

# Mapping of Anthropogenic Impact on the Landscapes of the Middle and Upper Zones of the Ak-Buura River Basin

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**Abstract.** The article considers the possibilities of mapping the anthropogenic impact on the landscapes of the Ak-Buura River basin using remote sensing and GIS data. Ak-Buura is a river of great importance in providing drinking and irrigation water to the city of Osh and most of the Osh agglomeration. The growth in the number and recreational needs of the population, the development of minerals, the construction of new roads and the reconstruction of highways have repeatedly increased the burden on natural resources in recent years. As a result, an increase in the intensity of land use for economic needs in the upper and middle zone of the river basin affects the stability of natural and anthropogenic landscapes. Their mapping will make it possible to create operational maps in order to monitor landscape changes and prevent possible environmental disasters.

## 1 Introduction

Thematic mapping includes geoinformation water-ecological mapping, considering the system of interactions of water bodies, their catchment areas and the anthropological impact on landscapes and the environmental problems caused by them. Of course, geo-ecological mapping at the present stage involves the widespread use of satellite image data and their processing by software tools of geoinformation systems to obtain digital maps. The availability of remote sensing data makes it possible to update maps published in the past, as well as create operational maps to monitor changes in the natural and anthropogenic landscape of the river basin. In the article, we give an overview of the landscapes of the upper and middle zones of the Ak-Buura River basin, on the maps we built in GIS and calculated the anthropogenic load using the "population density" indicator.

The Ak-Buura River (kirg. Ak-Buura daryasi, eng. Ak-Buura River) is a river in Kyrgyzstan and Uzbekistan, it is a left tributary of the Shakhrikhansai. The length of the river is 148 km, and the catchment area covers 2,540 km<sup>2</sup>. The long-term average flow rate of the river at the Tuleiken hydropost (the southern border of Osh) is 21.4 m<sup>3</sup>/sec, the inflow to the overflow water (June - July) is 50-67 m<sup>3</sup>/sec, in low flow rate (January) 5-6 m<sup>3</sup>/sec. The river is formed on the northern slopes of the Alai range at the confluence of the Chal-Kuyruk River and the Sary-Koi River near the village of Ak-Dzhylga at an altitude of 2000 m above sea level. Above the city of Osh, at the beginning of the Dangi Gorge, a dam is built on the

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river, forming the Papan reservoir. At the outlet of the river from the Dangi Gorge, a watershed node has been built, where channels separate from the main channel of the Ak-Buura to irrigate agricultural lands of villages of the Karasuysky region and the city of Osh. Flowing through the city of Osh, the river enters the territory of the Andijan region of Uzbekistan and flows from the left into the Shahrikhan-Sai canal [1].

## 2 Materials and Methods

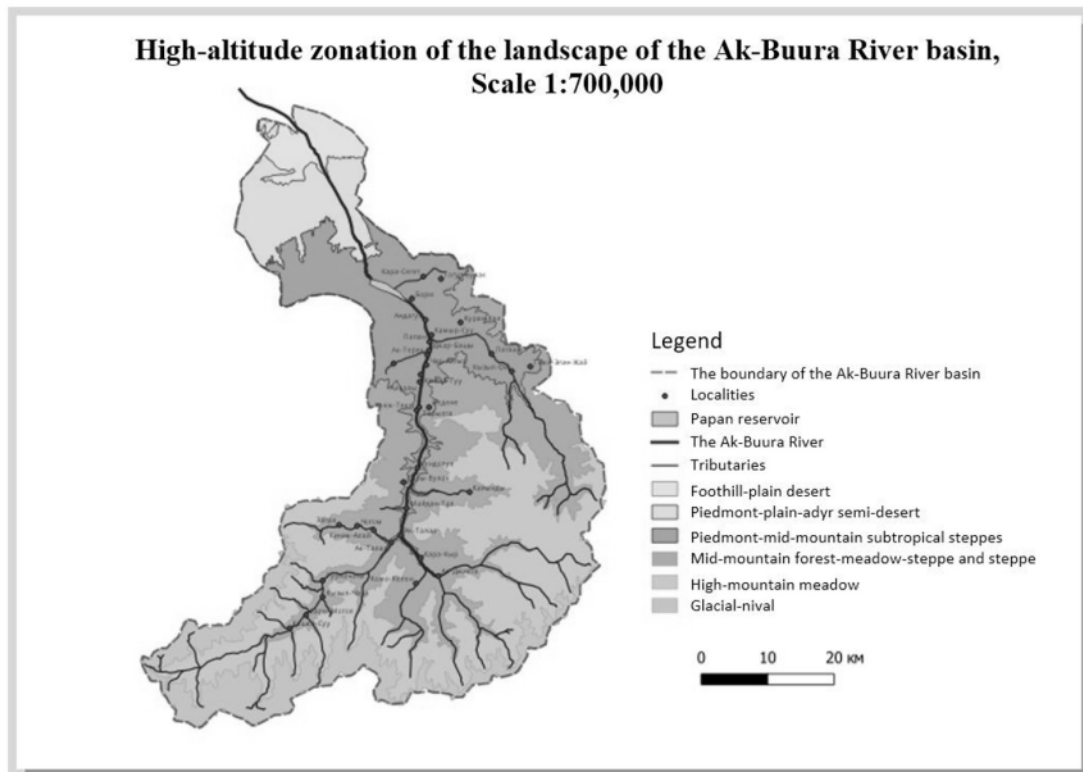
Maps from the Atlas of the Kyrgyz SSR, volume 1 "Natural conditions and resources", collection of the National Statistical Committee of the Kyrgyz Republic "Population and Housing Census of the Kyrgyz Republic 2022", digital topographic maps of the USSR M1:100000 and M1:200000 were used as information materials. The article uses systematic, geo-ecological, landscape-ecological approaches, a set of geographical methods: cartographic, geoinformation, statistical and software tools: QGIS 3.28.11.

