MODELLING OF SPATIAL STRUCTURE OF CHOSEN FORMS OF LAND COVER USING GEOMETRIC REFERENCE UNITS

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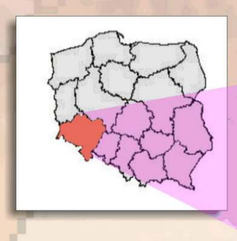
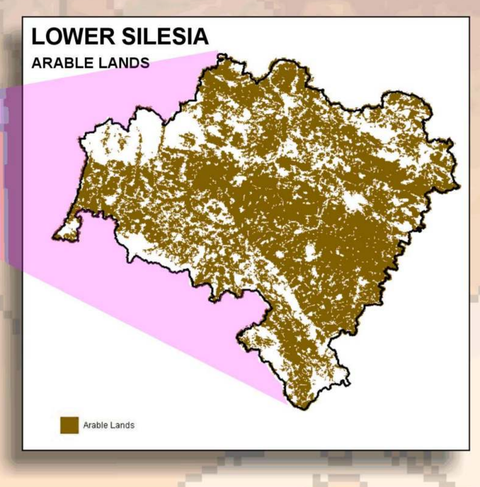
INTRODUCTION

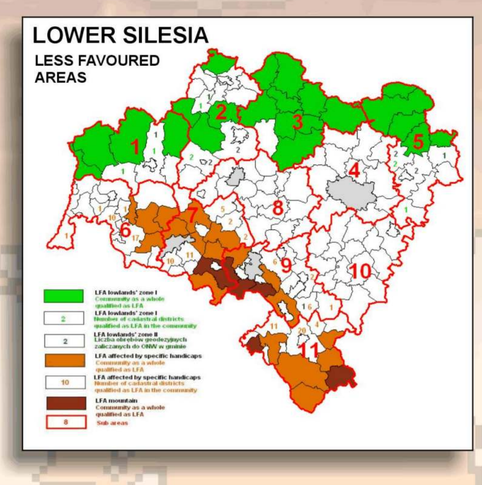
The complicated spatial nature of studied phenomena requires using various research methods. In algorithms of many of the methods it is necessary to use other than natural reference units. These can be administrative or geometric units.

What is proposed in the research, is to apply geometric (basic) units as reference units, which create a grid of units based on Temkart system. The unit's size can be accepted as observational scale since it decides about the degree of the generalization of the phenomenon and about the accuracy of the analyses. Creating subareas, with borders determined on the basis of the research's aim, is another solution. Correctly created subareas enable to indicate local indices of structures.

The research outcomes can be then presented in the form of cartographic models. It is one of the advantages of research carried out according to this method.Arable lands, which are indicated on the basis of satellite images in frame of Corine Land Cover programme and distributed by IGC in Warsaw, have been chosen for the research. The examined area is Lower Silesia.







THE INFLUENCE OF THE REFERENCE UNIT'S SIZE ON ESTIMATION OF THE PHENOMENON'S INTENSITY

In order to estimate the significance of the size of reference units in spatial analyses, there have been elaborated the cartograms presenting the density structure of the phenomenon in:

- subareas separated to estimate distribution of Less Favoured Areas
- counties
- communities
- grid of unit's size 1 km x 1 km
- grid of unit's size 0.5 km x 0.5 km
- grid of unit's size 0,25 km x 0,25 km

Grid of units have been constructed based upon the division of Poland in Temkart system (Podlacha 1986) into longitude columns and latitude bands. Additionally, modules being a combination of nine basic units have been used in the research.

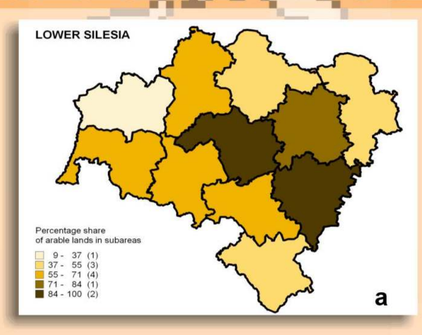


Fig. 1. Choropleth map presenting share of arable lands in sub areas (a) and communities (b).

Dazimetric map is particularly interesting since its elaboration requires applying grid of units. Selection of the unit's size should be adjusted to character and changeability of the phenomenon. In the paper, it has been adjusted to the extent of information loss. The possibilities of presentation of the research outcomes in the maps and visual assessment of spatial order of the phenomenon and its intensity have been also taken into account.

