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WATERSHED APPROACH IN TERRITORIAL MANAGEMENT AT THE LOCAL LEVEL

Article integrates the concepts about the watershed approach, territorial management and the use of GIS tools in the system of environmental management at the local level. A brief retrospective review of the use of the watershed approach in applied geography is presented. Advantages of the approach in solving the problems of natural resources are discussed. Attention is focused on a number of assumptions that justify the importance of the approach in environmental management at the local level. Some aspects of the use of GIS for the implementation of the approach in the territorial management are considered.

Key words: watershed, watershed approach, territorial management, geosystem, antropogenic transformation of environment, GIS.

Віталій Бережний. БАСЕЙНОВИЙ ПІДХІД У ТЕРИТОРІАЛЬНОМУ УПРАВЛІННІ НА МІСЦЕВОМУ РІВНІ.

Стаття інтегрує уявлення про басейновий підхід, територіальний менеджмент та використання ГІС-інструментарію у системі природокористування на місцевому рівні. Подано короткий ретроспективний аналіз використання басейнового підходу в конструктивно-географічних дослідженнях. Розглядаються переваги підходу при вирішенні проблем використання природних ресурсів. Акцентується увага на низці вихідних положень, що обґрунтовують важливість підходу в управлінні природокористуванням на місцевому рівні. Розглядаються деякі аспекти використання ГІС для реалізації басейнового підходу в територіальному управлінні.

Ключові слова: водозбірний басейн, басейновий підхід, територіальний менеджмент, геосистема, антропогенна трансформація довкілля, ГІС.

Віталій Бережний. БАСЕЙНОВИЙ ПОДХОД В ТЕРИТОРІАЛЬНОМУ УПРАВЛІННІ НА МІСЦЕВОМУ РІВНІ.

Статья интегрирует представления о бассейновом подходе, территориальном менеджменте и использовании ГИС-инструментария в системе природопользования на местном уровне. Представлен краткий ретроспективный обзор использования бассейнового подхода в конструктивно-географических исследованиях. Рассматриваются преимущества подхода при решении проблем использования природных ресурсов. Акцентируется внимание на исходных положениях, обосновывающих значимость подхода в управлении природопользованием на местном уровне. Рассматриваются некоторые аспекты использования ГИС для реализации бассейнового подхода в территориальном управлении.

Ключевые слова: водосборный бассейн, бассейновый подход, территориальный менеджмент, геосистема, антропогенная трансформация окружающей среды, ГИС.

Introduction. Currently, there is "isolation" of geography from the practice of solving of urgent problems of territorial management. Despite the fact that the geography provides a comprehensive study of processes in the system "nature-economy-society" and deals exclusively with the objects of study, which are complex and heterogeneous, such as watersheds, geographers do not always realize these achievements in solving of specific tasks. The way of overcoming these problems is use of the watershed approach and geographic information systems (GIS) in the system of territorial management. GIS provides to modern geography more pragmatic content and is an effective tool to support management decision making.

The main goal of article is to inform the general public of geographers about the importance and benefits of the watershed approach of territorial management at the local level, in particular, when using GIS.

Watershed approach in geographical studies.

Watershed approach can be considered as a methodology for research in the geosciences, and as a series of principles for the implementation of environmental management. The basis of the approach is the position about the continuity of geographical environment, where the main integrating factor is the surface runoff [1]. In accordance with the watershed approach, the spatial structure of geographical environment is represented as a system of watersheds, which dynamic unity determined by the unidirectional nature of matter transfer by permanent and temporary streams.

Beginning from the works of Robert Horton [2],

watersheds are considered as integral natural systems. Currently, the watershed approach is devoted a considerable amount of scientific researches in various fields of knowledge. Despite the fact that the watershed and the elements of its structure traditionally investigated in hydrology, watersheds are increasingly acquiring the status of the object of study of landscape science [3-5] and *applied geography* [6]. With the advent of the scientific and practical direction as *territorial management* [7] watersheds become important territorial units of environmental management [8-10]. Territorial management has been traditionally considered as a set of procedures for the analysis of the territory, revealing its structure, ecological condition, dynamics and prospects of development, optimizing the objects placement, tactical and strategic planning [7].

Implementation of the watershed approach in a constructive geography and environmental management has gone through a number of stages [11]:

1. Criticism of the description and collection of geographic information on the administrative territorial units, introduction of geographical researches on natural areas, the role of which are better suited watersheds.

2. Holistic analysis of the aqueous and landscape component of the watershed; analysis of the watercourse links with slopes and valleys part of the watershed; emergence of science-based programs of the interconnected use of water and land resources.

3. Study of watersheds in order to optimize the environmental management, understanding the watershed as a part of natural and economic system, development of researches of cross-border processes based on the watershed approach (based on the appearance of the

water and basin directives of international level, international programs of harmonization of the watersheds environment).

