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FORECASTING THE DEVELOPMENT OF VALLEY AND RIVER LANDSCAPE AND TECHNICAL SYSTEMS OF THE RIGHT-BANK UKRAINE

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The aim of the article. To forecast the development of valley and river landscape and technical systems and consider the possibility of occurrence of negative natural phenomena and processes within them on the example of the Right-Bank Ukraine.

Methods. The research is based on the general scientific paradigm of the model; the principles of geneticism, historicism and natural and anthropogenic coexistence; methods of modeling, extrapolation, landscape analogues, phenomenon, and expert evaluations.

Research results. The formation of valley and river landscapes and landscape and technical systems is under the influence of natural and anthropogenic factors. Their combined effect impedes the landscape and technical forecast. At the same time, it is possible due to the consideration of perspective plans for hydropower development, water, land or transport management. The attention is focused on the fact that even the most accurate prediction of the development of the system is «crossed out» by acquiring it the properties of the emergence. The analysis of emergencies on hydrotechnical structures of the world shows that in the valley and river landscape and technical systems of the Right-Bank Ukraine there are also risks of occurrence of negative natural phenomena and processes (flooding, flooding, landslides, villages, channel deformations, secondary salinization, secondary waterlogging and forest fires). Taking into account the history of development and the present state of the anthropogenic landscapes of the Right-Bank Ukraine, the author suggests an attempt to forecast changes in valley and river landscape systems for the next 10–15 years. It is noted that in the valleys of large rivers (Dnipro, Dnestr, Southern Bug, Danube), most of the valley and river landscape systems will be maintained at the stage of functioning. In the valleys of the middle and small rivers, the system will evolve in two directions: the transition from the stage of operation to the stage of «destruction» and the transition from the «destruction» stage to the stage of functioning of the geocomponent system.

It is concluded that the developed map of the landscape and technical forecast of the development of valley and river landscape and technical systems of the Right-Bank Ukraine should be used in the activity of control units (both at the national and local levels). By controlling the areas of river valleys with the possible manifestation of negative natural phenomena and processes, it is possible to prevent them from occurring and save significant funds for the elimination of the consequences.

Key words: anthropogenic landscape, landscape and technical system, valley and river landscape, forecast, optimization.

Introduction. Strengthening anthropogenesis and progressive increase of techno-substances in the landscape area of the planet cause an urgent need to optimize anthropogenic landscapes, the vast majority of which are represented by landscape and technical systems (LTCS). Forecasting the development of such systems is an essential condition to organize rational natural resources management. In this case, the landscape and technical forecast plays an important role and is aimed at predicting possible changes in the structure of the LTCS. Its fundamental difference from the landscape forecast grounds on the choice between the component, which is not taken, the block structure of the landscape. It complicates the definition of the future transformation of the LTCS, as it requires the simultaneous consideration of the development of the following three varied blocks: natural, technical and managerial.

Valley and river landscapes of the Right Bank Ukraine have undergone a long and comprehensive economic impact. Over the past century, the valleys of the

Dnipro, the Dnister, the Pivdennyi Bug, and the Dunay have become the paleo landscapes for the establishment and functioning of modern valley and river landscape and technical systems (VRLTCS). In the context of the global environmental and socioeconomic crisis, they are gradually degrading at the regional level. Constructively grounded forecasting will promote rational planning of economic and environmental activities. In the context of the VRLTCS research, the landscape and technical forecast will help to calculate the origin, formation, and destruction of their blocks.