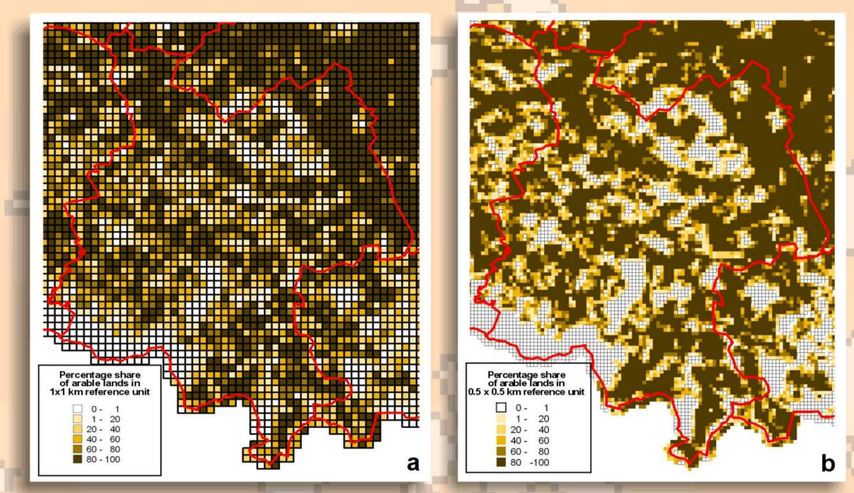


Fig. 2. Dasymetric map presenting share of arable lands in the 7th subarea for 1 x 1 km reference unit (a) and 0.5 x 0.5 km reference unit (b).

Intensity index - density (G) is the basic parameter describing spatial differentiation of the phenomenon. It characterizes "the level of phenomenon share" in reference unit and has been calculated on the basis of the following formula:

$$G = \frac{\sum_{i=1}^{n} P_i}{P_A}$$

where:
P_i - area of studied phenomenon of object *i* in reference unit
P_A - area of research (geometric units, administrative units etc)
n - number of objects

Depending on the accepted research unit, different range of index value has been obtained. The smaller reference unit, the more detailed information on the intensity phenomenon is. If the aim is the evaluation of spatial distribution of studied phenomenon on the basis of visual analysis, then the grid of units of 1km x 1km is a suitable base; then communities, counties and subareas at the very general level.

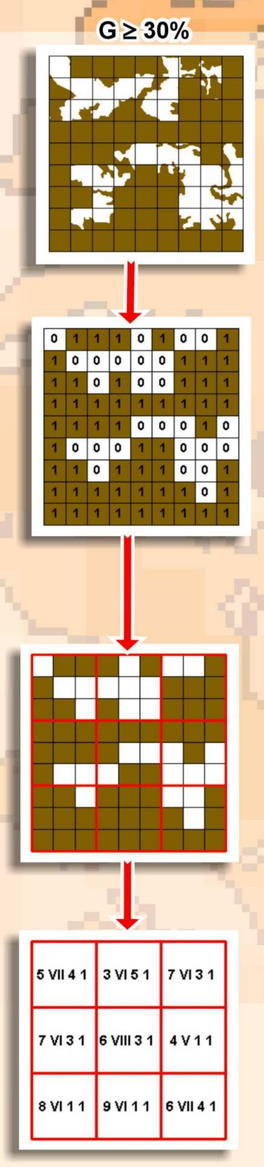
Choropleth map based on the grid of units' side: 0,5 km, 0,25 km and 0,125 km should be applied for more detailed analyses at the level of community, county or subarea.

DISCRETIZATION OF ARABLE LANDS' IMAGE

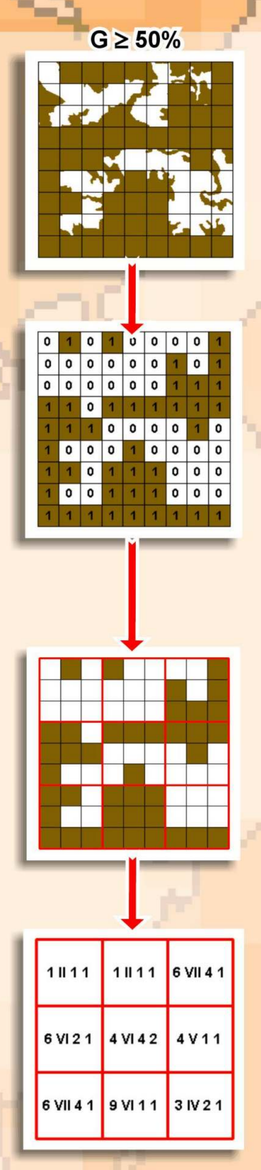
In order to carry out binary discretization of image it is essential to establish the level of qualifying the basic unit as 1 or 0. Initial analyses took into account the following levels of arable lands' shares in unit (value 1): G ≥ 30%, G ≥ 50%, G ≥ 70%.

Information loss measured by relative error in comparison to the real area of arable lands is presented in the table below.

