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CHANGES IN GEOGRAPHICAL ENVIRONMENT WITHIN A RANGE OF INFLUENCE OF A BIG CITY. A CASE STUDY OF THE NORTH-EASTERN PART OF THE WARSAW URBAN AGGLOMERATION

The study is mainly concerned with methodological problems, It is a presentation of a qualitative method of investigating the degree of transformations in geographical environment within the range of influence of a big city.

The following three problems have been set to be solved in the study:

1. To work out a method of a complex investigation of the range of influence exerted by economic activity of natural environment.
2. To verify the method by checking how it operates in a specific situation on a give area.
3. To apply the already verified method in further research work and to analyse results obtained.

The area under investigation was the north eastern part of the Warsaw Urban Agglomeration together with adjacent areas, covering altogether 64 525 ha.

Several spatial patterns which appear on this area differ sharply in the amount of anthropopressure: from the greatly transformed central part of the district of Praga with its densely built-up area of high residential and industrial constructions, recreation grounds and transport facilities through the suburban zone with its numerous storage facilities, facilities of intensive agriculture and livestock breeding, as well as single industrial works, to small towns, lying near Warsaw, like Radzymin or Wołomin, surrounded by an "agricultural landscape".

As it appears from the above there is a wealth of types of anthropogenetic transformations in that area. Mutual interrelations between those patterns create many possibilities of links between the theoretically differentiated associations and an objectively functioning reality. Moreover, ragulaties and trends in environmental changes can be detected and links uniting them investigated.

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In the initial stage of the research work a so-called matrix of one-sided influence was constructed: it contained all anthropopressure exerted in the conditions of the Polish lowland on the natural environment. The thus obtained "model" matrix contains a maximum of forms of anthropogenetic influences which have been detected in the investigated area as well as those which have not.

In constructing the matrix 11 forms of anthropopressure were taken into consideration, which contained 141 basic elements, the "donors" of the influence exerted on natural environment. The "taker" of anthropogenetic influences, that is natural environment, was also broadly treated, as the principal five environmental subsystems contained a total of 474 elements.

The elements of the "model" matrix were approached hierarchically in order to make it possible - when necessary - to gather them in groups and sub-groups.

The matrix presenting the interaction: man-environment was constructed on the basis of ranked one-sided influences (modification of the structures), as follows:

Influencing elements (donors)	$N_2 = 141$	In-taking elements (takers)			
		$i = 1, 2, 3, \dots, N_1$			$N_1 = 474$
		1	α_{11}	α_{21}	α_{31}
		2	α_{12}	α_{22}	α_{32}
		3	α_{13}	α_{23}	α_{33}
		$ij = 0, 1, 2, 3, 4$			

Altogether, in the model matrix there were 66 834 potential fields of interactions: each of them was analysed on the basis of hitherto available knowledge and evaluated adequately. The adopted system of evaluation was relatively simple: the occurrence or nonoccurrence of influence of a given element exerting influence (donor) on a given element (taker). It was therefore a "yes or no" system, which was subsequently made more complicated by the determination of the intensity of influences.

Certain, more complicated evaluations, such as "direct or indirect," physical or chemical", short-term or long-term", etc. influences were not taken into

consideration: this was a conscious act as in the initial stage of the study of a complex character the simplest approach should be adopted.

In order to determine the intensity of influences a five-class scale was adopted, in which 0 = none or very weak, 1 = weak, 2 = medium, 3 = strong, 4 = very strong, that is such when the whole system of the functioning of the given element is maximally changed.

The starting point, a so-to-say bench mark, for assessing the degree of anthropogenetic transformations was a hypothetical environment, in no way disturbed by man. In such an environment the total value of anthropopressure would equal, of course, zero, that is the mutual interaction of the separate components would be regulated by nature's laws only.

When the above described method is used in the evaluation of the degree of transformations of separate elements of natural environment it is relatively easy to determine a very weak influence (class 0) and a maximal one (class 4). The most difficult task was to designate intermediary ranks (classes 1, 2, 3) as most unstable and subjective by their nature.

The quality of evaluation of the degree of transformations depends both on the knowledge of literature and own experiences gained during field research, on the one hand, and on the other, on views held by the person who has prepared the ranking. It should therefore be assumed beforehand that this person could not be treated as a perfect measuring instrument. In such a subjective assessment of the degree of transformations there must be a measurable error, analogous to the error contained in the instrument. With such an approach the margin of error when evaluating the influence of a single element-donor on a single element-taker is naturally quite wide. However, the more elements are simultaneously taken into consideration, the lesser becomes the error. In such a case the law of large numbers operates. Therefore, in the described study the matrix was first of all, analysed as a whole, and the influence within the separate groups of elements was investigated subsequently, after its verification.