The analysis of recent studies. The experience of developing a landscape and technical forecast is based on the ideas of such foreign geographers as V. Preobrazhenskyi, L. Kunitsyn, L. Mukhina, V. Anoshko, K. Diakonov, and F. Milkov. Among the domestic scientists, the problems of forecasting were dealt with by representatives of a number of Ukrainian landscape studies schools. Famous scientist G. Miller substantiated the forecast of the development of dynamic phenomena in natural and territorial complexes during the researches of mountain and foothill areas [Miller, 1974]. Another researcher P. Shyshchenko, while developing applied aspects of physical geography, predicted the salt regime of landscapes under the influence of projected land reclamation and hydrotechnical structures [Shyshhenko, 1988]. G. Schvebs and O. Svitlychnyi predicted the development of natural and economic systems for agroecological monitoring on the example of the southern regions of Ukraine [Shvebs, Svitlychnyi, 1987, Shvebs, 1993]. In the context of the synergetic paradigm, K. Pozasheniuk analyzed the principles of forecasting for the geoecological expertise of natural and economic systems [Pozacheniuk, 1998]. Scientist M. Grodzynskyi made landscape and ecological forecasting of the development of geosystems that were transformed by man [Hrodzynskyi, 1993]. In the context of the synergetic paradigm, K. Pozashenyuk analyzed the principles of forecasting for the geoecological examination of natural and economic systems [Pozachenjuk, 1998]. Making geo-information and geo-ecological modeling V. Samoylenko predicted the state of the urban basin geosystems on the example of Kyiv [Samoylenko, Veres, 2007, Samoylenko, Dibrova, 2012]. Studying anthropogenic landscapes of the Right-Bank Ukraine, G. Denysyk and his followers attempted anthropogenic landscape forecast of this territory [Denysyk, 1998, 2001, 2012, Denysyk, Valchuk, 2005, Denysyk, Babchynska, 2006].

Foreign scholars in different geographical areas are interested in the issues of forecasting the development of transformed landscapes. P. Haff, introducing a new section of geomorphology – neo-geomorphology, takes into account the combined effect of physical, geographical and anthropogenic processes to determine the future of the global landscape state [Haff, 2001]. The latest developments in the field of geographic information technology are used to predict the future state of geographic objects. T. Beechie and H. Imaki develop models for the development of channels in the basin of the Columbia River (USA) for geomorphological control [Beechie, Imaki, 2014]. Scientists from India calculate the risks of flooding as a result of the sharp rise of the water level of the Himalayan rivers [Devrani et al., 2015]. Chinese geographers investigate the current influence of the Three Gorges Dam on adjacent landscapes and predict their future development [Lin Chu et al., 2018].

Materials and methods. The basis for the article is the material of many years field observations conducted within the framework of Vinnytsia School of Anthropogenic Landscape Studies under the guidance of G. Denysyk [Denysyk, 1998, 2001, Denysyk, Valchuk, 2005, Denysyk, Babchynska, 2006]. The author's contribution grounds on analyzing the structure and development of volley and river landscape and technical systems of the Right Bank Ukraine [Lavryk, 2011, 2015], which lasted for 2007–2018. The prediction of the development of the LTCS is based on the general scientific pattern of the model and the principles of geneticism, historicism and natural and anthropogenic compatibility. There are no universal landscape and technical forecasting methods. In the process of determining the possible development of LTCS methods of modeling, extrapolation, landscape analogs, expert assessments, etc. are combined.

The aim of the article is to forecast the development of valley and river landscape and technical systems and consider the possibility of occurrence of negative natural phenomena and processes on the example of the model region – the plain part of the Right-Bank Ukraine.

Results and discussion. At the beginning of the 21st century the river valleys of the Right-Bank Ukraine remained the places of significant concentration of technical systems landscape, with no or gradually lost control unit. In such circumstances, the role of professionals who are able to predict future changes in the structure and dynamics of the transformed landscape is growing. A well-known landscape expert and researcher of hydraulic engineering systems K. Diakonov believes that, the main task of forecasting in physical geography is to «determine the trends of the Earth's landscape layer as a whole and its separate parts and components ...» [Diakonov, 1972]. In the context of engineering landscape science development as a scientific direction, it is worth focusing on landscape and technical systems, the structural organization of which is complicated by the combination of geocomponents, technosubstances and society.

