

## METHODS OF DEFINING THE ANTHROPOGENIC TRANSFORMATION OF THE ENVIRONMENT

*The paper discusses some approaches to use the area ratios between different anthropogenic territorial complexes for assessments of environment state. The following definitions are considered: "natural-anthropogenic territorial complexes", "anthropization". Some GIS-methods to calculate the anthropization are suggested and results of such calculations at the example of key district are presented. The article raises the question of whether it is expedient to use basin approach while researching the environmental transformations. The attention is paid to the socio-economic context and the significance of such studies in human geography.*

**Key words:** anthropization, land use type, watershed, environmental management, transformation of environment, geoprocessing, natural-anthropogenic territorial complexes.

**Віталій Бережний. МЕТОДИ ВИЗНАЧЕННЯ АНТРОПОГЕННОЇ ТРАНСФОРМАЦІЇ ДОВКІЛЛЯ.** Обговорюються підходи до використання співвідношень площ поміж різними антропогенними територіальними комплексами для подальших якісних оцінок стану довкілля. Розглядаються поняття «природно-антропогенний територіальний комплекс», «антропізація». Запропоновано деякі способи розрахунку ступеня антропогенної трансформації у ГІС. Подано результати розрахунків антропізації довкілля для ключового району. Піднімається питання про доцільність використання басейнового підходу при дослідженнях антропогенної трансформації довкілля. Акцентується увага на соціально-економічному аспекті подібних досліджень та їх значимості у суспільній географії.

**Ключові слова:** антропізація, тип землекористування, водозбірний басейн, охорона природи, трансформація довкілля, геообробка, природно-антропогенний територіальний комплекс.

**Віталій Бережний. МЕТОДЫ ОПРЕДЕЛЕНИЯ АНТРОПОГЕННОЙ ТРАНСФОРМАЦИИ ОКРУЖАЮЩЕЙ СРЕДЫ.** Обсуждаются подходы к использованию соотношений площадей между разными антропогенными территориальными комплексами для последующих качественных оценок состояния окружающей среды. Рассматриваются следующие понятия: "природно-антропогенный территориальный комплекс", "антропизация". Предложены некоторые способы расчетов степени антропогенной трансформации в ГИС. Представлены результаты расчетов антропизации для ключевого района. Поднимается вопрос о целесообразности использования бассейнового подхода в исследованиях антропогенной трансформации окружающей среды. Акцентируется внимание на социально-экономическом аспекте и значимости подобных исследований в общественной географии.

**Ключевые слова:** антропизация, тип землепользования, водосборный бассейн, охрана природы, трансформация окружающей среды, геообработка, природно-антропогенный территориальный комплекс.

**Introduction.** Assessing the state of the environment and defining the level of its anthropogenic transformation can be performed using various methods. In many cases, the ratio of the areas occupied by the certain land use types in the landscape is taken into consideration. These types are preliminary ranged depending on the type of their destructive influence degree. On one part, the results of such investigations define the extent of the natural environment development on the territory, and on the other part, they are compared with the certain allowable level of the anthropogenic impact.

Defining the level of the environment anthropization (conversion) has constitutive and geographical meaning: it is the basis for further land use planning. Primarily, it refers to the natural-reserved fund objects and ecological networks. But any strategic programs of social and economic development that are eventually transformed into certain land use on the territory shall be checked for compliance with the requirements of the environmental protection in form of strategic ecological evaluations and environmental assessments. This is particularly where the achievements of social and physical geography are matched. It turned out that the investigators of the first above mentioned branch of geography study the economic activity predominantly within the framework of administrative-territorial division, and to some degree they are separated from the basis of their investigation – the areas occupied by the specific land use types. Such areas collectively define the typical anthropogenic territorial complexes (ATC), and by some

other interpretations – the natural-anthropogenic territorial complexes (NATC); cultural (anthropogenic) landscapes. All in all, NATC is the initial and final stage of economic and geographic research, while constitutive geography is the cross-disciplinary research direction that combines (and cannot exist without such a combination) artificially separated natural, economic, social and technical components of geographical environment.

**The purpose** of the article is the survey of the methodological foundations and approbation with the geographic information systems of the initial stage of assessing the level of anthropogenic development and transformation of the environment (at the example of watersheds of the river Oskol within the Kupiansky district of the Kharkiv region, Ukraine). The separate task of the article is defining the main principles and rules that are to be used as a basis for simulation of the territory development in terms of its interrelation with the certain allowable level.

