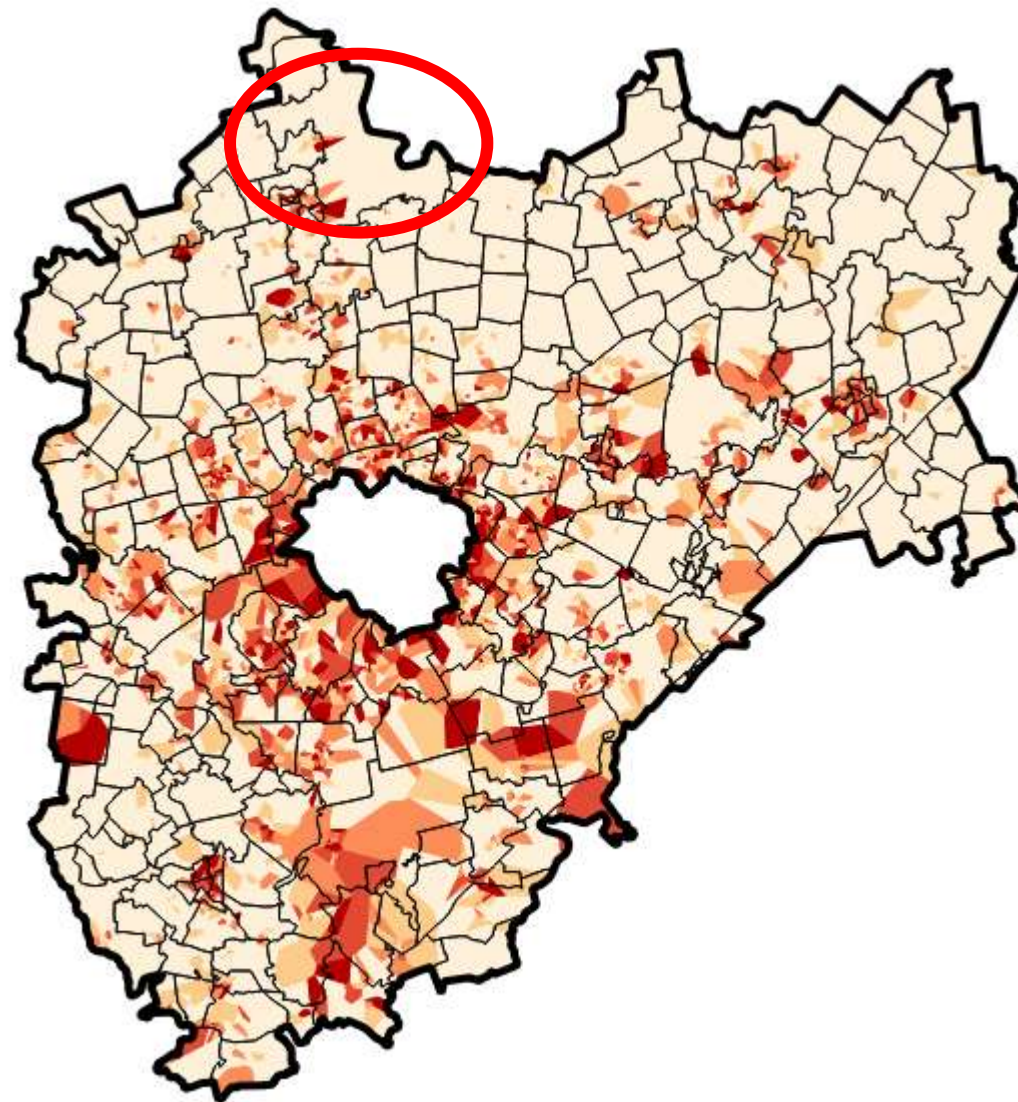
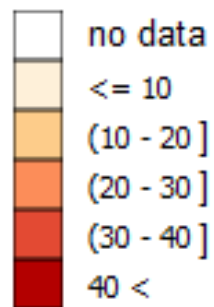