The formation of valley and river landscapes and landscape and technical systems takes place under the influence of two different types of factors – natural and anthropogenic. Natural factors include three main ones: tectonic, climatogenic and biogenic. And though they operate unitedly, at the same time, each of them can play a leading role in the development of a separate class of natural landscapes. Thus, a tectonic factor played the main role for the valley and river landscapes at the initial stages of the development of the planet. Many river valleys are genetically confined to faults of the earth's crust.

Tectonic activity accelerates the formation of a longitudinal equilibrium profile, reduces the basis of erosion and affects the power and direction of the water flow. Climatogenic factor manifests itself in the change of pluvial epochs, cooling or aridization of the climate, which also enhances or slows down the development of valley and river landscapes. A striking example of the climatogenic factor manifestation is valleys buried under the sands of the African rivers or the tropes of the Scandinavian Peninsula laid by glaciers. In some cases, the combined action of the biogenic and climatogenic factors leads to successions, which are manifested in the transformation of rivers into swamps, and so on. In some cases, the combined action of the biogenic and climatogenic factors leads to successions, which are manifested in the transformation of rivers into swamps, and so on.

Unlike natural, anthropogenic factor carries out influence locally, at different speeds, increasing or weakening depending on the needs of society. The combined effect of natural and anthropogenic factors hinders the forecast of the development of valley and river landscape and technical systems. At the same time, the landscape and technical forecast of the LTCS is possible due to the consideration of perspective plans for hydropower development, water, land or transport management. Changes in valley and river landscape and technical systems under the influence of anthropogenic factor (or after it has stopped its influence) will occur in accordance with the direction of development of the categories of LTCS: engineering and technical construction (ETCC) → landscape engineering system (LES) → landscape technogenic system (LTS) → actual anthropogenic landscape (AAL). This can be manifested at different levels: local – the emergence of new aqua facies and tracts after the construction of hydrotechnical structures; regional – the formation of large areas of peatlands on the site of drained Polissya marshes; and planetary – the complete transformation of the Aral Sea into saline plain.

There are diametrically contrary views on the development of landscape forecast. So, K. Pozacheniuk supports the principle of nonlinearity in the development of systems, in which «at certain stages some conditions are created which are favorable for the development of several subsystems in the geosystem, and the choice of dominant depends on random deviations at the points of bifurcation, which determines the further structure. Accordingly, the development of geosystems does not always depend only on its past and present, therefore, the forecast scheme «past – present – future» is not enough» [Pozacheniuk, 1998].

F. Milkov and G. Denysyk deny the «flexibility and multivariance» of landscape forecast, as it can lead to negative effects of human influence on the landscape. In their opinion: «the forecast should be ... exact «hard» only then it will be real and correspond to reality» [Milkov, 1973]. Taking into account both aspects, the author believes that even the most accurate forecast of the development of LTCS «is crossed out» by acquiring the property of the emergency by the system. In addition to this aspect there is a possibility of military emergencies (such as armed conflict in eastern Ukraine). This makes the landscape and technical forecast (like any other) imperfect.

In the history of economic development of valley and river landscapes there were many cases of negative emergence manifestation of landscape and technical systems. Significant catastrophes associated with the destruction of oarsmanships and dams were noticed on the rivers the Huanghe, the Yangtze, the Mississippi, the Missouri, the Danube and the floodplains of the Netherlands. Failure to consider the stability of building materials by the designers, unsuccessful calculations of the parameters of structures, and most importantly – the natural conditions, which formed the landscape and technical system, lead to the destruction of LTS and human victims. According to the International Commission of Large Dams (ICOLD), about 3 thousand accidents occur annually in the world at hydroelectric power plants [Malik, 2009]. Often bridges of LTCS as strategic objects are destroyed purposefully in the course of terrorist attacks or hostilities. A separate threat is accidents at nuclear power plants, plants and factories, the construction of which is timed to river valleys with the purpose of using water for technological processes.

The analysis of emergencies in hydraulic structures shows that they are mainly in zones of seismic activity and over-humidified climate. On the territory of the Right-bank Ukraine there are also risks of negative natural phenomena and processes in valley and river landscape systems (table 1).