The total absolute error committed in the designation of the evaluation of transformations β_N , approached as a whole, results from errors committed when the values of separate $\Delta \alpha_N$ were determined and, at its maximum it amounts to

$$\Delta \beta_N = \pm 25 \%$$

The value of the maximal error was calculated on the assumption that the person entrusted with the evaluation committed the maximal absolute error, that is always +1 or -1. This is, however, hardly probable, especially when N is a large number. As it is also hardly probable that the person who has been entrusted with ranking always committed the same error of overevaluating ($\Delta \alpha_N = +1$), or underevaluating ($\Delta \alpha_N = -1$), it can be accepted that

the actual error oscillates between ± 15 per cent.

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The construction of the basic matrix, representing a generalized evaluation of the influence of anthropogenetic forms on natural environment, was followed by a stage of collecting data in field research.

This part of the study was based upon a 1:25 000 topographical map of the north-eastern area of the Warsaw Urban Agglomeration, published in Warsaw in 1965. All anthropogenetic forms were plotted on the base map: namely, those which were presented on the map as well as those which were established in a period following the editing of the map sheets. It appeared that in certain area, especially in the suburban zone, the topographical and actual situation coincided in a rather broad outline only as in the meantime the geographical environment had undergone outstanding changes. The main task of the detailed field studies was therefore to register all anthropogenetic forms occurring on the investigated area in 1974. To obtain a real current picture of the area air photographs, made on the 1:30 000 scale, were used. The analysis of those photographs greatly speeded up the preparation of the much more detailed anthropization map of the environment, which became a basis for further investigation.

Material, obtained from the Office for Planning the Development of Warsaw (Biuro Planowania Rozwoju Warszawy) and from the Department of the Geography of Industry of the Polish Academy of Sciences' Institute of Geography and Spatial Organization, was used to make a list of industrial works operating on the investigated area. Moreover, data illustrating amounts of emitted pollution, its types and sources were also collected.

Territorial mapping and the analysis of air photographs made it possible to construct the current map of the investigated area and to use it as a basis for the evaluation of the degree of the degradation of the natural environment under the influence of anthropogenetic factors. In the next stage the general matrix was verified in the following way:

- a) The scale of evaluation was adapted to the situation occurring in the north-eastern part of the Warsaw Urban Agglomeration: certain influences, potentially relevant and highly evaluated in the general matrix, appeared to be, when analysed in a given actual case, not so strong a typical example is the influence of gases, which though emitted on the investigated area, were really harmful elsewhere, namely in the south eastern part of the Warsaw Urban Agglomeration.
- b) Those elements and influences which were not detected in field research were eliminated and thus the number of "donors" fell down from 141 to 80, and of the number of potential influences decreased from 66 834 units to 18 400 units, that is almost 3,5 times.

The verification of the elements of the matrix and of the scale of evaluation was followed by the determination of the degree of influence on every element of the natural environment for 80 anthropogenetic characteristics. The elements of the environment were previously grouped in 5 principal sections, namely: the atmosphere - 35 elements, the lithosphere - 31 elements, the hydrosphere - 79 elements, the pedosphere - 53 elements, the biosphere - 32 elements.

The grouping made it possible to calculate the average range of transformations both for the environment as a whole, as well as for the separate groups, i.e. the percentages of the elements transformed by a given form of anthropopressure in relations to all 230 elements forming the natural environment.

On this basis it was possible to establish the range of influence of the given elements of anthropopressure on the environment and to arrange all the elements according to those values. However, in this arrangement the intensity of influence was not accounted for, as the sum total of the values was not taken into consideration. The determination of this value of the interrelation "man - environment" became the subject of further studies.

As stated above, each of the 80 forms of anthropopressure exerted an influence on each of the 230 elements of the natural environment, grouped according to the five-degree scale. The arithmetic means were calculated for 80 types of anthropopressure on the basis of the sum total of their values. The values of the mean totals of the values for the separate form of anthropopressure in relation to the total set and to the atmosphere, lithosphere, hydrosphere, pedosphere and biosphere, were thus obtained.

The intensity of anthropogenetic influence is therefore an arithmetic mean of the total sum of the values of the separate forms of anthropogenetic influence, calculated for the active elements (1-4) within every one of the 5 subsystems of the natural environment.

The percentage of the total of maximally possible values was adopted as the third index determining the degree of transformations of the environment, on the basis of the assumption that the anthropogenetic feature transforms all the elements of the environment, that is class 4. The obtained value demarcates the boundary of the theoretical complete destruction of the natural environment.

The result of the analysis of the matrix was compared with the theoretical value, accepted as 100 %: the percentage of the deformation of the natural en-

vironment was calculated and the index of the degree of transformations, i.e. of actual changes which had occurred in the natural environment in relation to the sum total of maximal possible values, was obtained.