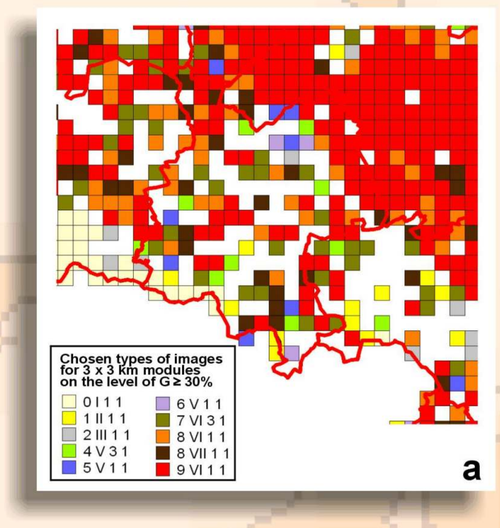
Units size	Qualification level	G ≥ 30%	G ≥ 50%	G ≥ 70%
1 km X 1 km	number of units	20 936	20 936	20 936
	number of units with attribute 1	15 177	13 349	11 096
	area of units with attribute 1 (km²)	15 164,6047	13 338,5899	11088,3705
	Real area (km²)	12 888,8619	12 888,8619	12888,8619
	relative mistake %	**17.7**	**3.5**	**-14.0**
0.5 km X 0.5 km	number of units	83 687	83 687	83 687
	number of units with attribute 1	57 736	52 266	45 864
	area of units with attribute 1 (km²)	14 422,3692	13 056,4143	11 457,3457
	Real area (km²)	12 850,6292	12 850,6292	12 850,6292
	relative mistake %	**12.2**	**1.6**	**-10.8**
0.25 km X 0.25 km	number of units	334 782	334 782	334 782
	number of units with attribute 1	219 939	206 231	192 205
	area of units with attribute 1 (km²)	13 734,9741	12 879,1979	12 003,5539
	Real area (km²)	12 850,6292	12 850,6292	12 850,6292
	relative mistake %	**6.9**	**0.2**	**-6.6**



Overlaying basic grid units on the analyzed area, and assigning value 1 to the units, in which the phenomenon occurs and value 0 to the remaining units we produce an image consisting of repeatable patterns which fill the entire plane under consideration.



The composite image is divided into simpler sub-images – modules of fixed dimensions, which are distinguished by adjusting them to the modules determined and defined *a priori*.



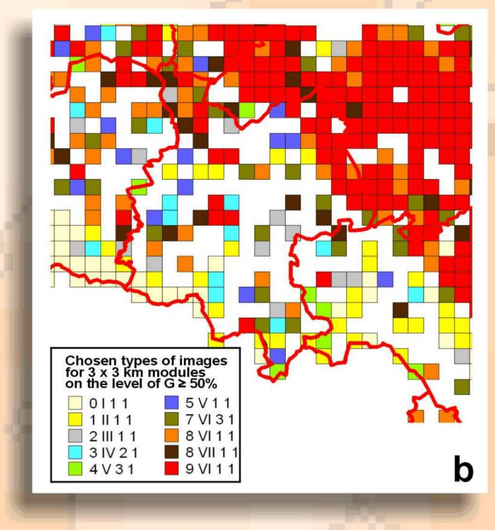
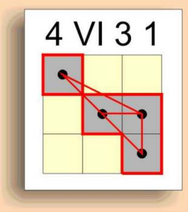


Fig.3. Distribution of the most popular types of pictures of arable lands (5th configuration) in 3 x 3 km modules for 30% (a) and 50% (b) share of phenomenon in basic unit, in the 7th subarea.

ANALYSIS OF THE PHENOMENON'S IMAGE BY COMPARING IT TO THE PATTERNS

A way of classifying and recognizing the image is adjusting it to patterns. In such a situation it is necessary to elaborate such patterns. The example of how to establish patterns, taking into account compact units with the phenomenon's occurrence, has been presented in the paper by Klimczak (2003). This paper presents new classification which also took into consideration the cohesion of units of attribute 1.

The example of pattern layout together with the description of criteria used for classifying the images is presented below:



4 LP - the number of filled units
VI O1 - periphery of filled units counted as a sum of sides
3 D - sum of distances between centorids of filled units
1 W - index of cohesion counted according to formula:

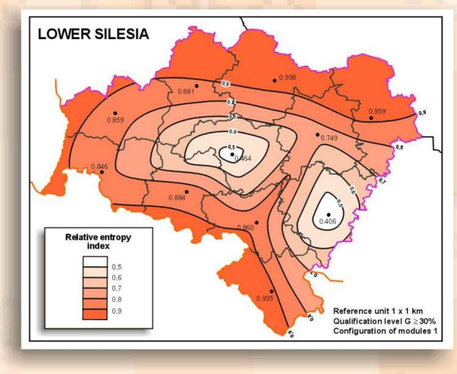
$$W = \frac{P}{O2}$$

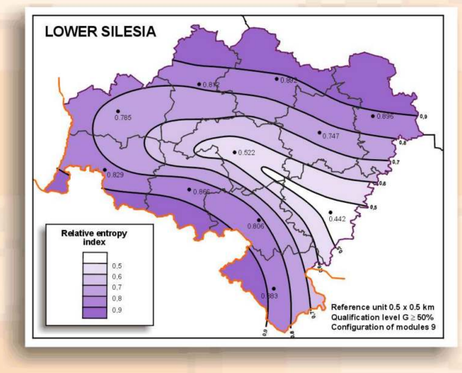
P - area of polygon created by linking centroids of filled units,
O2 - the polygon's periphery, created by linking outside centroids