Table 1

Possible manifestations of negative natural phenomena and processes in the valley and river landscape and technical systems of the Right-Bank Ukraine

№ з/п	Negative natural phenomena and processes	Emergent causes of occurrence	Localization of manifestation of negative natural phenomena and processes within:	
			anthropogenic zones	river basins
1.	Flooding	Change of flood regime of	Forest and pasture	The basins of the

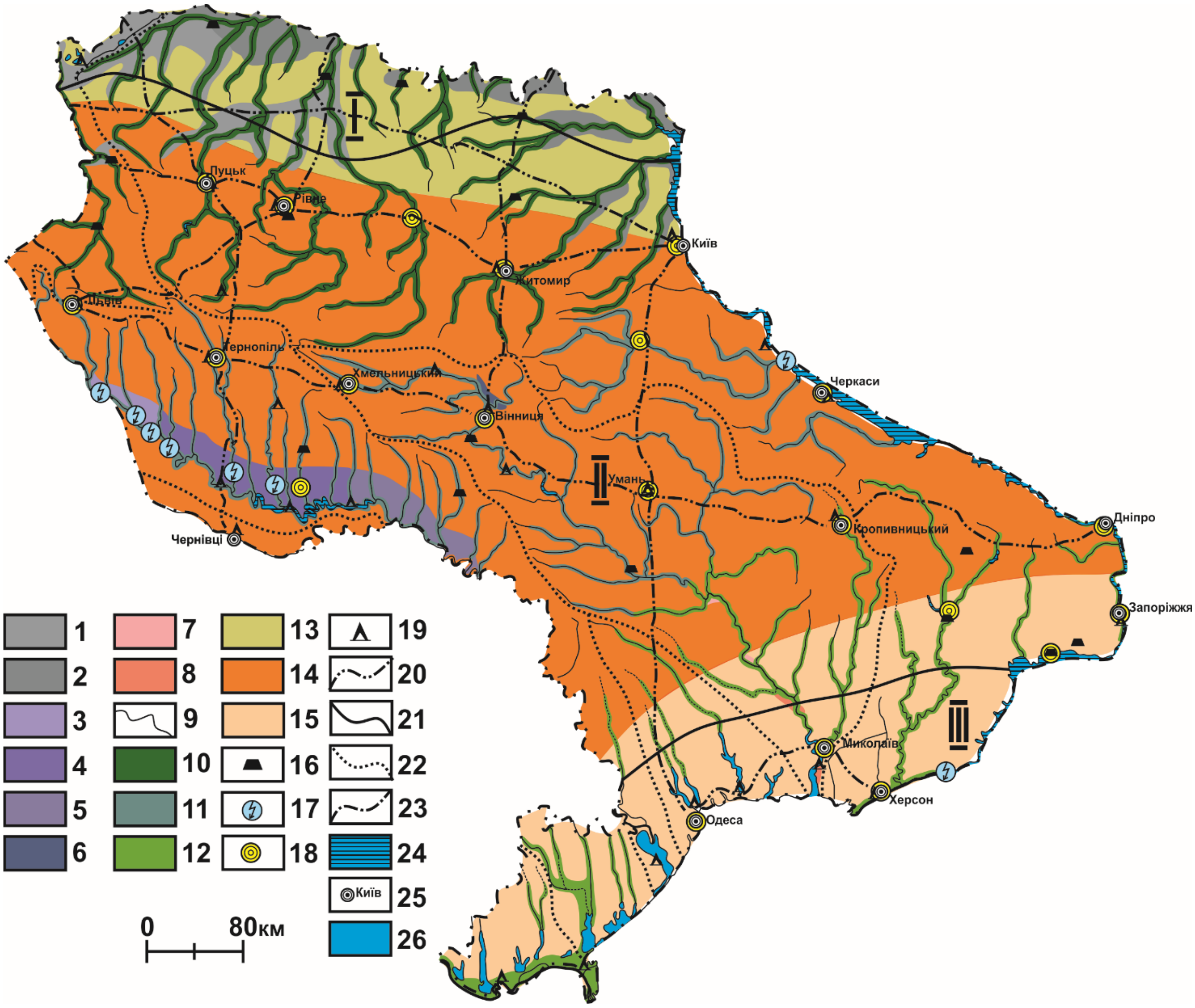
		rivers; the formation of odd, but powerful floods; ice congestion; instability of engineering constructions	zone, northwest of the forest and field zone, south of the field zone	Dnipro, the Vistula, the Dniester and the Danube
2.	Saturation	Changing the conditions of surface and underground drainage; infiltration of groundwater	Forest and pasture zone, forest and field zone	The basins of the Dnipro, the Vistula, the Dniester and the Southern Bug
3.	Landslides	Violation of equilibrium of rocks; permanent drainage of the banks of reservoirs; overflow of soils; destruction of vegetation and soil cover of the valley	Forest and pasture zone, forest and field zone	The basins of the Dnipro, the Vistula, the Dniester and the Southern Bug
4.	Torrents	Destruction of vegetation and soil cover of the valley; change in the density of rocks; increase slope steepness	West of the forest and field zone	The basins of the Dniester and Prut
5.	Ridge deformations	Flushing of the bottom and shores of the stream in the lower pounders; lifting of bridge supports; accumulation of alluvium in the zone of variable support of water and in the upper pounders	West of the forest and field zone	The basins of the Dniester and the Prut
6.	Secondary salinization	The rise of mineralized groundwater due to the laying of irrigation canals	Field zone, south of the forest and field zone	The basins of the Dnipro, the Dniester, the Southern Bug
7.	Secondary waterlogging	Rise of groundwater level, sedimentation and overgrowth of drainage channels with vegetation	Forest and pasture zone, north of the forest and field zone	The basins of the Dnipro, the Vistula, the Dniester and the Southern Bug
8.	Forest fires	Lowering the level of groundwater due to the laying of drainage channels	Forest and pasture zone, north of the forest and field zone	The basins of the Dnipro, the Vistula, the Dniester and the Southern Bug