## 3 Results and Discussion

The QGIS program used the OpenTopography DEM Downloader plugin to download digital terrain models (DTM) of the Ak-Buura River basin. After processing by software, elevation horizons were obtained after 100 m and after 500 m. The use of analysis tools (spatial operations, vector geometry) made it possible to create digital maps of the zones of the Ak-Buura River basin and the altitude zonality in this selected research area. Also, based on the data of the National Statistical Committee of the Kyrgyz Republic "Population and Housing Census of the Kyrgyz Republic" and the use of the GIS - raster mapping tool, data from digitized topographic maps of the USSR on a large scale were analyzed and the location of settlements were clarified on maps.

**Table 1.** High-altitude landscape zonation of mountainous territories [2]

High-altitude area	Absolute heights (in meters)
Central Asian mountainous country	
Alai-Turkestan (Pamir-Alai) type	
Foothill-plain desert	600-1000
Piedmont-plain-adyr semi-desert	1000-1300
Piedmont-mid-mountain subtropical steppes	1300-2000
Mid-mountain forest-meadow-steppe and steppe	2000-3400
High-mountain meadow	3000-4000
Glacial-nival	4000-5800



**Fig. 1.** Map of the high-altitude landscape zonation of the Ak-Buura River basin

The map was developed based on data from Table 1 to establish the high-altitude landscape zonality of the Ak-Buura River basin. The map shows that most of the river basin consists of piedmont, middle mountain steppes and forest-meadow-steppe and high mountain meadow zones. And these are pastures close to the villages, which are actively used in spring and autumn, as well as woodland pastures, to which cattle are driven in the summer not only from villages in the river basin area, but also from lowland villages and towns. The intensity of the use of natural resources and the closely related state of the environment in the modern era are objectively influenced by two groups of factors: the first is the scientific and technological revolution (STR) and its manifestation in the production activities of human society, the second is demographic factors (population growth, urbanization). Both groups of factors are mutually dependent. On the one hand, the achievement of the STR in the course of production activities is realized by people who simultaneously act as creators of scientific and technological progress (STP). On the other hand, the achievements of the STR objectively affect the increase in the population due to an increase in food production and a decrease in mortality [3].

The map of the physical and geographical zoning of the Ak-Buura River basin was made on the basis of data from the map of the physical and geographical zoning of the Kyrgyz SSR [2], from which data on the river basin were extracted and the boundaries of districts and regions were clarified according to Table 2.