Watershed as a territorial unit of land use management. Territorial management on a *topological level* [12] that in the spatial extent corresponds the *watershed of small rivers*, is understood as the most relevant for the following reasons:

1. Just at this level the state of watersheds is the most vulnerable to external anthropogenic impact;

2. Territorial management at the local level proceeds not from an abstract model representations, "detached" from the real terrain, but takes into account its smallest features (at level of terrain mesoforms and elements of landscape structure, individual farms and the slightest changes in land use);

3. Exactly at the level of the small river watershed both intrinsic and extrinsic factors of geosituations [13-15] are simultaneously tracked, so it is possible to carry out a joint study of these factors without changing the spatial coverage.

4. Exactly at local level the nation-wide strategy and policy decisions acquire a specific project "filling", including financing. The last, along with a lack of experts, is a limiting factor in the implementation of many projects.

5. In any territory, the small rivers and their watersheds are the vast majority. In this case, water and energy resources of the small rivers can be estimated only approximately, because hydrological observations are carried out on them very limited. The key quantitative criteria for the classification of rivers as small, medium and large are the length of the river and its watershed area. As a rule, the group of small rivers includes rivers with the watershed area no more than 2000 square kilometers. This is roughly equivalent to the area of the administrative district in Ukraine.

The papers [8, 9] argue that it is possible to talk about the watershed as an elementary unit of the ecological and economic management. We define a number of factors that contribute to the use of the watershed approach in the territorial management:

1. *Watershed is a geosystem of high degree of integrity* [16, 17], the main function of which is to organize the movement of water and sediments in the form of surface runoff. Characteristics of channel network are the integral indicators of the state of the processes occurring in the watersheds.

2. *Universality of watersheds*: a continuous distribution of watersheds by land area and the spatial belonging of any territory to the watersheds.

3. *The decisive role of watershed topography organization in the formation of the morphological structure of natural complexes* [18].

4. Objectivity of finding of the watershed boundary on maps compared to some elements of landscape structure that makes the watersheds more reliable territorial units of management; and "*naturalness*" of boundaries that makes the watersheds more suitable for environmental management than the administrative territorial units.

5. *Hierarchy*. This allows us to compare the watersheds on a complex of characteristics and use them as isomorphic models in the organization of land use and water resource management on the territories of the correspond-

ing level.

6. *Concentration role*: economy tends to rivers in connection with the ever-increasing importance of water factor of production.

7. *Reflection of watershed configurations* [5] in territorial organization of environmental management. This relates primarily to agriculture and forest management, water management, recreational and environmental activities.

Previous research of the spatial structure of land use within the watersheds of middle course of Oskil River [19] allowed us to estimate characteristics of its watershed configuration. The spatial distribution of the degree of anthropogenic modification of the natural environment and a variety of ways to use the lands is strongly correlated with the value of the distance from the watercourse. Diversity in general is growing towards the watercourse. Anthropogenic modification of the environment has pulsating character: it is significant in the case of location within the valley of the village and, advantageously, decreases towards the watercourse. The reasons for this are as follows: the increasingly important role of water factor of production, dominance throughout Ukraine of valley method of settlement, as well as the dependence of agriculture on the landscape structure, which accordingly is subject to a system of watercourses.

8. *Unity of response* of the various subsystems of the watershed on the changes of synoptic conditions and land use on the territories of the corresponding level.

The watershed approach is an alternative in the study of the territorial organization of different sectors of the economy [11]. The results of these researches and evidence-based guidelines are the baseline information for decision making in management. Geographical aspect of using the watershed approach is to define the degree of economic development of the territory and anthropogenic modification of the environment, the degree of compliance (or adaptivity) of natural to anthropogenic. The approach is also relevant in the research of renewable natural resources.

Solving these problems is possible through the creation of attributive geographic databases and through GIS modeling of natural processes that occur in the watersheds.

One example of studies of the human impact on watersheds is the identification of the degree of their anthropization [20]. This takes into account the area ratios of land use types within the watershed and the degree of their transformative impact on the environment. GIS integrates watershed geoinformation model with geographic information layers of administrative territorial units, land use types, natural territorial complexes, etc. As a result of performing basic geoprocessing commands (Split, Erase) user can get the new output polygonal GIS-layers of natural and anthropogenic territorial complexes: with the new values of the area and the recalculated values of quantitative attributes of GIS features. Attribute values of the type "category" are saved with no changes. Thus we can obtain the percentages of areas occupied by different types of land use and determine the degree of their destructive influence within each specific watershed for further calculation of anthropization.