The current state of the natural and technical units of the LTCS of the Dnipro reservoir creates a significant problem. In particular, in the bottom sediments of Kiev reservoir there is an accumulation of about 90 million tons of loose radioactive sludge accumulated since 1986 after the Chernobyl accident. In case of the dam's breakthrough the radioactive material can enter the reservoir, which is located below the flow. According to experts, the dam of Kaniv reservoir is fractured due to serious violations of the reinforced concrete structures materials use [Bondar et al., 2014].

Anti-flood dams of the Dnipro, the Danube, the Dniester and the Prut rivers have been used for more than 50 years and require immediate reconstruction. Outdated equipment of pumping stations on rivers detached from the Dnipro reservoirs can cause flooding of the territory with an area of 190 thousand hectares and 150 settlements [Natsionalna…, 2012]. Sudden thaws in the Prydnisteria and active ice drifts gradually destroy bridges in the Dniester Valley. Therefore, when developing the forecasting of valley and river landscape and technical systems it is always necessary to consider their technogenic origin and the emergence of possible dangerous situations.

All changes in the landscape structure of certain regions should be reflected in predictive landscape maps with an exact network of modern engineering and technical structures and landscape complexes. This will make it possible to compare the magnitude of the future transformation of landscapes. The basis for creating a map for forecasting the development of valley and river landscape systems is the schemes of basin zoning and division into anthropogenic zones of Ukraine [Denysyk, 1998]. Superposing, they create a single genetic series of projected landscape maps. Taking into account the history of development and the current state of the anthropogenic landscapes of the Right-Bank Ukraine, the author proposes an attempt to forecast changes in the LTCS (pic. 1) for the nearest 10–15 years. This is the most optimal kind of forecasting. This is an indicative period when, in the absence of control between the natural and technical units of the typical LTCS (reservoir, pond, channel), stable interaction is established. Crisis and emergency intervention at this stage in the course of the system development allows restoring its functional suitability.

