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Research on the dynamics of the South Fergana landscapesscientific and theoretical issues

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Abstract. This paper examines the scientific and theoretical issues underpinning the dynamics of landscapes in the South Fergana region. Building on interdisciplinary literature in landscape ecology, geomorphology, and land-use science, the study synthesizes drivers and processes that shape landscape change-climatic variability, irrigation and drainage management, soil salinization, erosion, urbanization, and agricultural intensification. It reviews conceptual frameworks for understanding landscape dynamics (landscape metrics, hierarchical patch dynamics, socio-ecological systems, and resilience theory) and evaluates methodological approaches including historical cartography, field surveys, remote sensing, GIS-based change detection, and landscape modelling. The paper highlights how the interaction of natural processes and human activities produces spatially heterogeneous outcomes: loss of productive land through salinization and erosion, fragmentation of natural habitats, and altered hydrological regimes. Key theoretical challenges are identified: integrating fine-scale process understanding with regional-scale patterns, coupling biophysical and socio-economic drivers in predictive models, and developing indicators that are both scientifically robust and policy-relevant. Finally, the study outlines priorities for future research and practice-improved long-term monitoring, participatory approaches to land management, nature-based solutions for reclamation and resilience, and policy instruments that align agricultural productivity with ecological sustainability. The paper aims to provide a clear theoretical foundation to inform applied research, landscape planning, and sustainable development strategies in South Fergana and comparable irrigated valley systems.
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Key words: South Fergana; landscape dynamics; landscape ecology; land degradation; soil salinization; irrigation and water management; socio-ecological systems; resilience; land reclamation.

1. Introduction.

In the 20th century, as a result of the sharp increase in the population and their impact on the surrounding landscape complexes, the expansion of the area of landscape complexes created by human activity on the surface of the Earth accelerated sharply. Under the influence of such factors as the growth and expansion of cities and villages, the sharp increase in arable land, the construction of automobiles and railways, natural landscapes were replaced by landscapes created by human hands and intelligence. Their widespread distribution on the surface of the Earth led to the emergence and rapid development of a separate branch of landscape science - anthropogenic landscape science.

The scientific and theoretical issues of landscape research are related to the study of the structure, origin, functioning, dynamics and change of terrestrial landscapes. They include the analysis of the natural components of the landscape, such as relief, climate, water, soil, flora and fauna, as well as the study of the interaction of these components and their impact on the environment. In addition, landscape science studies the impact of human activity on landscapes, including anthropogenic and natural-anthropogenic landscapes.

The three main levels of human impact on nature - local, regional and global - have today become a complex set of closely interconnected problems. Often, the main reason for this situation is the deliberate interference of man in the dynamics of geosystems, the violation of the rules of interaction with them. However, an equally serious problem is the fact that the dynamics and functional laws of natural geosystems, their interaction with human society, have not yet been sufficiently scientifically studied. To solve the problems of rational nature use, it is necessary to determine in what direction, at what speed and in what specific forms the properties of the landscape are changing - both in space and time. However, this issue is not easy to solve, since landscapes undergo significant changes in the process of their natural development as a result of human economic activity.

2. Material and Methods.

The landscape as an open, dynamic, space-time system meets the important tasks of theoretical and applied research on landscape and ecology. This approach implies the need to take into account the time factor, which can be considered from a natural-historical (genetic) and experimental-transformational perspective. The study of the inventoried features of the landscape structure, the laws of their functionality and dynamics opens up ways to justify the types of landscape use, determine the norms of loading.

Another scientific center dedicated to the study of landscape dynamics was formed in the Caucasus region. In 1965, research conducted at the Tbilisi State University under the leadership of Beruchashvili introduced new approaches to the study of the dynamics of geosystems. This approach was based on physical-geographical methods, and the functional relationships between components and the state of the PTC were studied with precision. The scientist proposed to determine the state of the landscape within geohorizons through the total volume indicators of aero-, hydro-, litho-, pedo-, mort-, phyto- and zoomass.

In the second half of the 20th century, interest in the time factor in geographical research increased significantly. The scientific direction "Study of time and movement in the landscape" was developed by scientists such as A.G. Isachenko, D.L. Armand, E. Neef, Y. Demek and A.A. Krauklis. These studies laid the foundation for the scientific analysis of the interrelation of time and space in landscapes through such categories as development, processes, equilibrium, stability, genesis and succession.

The development of the language of landscape science has occurred not only through the creation of new methods and concepts, but also through the adoption of interdisciplinary terms. For example, concepts such as "time", "motion", "change" came from philosophy, terms such as "organization", "state", "activity" came from the systematic approach, and "dynamics", "characteristic time", "invariant" came from physics and mathematics.