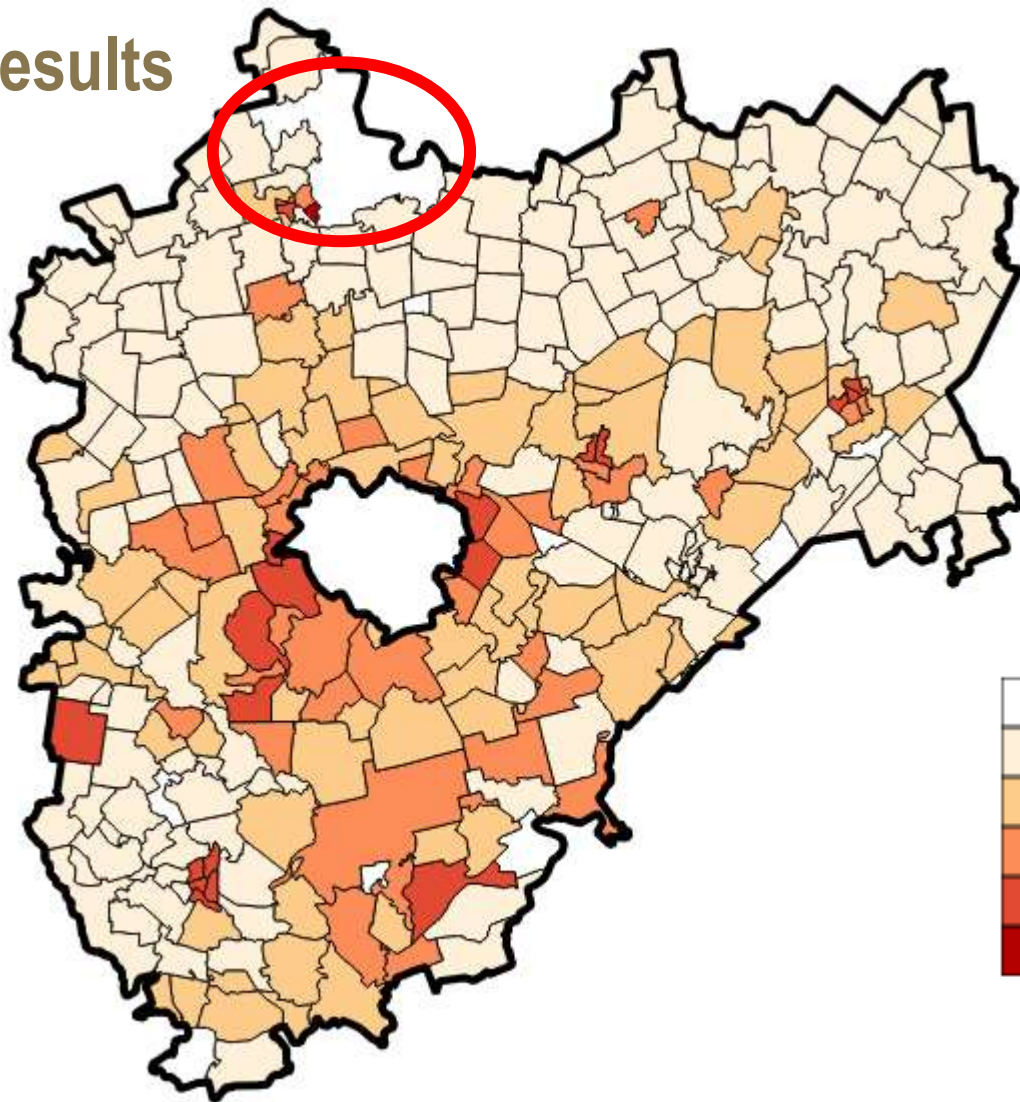
Results