Landscape and technical systems of the valleys of the middle and small rivers of the Right-bank Ukraine will develop in two directions: 1) transition from the stage of functioning to the stage of «destruction» (LES → LTCS); 2) from the stage of «destruction» to the stage of functioning of the geocomponent system (LTCS → AAL). In the first case, the sections of roads with bridges, flood dams, ponds with dams, residential buildings, reclamation channels will pass into the category of «landscape and technogenic systems», in which the control unit is presented occasionally. In the second one – the remains of «water» mills, small hydroelectric power stations, river channels, etc. will be completely destroyed. Control over the majority of such LTCS has never been restored since the termination of use in the national economy (from the middle of the 20th century). The full functioning of the VRLTCS in the valleys of the middle and small rivers is possible narrowly and depends on the blocks of the territorial communities' management.



***Picture 1.* Map of forecasting the development of valley and river landscape and technical systems of the Right-Bank Ukraine (for the next 10–15 years)**

Natural landscapes: 1 – sandy terraces, hilly-wavy, with sod-weakly podzolic sandy soils, mostly under the arches; 2 – sandy terraces, flat-wavy and hilly, with sod-weakly and medium podzolic sandy soils, under the island's arches and sub-basins, with lowland swamps; 3 – high Dniester terraces with chernozems lydzilnymi and dark gray forest soils, island oak groves; 4 – high Dniester terraces, dissected by valleys, cut into Paleozoic deposits, with gray and dark gray lydized forest soils, deep black soil, hornbeam owls; 5 – high Dniester terraces, dissected by valleys, cut to crystalline rocks, with gray and dark gray podzolennymi soils, island oak and hornbeam owls; 6 – sand terraces with sod-podzolic soils, with hornbeam sub-basins; 7 – sandy terraces with turf soils, in combination with pale saline soils, with steppe borers and suboras; 8 – forest terraces, with chernozems in the southern part of the low-humus in the complex with salinized, in the past under fescue-keuvial vegetation; 9 – streams, formed by aquatic plots of rumble and ples; 10 – forest and meadow-swamp floodplains; 11 – forest, meadow-calcareous and salt-flooded floodplains; 12 – smooth, meadow-steppe saline-solonchakite floodplains.

Areas of forecasting: 13 – Areas of change of landscapes as a result of construction of drainage VRLTCS channels; 14 – areas of change of landscapes through liming and waterlogging of pond and reservoir VRLTCS; 15 – areas of landscape change due to the construction of VRLTCS channels irrigation; 16 – areas of formation of new or expansion areas of existing industrial VRLTCS; 17 – new hydropower VRLTCS; 18 – expansion of residential areas of VRLTCS; 19 – areas of formation of new or expansion of areas of existing recreational VRLTCS; 20 – changes of valley and river landscapes as a result of construction and reconstruction of road VRLTCS.