**Analysis of previous researches.** The example of the simplest norms that can be used when studying the influence of the people economic activity in nature are the area standard norms. The articles [1-3] suggested optimal relations between the areas of transformed and relatively unaltered natural lands that allow maintaining geosystem balance at the territory. Such relations seem to be the simplest, the most demonstrative and convenient for calculation by means of standard geoprocessing procedures in geoinformation systems. However, they are not the final characteristic of territorial organization of economy, which except for the metric relationships includes also the position ones: how are the land use

types interchanged, are there any common borders in space?

The most popular among the studies of the Ukrainian scholars addressed to researching the anthropogenic transformation of the environment is the suggestion to define the anthropization coefficient ( $K_a$ ), using which each land use type on the specific territory is assigned with the coefficient of destructive impact [1]. The natural-reserved fund lands have the lowest "weight", while the ones with the highest weight are the industrial mining complexes where transformations substantially impact geologic and geomorphologic components of the environment.

The anthropization coefficient is defined using the following formula:

$$K_a = \frac{\sum r p q_i}{100},$$

where  $K_a$  - the anthropization coefficient;  $\sum r p q_i$  - the sum of productions of the area ratio (in percents) of the specific land use type, its weight rate and its range in the ranged sequence of the economic impacts (from 0 for the natural reserves to 10 for the industrial lands) respectively. The above mentioned scholars consider the natural complex of the certain range to be the territorial unit for  $K_a$  defining. The authors suggested the following ranging of the coefficients for the environment conversion stage definition: <3.80 – slightly transformed; 3.81-5.30 – transformed; 5.31-6.50 – moderately transformed; 6.51-7.40 – greatly transformed; > 7.41 – heavily transformed.

It should be noted that this method is not completely estimating, though it is a prerequisite for assessment researches of the environment transformations and allows visualization of the anthropization spatial arrangement.

As it was previously stated, considering of the lands both adjacent and located at the certain distance is as much important as their distribution in the specific  $K_a$

definition area. The specific territories can stay relatively undeveloped, though, for instance, in view of natural flows of the substances, they can fall under substantial anthropogenic impact (i.e. through economic activity outside their boundaries). By supplementing the area ratio with the positional properties of the lands and the type of their "pattern", this is the only way to come up with the more detailed explanation of the territorial land use organization compliance with the certain requirements.

**Presentation of primary material.** The Kupiansky district of the Kharkiv region is chosen to be the key territory for research (Figure 1). Such decision is based on the set of both natural and economic components of the geosituation within the specified district. As to the nature aspect, the Kupiansky district is representative among the districts of the north-eastern part of the Kharkiv region, while in physical and geographical zoning it takes the intermediate topologic position between the Left Bank forest steppe and Steppe [4], coupling with the nature complexes in the valley of the river Oskol. Such location makes certain impact on the land use system (the stage of plough up, agricultural sector specialization) and on the spatial organization of settlements, that in its turn requires consideration of such special aspects in the systems of the nature utilization optimization. The state of geologic and orographic components of the environment is defined by the location of the district within the valley of the river Oskol. The relief ratio facilitates development of gullying and landsliding, as well as sheet erosion. The combination of the above mentioned factors facilitates appearance of the natural complexes of low productivity and environmental capacity, increases erosion and landsliding hazards, being the reason for dangerous state of numerous buildings and engineering structures [5], and consequently causes certain social tension at the local level.