The concept of “landscape dynamics” was first introduced into scientific circulation about 40 years ago, initially expressing any changes in the landscape in a general way. VBSochava interpreted this concept as “a set of processes occurring in modern geosystems (under external or human influence) and leading to their various transformations” [19. P. 58].

Richard Forman stated that " landscape dynamics is the change in landscape elements and their spatial relationships over time under the influence of natural and anthropogenic factors. In particular, the location of various elements (forests, fields, water bodies) and the ecological connections between them are the main dynamic forces of the landscape."

Andrew Goudie "landscape dynamics are more related to geomorphological processes (erosion, deflation, wind, water flows) and human activities enhance these processes. Dynamics is the sum of changes that are formed under the influence of the constant movement of the earth's crust and the climate in arid regions."

Werner Konold "Landscape dynamics are a product of cultural evolution and occur throughout history in connection with human activity. At each historical stage, the landscape takes on a different appearance." German scientist K. Troll, on the other hand, assessed the landscape as an ecological system and explained its dynamics by linking it to energy flows, anthropogenic loading, and climatic rhythms.

In recent years, the temporal component, along with spatial factors, has been deeply integrated into the dynamics of landscapes. The landscape is now being analyzed not only as a spatial, but also as a space-time system. According to the concept of A. Gettner, space and time are two inseparable elements of existence, which should be analyzed not separately, but in an interconnected manner.

F.N. Milkov defines landscape dynamics as “all functional, spatial and structural changes occurring in the natural-territorial complex.” He distinguishes the following three main types of landscape dynamics:

1. Chorological dynamics (represented by the spatial change of the boundaries of landscape complexes);
2. Structural dynamics (manifested by changes in the morphological structure of the landscape complex);
3. Temporal dynamics (includes dynamic processes in the landscape that are temporal, continuous, and rhythmic in nature (functional dynamics, cyclical, diurnal, seasonal, periodic, and fluctuating)).

3. Results.

This classification gives the impression that all types of dynamics appear independently of each other. However, they are all closely interconnected, and this aspect should not be overlooked in scientific analyses. The issues of studying the dynamic changes, ecological situation and dynamics of the landscapes of South Fergana under the influence of human economy are covered in the scientific research works of A. Abdulqosimov, A. Rafikov, A. Maqsudov, Yu. Sultanov, I. Abdug'aniyev, R. Kuziyev, V. Rafikov, Yu. Ahmadaliyev, B. Kamalov, K. Boymirzayev, R. Kholikov , K. Tojiboyev , O. Abdug'aniyev, O. Mirzamahmudov, A. Nazarov, O. Kuziboyeva, V. Fedorko , E. Soliyev, I. Soliyev, H. Abduvaliyev, I. Mirzahmedov and others .

The theoretical foundations of landscape dynamics research cover the following areas:

– The landscape is studied as a whole system, in which each component (soil, water, climate, vegetation) is interconnected. In South Fergana, this approach is used to analyze the impact of relief on erosion, soil fertility, and the distribution of water resources.

– GIS technologies are an important tool for monitoring and mapping landscape changes. The use of GIS in tourism zoning in the Fergana Valley has proven to be effective in assessing the state of landscapes and predicting future prospects.

– In South Fergana, agriculture (e.g., pomegranate, grape, and cotton) and urbanization are having a major impact on landscape change. For example, pomegranate development programs are aimed at creating new varieties adapted to soil and climatic conditions and optimizing agrotechnical measures.

– The protection and rational use of landscapes is a key goal of sustainable development. The work carried out in South Fergana to protect reserves and natural monuments serves to maintain the ecological balance of landscapes.

– Changes in temperature and precipitation in South Fergana are affecting the hydrological and geobotanical characteristics of landscapes.

– Urbanization, agricultural intensification, and industrial activity are leading to soil erosion, water depletion, and landscape degradation. Rational management of water and soil resources, especially in irrigated areas, is essential to ensure landscape sustainability.

Studying the dynamics of the landscapes of South Fergana is important for analyzing changes occurring under the influence of natural and anthropogenic factors and ensuring sustainable development. Theoretical approaches are based on methods such as GIS, systematic analysis and modeling. Activities in the field of agriculture, urbanization and tourism of South Fergana have a significant impact on the state of landscapes.

Due to the connections between components and between regions, new natural geographical processes are being formed in South Fergana , the accumulation of some substances and the depletion of others are observed. In particular, salinity in the soils of all river deltas in the territories of our republic has a tendency to increase. The importance of intensive development and agrotechnical measures carried out by people in the emergence and formation of the landscapes of this region is of great importance. Although the landscapes of South Fergana are considered anthropogenic landscapes formed as a result of the transformation and adaptation of natural landscapes, they can also turn into completely degraded landscapes due to the incorrect impact of humanity on nature. Such processes arise as a result of the development of landscape-ecological problems in the research object.