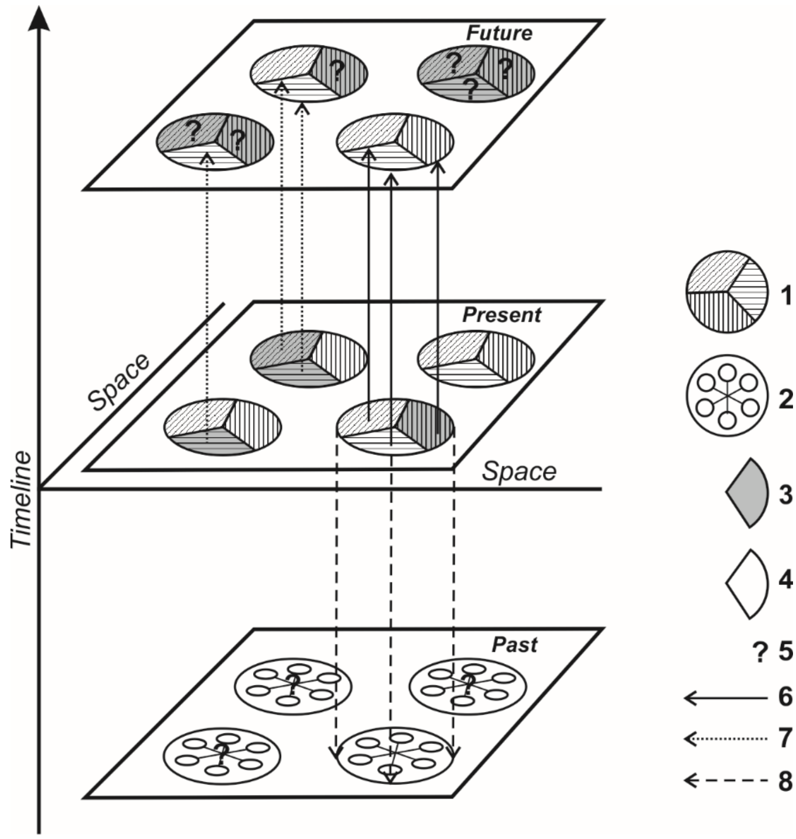
Borders: Landscapes. Anthropogenic: 21 – zones. **Basin:** 22 – watersheds. **Conditional:** 23 – regions of research.

Other marks: 24 – reservoir LTC; 25 – city LTCS (administrative centers); 26 – lakes and estuaries.

Anthropogenic zones: I – forest and pasture zone; II – forest and field zone; III – field zone.

In the zonal relation, the valley and river landscape of the forest grassland and northern woodland areas will undergo changes as a result of the impact of past drainage reclamation. This will be manifested in overdrying, secondary waterlogging and possible forest fires [Bal'kovskiy, 2009, Tsaryk, Tsaryk, 2016]. In the central part of the woodland zone, the processes of steppe formation and waterlogging of pond-flood areas will predominate. In the south of the woodland and field zones, changes in valley and river landscapes will occur as a result of the operation of irrigation canals (secondary salinization, soil compaction, drainage of estuaries). In the future, the problem of degradation of the natural landscapes of small rivers valleys, which will gradually disappear as a result of climate irregularities [Pylypenko et al., 2002, Sytnyk, 2009] and antropogenic pressure [Denysyk, 2012], will become particularly acute. All this together determines the urgency of the protection of anthropogenic valley and river landscapes and the development of possible directions for their optimization.

The forecasting specificity of VRLTCS optimization (pic. 2) lies in taking into account its morphological structure at the initial stages of its origin, the present state of the blocks and the integrated impact on all its components in the future. If we propose ways to improve the status of only a single block, then such a forecast will be futile in advance. After all, the effectiveness of the system depends on the complementary activity of all units. And the calculation of the future state of only technogenic cover or one of the geocomponents does not guarantee the full functioning of the VRLTCS. Failure to predict generates a multi-variation of possible system changes. This, in turn, leads to uncertainty about its further activity and inefficient use in the national economy.



Picture 2. **The scheme of forecasting optimization of the development of a typical VRLTCS**

1 – landscape and technical system; 2 – geocomponent system; 3 – unsatisfactory condition of the block; 4 – optimal condition of the block; 5 – unknown (multi-variational) state of a block or system; 6 – probable forecast; 7 – unreliable forecast; 8 – analysis of the previous state of the system.

Conclusion. Stable tendencies in the destruction of the VRLTCS in the valleys of the small and middle rivers of the Right Bank Ukraine predetermine the need to develop areas of nature conservation, preservation of existing and creation of new protected objects. The developed map of the landscape and technical forecast of the development of valley and river landscape and technical systems should be used in the activity of control units (both at the national and local levels). By controlling the areas of river valleys with the possible manifestation of negative natural phenomena and processes, it is possible to prevent them from occurring and save significant funds for the elimination of the consequences.