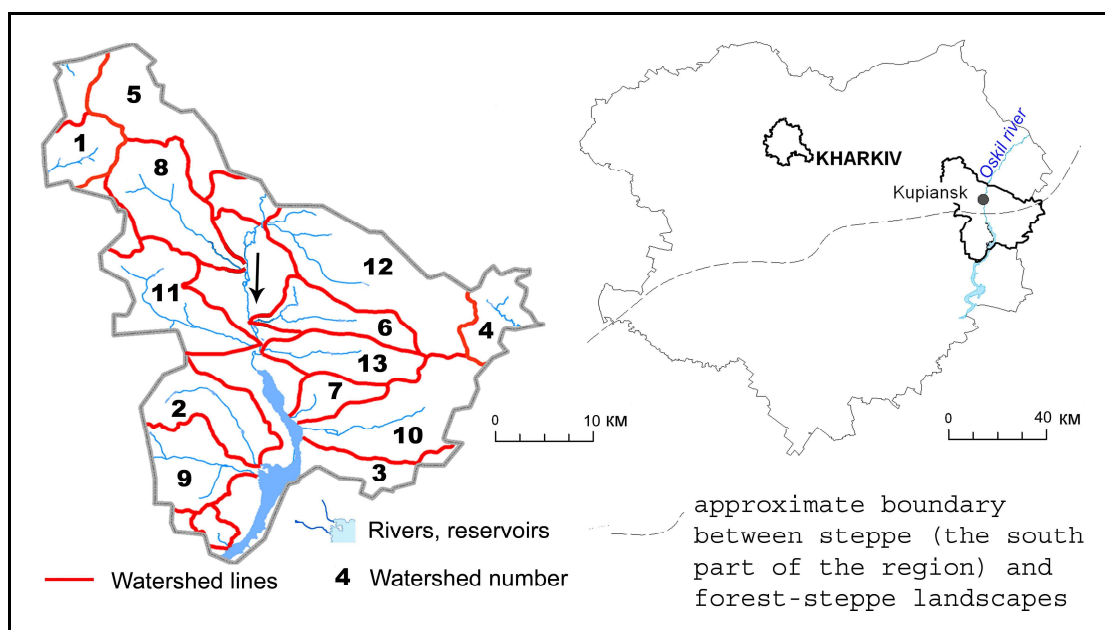
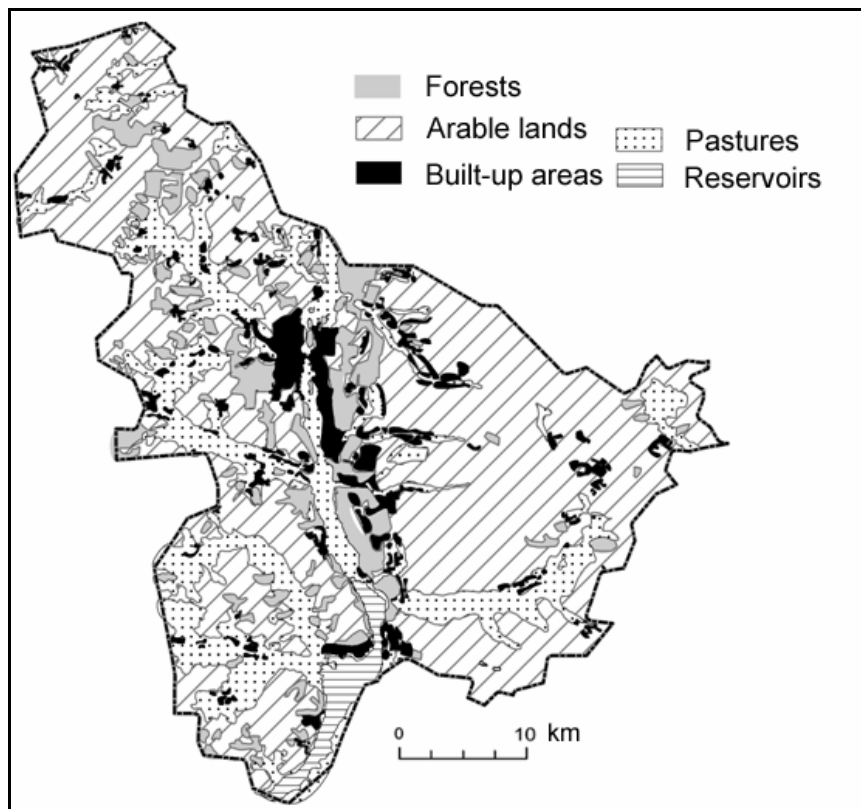


Figure 1. Location map and basin structure of the Kupiansky district

Among the prerequisites of selecting this district are availability of the detailed map of the anthropogenic territorial complexes compiled by S.Ye. Ignatiev within the framework of researching Oskol ecological corridor [6], as well as the long period of the district field studies. The simplified map of land use structure of the district is represented in *Figure 2*.

The specific feature of the district is the regulated

run-off: large areas are flooded with water from the storage lakes. With this regard, there is certain contradiction: such anthropogenic object as the storage lake substantially changes the initial natural complex and is assigned with the high coefficient in course of researching the stage of the environment transformation, but to certain extent facilitates the growth of the habitat forming functions of the territory.