Results



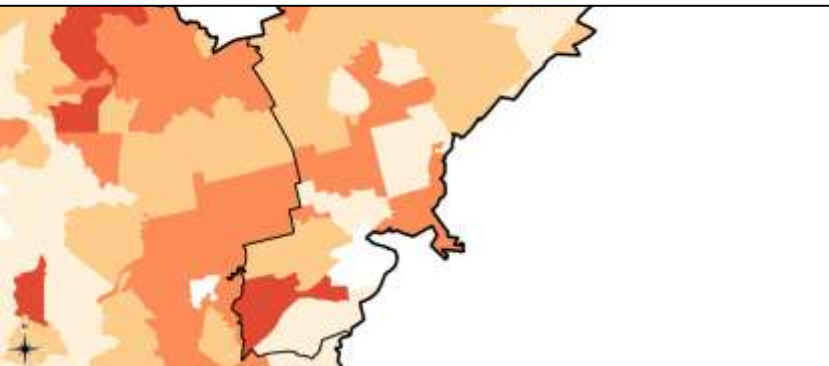
Results



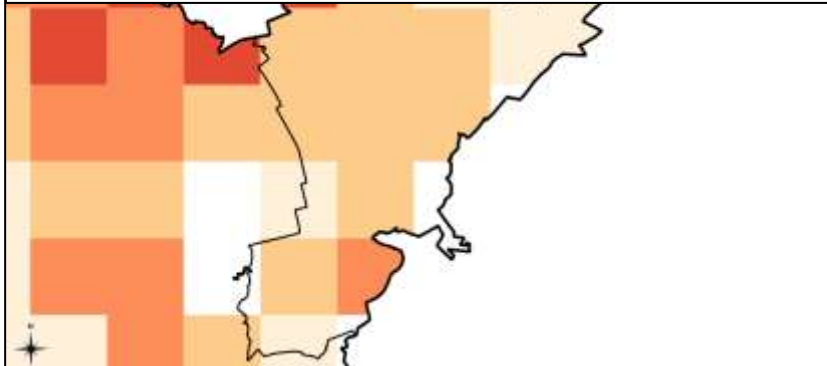
Results

Purda commune

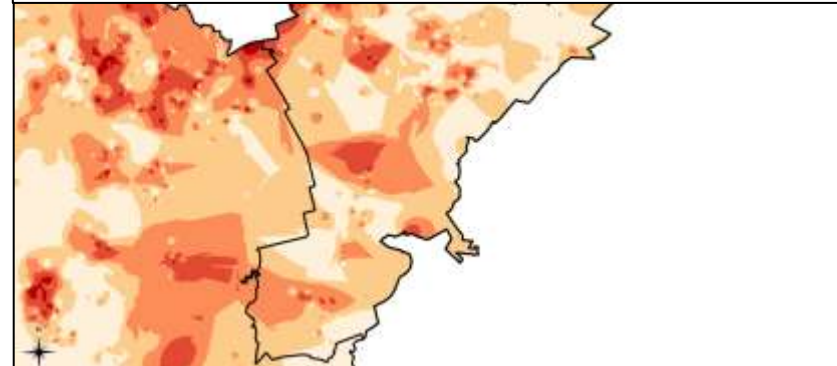
geodetic division



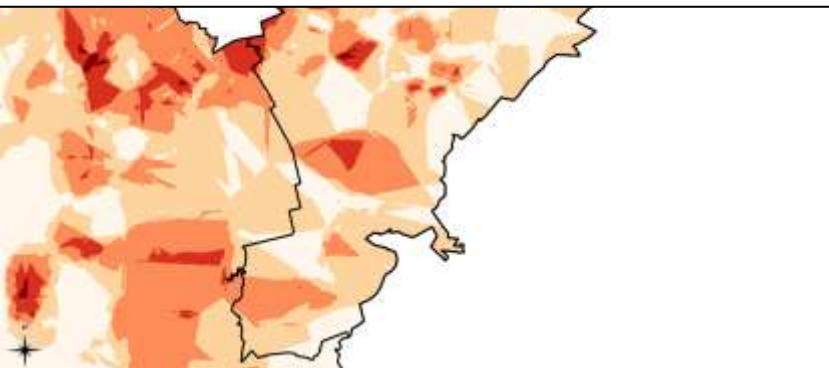
square tessellation



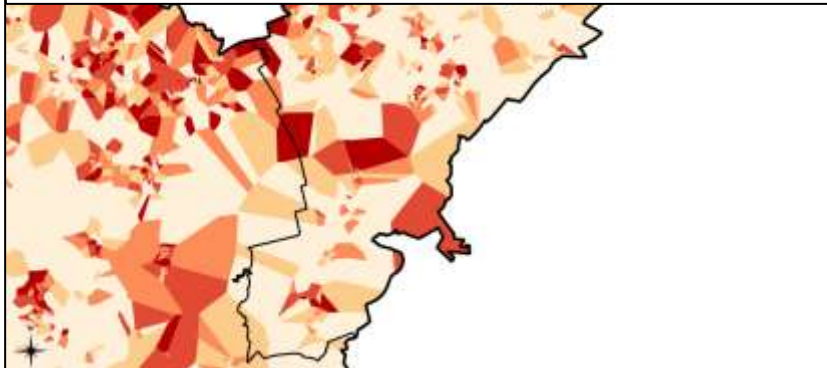
inverse distance weighting (IDW) interpolation