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Григорій Денисик, Олександр Лаврик. Прогнозування розвитку долинно-річкових ландшафтно-технічних систем Правобережної України.

На основі попереднього досвіду розроблено прогноз розвитку долинно-річкових ландшафтно-технічних систем Правобережної України. Зазначено, що формування долинно-річкових ландшафтів і ландшафтно-технічних систем проходить під дією натурального та антропогенного чинників. Їх сукупна дія перешкоджає ландшафтно-технічному прогнозу. Разом з тим, він є можливим завдяки врахуванню перспективних планів гідроенергетичного розвитку, водного, земельного або транспортного господарювання. Акцентовано увагу на тому, що навіть найточніше прогнозування розвитку системою «перекреслюється» набуттям нею властивості емерджентності. Аналіз надзвичайних ситуацій на гідротехнічних спорудах світу показує, що у долинно-річкових ландшафтно-технічних системах Правобережної України також є ризики виникнення негативних природних процесів і явищ. Враховуючи історію розвитку та сучасний стан антропогенних ландшафтів Правобережної України, автори пропонують спробу прогнозу змін долинно-річкових ландшафтно-технічних систем на найближчі 10–15 років. Зазначено, що в долинах великих річок більшість долинно-річкових ландшафтно-технічних систем будуть утримувати на стадії функціонування. У долинах середніх і малих річок системи розвиватимуться у двох напрямах: перехід з стадії функціонування до стадії «руйнування» та перехід від стадії «руйнування» до стадії функціонування геокомпонентної системи. Зроблено висновок про те, що розроблену карту ландшафтно-технічного прогнозу розвитку долинно-річкових ландшафтно-технічних систем Правобережної України варто використовувати у діяльності блоків управління. Контролюючи ділянки річкових долин з можливим проявом негативних природних процесів і явищ, можна запобігти їх виникненню та заощадити значні кошти на ліквідацію наслідків.

Ключові слова: антропогенний ландшафт, ландшафтно-технічна система, долинно-річковий ландшафт, прогноз, оптимізація.

Григорий Денисик, Александр Лаврик. Прогнозирование развития долинно-речных ландшафтно-технических систем Правобережной Украины.

На основе предыдущего опыта разработан прогноз развития долинно-речных ландшафтно-технических систем Правобережной Украины. Отмечено, что формирование долинно-речных ландшафтов и ландшафтно-технических систем проходит под действием натурального и антропогенного факторов. Их совместное действие препятствует ландшафтно-техническому прогнозу. Вместе с тем, он возможен благодаря учету перспективных планов гидроэнергетического развития, водного, земельного или транспортного хозяйственного пользования. Акцентировано внимание на том, что даже самое точное прогнозирования развития системы «перечеркивается» приобретением им свойства эмерджентности. Анализ чрезвычайных ситуаций на гидротехнических сооружениях мира показывает, что в долинно-речных ландшафтно-технических системах Правобережной Украины также возможен риск возникновения негативных природных процессов и явлений. Учитывая историю развития и современное состояние антропогенных ландшафтов Правобережной Украины, авторы предлагают попытку прогноза изменений долинно-речных ландшафтно-технических систем на ближайшие 10–15 лет. Отмечено, что в долинах крупных рек большинство долинно-речных ландшафтно-технических систем будут удерживать на стадии функционирования. В долинах средних и малых рек системы будут развиваться в двух направлениях: переход от стадии функционирования к стадии «разрушения» и переход от стадии «разрушения» к стадии функционирования геокомпонентной системы. Сделан вывод о том, что разработанную карту ландшафтно-технического прогноза развития долинно-речных ландшафтно-технических систем Правобережной Украины следует использовать в деятельности блоков управления. Контролируя участки речных долин с возможным проявлением негативных природных процессов и явлений, можно предотвратить их возникновение и сэкономить значительные средства на ликвидацию последствий.

Ключевые слова: антропогенный ландшафт, ландшафтно-техническая система, долинно-речной ландшафт, прогноз, оптимизация.