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Theoretical and applied aspects of landscape technogenic morphology

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INTRODUCTION

Landscape is a complicated system of many interrelated structures and processes, which can be investigated separately or in union. Structural investigations form the morphological point of view in landscape science while processes are mostly the object of geoecological research. Integration of these two approaches to landscape leads towards the holistic approach. This paper, however, is intended to focus mostly on the morphological aspects of contemporary landscape research together with the ways of the application of derived results in physical planning.

Landscape morphology as a science has old worldwide traditions among geographers, reaching the beginning of the 20th century (Sauer, 1925; Berg, 1931; Passarge, 1933) However, the further development of morphological ideas found its way and anchored only in some limited regions of the world, such as Russia, Germany, Poland and other East European countries. After several decades dedicated to natural landscape morphology (Solntsev, 1949; Reteyum, 1966; Kondracky, 1969) gradually more and more works on the anthropogenic landscape change were presented. During that time terms like cultural landscape, anthropogenic landscape, technogenic landscape (Milkov, 1970; Fedotov and Dvuretshenskij, 1977; Khokhlova, 1979), anthroposphere (Rodoman, 1967), technosphere (Balandin, 1982), cultural layer (Tshalaya and Vedenin, 1997) and their concepts were introduced. The application of the General System Theory in the landscape science brought about the concepts of the so-called geotechnic systems, geotechsystems, etc. (Reteyum et al., 1972; Muchina et al., 1976; Demek, 1977; Preobrazhenski, 1986). Several works stressing the technogenic landscape morphology (Richling, 1999; Rozanov, 2001) were produced during the last decades.

The most significant foundation of Lithuanian landscape morphology was given by A. Basalykas, geographer from Vilnius University. He performed a detailed landscape regionalization based on geomorphological structures (Basalykas, 1965). However, later the concept of cultural landscape was intensively propagated and developed, specifying the emerging technogenic layer constructed and introduced in the natural landscape space by man (Kavaliauskas, 1976, 2000; Basalykas, 1977, 1986). The methodology for analysing this technogenic structure of landscape has been recently worked out (Veteikis, 2003), and this strengthened the theoretical basis of landscape geography as well as contributed to the physical planning on various levels (national, regional, local).

THEORETIC GROUNDS

Landscape, being a very complicated system and allowing too many investigation aspects, is defined also in many different ways. In Lithuanian geographical tradition landscape is understood as a spatial compound of natural and anthropogenic Earth surface components (ground rocks, bottom air, surface and ground waters, soils, vegetation, fungi, animals, people, archaeological relics, land use plots, buildings, technical equipment, information field), which are connected by vertical and horizontal relations of matter, energy and information. This determination of landscape is used even in the legal base (the law of protected areas of Lithuanian Republic).

Natural and anthropogenic components create different types of structures (or spheres) in landscape. The most complex are the biosphere and the technosphere, both consisting of spatially expanding elements. This feature of expansion of biospheric and technospheric structures has roots in the negentropic, reproductive and even creative characteristics of bioorganisms, including man. The least explored is the noosphere, the information field, as if an aura or layer associated with paraenergetic survivals of man activities, especially cultural, sacral, mental etc. People (anthroposphere) standing in the midst of natural and anthropogenic components become as transformers and directors of natural energy, switching the process of naturalization towards socialization.

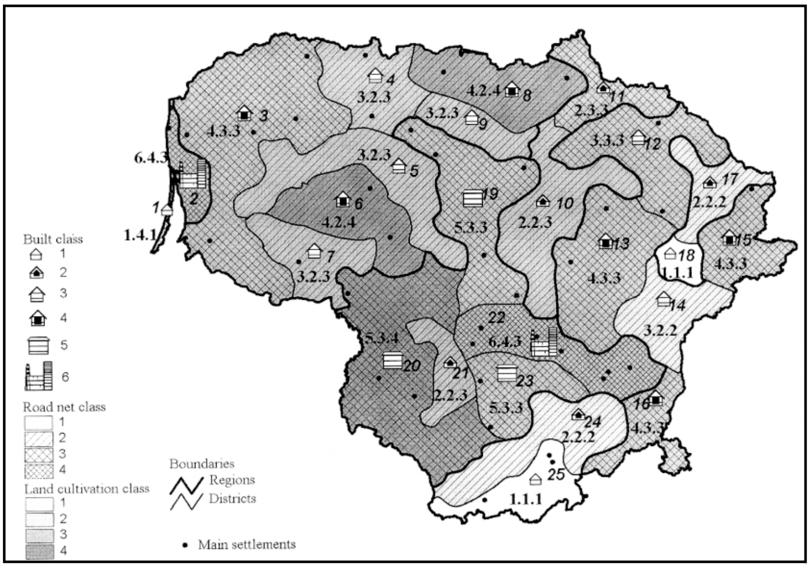

Figure. Technomorphological regionalization of Lithuania. Built-up area (urbanization), road network, and land cultivation classes are explained in Table 1. Digits in italic represent the number of districts. Digit triplets (*e.g.*, 2.2.3) describe the type of the region by all three features