**Table 2.** Physical and geographical zoning of the Ak-Buura River basin[2].

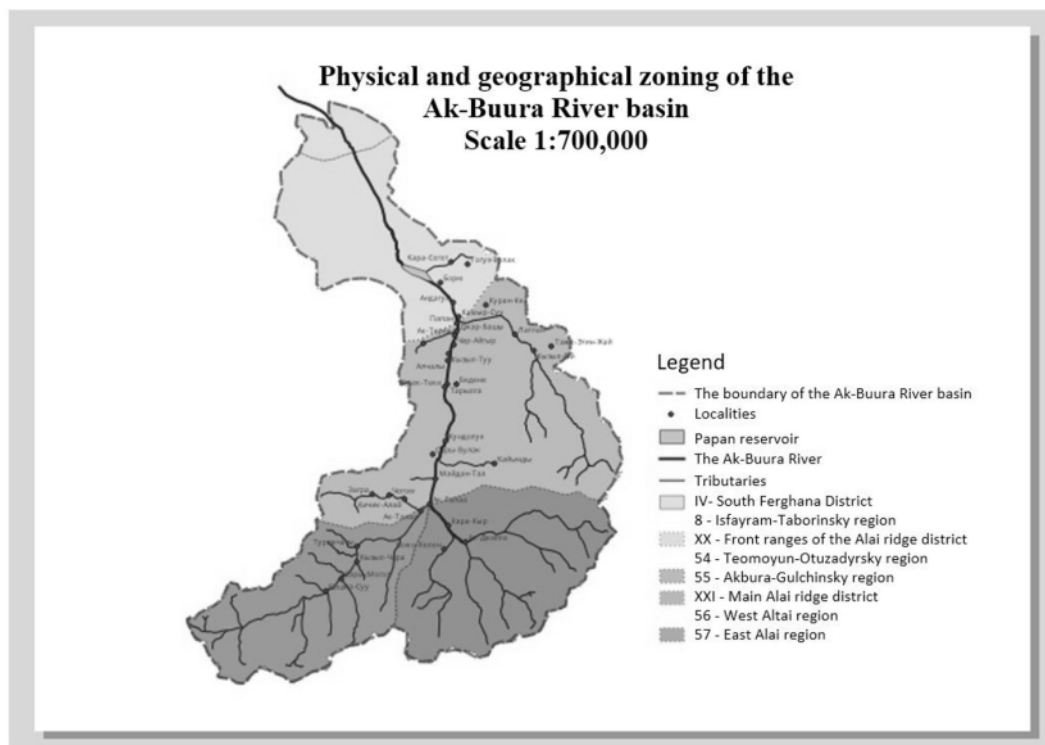
Country	Region	Province	Sub-province	District	Region
<b>A</b> – Central Asian plain country	<b>b</b> - Southern desert zone - transitional to subtropical	<b>b1</b> - Ferghana		<b>IV</b> - South Ferghana	<b>8</b> - Isfayram-Akburinsky

<b>B</b> - Central Asian mountainous country	<b>d</b> - Prifergeran mountain region with types of spectra of high-altitude zonation, with subtropical features of nature in the low and middle mountains	<b>d2</b> - Alai-Turkestan	<b>XX</b> - Front ranges of the Alai ridge	<b>54</b> - Teomoyun-Otuzadyrsky <b>55</b> - Akbura-Gulchinsky
			<b>XXI</b> - Main Alai ridge	<b>56</b> - West Alai <b>57</b> - East Alai

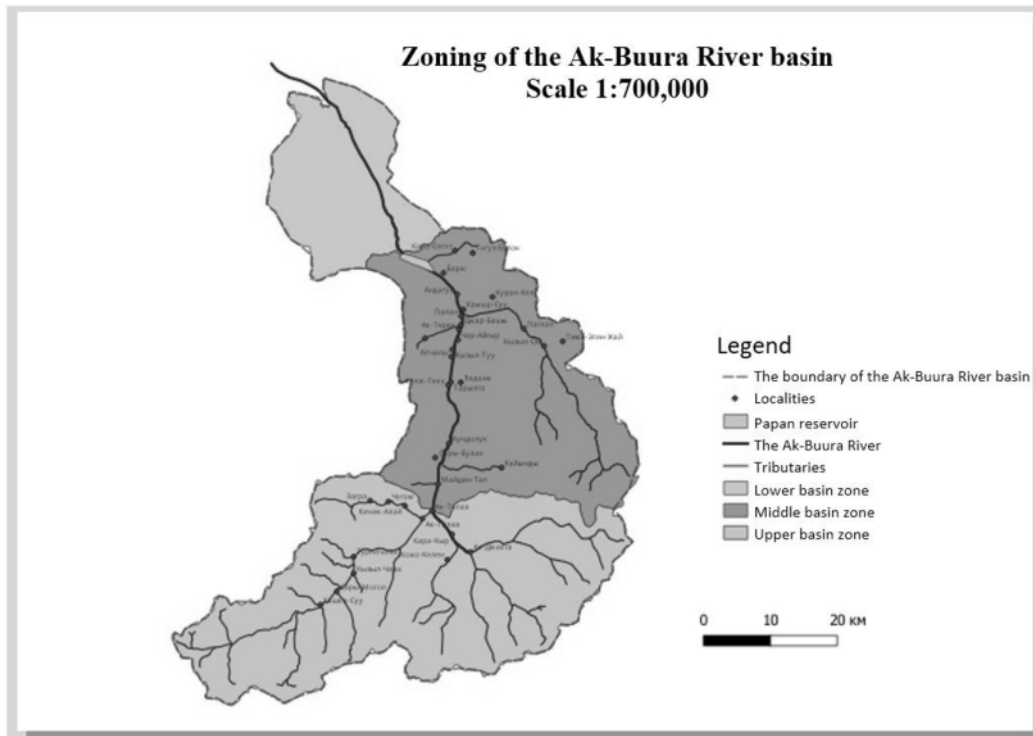
Based on the above two tables and the maps made by the authors, a zoning map of the Ak-Buura River basin has been made, which includes all tributaries of the Ak-Buura River and takes into account the peculiarities of high-altitude zonation and physico-geographical zoning.