GIS performs procedures on spatial data to obtain information. These information systems are in most cases designed to reduce uncertainty, and hence to support the adoption of the most appropriate, reasonable and *cost-effective solutions* in a shortage of adequate amounts of baseline data, means, time and other resources.

Elements of information services provided by specialists in the field of geography and geoinformatics in the implementation of the watershed management systems can be combined in the following groups performed sequentially:

1. Collection and automatic primary analysis of data about natural and anthropogenic environment of the watershed.

2. Representation of data in the form of electronic maps, graphs and tables; creation of databases of geographic data for watersheds.

3. Development and implementation of methods of spatial data analysis and models of geoprocessing.

4. Spatial analysis, search for alternatives of economic development in watersheds, definition of development prospects of industries and enterprises; optimization of business processes, etc.

Further we give examples of the main components of the project of territorial management and examples of specific tasks that can be solved on the basis of watershed management system.

1. Research of adverse physical and geographical processes, in particular, geological and hydrological those are relevant in the study of natural resource potential of the watersheds. This is because the limit of use of a certain type of resource depends not only on its ability to reproduce, but also from all adverse natural processes, which may be caused by the use of this resource.

Rational environmental management is a historically relative category: at different stages of development of the productive forces, natural resources are estimated taking into account the technical capability, economic feasibility and environmental justification for their use [21]. Geographical sense of "environmental management" and "natural resources" categories is that they exist just for a certain area, it is an integral part of territory, and cannot be separated from it [22]. Assessment of natural resource potential provides spatial zoning that can be performed based on the watershed approach.

2. Numerical modeling of watershed topography organization, modeling of erosion processes, morphology and morphometry of the topographic surface for assessing the sustainability of soil and for the establishment of areas suitable for farming.

3. Creation of geographic databases (GDB) of the

watersheds for organization of inventories of lands in agriculture, forest and water management, recreation and tourism. Along with the vector GIS objects, GDB may contain raster data (digital elevation models, remote sensing data), to which at any time can make the necessary queries to carry out the necessary analysis. GDB will not only reliably store data, but also provide a convenient method for continuously updating, sorting and processing of data in accordance with the "spatial requirements" set by the customer in the form of a set of rules, «topologies» and the like.

4. Study of the territorial organization of land use in the context of the watersheds, determination of its shortcomings, identifying ways to optimize the territorial structure of agricultural lands. Relevant is to identify ways of coordinated, integrated use of natural resources that provide the greatest economic benefit, as opposed to their limited mutually exclusive use.

5. Software solutions for the optimization of business; spatial and temporal analysis and forecasting of a condition of the geosystems of the watersheds.

Conclusions.

1. Use of the watershed approach acquires special significance in a constructive geography, investigating the natural and anthropogenic components of the environment in a complex, in their entirety and inseparable connection.

2. In accordance with the watershed approach, the spatial structure of a geographic space is a cascade system of the interconnected watersheds of different ranks. Watersheds are complex heterogeneous geosystems regulating flows of energy and matter. Watersheds act as a united functional integer despite the multicomponent structure.

3. Watershed of the small river is an elementary cell of territorial management. This is facilitated by the benefits of implementing the watershed approach as compared to other territorial units: integrity, pervasiveness of the watersheds, geocological role, hierarchy, reflection of the watershed configuration in the spatial organization of natural complexes and types of land use.

4. The local level in the watershed system of territorial management is the key: the nation-wide territorial development strategies are implemented at this level.

5. Geographic information systems are designed to reduce uncertainty in management decision making. GIS integrates models of the watershed topography organization with other spatial data sets of natural and anthropogenic environment to determine the current state and prospects for the optimization of land use in the watersheds.

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Summary

Vitaliy Bereznyi. WATERSHED APPROACH IN TERRITORIAL MANAGEMENT AT THE LOCAL LEVEL.

Watershed approach, which today is primarily concerned with water management, can be the spatial basis of the territorial management in general. Despite some unresolved issues of implementation, the approach is an alternative embodiment of the territorial organization of environmental management.

Many researchers consider the division of the territory on the river watersheds (i.e., basin structure) is the most reasonable. This is evidenced by the objectivity of finding of the watershed's boundary, and functional-spatial unity of each of the watersheds as separate unit of surface runoff, and the object of land management. The watershed configuration determines the territorial organization of society: population and economy are attracted by the water objects. Watersheds of the small rivers are in such an extent entire that are the basis for their consideration as territorial units of geographical research and land management. Particularly relevant is the local level of implementation of the watershed approach, since the national programs of territorial development find their practical implementation exactly at this level.

Watershed as a spatial object satisfies the requirements for structuring of spatial information, and can be appropriately simulated by GIS tools.

Key words: watershed, watershed approach, territorial management, geosystem, antropogenic transformation of environment, GIS.