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On the basis of investigations carried out the character of the influence exerted by the separate anthropogenetic elements on the natural environment was determined. The following three aspects were taken into consideration: 1) the range of influence, 2) the intensity of influence, and 3) the degree of transformations.

Further research work was mainly based on the index of the degree of anthropogenetic transformations, as this measure seemed to be more adequate in this respect than the remaining two. The average values, tabulated globally for the separate sub-systems of the natural environment of the investigated area, are as follows: 1) the biosphere 59.0, 2) the pedosphere 41.0, 3) the lithosphere 21.0, 4) the hydrosphere 19.2, 5) the atmosphere 15.5. This would have been a trivial effect, not worth while investigating, if the analysis had been concerned only with discovering which of the sub-systems was most strongly affected by anthropopressure.

However, it was not the global relationships between the transformations of the separate "spheres" which was the most essential factor but their internal variations in relation to the character of the donors of influence. It was calculated that, against the generally accepted views, the strongest influence was not always exerted by the same elements, and that the significance of the various forms of anthropopressure was different in various sub-systems of the natural environment. An analysis of the size of the indices of the degree of transformations occurring within those systems makes it possible to discover the most essential threats and therefore can supply guiding principles for a rational spatial development as far as the protection of the values of a given group of elements of the natural environment is concerned.

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Following the determination of the indices of the degree of transformations for every element represented in the legend of the map an attempt was made to generalize cartographically the obtained values. The 1:25 000 base map was therefore divided into squares, the dimensions of which were 2 x 2 cm (i. e. 500 x 500m), the data for those squares were integrated and properly interpreted mathematically.

Intergration was based on the indices of the degree of anthropogenetic transformations, calculated for the separate types of influence, which occur in every square. The following formula was used:

$$H_k = \sum_{i=1}^k \xi_i^k F_i^k$$

where: H_k is a spatially averaged index of anthropopressure in a given square,

ξ_i^k = the area with the k-th square, occupied by a given element of anthropopressure,

F_i^k = the percentage of the degree of transformations.

This formula served as a basis for the calculation of spatial transformation of the investigated area.

The generalized picture of the effects of the various forms of anthropopressure was presented in the form of a cartogram in which the global value of the indices of transformations within the separate squares was expressed by means of 10 types of hachures. Within the investigated area this value oscillated between 0,1 and 59,6 % for the separate squares.

The squares with similar value were gathered in the following 4 principal groups:

- 1) An almost natural landscape. This group contains the squares with the values of the indices oscillating between 0,1 and 10,0 %. There are mainly forest areas with a small percentage of other forms of land use (roads, dispersed buildingd, etc.).
- 2) Agricultural landscape. This group combines the squares with the indices of transformations oscillating between 10 and 30 %. The following territories were differentiated within this group: areas with the dominance of extensively utilized arable land and grassland with the dominance of rural construction as well as settlements composed detached houses in the suburban zones surrounded by arrable land, forests or grassland, and also agricultural land consisting of arable land utilized intensively or extensively, but with intensive livestock breeding of hot houses.
- 3) Suburban landscape. As far as the global values of the indices of the degree of transformations are concerned, this zone is the same as the previous one, i.e. that of agricultural landscape. It differs, however, in the character of its spatial organization. the indices of anthropopressure oscillate between 10 and 30 %. Spatial forms of settlement construction are various: loose groups of detached houses, predominantly with small gardens, often with a hot house:

loose groups of high buildings of the suburban type, surrounded however by natural forests. Moreover, objects with special functions, which could not be localized in the residential area, are also represented in this group.

4) Urban landscape. This group contains areas with the highest indices of changes falling within the interval from 30-60%. Two subgroups can be differentiated within this group: I - an urban zone (indices from 30 to 40 %) in which fragments of loose groups of modern buildings with a small percentage of compact construction are dominant: II - an urban zone covering the areas with anthropopressure indices exceeding 40 %. These are central parts of the town, with compact construction and buildings over 4 storeys high. This type includes the fragments which were built several decades ago and are never seen in modern town districts. Industrial works, built in the peripheral zone in the post war period, are characterized by a strong concentration of the various types of anthropopressure: indices referring to them also exceed 40 %.

The results obtained during the study, carried out by means of the described method, have been graphically expressed in the form of enclosed diagrams and cartograms. They justify the conclusion that the approach adopted in the study proved to be quite useful both in the cognitive as well as practical sense.

A handicap of this method is that it provides a static picture. The dynamic picture of changes taking place in the natural environment following the increasing anthropopressure can be obtained by way of periodical repetitions of the study. As the method of approach has already been established, the consecutive periodical studies will not take too much time.