*Figure 2. Spatial configuration of land use types of the Kupiansky district*

The anthropogenic transformation of the environment can always be unambiguously interpreted: the larger the modern anthropogenic territorial complex differs from the initial natural, the larger is the transformation. In such a case the most modified ones are those natural complexes, in which the components are changed at the level of cardinal transformation of its most inert parts: soils, lithogenous basis. This refers to the industrial zones and developed town areas, where the landscape is substantially conversed and the vast areas of soil are replaced with impervious surfaces [7]. Besides, the areas where the landscape is totally changed turn out to be the substantially transformed: for instance, when it is conversed to aquatic (in case the territory is flooded with the storage lake water), or when agricultural fields are arranged in place of the initial forest lands.

The anthropogenic transformation primarily has negative connotation, as any interference of people into nature is extraneous. However, sometimes substantial anthropogenic changes in the environment can facilitate the growth of its habitat forming functions.

When it refers to the stage of the environment development, complexity of using the natural resources at

the territory is also taken into consideration. The more environmental resources are involved into the economy both commonly and separately (in case of incompatible land use types), the more developed the territory is considered.

As to the concept of "anthropization", to our thinking it depends on the general understanding of dependency of the anthropogenic objects from nature: it should be defined, what is the extend of correlation between the natural mode of the substance (energy) flows and the similar flows, though already changed by the human activity, in the anthropogenic transformed geosystem. In many studies such question is much broader and is formulated kind of differently: is any natural and anthropogenic territorial complex considered to be a cultural landscape? Detailed analysis of such question is provided in the monograph of M.D. Grozdinsky [8].

The following options are possible:

- cultural landscape = anthropogenic landscape;
- cultural landscape is just a particular type of the anthropogenic landscape. It varies by the specific modification level and, depending on concurrency of the "targets" set for the natural and the anthropogenic land utili-

zation subjects, is the landscape with minimal possibility of conflict regarding using of natural resources. The modern views on rational use of natural resources are most definitively realized for the cultural landscape.

The anthropogenic transformation of the environment is the continuously distributed characteristic, therefore it can adequately be represented in continuum, in form of the field (i.e. grid in GIS), in contrast with the discontinuous generalized representation within the landscape territorial units. Under such conditions the procedure of *Ka* defining becomes more difficult. When calculating the relation of the areas of various nature utilization types for some averaging district (for instance for sliding window of the square), it is necessary to consider not only distribution of the anthropogenic lands within it, but also distribution of that natural background that has been changed. Within the averaging district there can be at least two following options of combining natural and transformed complexes:

1) several natural territorial complexes conversed using the same land use type;

2) one natural complex conversed using various land use types.

Both in the first and in the second options a certain resulting polygon is formed being the consequence of spatial difference of the natural territorial complexes with the anthropogenic ones. Therefore, the weight coefficients in the formula shall be adjusted and will be different even for the same land use type. Such adjustment considers higher sensitivity or inactivity of each separate natural complex to a certain type of land use. Considering small variety of natural complexes and land use types at the territory of the district, such approach can be ignored.

The basis of geoprocessing for calculating the coefficient consists of simple analytic operations of selection and further storing of the selected objects, among which there are the queries by location: "completely contain" or "partially contain" [9]. That means the selection

of all anthropogenic territorial complex polygons, matching with the specified space borders of the natural complexes (in order to define the coefficients of the conversing impact of land use type in the specific natural background), and then the specified space borders of the sliding squares for final calculation of the areas of the anthropogenic territorial complexes. The areas and the coefficients are subsequently used for creation of the continuous model anthropization.

In this article we also raise the question of whether it is expedient to use basin approach while researching the environmental transformations (in contrast with the landscape units). A lot of researches consider separation of the territory by the river watersheds (basin structure) to be the most rational [10, 11]. This is associated with the objectivity of marking the watershed borders and functional-and-space consistency of each of the watersheds as partially detached land drainage unit, land use and pollution transfer object. Usually watersheds of the small rivers are so integral that it allows analyzing them as operational territorial units of the environmental transformations research. Therefore, it is rational to calculate the anthropization coefficient for similar watersheds of the first and the second rank. Such calculations were performed using the regional statistics means based on the data of *Ka* value field for the watersheds of the small rivers of the Kupiansky district (Table 1).

