LANDSLIDE COMPLEXES IN LANDSCAPES OF THE DAGESTAN REPUBLIC AND THEIR ENVIRONMENTAL OPTIMIZATION

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The article analyzes, how landslides influence on landscapes, regards the questions of the landscape changes under the influence of landslides, structure and elements of landslide complexes in landscapes, classification of landslide complexes in landscapes, criteria of landslide landscapes, environmental optimization of landslide landscapes under condition of environmental monitoring.
Keywords: landslide, landslide process, landslide landscape, landslide complexes in landscapes, landslide region, environmental optimization of landslide landscapes

The question of the landslide-affected landscapes is an important part of environmental studies on landslides. Terrain and hydrology of landslide regions let regard a landslide landscape as a special ecosystem, as the landslip areas receive, with due time, vegetative ground cover and turn from a geomorphological structure into a natural complex. Of course, landslides have a different influence on various elements of landscapes. Firstly, the landslide forms a morphological sculpture. Terrain-forming role of landslides is the most strong in the area of accumulation, where block slides move as the water stream cuts the lower part of slopes and activates smaller landslides, mostly in the stream channel of valley [1], also causing cave-ins in some areas. In streambeds of Dagestan's small and big rivers, one can observe erosions of alluvial-proluvial deposits and original channels of mountain streams. Outburst of lakes, formed by landslides, as well as break of side alluvial cones, blocking the valley are also reported. Water streams activate block landslides, ancient landslide deposits, mud avalanches in tongue parts of modern landslides, small landslides in areas close to river channel and occasionally cave-ins. Sometimes, ancient landslide masses move recurrently along the channel. Landslides influence the flora considerably: they either destroy it on their way or damage it significantly. Landslide surfaces get covered with specific vegetation.

Landslides do not only affect some elements of a landscape, but also form specific natural territories. In our opinion [3], it is necessary to develop a stability theory of mountain slopes. Therefore, besides considering separate elements of landslide structures, it is essential to study the structure of natural complexes and their environment.

The structure is closely connected with the functioning, which runs under the influence of geosystems of a higher order. Earlier, we have [3] defined three types of landslide slope development: 1) pre-landslide; 2) landslide; 3) post-landslide, which describe the direction and changes of the slope stability. Each phase of the slope development is characterized by specific features of functioning.

According to susceptibility to landslides, Dagestan's landscapes could be divided into interfluvial and valley-fluvial. Landscape morphological structure, functioning and dynamics change differently under the influence of soil slips [2, 3]. For example, the soil slips in interfluvial areas change the local morphological structure of landscapes, in connection with ground water draining and formation of hydromorphic landscapes.

Especially strong transformations, caused by soil slips, down to disturbances in the morphological structure of an original landscape and its substitution with a new one, happen on steep slopes of river valleys. The process can be clearly observed in the valleys of the Samur, Kurakh, Akhtychay, Usukhchay and Gulgerichay rivers. Slope landscapes of river valleys get a new development dynamics (Fig. 1).

Figure 1. Landslide, which fell from the Akhalchi range and dammed the valley of the Mochokhtolar River, inducing the formation of the Mokhochsky Lake (Khunsakhsky region).

Landslides play a relatively small landscape-forming role on accumulative terraces, as they happen rarely there. According to D.A. Lilienberg [5] and I.N. Safronov [6], morphological structure of landscapes changes a lot on terrace cusps, divided by ravines in areas of river or water reservoir abrasion.

Landslide landscapes can form in alluvial plains under the following conditions: presence of clays, covering alluvial plain depth; wash; excessive water saturation of alluvial plains with their drift soils and herb meadows. Dynamic landscape transformations can be seen in flood plain cusps, where landslides are active [7], though weak and water-logged. They are characterized by a simple landscape structure.

It is important to mention the role of landslides in formation of ravine structures in the Southern Dagestan and, in particular, their landscape structures, functioning and dynamics. There is no doubt, that landslides play an extremely important role in formation of slope ravine landscapes. According to the observations in the Shur-dere area (interfluvial area between Gulgerichay and Korchagsu), the structure of the erosive relief and landscape in general has changed under the influence of landslides. Many parts of avines are destroyed, substituted by butte landforms, which are typical for the morphological structure of ravine ecosystems.

Landslides in Dagestan are influenced by zonal and regional natural factors. Landslide zonal distribution means their dependence on the seasons of the year and climate

zones. When the conditions differ from the normal ones in this zone, it creates favorable prerequisites for a landslide process.

Regional differentiation of landslide landscapes is complex and diverse, and depends on multiple reasons, first of all, history of territorial development in the neogene quaternary period, including modern time [4]. This let follow up the contouring of the lithogene base of the regional landslide systems.

In areas with homogenous geological structure, landslides usually have common morphology and formation scheme. Such landslides belong to the same category or a limited number of regional types. In our opinion [2], regional landslide peculiarities should be analyzed within the boundaries of physical geographical areas in the republic, as they have more or less similar physical and geographical conditions. Borderlines of the physical geographical areas in Dagestan can be taken as limits of landslide regions. **Landslide region** is a historically formed and genetically common territory, characterized by specific natural conditions and human activities, which determine the intensiveness and direction of the andslide development, current relief and morphological structure of the landscape [3].