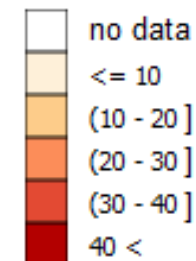
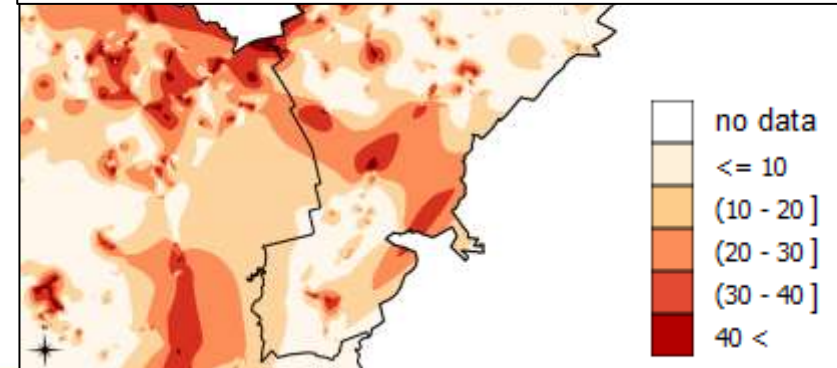
kriging



Voronoi diagrams



natural neighbour interpolation



Results

Purda commune

geodetic division



square tessellation



inverse distance weighting (IDW) interpolation



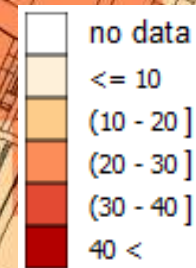
kriging



Voronoi diagrams

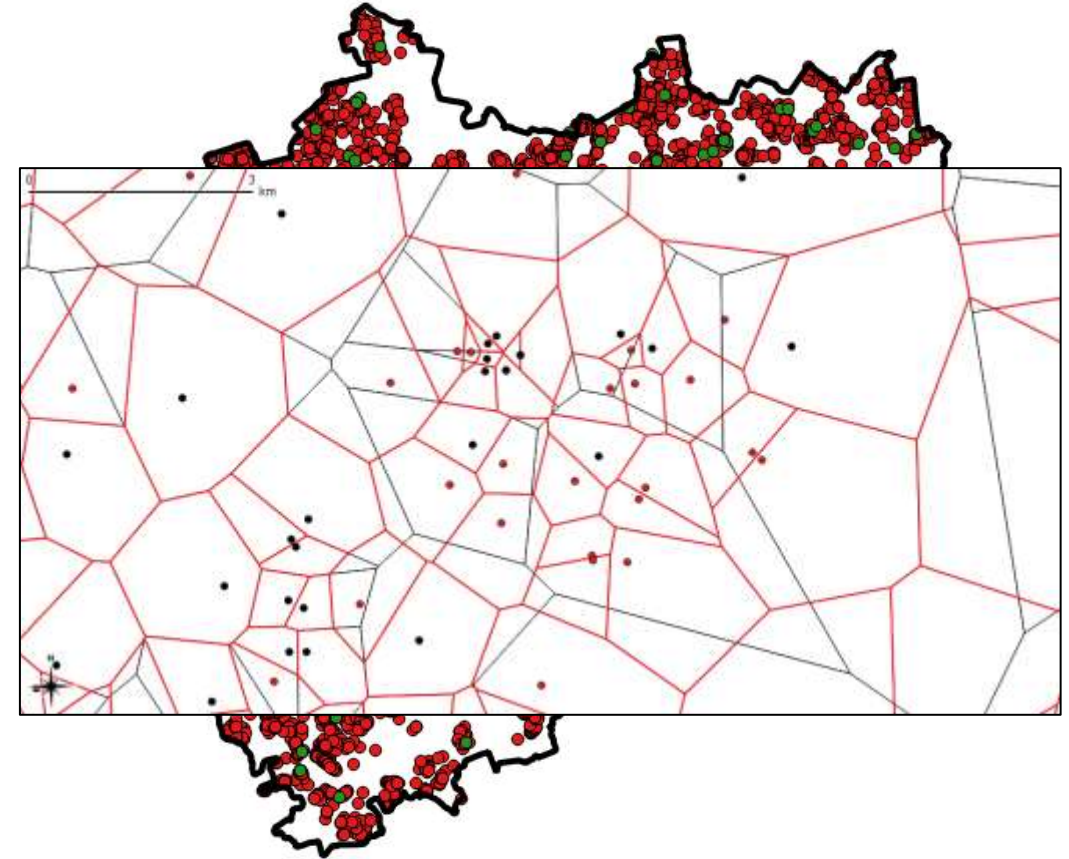


natural neighbour interpolation



Results

- **VALIDATION:**
 - a **subset** of 261 transactions concluded in the first half of 2017;
 - subset treated as **new data** with unknown prices added to the database with values determined on the basis of analysed methods;
 - comparison of the results with the **prices actually obtained** in the transactions;
 - for each comparison calculation of the arithmetic mean, root mean square (RMS) and standard deviation of the calculated prices and the relative **differences** between the interpolated and transaction prices.