Pav. Technomorfologinis Lietuvos rajonavimas. Uþstatymo (urbanizacijos), keliø tinklo ir þemës naudojimo klasiø paaiðkinimà þr. 1 lentelëje. Pasviræ skaitmenys nurodo rajono numerá. Trinariai skaièiai (pvz., 2.2.3) apibûdina rajono tipà pagal visus tris poþymius

Landscape is an integral of all these components with their structure, genesis, dynamics and development. This multivariable integration, however, should be preceded by a full and exhaustive analysis of each component, avoiding uncompleteness of the conception. Every component can be described by the type of territorial structure, manifested in the mosaic of morphological territorial units, or topes (lithotopes, hydrotopes, biotopes, technotopes, sociotopes, 'tope' coming from the Greek 'topos' – locality), relatively homogeneous patches. The mentioned integrated analysis can differ by the kind (fundamental or applied) and level (number of analysed attributes) of integration and is based on the territorial distribution of respective topes.

Until today not all the components have been investigated equally. The geological substratum, hydrographical network, even climatic conditions and biotic mosaic are investigated in the structural, genetic and dynamical aspects. But these elements cannot fully represent today's landscape so intensively changed by man. There is a need to start analysing the technogenic component in the landscape science. It cannot be developed into a vast scientific branch like geomorphology or hydrology in a short time, but new mapping technologies can assist to a great extent while dealing with the technogenic structure, calculating landscape technogenization characteristics, revealing the territorial structure created by technotopes. In this paper the methodology and some representative results of such technogenization analysis are presented.

In perspective, the concept of sociotopes expressing the territorial distribution of geosocial formations could be included in the general understanding of contemporary landscape and its morphological structure.

Fundamental landscape research cannot be completed without understanding the processes represented by matter, energy and information fluxes. Therefore the processological territorial units (topes: gravitopes, energotopes, chemotopes, bioecotopes, informotopes) can be equally distinguished and integrated in the whole structure of landscape.

Fundamental investigations of landscape **as such** should be followed by the applied research of landscape **for us**. For that purpose several directions of applied (socially oriented) investigations are established in connection to visual relations, the potential for use, environment convenience. The mentioned directions of applied research should again result in distinguishing territorial units, or topes, which in their turn are the most effective means to locate and define the will of planners and decision-makers. Visual relations in landscape can be reflected in the mosaic of so-called videotopes, the potential of use can be expressed in resource-topes, while planning requirements can be revealed by distinguishing the planotopes.

In this context, the suggested methods for analysis of landscape technogenic morphological structure is an important contribution to landscape science in general and to its physical planning in particular.

TECHNOGENIC REGIONALIZATION OF LITHUANIA

Relatively independent combinations of man-made/ modified and supported objects that are territorially concentrated and connected to each other by particular energy and substancial links are called technotopes. The constituent technotope elements (technogenic objects) are classified into large types depending on their genesis (man-made or man-modified objects).

Technotopes can be described by several technogenization characteristics: a built-up area, road network density, percentage of agricultural plots in land use structure. Every characteristic is rather complicated in itself, e.g., a built-up area can be compact or disperse, consist of multistoreyed houses or village cottages; roads also are of different importance, load, and cover; agricultural plots can be cultivated differently. Therefore first regionalization according to each of the characteristics was performed as the medium link towards complex technomorphological regionalization, which was later obtained as a combination of all the three partial regionalizations. Attempt was made to distinguish large regions and districts with a different prevalence of the mentioned features (built-up area, road network density, percentage of agricultural lands). The result presents the general technogenic structure of the landscape on the regional or national scale. The suggested territorial units (Figure) finally can be attributed to the descriptive classes (Table 1).