**Table 3.** Zoning of the Ak-Buura River basin[4]

Lower zone	Osh - Dangi Gorge
Middle zone	Papan reservoir - the confluence of the Ak-Buura River and the Turuk River, Kayyndy, Maidan-Tal, Sary-Bulak, Kuyuk-Teke, Kamy-Suu, Kyrk-Kechuu, Berk-Suu, Taldy-Bulak, etc.
Upper zone	Above the confluence of the Ak-Buura River and the Turuk River are the sources of the Kichik-Alai, Chogom, Kindik, Sary-Mogol, Sary-Koi, Chal-Kuiruk, Dzhiptyk, Kalta-Boz, Kashka-Suu rivers, etc.



**Fig. 2.** Map of the physical and geographical zoning of the Ak-Buura River basin



**Fig. 3.** Zoning of the Ak-Buura River

Using statistical data from the National Statistical Committee of the Kyrgyz Republic "Population and Housing Census of the Kyrgyz Republic 2022", the authors made a sample of the population of the villages of Aravan, Kara-Suui and Nookat districts of Osh region, located in the middle and upper zone of the Ak-Buura River basin. A total of 25 villages were included in the sample (26 - Ak-Dzhilga village there is no data on the number of population, but it is located at the confluence of the Sary-Koi and Chal-Kuiruk rivers and the Ak-Buura River begins here). According to Kochurov's classification (1977), the authors proposed to calculate the anthropogenic load on the landscape by population density per 1 sq.km. In addition, the authors clarified such indicators as the height of the center of the settlement above sea level, which zone of the river basin it belongs to and in which altitude zone it is located and obtained the data summarized in the following table.

**Table 4.** Data of settlements in the Ak-Buura River basin

No	Ak-Buura River (main channel, its tributaries)	Village	Abs. height, m	River basin	High-altitude landscape zonation of mountainous territories	Population, people	Population, people [5]	%	Area, sq.km.	Density, people/sq.km.
1	Kara-Sogot	Kara-Sogot	1,677	Middle	Piedmont-mid-mountain subtropical steppes	1,010	25,559	85%	1,066.52	23.96
2	Kara-Sogot	Toguz-Bulak	1895			489				
3	Main channel	Boru	1,352			2,233				
4		Andagul	1,330			927				
5		Kamyr-Suu	1,355			1,683				
6	Kok-Bel	Kok-Bel	1,623			8,087				