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SPREMENBE GEOGRAFSKEGA OKOLJA POD VPLIVOM VELIKEGA MESTA NA PRIMERU SEVEROVZHODNEGA DELA VARŠAVSKE MESTNE AGLOMERACIJE

Posamezni deli območja, ki obsega 64 525 ha, se močno razlikujejo med seboj po različni stopnji preoblikovanja pokrajine: od močno preoblikovanega srednjega dela okrožja Praga, do majhnih mest v bližini Varšave. Prvo območje je gosto zazidano z velikimi stanovanjskimi in industrijskimi objekti, ima obvezne rekreacijske površine, dobro razvito prometno omrežje, skladiščne cone, intenzivno poljedelstvo in živinorejo itd. Za drugi skrajni tip pokrajine je značilno, da so mala mesta neposredno obdana z agrarno pokrajino.

V začetnem delu raziskave je bila izdelana matrika t.im. enostranskih vplivov; vsebuje vse načine človekovega posega v naravno okolje, ki nastopajo v nižinah Poljske. Taka "modelna" matrika vsebuje največje možno število oblik človekovih vplivov, takih ki so bili ugotovljeni na obravnavanem območju, pa tudi takih, ki tu ne nastopajo.

Pri oblikovanju matrike je bilo upoštevanih 11 oblik človekovega delovanja (pritiska) na naravno okolje, ki vsebuje 141 osnovnih elementov "dajalcev". "Prejemnik" je naravno okolje, ki je bilo obravnavano tudi zelo široko, saj pet osnovnih podsistemov vsebuje 474 elementov.

Elementi "modelne" matrike so bili razvrščeni hierarhično, pri čemer se je težilo k oblikovanju skupin in podskupin. V modelni matriki je bilo 66 834 potencialnih polj medsebojnega učinkovanja, za katere se je ugotavljala prisotnost učinkovanja ("da ali ne" sistem).

Za ugotavljanje intenzivnosti vplivov je bila prevzeta skala s petimi razredi, pri kateri 0 pomeni, da vpliva ni ali pa je zelo slaboten, 4 pa predstavlja zelo močan vpliv.

Kot izhodiščna točka za ugotavljanje stopnje človekove preobrazbe pokrajine je služilo hipotetično okolje, na katerega človeška družba še ni vplivala; stopnja človekovega pritiska nanjo je torej nič. Pri vsem omenjenem postopku pa prihaja do napak zaradi subjektivnosti ocenjevanja človekovih vplivov in njihove intenzivnosti na okolje.

Lahko pa ugotovimo, da se napake pojavljajo tudi pri t.im. objektivnem merjenju z inštrumenti. Z večjim številom elementov, ki jih obravnavamo istočasno, se zmanjša tudi napaka. Zato je bila sprva obravnavana matrika kot celota, nato pa vpliva znotraj posameznih skupin in podskupin elementov.

Po izdelavi osnovne matrike, ki je predstavljala posplošeno oceno vpliva oblik človekovega delovanja na naravno okolje, je sledilo zbiranje gradiva na terenu. Na topografsko karto v merilu 1:25 000 so bile nanešene vse antropogene oblike. Velik del podatkov je bil zbran s pomočjo interpretacije letalskih posnetkov. Po preverjanju elementov matrike ter jakosti njihovega vpliva je sledila faza določevanja stopnje vpliva vsakega elementa na naravno okolje in sicer za 80 "dajalcev" ali oblik človekovega delovanja. Pred tem so bili elementi okolja razdeljeni na 5 osnovnih skupin: atmosfero (35 elementov), litosfero (31), hidrosfero (79), pedosfero (53) in biosfero (32 elementov).

Kot izhaja iz nakazanega postopka vsaka od 80 oblik človekovega delovanja učinkuje na vsakega od 250 elementov naravnega okolja, intenzivnost vplivanja pa je izražena z vrednostjo stopenjske skale.

Intenzivnost človekovega vpliva je aritmetična sredina skupne vrednosti posameznih oblik človekovega vpliva, izračunana za aktivne elemente (1-4) znotraj vsakega od 5 podsistemov naravnega okolja.

Z raziskavo je bil ugotovljen značaj vpliva posameznih elementov človekovih posegov v naravno okolje. Upoštevani so bili naslednji trije aspekti: 1. obseg vpliva, 2. intenzivnost vpliva 3. stopnja preobrazbe. Nadaljna raziskava je v glavnem slonela na indeksu, ki je predstavljal stopnjo človekove preobrazbe okolja, ker se je ta mera pokazala za ustreznejšo od ostalih dveh.

V končni fazi je bila izvedena tipologija, ki je opredelila štiri osnovne skupine območij:

1. skoraj naravna pokrajina: obsega predvsem gozdna območja z majhnim deležem ostalih oblik izrabe zemlje;
2. kmetijska pokrajina;
3. obmestna pokrajina;
4. mestna pokrajina.

Pomanjkljivost metode je v statičnem prikazovanju. Dinamično sliko bi lahko dobili z občasnim ponavljanjem raziskave.