Table 1. **Classification features of technomorphological territorial units**
1 lentelë. **Technomorfologiniø teritoriniø vienetø poþymiø klasifikacija**

1. Urbanization classes (percentage of built-up area): 1. Urbanizacijos klasës (uþstatytas plotas %):		
Low / Maþa 1: <2% 2: 2–3%	Medium / Vidutinë 3: 3–4% 4: 4–5%	High / Didelë 5: 5–8% 6: >8%
2. Road network classes (road density): 2. Keliø tinklo klasës (pagal keliø tankumà):		
1 (very rare net / labai retas tinklas): <0.75 km/km^2 2 (rare net / retas tinklas): 0.75–1 km/km^2 3 (dense net / tankus tinklas): 1–1.25 km/km^2 4 (very dense net / labai tankus tinklas): >1.25 km/km^2		
3. Land cultivation classes (percentage of agricultural lands): 3. Þemës naudojimo klasës (agrariniai plotai %)		
1 (very low cultivation / labai maþai naudojama): 0–25% 2 (low cultivation / maþai naudojama): 25–50% 3 (high cultivation / daug naudojama): 50–75% 4 (very high cultivation / labai daug naudojama): 75–100%		

The built-up area (urbanization) was divided into six classes (coupled into three groups) according to the percentage of the urbanized area in a region. The four road network classes represent the total density of all the roads (arterial, regional, local) in a region. The four land cultivation classes are distinguished according to the percentage of agriculturally cultivated land in the region.

Finally, the results of technomorphological (qualitative) analysis of landscape structure can suggest a quantitative approach to landscape research, namely the calculation of technogenic mass. Technomass is understood as a quantitative characteristic of man-made, transformed or injured objects. Its value depends on the direction and intensity of both technogenic and natural impact. Complete evaluation of technomass could comprise three indices: a) effective work done by enginery (ergotechnical index); b) artificial-ness of the man-made or affected matter; c) technogenic resistance of the object (technogenic life; opposite to the objects submission to renaturalization). As will be shown bellow, this quantitative anthropogenic landscape analysis is also important in physical planning.

POSSIBILITIES FOR LANDSCAPE PLANNING

Landscape development includes a combined effect of autonomous changes and planned steps (Antrop, 1998), because each new state of landscape structure, especially in large areas, is the result of adapted planning mixed with processes of stochastic changes. Presentation of general planning directions for regulating these processes is the main objective of physical planning, especially in the sphere of landscape design.

Landscape design in Lithuanian experience is based on geographical and architectural paradigms (sets of potential criteria and design principles) (Table 2) applied on a number of specific landscape planning models. Realisation of these paradigms in landscape planning depends on the previously mentioned fundamental and applied research advance. Landscape technogenic morphology as a discipline of fundamental science possesses important keys for performing many planning tasks, such as protecting, preserving, controlling, etc., both the structural and emotional potentials of landscape. The main contribution of landscape technogenic morphology to landscape planning is through rendering the knowledge of the distribution and concentration of technogenic elements, their territorial complexes (technotopes), their multiple features such as mass, shape, function, impacts on natural objects, phenomena and processes. Different criteria of landscape structural and emotional potential must be equipped with understanding the different aspects of technogenic complements that can influence the quality and sustainability of the environment and at the same time the decisions for its control and improvement.

As the types of landscapes to be dealt with are unequal in respect of functional priorities, the differentiation of planning and management means in the planning process was achieved by introducing a system of landscape

Table 2. **Landscape design paradigms and the forms of the application of landscape technogenic morphology in landscape design**
2 lentelë. **Kraðtovaizdþio formavimo paradigmos ir technogeninës morfologijos pritaikymo kraðtovaizdþio formavimui bûdai**

Paradigm Paradigma	**Criteria Kriterijai**	**Represented aspects Atstovaujami aspektai**	**Design principles (tasks) Formavimo principai (uþduotys)**	**Objects of technogenic morphology studies Technogeninës morfologijos tyrimø objektas**
		Structural potential Struktûrinis potencialas		
Geographical Geografinë	1. Typological diversity Tipologinë ávairovë	Structurization Struktûrizacija	To preserve and increase the structural diversity of landscape Iðsaugoti ir didinti kraðtovaizdþio struktûrinæ ávairovæ	Types of technogenic territorial units (technotopes) Technogeniniø teritoriniø vienetø (technotopø) tipai
	2. Anthropogenic polarization Antropogeninë poliarizacija			Territorial proportion of technogenic and natural areas Technogenizuotø ir natûraliø plotø santykis
	3. Shape-line complexity Kontûriðkumas			Boundaries between natural & techno-elements Ribos tarp gamtiniø ir technoelementø
	4. “Relief energy”[1] „Reljefo energija“[1]			Technogenic surface slopes Technogeniniø pavirðiø ðlaitai
	5. Technogenic energy[2] Technogeninë energija[2]	Potence Potencija	To regulate and control the energy potential of landscape Reguliuoti ir kontroliuoti kraðtovaizdþio energetiná potencialà	Technogenic patches with potential and kinetic energy domination Technogenizuoti plotai vyraujant potencinei ir/arba kinetinei energijai
	6. Thermal regime Terminis reþimas			Technogenic patches with different insolation Technogenizuoti skirtingos insoliacijos plotai
	7. Hydrological balance Hidrologinis balansas	Physiology Fiziologija	To adapt the activities according to physiological needs of landscape Pritaikyti veiklà kraðtovaizdþio fiziologiniams poreikiams	Regulating hydrotechnical objects Reguliuojantys hidrotechniniai objektai
	8. Geochemical barriers Geocheminiai barjerai			Technogenic patches with different geochemical permeability Technogenizuoti skirtingo geocheminio pralaidumo plotai
	9. Environment trophicity Aplinkos trofiškumas			Anthropogenic desertification patches Antropogeninës dykros
	10. Biomass density Biomasës tankis	Productivity Produktyvumas	To balance territorially the productivity of landscape Teritoriškai subalansuoti kraštovaizdþio produktyvumà	Biomass potential of technogenic patches Technogenizuotø plotø biomasës potencialas
	11. Technomass density Technomasës tankis			Distribution and intensity of technomasses Technomasiø pasiskirstymas ir intensyvumas
	12. Information density Informacinis tankumas			Diversity of technogenic objects and their forms Technogeniniø objektø ir jø formø ávairovë