Historical sources indicate that in South Fergana there were settlements with dense populations engaged in irrigated agriculture from ancient times. As a result of irrigation work carried out over the years, salinity in the soil has increased, groundwater levels have decreased, and sand dunes have taken over agricultural lands. Productive landscape complexes are being replaced by degraded landscapes, which we can see reflected in the following stages (Table 1).

Table 1. **Formation of the ecological situation of the landscapes of South Fergana and their dynamic changes**

Periods	Ecological situation and dynamics
The era before human activity	- At this stage, significant morphological and functional changes are observed in natural landscapes. Natural ecosystems that initially existed in their original state are gradually transformed by the introduction of human activity. As a result, cultivated areas appear on the surface of the earth, and the structural and functional composition of landscapes changes radically. - the natural vegetation cover is reduced, and in some places it disappears completely. This, in turn, leads to a narrowing of the composition and distribution area of the fauna. The disruption of the ecological balance is accompanied by a decrease in biodiversity. - although the soil layer at this stage still retains a relatively natural state, it is already beginning to be affected by anthropogenic pressure. The amount of humus (humus) is lower than in natural ecosystems, the humus layer is thinner. Soil fertility is low, large-scale agro-irrigation systems have not yet been formed, and artificial irrigation basins are not clearly visible. - the microclimate characteristics do not yet differ sharply from the microclimate of natural landscapes. That is, climatic factors such as air temperature, humidity, and wind continue in a natural rhythm, with only local changes observed. - population settlement during this period was relatively sparse, limited mainly to land-based activities - animal husbandry and primitive agriculture. Although human activity has not yet

	fully begun to affect landscape structure and ecological stability, it is emerging as a major transformative factor for the following stages.
The beginning of human activity	- At this stage, the process of culturalization is further accelerated, and the formation of anthropogenic landscapes is stabilized. Cultivated crops are planted on large areas, the natural vegetation cover is gradually narrowed, and many wild plant species are replaced by cultivated agrophytocenoses. As a result, the phytocenotic structure changes, and the stability of ecosystems shifts to a state controlled by humans. - the animal world also undergoes a significant transformation at this stage. Wild animals leave their habitats or move to new, less anthropogenically affected areas. At the same time, some animal species adapt to cultural landscapes and become synanthropic. As a result of the intensification of animal husbandry and agriculture, human breeding of animals and a change in the gene pool are observed. - positive changes also occur in the soil layer. As a result of constant tillage, the use of fertilizers and improved water supply, the amount of humus increases, the humus layer thickens, which significantly increases soil fertility. Irrigation systems are developed, agroirrigation beds are formed. As a result, cultivated soil types characteristic of agrogeosystems are formed. - population density increases significantly at this stage, the number of settlements increases, settlements are interconnected, and large agricultural areas emerge. Along with farming and animal husbandry as the main types of activity of the population, light industry and enterprises serving agriculture (for example, cotton ginning, milk processing, seed centers) are formed to support them. - microclimate characteristics also change significantly under the influence of anthropogenic factors. The relative humidity in the air increases, evaporation increases, and the water cycle intensifies. As a result of the expansion of irrigated lands, a specific distribution of precipitation occurs in the microclimate due to increased humidity and evaporation. Thus, cultural landscapes are formed and are characterized by new ecological and climatic conditions.
Anthropogenic pressure period	- By this stage, the impact of anthropogenic factors on oases will sharply increase, and these territories will undergo complex changes. Dense population density, accelerated urbanization processes, and improper use of natural resources will lead to a disruption of the ecological balance. As a result, various environmental problems will develop in the environment - land degradation, depletion of water resources, air pollution, and loss of biodiversity. - as a result of the increase in the number of industrial enterprises, the expansion of infrastructure (roads, communication networks, transport lines), the densification of urban and rural settlements, natural landscapes are completely replaced by anthropogenic landscapes. This leads to a reduction in wild flora and fauna, the complete extinction of some species. The natural functions of ecosystems are disrupted and the negative consequences of anthropogenic transformation are intensified. - As a result of increased agricultural intensity and excessive exploitation of water resources, the soil cover is completely transformed into a cultivated form. Agro-irrigation beds are significantly thickened. In some places, especially as a result of damage or inefficient operation of collector-drainage systems, salinization (secondary salinization) in soils increases. This, in turn, leads to secondary waterlogging of lands in some regions. Such situations lead to a reduction in arable land and a decrease in productivity. - microclimate changes are becoming more intense, and local climate characteristics are changing as a result of anthropogenic impact. Air temperatures are increasing, temperature ranges are expanding, and in some places the amount of humidity and dust is increasing. This has a negative impact on human health and the animal world. - the share of anthropogenic landscapes increases to the maximum, but at the same time, degraded landscapes are formed, which are damaged or become unusable. This situation creates the need to restore the landscape-ecological balance and introduce sustainable landscape management.