7	Kayyndy	Kayyndy	2,270			179								
8	Main channel	Papan	1,355	Upper	Piedmont-mid-mountain subtropical steppes	433	4,617	15%	1,358.65	3.4				
9		Chychkan-Kol	1,365			1,712								
10		Ak-Terek	1,380			1,038								
11		Zhar-Bash	1,370			2,023								
12		Kyzyl-Tuu/Char-Aigyr	1,414			1,720								
13		Alchaly	1,427			1,677								
14		Kamyr-Suu - Kuran-Kel	Kuran-Kol			1,718					246			
15	Kyrk-Ketchuu	Laglan	1,523			968								
16	Kyrk-Ketchuu	Teke	1,867			891								
17	Kundoluk	Kundoluk	1,881			153								
18	Sary-Bulak	Sary-Bulak	1,910			29								
19	Maidan Tal	Maidan Tal	1,730			61								
20	Chogom	Kichik-Alai	2,070			626					4,617	15%	1,358.65	3.4
21	Chogom	Chogom	2,301			785								
22	Kara-Kyr	Kara-Kyr	1,885	Upper	Piedmont-mid-mountain subtropical steppes	543	30,176	100%	2,425.17	12.44				
23	Kichik-Alai	Ming-Teke (met.st.)	2,477			34								
24	Kichik-Alai	Kichik-Alai-Kashka-Suu	2,640			304								
25	Dzhiptyk-Suu	Kozho-Kelen	2,814			2,325								
26	Chal-Kuiruk - Sary-Koi	<i>Ak-Zhylga</i>	2117											
		<b>TOTAL:</b>									<b>30,176</b>	<b>30,176</b>	<b>100%</b>	<b>2,425.17</b>

As a result, the total population in the middle and upper zone of the Ak-Buura River is 30,176 people. The basin area of the middle zone is 1,066.52 square kilometers, and the upper one is 1,358.65 square kilometers. Calculations of the areas and absolute determination of the heights of settlements are carried out in GIS. As a result, with an average population

density of 12.44 people/sq.km., in the upper zone the population density is 7 times lower than the average (3.4 people/sq.km versus 23.96 people/sq.km). This is due to the harsh climatic conditions and the relative inaccessibility of places of residence in the upper zone.

In the modern world, due to the increasing diversity of human activity, changes in the nature of its impact on the natural environment, risks or dangers for humans and the world around them are becoming more diverse and tend to expand in structure and frequency. According to their genesis, they should be divided into two types: natural and anthropogenic (man-made and socio-political)[6].

In general, according to Kochurov's classification (1977), the degree of anthropogenic impact on the landscape (degree of development) is divided into 4 groups according to population density:

1. Underdeveloped lands with a predominance of natural landscape (with a density of less than 1 person/sq. km)
2. Lands with an average intensity of use, with the predominance of one type of use (1-200 people/sq.km)
3. Intensively developed lands, with a predominance of anthropogenic landscape (200-1000 people/sq.km)
4. Predominantly urbanized landscapes (more than 1000 people/sq.km)

The Ak-Buura River basin belongs to the 2nd type of degree of anthropogenic impact - with an average intensity of use. Assessment of the sustainability of natural geosystems is an essential and necessary element of the content of any scientific reference ecological map. At the same time, maps of environmental resistance to anthropogenic impact are less common, accounting for only 2% of the total number of environmental maps[7]. Types of environmental maps are most often combined into a group of maps intended for practical activities, and the classification of maps into:

- inventory and evaluation (contain indicators and evaluations of the state of individual components and landscapes as a whole, characteristics of the territorial distribution of influencing factors);
- forward-looking (represent hypothetical development results for certain dates in the future, while maintaining current trends or within certain scenarios);
- recommendatory (show the territorial location of the proposed measures in order to optimize environmental situations);
- monitoring maps (designed to track situations as recommended measures are implemented) [8].

The maps created by the authors according to the above classification belong to the inventory and evaluation ones. In the future, the authors propose to create monitoring and recommendatory maps.

## 4 Conclusions

If earlier, in order to go to the highlands, people weighed their options and decided for a long time, now they make a decision very quickly. All-terrain vehicles and modern road repair equipment have made it possible for more people to spend their holidays in nature high in the mountains. At the same time, the steady population growth observed in recent years leads to the fact that villages located in mountain gorges are growing. Here, sometimes the only source of livelihood is the maintenance of livestock, grazing cows and sheep driven away from the plain in the summer. If we add the development of mineral deposits (coal, stone, etc.) to all of the above, then it is not necessary to talk about reducing the degree of anthropogenic impact on the landscape or at least stabilizing it. A large amount of garbage on pastures and tourist recreation areas, degradation of pastures, deterioration of water quality, reduction in the number of trees due to the construction of new roads for coal mining

- all this can very quickly lead to a deplorable state of the ecology of the Ak-Buura River basin. The regions need to develop the structure, ways and stages of the formation of ecological and cartographic support to solve the problems of optimizing territorial planning and management, as well as for educational purposes [8]. Therefore, we believe that the creation and updating of digital maps of this area will help state and local authorities to monitor and make operational decisions for nature protection.

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