



Assessment of landscape transformation and ensuring stability in river basins (a case study of the Fergana valley)

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Abstract. This thesis analyzes the transformation of landscapes in the river basins of the Fergana Valley, its causes, and manifestations. Proposals and recommendations have been developed to address the changes and ecological issues that have arisen to ensure the sustainability of the landscapes. The analyses present scientifically based solutions for maintaining the ecological stability of landscapes and improving their current state.

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Key words: landscape transformation; sustainability; ecological issues; river basins; Fergana Valley; ecological analysis; anthropogenic impact; natural balance.

1. Introduction.

Under the influence of anthropogenic pressure, qualitative and quantitative changes in landscapes are becoming increasingly evident around the world. In particular, in recent decades, the complexity of ecological and socio-geographic processes has been observed in Central Asia, especially in the Fergana Valley. This situation is especially noticeable in river basins. The natural landscapes of river basins are changing dramatically under the influence of various factors, their ecological functional capabilities are decreasing, and this is manifested in the form of landscape transformation. After all, landscape transformation is a change in the structural, functional and dynamic characteristics of the natural environment as a result of human activity and natural changes. This thesis analyzes the essence, causes and consequences of these changes.

The Fergana Valley is one of the most densely populated and intensively developing socio-economic regions in the Central Asian region [7; 25]. The increasing pressure on the natural resources of this region, especially water and land reserves, makes it necessary to conduct a thorough analysis of the landscape transformation taking place in river basins and to reconsider the principles of sustainability. To fully understand this process, it is important to analyze the theories of landscape transformation studied on a global scale, cartographic assessment methods, and foreign experience.

River basins are dynamic structures of the

natural environment, which should be considered not only as a hydrological system, but also as a complex landscape unit in which climate, geological structure, soil, flora and fauna, and human activity are harmoniously combined. This approach has been formed as one of the leading directions in the scientific schools of the USA, Canada, Germany, China, and Japan. For example, in a dissertation study conducted by Weng (2007) in the Little Miami River Basin in Ohio, USA, fragmentation of landscape structure and changes in the hydrological regime were analyzed using modern cartographic methods [5]. His research showed that urbanization, infrastructural expansion, and agricultural intensification around river basins significantly deteriorate the quality of water resources, which undermines landscape stability. A similar situation exists in the Fergana Valley. Anthropogenic changes are occurring particularly rapidly in river basins, in particular in the Kosonsoy, Podshootasoy, Sokh, and Karadaryo basins. The sharp expansion of irrigated agricultural areas, artificial river flow management, construction of hydraulic structures, and most importantly, water shortages caused by climate change in water catchment areas (mountain glaciers, snow zones) are disrupting the natural balance of the landscape system in these areas.

In foreign literature, such transformations are described as “landscape degradation stages” or “transitions from balanced functional landscapes to systems under anthropogenic stress”. For example, L. Turner (2010) in his dissertation analyzed the impact

of climate change and water infrastructure on biodiversity in river basins in Southeast Asia and proved that landscape ecosystems do not have the potential to recover [3,26]. When applying this approach to the conditions of the Fergana Valley, especially in the Shahimardonsay basin, such indicators as the reduction in the number of biological species, the reduction of foothill forests, and the increase in soil salinity in the last decade confirm these conclusions.

An approach based on cartographic analysis methods allows us to determine landscape transformations spatially and in a modern way. S.S.Dyshlyuk highlighted the aspects of sustainability based on transformed areas in river basins [6]. This approach allows us to form a system of indicators of ecological sustainability: the amount of water resources, the level of erosion, biodiversity, the physicochemical properties of the soil and the level of anthropogenic load, among others.

However, the outdatedness of existing monitoring systems, the lack of integrated management of land resources, and the insufficient application of scientific approaches in practice accelerate the degradation of landscapes. In this regard, the Canadian scientist G. Brown [1] says in his study: "Sustainable landscape management is effective only in cases where it can ensure a balance of not only ecological factors, but also social and economic interests." This principle can be applied in the conditions of the Fergana Valley.

2. Material and Methods.

In this article, changes in their areas are analyzed using geographical comparison, historical analysis, and cartographic methods based on data from 1970 and 2018.

3. Results.

The causes of landscape transformation are specific to the basin. Fergana Valley This situation, first of all, leads to excessive use of water resources. As a result of the expansion of irrigated agricultural lands, the construction of numerous irrigation and drainage networks, river flows have been artificially controlled. This disrupts the natural rhythm of the river ecosystem [8]. At the same time, the construction of hydraulic structures (reservoirs, canals, dams) leads to water shortages in the lower reaches of rivers, which leads to the reduction of natural landscapes dependent on water (meadows, reed beds, groves).

As the graph shows, landscape transformation is directly related not only to anthropogenic factors, but also to natural and geographical conditions, in particular, climate change. In recent years, the Fergana Valley has experienced a decrease in precipitation, an increase in temperature, which leads to a lengthening of the drought period. As a result, glaciers and snow cover in water catchment areas located in mountain and foothill zones are shrinking, which negatively affects the sources of nutrition of rivers.

The combined impact of human activity and climate change is leading to an increase in the ecological load on river basins. This load is already exceeding the limit of sustainability. Excessive use of fertilizers and pesticides in agriculture, discharge of industrial and household waste into rivers - all this leads to chemical pollution of land and water resources. Landscape transformation is a complex, multi-stage process, which in most cases develops slowly. However, its consequences can be profound and long-term. In particular, in the form of soil erosion. Due to the reduction of vegetation cover and improper land use, soil washing, i.e. erosion, is increasing. This is accelerating processes such as reduced productivity, salinization and sand deposition.