Source: Compiled by the author using historical literature and cartographic sources.

Such changes are reflected in all components of the landscape complexes (Fig. 1). The structure of the surface of South Fergana is extremely diverse. The surface can be divided into several hypsometric steps (zones). Its northern part is a plain, through which the Syrdarya flows. The northern part of South Fergana is occupied by the Syrdarya ridges, terraces I, II and III, and on the surface of the high terraces, sand dunes occupy a considerable area. Their height does not exceed 5-15 meters. The largest sand massifs here are the Yozyavon and Karakalpak deserts. Now most of the sand dunes have been leveled and converted into arable land. Several large rivers originate from the mountain ranges surrounding the region, most of which dry up before reaching the Syrdarya. They form large expanses in their lower reaches. The spreads intersect, forming alluvial-proluvial plains.

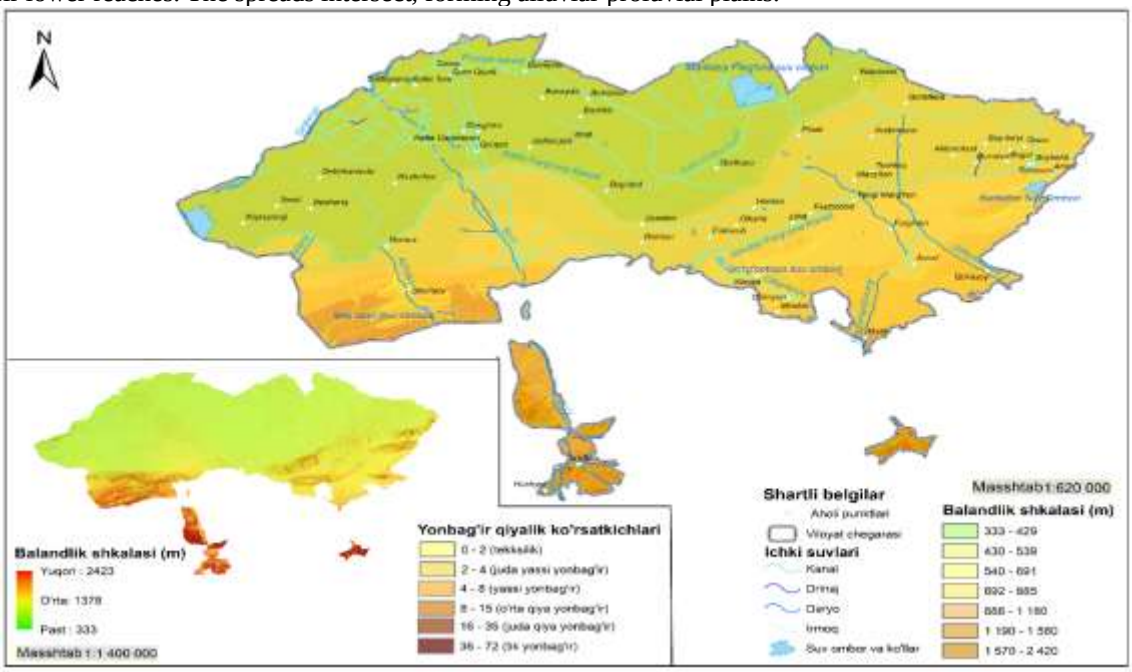

Fig. 1. Altitude regions of South Fergana map

If we analyze this map, the slopes of the Aloy Range, such as Qatronbashi, Khaydarkan, Nazar, Kyzylgaza, Almalyk, Ispisar, Belmazor; the slopes of the Turkestan Range, such as Kampirkoq, Guzan, Burgan, Kyzylsuv, Kulantog', Suratbashi, Aktash, Kyzylqiyok, are located in the South Fergana region. The height of these mountains ranges from 900 to 2800 meters, the highest point is located in the Sarykkamysh mountain range in the Sokh district (2817 m).

Most of the sand dunes have now been flattened and converted into farmland. Several large rivers originate from the mountain ranges surrounding the region, most of which dry up before reaching the Syr Darya. They form large flatlands in their lower reaches. The flatlands connect with each other, forming alluvial-proluvial plains .

4. Conclusion.

In conclusion, the results of comprehensive ecological and hydrogeological studies conducted in South Fergana show that the main sources of anthropogenic pollution in this region are the irrigation system of agricultural lands, the activities of industrial enterprises, and various wastes from households. In particular, it is important to scientifically study the negative impact of industrial enterprises on the ecological environment, strengthen their monitoring, and establish continuous, systematic scientific research and ecological assessment work aimed at eliminating their negative consequences.

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