THE INDEX OF RELATIVE ENTROPY

In order to indicate the parameter expressing the structure of aeral phenomena, the outcomes of the image's analysis and the base of types for 9-unit modules of 3 x 3 km and 1,5 x 1,5 km have been used. The research was carried out calculating indices of local relative entropy in 11 subareas according to following formula:

$$h = \frac{\sum_{i=1}^{k} H_i}{H_{max}}$$





where: H - entropy index in class i,
ω_i - frequency in class i,
H_{max} - maximum entropy calculated according to the formula:

$$H_{max} = \log_2 k$$

where: k - number of class

Relative entropy can range its values from 0 to 1. The value closest to 0 indicates the concentrated distribution, and the one closest to 1 maximum varied distribution in accepted density classes.

In the map, the isolines layout is more dependent on the accepted way of qualification. The layout of isolines is quite interesting. It can be concluded that in the central part of the voivodship concentrated system prevails, that is the great number of modules in one density class, which is the class of full modules. It confirms the measurement on the basis of dazimetric map of concentration of arable lands in that part of studied area.

The calculations have been made for 9 configurations of types and two levels of qualification. The outcomes are shown in table below. The modules' size for the same level of qualification is differentiated by the index which decreases its value for the smaller module of about 0.07. The level of qualifying units has little influence on the value of index for bigger modules, and for smaller ones it changes in the range of 0.05. For subareas in the central part of the voivodeship this difference is higher.

Elaborated maps of isolines of relative entropy confirm these assessments.

Module size	Share of phenomenon [%]	Configuration	Number of subarea											Voivodship
			1	2	3	4	5	6	7	8	9	10	11	
3 km	30	**1**	0,859	0,881	0,938	0,749	0,959	0,846	0,884	0,464	0,860	0,406	0,935	0,861
		5	0,861	0,877	0,934	0,754	0,960	0,852	0,868	0,456	0,860	0,373	0,954	0,868
		9	0,859	0,881	0,935	0,753	0,964	0,839	0,889	0,463	0,859	0,393	0,938	0,867
	50	**1**	0,825	0,951	0,974	0,878	0,986	0,930	0,970	0,640	0,934	0,554	0,972	0,946
		5	0,832	0,961	0,975	0,889	0,988	0,960	0,972	0,630	0,949	0,550	0,984	0,949
		9	0,807	0,944	0,974	0,881	0,983	0,940	0,975	0,613	0,962	0,567	0,978	0,945
1,5 km	30	**1**	0,778	0,808	0,877	0,734	0,915	0,825	0,868	0,521	0,811	0,454	0,877	0,811
		5	0,792	0,814	0,898	0,752	0,898	0,828	0,862	0,531	0,809	0,432	0,881	0,814
		9	0,785	0,812	0,892	0,747	0,896	0,829	0,866	0,522	0,806	0,442	0,883	0,812
	50	**1**	0,778	0,882	0,933	0,836	0,946	0,911	0,945	0,667	0,897	0,581	0,920	0,885
		5	0,778	0,890	0,944	0,852	0,943	0,909	0,942	0,659	0,899	0,566	0,924	0,887
		9	0,767	0,887	0,942	0,856	0,936	0,911	0,945	0,651	0,899	0,575	0,933	0,887

CONCLUSION

The presented method, of studying spatial distribution of phenomena referring to area, used geometric reference units in different phases of analysis. In the research, in which the voivodeship or region are the areas, it should be carefully considered whether using smaller unit is necessary. It often happens that generalization is a conscious simplification and it helps to estimate the phenomenon's structure. In a holistic view, too detailed models do not help the assessment. The decision about accepted reference unit depends on the character of studied phenomenon.In the presented research, the best reference unit is the one of 0.5 km side. It is confirmed by studies and analyses of the same indices and parameters, which are the ones indicated for the units considered arbitrarily as optimal and of sides twice as big and twice as small.

The use of geometric reference unit in the studies enables the comparison of the analyses and the evaluation of the spatial structure in many directions: one can assess the distribution of the intensity of the phenomenon, one can indicate typical images and their spatial layout, or assess what the density differentiation represents the modules in studied area.

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