This approach should also be action-oriented and provide the basis for anti-landslide measures, in accordance with the regional environment.

There are many landslide classifications, developed by geologists, hydrogeologists and geomorphologists, but there is no classification of landslide systems in landscapes. Basing on causes of landslides, we [3] can define the following genetic types of *landslide areas* in Dagestan*:* а) seismogenic; б) hydrogeologenic; в) hydrogenic; г) climatogenic; д) biogenic; е) polygenic (mixed).

Every genetic type of landslide system includes the kind of landslide area, which differs in vegetative and soil cover, which is the most dynamic and is necessary for the landscape environmental approach to landslide studies. At the same time, it is important to consider the successive character of landslide vegetation.

Two types of landslide landscapes can be distinguished in Dagestan*:* natural and anthropogenic. The latter can be divided into two further classes*:* natural-anthropogenic and anthropogenic as such. Both categories of the landslide ecosystems have an anthropogenic genesis, but they differ in duration of anthropogenic effects. A landscape of anthropogenic origin, where human interference continue, form the group of anthropogenic landscapes. A landscape, which experienced human influence only in the past and develops further naturally, belongs to the natural-anthropogenic group. But, if a landslide was an object of technical anti-landslide measures, it turns into a natural-technical system and should be considered as an anthropogenic one.

The diversity of natural-anthropogenic landslide areas and their expansion mechanisms is determined by the kind of human activities in the landslide risk areas.

We offer a classification of the natural landslide areas in Dagestan, which can be also used to distinguish genetic types of natural-anthropogenic landslide systems in landscapes, with the difference, that instead of the natural landslide causes, one regards human activities, for example, earthquakes – vibration, wash – slope cutting and etc. As a result, we can define the following genetic types of natural-anthropogenic landslide complexes in landscapes:

a) natural-anthropogenic landslide complexes in landscapes, caused by slope cutting during road building, linear erosion due to sewage waters and reservoir abrasion;

b) natural-anthropogenic landslide complexes in landscapes, caused by blasting operations in mines, vibration, seismic effects in reservoir areas;

c) natural-anthropogenic landslide complexes in landscapes, caused by ground water activities due to input of sewage waters;

d) natural-anthropogenic landslide complexes in landscapes, caused by extreme

water saturation of soil as a result of human activities;

e) natural-anthropogenic landslide complexes in landscapes, caused by human influence on biochemical processes in soil, which activate microorganism activity, affecting the mineral composition and rock fineness;

f) polygenic (mixed).

Despite of the different origin, development schemes of natural and natural-anthropogenic landslides are very similar, especially at the mature phase of development.

Environmental optimization of landslide landscapes depends on their formation factor and low quality degree of acultured landscapes, and requires a complex and differentiated approach.

Environmental optimization of landslide landscapes in the republic should, in our opinion [3], go in three directions: regional, typological and paradynamic (paragenetic), under condition of environmental monitoring [8].

Regional environmental optimization of landslide systems in landscapes bases on a great variety of landslide complexes, determined by the environment and human activities in the area.

Anti-landslide measures should depend, first of all, on intensiveness and effects of landslides, which will let avoid mistakes and unnecessary expenses.

Besides, every region uses its own criteria for planning anti-landslide measures. They are completely different in, for example, Izvestnyakovy and Slantsevoy regions of Dagestan, or in the republic's humid piedmont Northwest and arid piedmont Central part. This is determined by differences in lithogene base, humidity factor, landslide power and etc.

Regional approach to environmental optimization of landslide-affected landscapes is closely connected with local natural resource use and territorial structure of agriculture, aimed at revision of agricultural lands according to the landslide risk. In this respect, it is vital to register the landslide-affected lands, which are listed as miscellaneous in official documents.

Typological approach to environmental optimization of landslide systems in landscapes in the republic should, in our opinion [3], include a thorough diagnostics and search for the landslide main reasons and mechanisms. Clearing the main cause can provoke self-elimination of all other secondary factors.

The typological approach to the environmental optimization bases on the genetic classification of landslides, which distinguishes natural and natural-anthropogenic landslide areas with different morphological structure, functioning and dynamics. The next step includes planning anti-landslide measures. The main of them are anti-erosion plowing of slopes and phytomelioration.

Paradynamic approach is applicable to the environmental optimization of river basins and ravines, which landscapes were transformed under the influence of landslips together with some other exogenous processes. Environmental optimization of ravines should consider their diversity, level of the slope stability, as well as stability of their relief structure and landscape in general. In this case, the environmental optimization focuses on the morphological structure, which can be made stable by means of agro-, forest- and hydro-melioration measures in the whole drainage basin. At the same time, there can exist landslides of different genesis within one ravine, which requires different anti-landslide steps.

To sum up, basing on the regional distinctions, classification of landslide systems and complexity of their morphological structure, it is essential to choose the most efficient way of the environmental optimization, which would not disturb the hemostasis, i.e. the mechanism, providing relative dynamic stability of the system. Approaches to the environmental optimization of natural-anthropogenic landslide systems in landscapes are the same as for the natural ones, but with due account for their anthropogenic genesis.

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