It was determined that the level of the watersheds modification within the borders of the Kupiansky district is very differentiated and marked by more substantial anisotropy closer in the direction of the right bank valley of the river Oskol. Maximal values of *Ka* are more typical for the left bank watersheds, characterized by the industrial territory development, as well as by the substantial share of the agricultural lands. As to the right bank watersheds, which under the set of the natural conditions are less convenient for economic development, the minimal *Ka* values are demonstrated.

Table 1

*Anthropization coefficient for the watersheds of the Kupiansky district*

| Watershed number | Anthropization coefficient |        |        |                    |
|------------------|----------------------------|--------|--------|--------------------|
|                  | Max                        | Min    | Median | Standard deviation |
| 1                | 4,420                      | 7,516  | 6,815  | 0,530              |
| 2                | 4,218                      | 7,394  | 5,945  | 0,634              |
| 3                | 6,863                      | 8,425  | 7,383  | 0,232              |
| 4                | 5,144                      | 7,727  | 6,931  | 0,675              |
| 5                | 4,960                      | 7,545  | 6,893  | 0,730              |
| 6                | 4,892                      | 9,070  | 7,213  | 0,695              |
| 7                | 4,817                      | 8,005  | 7,434  | 0,443              |
| 8                | 3,307                      | 10,270 | 5,676  | 1,162              |
| 9                | 3,775                      | 8,468  | 5,848  | 0,561              |
| 10               | 4,559                      | 8,062  | 6,499  | 0,716              |
| 11               | 3,691                      | 7,845  | 5,711  | 0,601              |
| 12               | 3,153                      | 7,647  | 7,252  | 0,890              |
| 13               | 4,286                      | 8,820  | 7,321  | 0,626              |

**Conclusions.** 1. As a result of simulation based on the methodological principles described above, the environmental transformation fields and regional statistics indicators were calculated for watersheds of the small rivers at the Kupiansky district of the Kharkiv region. Particularly on the local level, considering the watershed area and the set of hydrology indicators, the basin systems are the most sensitive to the external influences. At the same time the governmental strategies of land utilization on the local level are fulfilled at the level of the specific projects, that are implemented in the appearance or change of the space, structural and functional characteristics of the natural and anthropogenic territorial complexes.

2. The described methods constitute the reliable means for studying the anthropogenic transformation of

the environment. The specified methods allowed revealing spatial organization and relative indicators of the environmental transformations by various land use types within the key district. The left bank basins are the most transformed ones, which is associated with the set environmental prerequisites.

3. The "weight" of the separate local centers of the intensive economic management (towns and industrial zones) in the calculated values of the coefficients by the basin territorial units is reduced at the expense of the other lands with the "moderate" environmental stresses. Therefore, it is expedient to perform such calculations within the specified averaging district with their further interpretation through the continuous models of geographic locations and phenomena.

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*Summary***Vitaliy Berezhnoy. METHODS OF DEFINING THE ANTHROPOGENIC TRANSFORMATION OF THE ENVIRONMENT.**

Defining the level of anthropogenic transformation of environment can be performed using the ratios of the areas occupied by the certain land use types in the landscape or watershed. It is assumed that there is optimal relation between the areas of transformed and relatively unaltered natural lands that allow maintaining geosystem balance.

One of the methods to define the level of environment conversion is to calculate the anthropization coefficient. When calculating the coefficient, land use types are assigned with the parameter of destructive impact.

The Kupiansky district of the Kharkiv region is chosen to be the study area. The initial data to calculate the level of anthropogenic transformation was the map of natural territorial complexes and the map of land use types. The larger the modern anthropogenic territorial complex differs from the initial natural, the larger is the transformation.

The anthropogenic transformation of the environment is the continuously distributed characteristic. It should be represented through the continuous models of the field. It is necessary to consider not only distribution of the anthropogenic lands within sliding window, but also distribution of that natural background that has been changed.

It is also proposed to calculate the anthropization coefficient for watersheds. Such calculations were performed using the regional statistics means based on the data of the coefficient value field. It was defined that the level of the watersheds modification within the Kupiansky district is differentiated. Maximal values of the coefficient are more typical for the left bank watersheds.

**Key words:** antropization, land use type, watershed, environmental management, transformation of environment, geoprocessing, natural-anthropogenic territorial complexes.