Results

Method	Value	Average	RMS	Std
inverse distance weighting (IDW) interpolation	Price [PLN/m ²]	15.56	20.85	13.88
	Absolute difference [%]	84.96	212.93	195.25
kriging	Price [PLN/m ²]	12.34	13.23	4.78
	Absolute difference [%]	180.75	317.64	261.19
geodetic division	Price [PLN/m ²]	12.08	12.99	4.79
	Absolute difference [%]	203.06	354.04	290.02
square tessellation	Price [PLN/m ²]	13.18	15.60	8.34
	Absolute difference [%]	136.76	260.56	221.79
natural neighbour interpolation	Price [PLN/m ²]	15.56	20.45	13.26
	Absolute difference [%]	82.93	192.01	173.18
Voronoi diagrams	Price [PLN/m ²]	15.71	22.02	15.43
	Absolute difference [%]	92.23	242.73	224.53

geodetic division

square tessellation

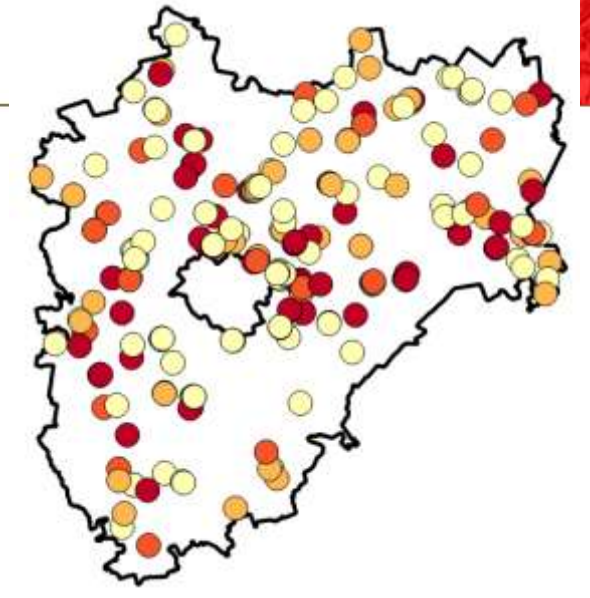
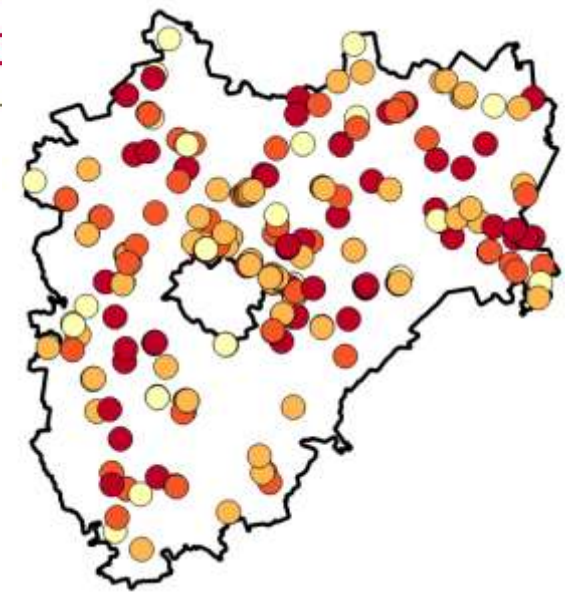
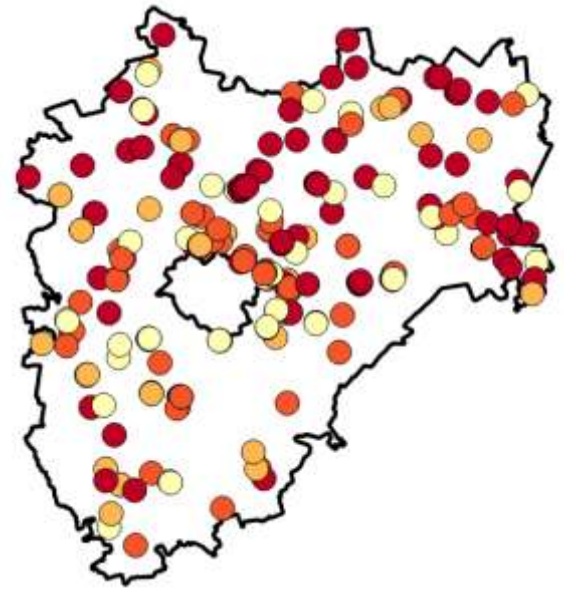
inverse distance weighting (IDW) interpolation