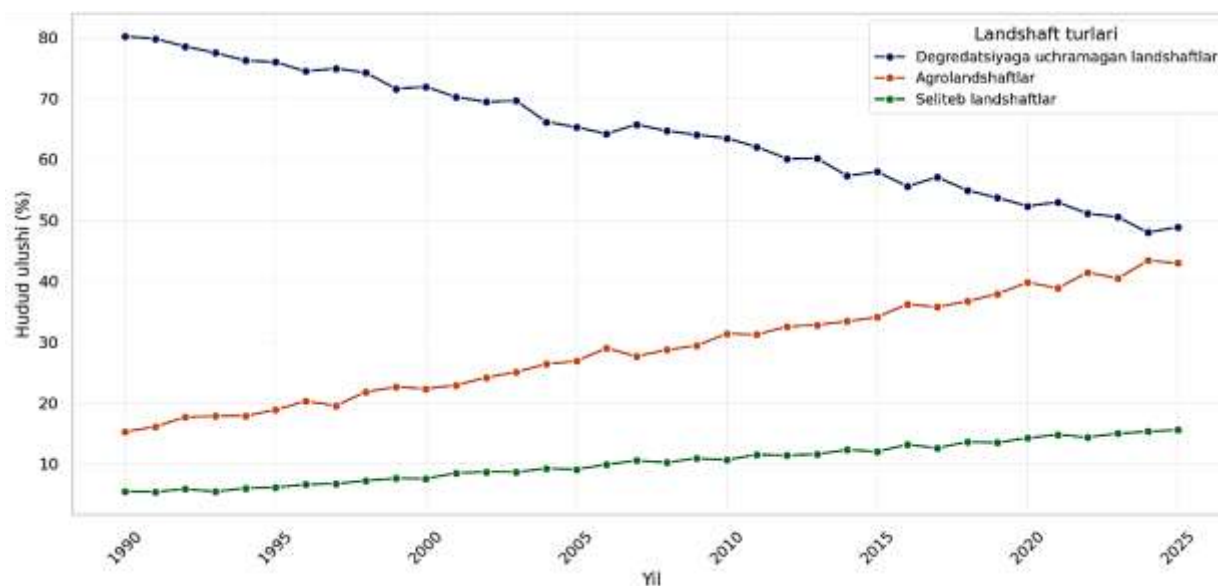


Fig. 2. Changes in landscape composition in the Fergana valley river basins from 1990 to 2025

4. Discussions.

The decline in biodiversity is also critical. Along with the deterioration of water quantity and quality, changes in the hydrological regime, in turn, are leading to a decrease in hydrophyte and mesophyte species. Some plant and animal species are losing their habitat. Another manifestation of this is the decline in water levels and salinization. Groundwater levels have decreased in several places, and in other areas, salinization has increased as a result of improper irrigation. This is especially observed in the hilly zones around the Syrdarya basin. In general, the area of natural landscapes in the Fergana Valley has been shrinking for more than 30 years, and anthropogenic pressure has been increasing (Figure 2). It should be noted that if this process continues, the stability of landscapes will be sharply disrupted and the tolerance coefficient will become negative. This will only cause problems. Undegraded landscapes In the 1990s, these landscapes accounted for about 80% of the total area. By 2025, this figure had decreased by almost 2 times. This decrease is explained by population growth, increased demand for irrigated land, and the conversion of forests and natural pastures to agriculture.

This situation is also noted in the scientific literature. In particular, it has been determined that in the transboundary river basins of Kazakhstan, Kyrgyzstan, and Uzbekistan, landscape structures changed by 25–35% in 1990–2020 [8]. In this regard, in order to maintain natural balance, it is necessary to establish nature conservation areas (such as reserves, national parks, reserves, and natural monuments) in the basin. On the contrary, the area of agro-landscapes has expanded sharply. Agrolandscapes, which accounted for about 15% of the basin in 1990, are expected to reach almost 45% by 2025.

This increase is due to the expansion of irrigation systems; the transition to intensive farming; and the demand for cotton, wheat, and melon crops. In this regard, studies conducted in Germany (Schröder & Hagedorn [4], 2018) have shown that the excessive expansion of agrolandscapes leads to disruption of hydrological regimes, a decrease in biodiversity, and an increase in the risk of erosion. Another aspect is that the areas occupied by settlements - seliteb landscapes - are even “eating” agrolandscapes. In particular, these landscapes increased from 5% to around 20% during the period 1990–2025. The migration of the population to cities, the construction of new housing estates, the development of roads and other infrastructures ensured this. As shown in foreign dissertations (for example, Liu [3], on the example of the Yangtze River basin in China), urbanization increases ecological pressure in river basins, and the concreting of lands disrupts the natural cycle of water flow.

To ensure natural stability, it is necessary to create a landscape monitoring system, modernize the technologies of the agroecological approach to farming, introduce a system of environmental payments, and plan urban construction based on ecological assessment. Thus, landscape transformation in the river basins of the Fergana Valley is not only an ecological problem, but also a complex process that directly affects socio-economic stability. To stop or mitigate this process, the integration of cartographic, scientific and institutional approaches is necessary. The restoration of transformed basins will be an important guarantee of ensuring regional ecological security.

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