		Emotional potential Emocinis potencialas		
Architectural Architektûrinë	1. Vitality Gyvybingumas	Vitalics Vitalika	To shape the vital landscape Formuoti gyvybingà kraðtovaizdá	Condition of technogenic objects Technogeniniø objektø bûklë
	2. Expression Raiškumas	Tectonics Tektonika	Preserve and increase the expressivity of landscape Iðsaugoti ir didinti kraðtovaizdþio raiðkumà	Expression of technogenic form, match with natural plastic forms Technogeniniø formø raiðka, darna su gamtinëmis plastiðkomis formomis
	3. Diversity Ávairumas	Signalics Signalika	To sustain the optimal structural diversity of landscape Palaikyti optimalià kraðtovaizdþio ávairovæ	Diversity of technogenic forms and surfaces Technogeniniø formø ir pavirðiø ávairovë
	4. Originality Originalumas	Phenotypics Fenotipija	To individualise moderately shaped landscape structures Individualizuoti neiðsiskirianèias kraðtovaizdþio struktûras	Degree of technogenic object individuality/recurrence Technogeniniø objektø individualumo / pasikartojamumo laipsnis
	5. Harmony Harmoningumas	Composition Kompozicija	To ensure harmonious compositional organization of landscape Uþtikrinti harmoningà kompozicinæ kraðtovaizdþio organizacijà	Visual balance of technogenic objects, their interrelation and relation with natural objects Technogeniniø objektø vizualus balansas, sàveika su gamtiniais objektais

[1] Potential energy depending on relief forms
(nuo reljefo formø priklausanti potencinë energija).
[2] Two types of technogenic energy: 1) potential energy stored in buildings as objects of technogenic relief, and 2) kinetic energy circulating through mobile technogenic objects
(du technogeninës energijos tipai: 1) potencinë energija, sukaupta pastatuose kaip technogeninio reljefo objektuose, ir 2) kinetinë energija, cirkuliuojanti per mobilius technogeninius objektus).

planning models. All landscape planning models, distinguished according to the land use functional priorities, are grouped into three main landscape types – natural, agrarian, and urban. The landscape planning models for each landscape type are listed bellow.

Natural landscapes: 1) natural landscape with priority of conservation, 2) natural landscape with priority of recreation, 3) natural landscape with priority of ecological protection, 4) natural landscape with priority of economy; **agrarian landscapes**: 1) agrarian landscape with priority of conservation, 2) agrarian landscape with priority of recreation, 3) agrarian landscape with priority of ecological protection, 4) agrarian landscape with priority of economy; **urban landscapes**: 1) urban landscape with priority of conservation, 2) urban landscape with priority of recreation, 3) urban landscape with residential and commercial priority, 4) urban landscape with priority of economy.

These models comprise all the possible directions of landscape planning. In the process of this landscape moulding for sustainable co-living of man and nature, the clearly determined conceptions of each landscape planning model must be created and applied in physical planning. Every type of landscape planning model deals with a number of specific vertical and horizontal structures of natural and anthropogenic (technogenic) components. Actually, agrarian and urban groups of landscape planning models comprise mostly technospheric landscapes. This makes the fundamental and applied research of the landscape structure (including the above-mentioned technogenic structure) essential. In respect of landscape planning models technogenic morphology becomes responsible for several investigation tasks, such as search of the optimal structure of technocomplexes, means of harmonisation of technocomplexes and natural environment in every landscape planning model.