Res

11-15 SEP

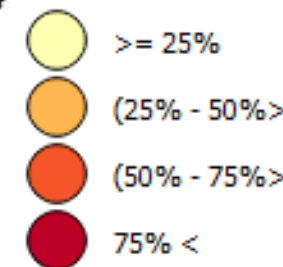
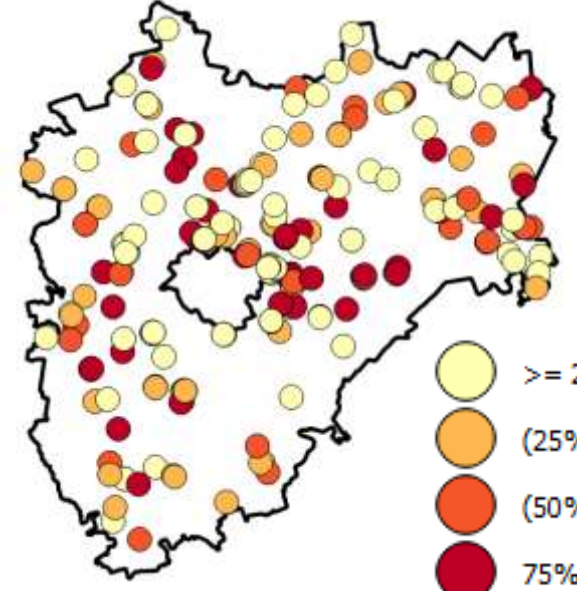
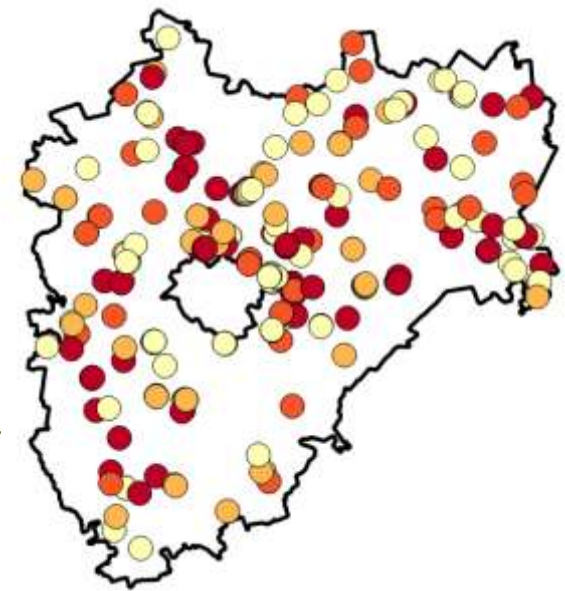
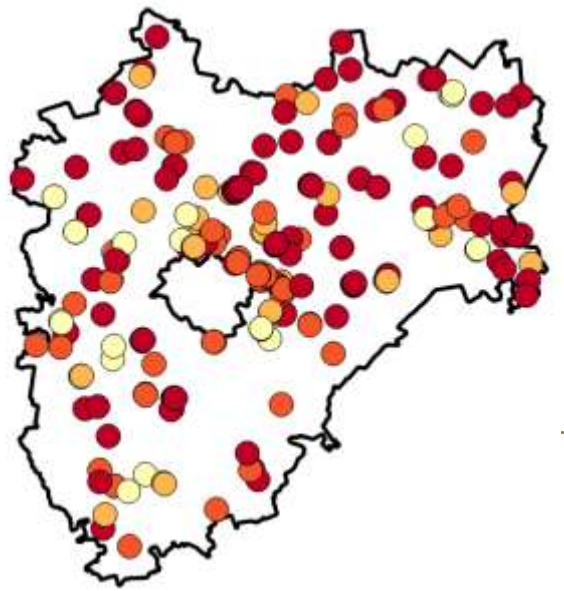
, Poland