On the regional and national levels where the postulates of Master Plan are being constructed, understanding of the landscape technogenic structure enables realisation of several planning tasks. Landscape studies from the point of technogenic morphology have resulted in the complex nationwide technomorphological regionalization (Fig.ure). This kind of research material can be of great support while shaping the national urban frame, as the technomorphological regionalization contains information on the built-up area, road net, etc. On the other hand, this information can be useful in delimitation of the opposite landscape structure – national natural frame, in determination of areas of overlapping/friction between urban and natural frames. Most monuments of cultural heritage are also technogenic objects in the general sense, therefore landscape technogenic morphology has to play an important role in the cultural landscape protection policy as well.

CONCLUSION

Lithuanian experience shows that in the process of landscape research and planning through all the levels (local, regional, national) a scientific approach to understanding the landscape structure represented by multiple types of territorial units (topes) is required. The conception of technogenic territorial complexes – technotopes occupies an important place in the fundamental landscape science as it reflects the most intensive and expressive form of landscape change, which is technogenic transformation.

Analysis of landscape technogenic structure using the methodology of technotopes gave a territorial view of technogenization distribution and concentration. The complex technomorphological regionalization of Lithuania reveals the areas of various built and road net density and land cultivation intensity types.

The results of the research prove that landscape technogenic morphology makes a solid contribution to landscape design paradigms, both geographical and architectural. Dealing with various aspects of landscape technogenic structure, it provides a necessary information and knowledge for a proper understanding of landscape design targets and objectives (preserving, controlling, protecting the constituents of landscape potential). In perspective, landscape technogenic morphology could contribute to developing conceptions of different landscape planning models and to improving the National Master Plan.

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TEORINIAI IR TAIKOMIEJI TECHNOGENINËS KRAÐTOVAIZDÞIO MORFOLOGIJOS ASPEKTAI

Santrauka

Morfologija – tai viena pagrindiniø geografinës kraðtovaizdþio interpretacijos formø. Kraðtovaizdþio morfologijos mokslas, atsiradæs jau XX a. pradþioje, per visà ðimtmetá labiausiai buvo plëtojamas Rusijoje, Vokietijoje, daugelyje Rytø Europos ðaliø. Straipsnyje apibendrinama ilgametë Lietuvos kraðtovaizdþio morfologijos mokyklos patirtis, pateikiami teoriniai kraðtovaizdþio morfologiniø tyrinëjimø pagrindai, bandomos numatyti kraðtovaizdþio morfologijos mokslo perspektyvos, susijusios su morfologiniais kraðtovaizdþio technogenizacijos tyrinëjimais. Teigiama, kad bûtina plëtoti kraðtovaizdþio, integruojanèio skirtingus komponentus (litogeniná pamatà, dirvoþemá, vandenis, oro mases, biotà, þmonijà, technosferà, noosferà), tyrinëjimus, susijusius su didelës tipologinës ávairovës teritoriniø vienetø („topø") iðskyrimu, atsiþvelgiant ne vien á fundamentalaus mokslo, apimanèio tiek morfologines, tiek procesines kraðtovaizdþio savybes, bet ir taikomøjø mokslø, susijusiø su kraðtovaizdþio pritaikymu þmogaus gyvenimui, poreikius. Viena pagrindiniø ðiuolaikinës kraðtovaizdþio geografijos uþduoèiø – iðtobulinti technogeninio kraðtovaizdþio komponento morfologinës analizës metodologijà. Vienas tokios metodologijos variantø buvo pasiûlytas Vilniaus universitete, jos pritaikymo rezultatas – visoje Lietuvos teritorijoje iðskirti ir suklasifikuoti 1969 technomorfologiniai teritoriniai vienetai (technotopai). Tipologinë technotopø analizë tapo technomorfologinio Lietuvos teritorijos rajonavimo pagrindu (pav.); kiekvienas rajonas buvo apraðytas pagal urbanizacijos lygá, keliø tinklà, þemës naudojimo intensyvumà (1 lentelë). Technogeninë kraðtovaizdþio morfologija, kaip fundamentalus mokslas, gali bûti pritaikyta teritoriniam planavimui daugeliu bûdø ir teikti informacijà ávairiems planavimo etapams ir aspektams. Informacinis aprûpinimas reikalingas tiek geografinei, tiek architektûrinei kraðtovaizdþio formavimo paradigmai (atitinkamai – kraðtovaizdþio struktûrinio ir emocinio potencialo palaikymo kriterijams) (2 lentelë).