kriging

Voronoi diagrams

natural neighbour interpolation



Results

Olsztyn city

Method	Value	Average	RMS	Std
inverse distance weighting (IDW) interpolation	Price [PLN/m ²]	4,216.42	4,306.31	875.29
	Absolute difference [%]	16.42	25.66	19.72
kriging	Price [PLN/m ²]	4,200.44	4,201.72	103.57
	Absolute difference [%]	17.28	24.52	17.39
geodetic division	Price [PLN/m ²]	4,193.70	4,198.64	203.54
	Absolute difference [%]	17.93	25.23	17.75
square tessellation	Price [PLN/m ²]	4,206.90	4,222.51	362.75
	Absolute difference [%]	15.55	22.61	16.41
natural neighbour interpolation	Price [PLN/m ²]	4,232.81	4,309.30	808.37
	Absolute difference [%]	15.84	25.45	18.55
Voronoi diagrams	Price [PLN/m ²]	4,221.56	4,321.61	924.56
	Absolute difference [%]	17.31	25.62	18.89

Conclusions

- Voronoi diagrams – advantages:
 - **flexibility** and possibility to **adapt** to any shape of the analysed space, contrary to methods based on regular shapes;
 - more realistic (**similar to human perception**) representation of the dynamics of phenomena observed in space – proper definition of **relationships** occurring **between** analysed **elements**;
 - no unnecessary filtering of the original data and basing only on the **data actually observed**, i.e. the true magnitude of the phenomenon under study instead of the predicted one;
 - not searching for a specific source geometry and **completely parameter-free**;
 - detection of **local anomalies**;
 - **MUCH SHORTER CALCULATION AND VISUALISATION TIME** compared to classical methods, **REQUIRING LESS COMPUTER PROCESSING POWER**;

Conclusions

- Voronoi diagrams – disadvantages:
 - **vulnerable** to the different **spatial distribution** structures of the analysed points;
 - some of the **polygons** created as a result of tessellation (primarily the cells located on the periphery of the diagram) are **open figures**;
 - rather **abrupt changes** of values occurring at the **borders** of particular cells;

Conclusions

- Geospatial analyses of socio-economic phenomena → instead of geodetic or regular division, an irregular subdivision → **reflection of phenomena's specificities**;
- **Lack of correlation** between the **activity** of the real estate market and the **geodetic division** in a macro (districts/poviats), meso (geodesic precincts) and micro (land lots) division;
- **Generalization** of data within geodetic division or selected interpolation methods → **deformations** and **overinterpretations** (in some cases);
- Extremely **dispersed data** or a **shortage** of them → consideration of the “**natural**” shape of chosen tessellation methods;

Conclusions

- Voronoi diagrams + cartogram → **clusters independent** from the **geodetic division** → observation of behaviour over time → **prediction of changes**;
- Voronoi diagrams → spatial distribution of phenomena → irregular distribution + **areas of discontinuity** → research of the **actual heterogeneous nature** of the phenomena → space management.
- **A UNIVERSAL METHOD OF DATA INTERPOLATION OR TESSELLATION DOES NOT EXIST AND THE OPTIMUM METHOD FOR A SPECIFIC TASK MUST ALWAYS BE SOUGHT.**



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