Hydrological analysis of livestock water reservoir using GIS technologies

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Abstract. To correct this deficiency of nature, water reservoirs are built at existing water sources and water resources are managed (corrected). In order to fully and effectively use the water of rivers and streams and to prevent floods, it is necessary to correct the order of the river flow. This problem can be solved by building artificial water bodies - reservoirs. Each river is unique in terms of its source of saturation and hydrological regime. At the same time, depending on the type of management of water resources in the reservoir, and the plan for the use of collected water throughout the year, a separate plan is drawn up for each reservoir. Therefore, in studying the role of reservoirs in water resources management, attention should be paid to the characteristics of each water source and each reservoir. Water resources in our republic are extremely limited and unevenly distributed across the territory of our country. In order to correct this deficiency of nature, water reservoirs are built at existing water sources and water resources are managed. Today, geo-information systems offer their convenient capabilities in hydrological analysis. This work carried out hydrological analysis through geo-information systems. A river basin located on the base of the livestock reservoir was identified and the area was calculated. The area was found to be 392.5 km. The sequence of currents in the river basin and its total length were calculated, indicating 297.7 km. The flow density in the river basin was determined and divided into 5 categories, each category was given a separate color. The flow density was 0.76.

1 Introduction

Water resources in our republic are extremely limited and unevenly distributed across the territory of our country. In order to correct this deficiency of nature, water reservoirs are built at existing water sources and water resources are managed (corrected) [1-5]. In order to fully and effectively use the water of rivers and streams and to prevent floods, it is

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necessary to correct the order of the river flow [7-10]. This problem can be solved by building artificial water bodies - reservoirs. Each river is unique in terms of its source of saturation and hydrological regime [4-9]. At the same time, depending on the type of management of water resources in the reservoir, and the plan for the use of collected water throughout the year, a separate plan is drawn up for each reservoir. Therefore, in studying the role of reservoirs in water resources management, attention should be paid to the characteristics of each water source and each reservoir [9-14].

In order to minimize the dependence of Uzbekistan's water economy on the water policy of neighboring countries and to ensure the stability of water supply to irrigated areas, a number of measures are currently being implemented at the level of the country's government, among which research on the organization of seasonally managed and re-regulating water reservoirs in the country is of great importance [1-6]

Currently, more than 55 water reservoirs are serving for seasonal adjustment of the flow of water resources across the country. However, the useful volume of this water reservoir cannot fully satisfy the demand for irrigated areas of the country. Moreover, these reservoirs, which were built 30-50 years ago, are losing their volume due to changes in hydrological processes and siltation of their beds [2,3,10]. Due to technical wear and tear of facilities and climate change during operation, dramatic changes in hydraulic and hydrological parameters of water reservoirs are observed. Due to the changes in these processes, the reliability of water supply is also reduced. As a result, the risk of interruptions in water supply to irrigated areas is increasing. Therefore, keeping the water reservoir in a constant state of operation is a task of state importance. The main problem in carrying out this task is the safe use of facilities and equipment in the reservoir complex and the problems of efficient use of water in the reservoir reserve. Because each reservoir is a potentially dangerous object in its own right [11-14]. The volume of water in the upper reaches of reservoirs has a large pressure, that is, potential energy, and if it goes uncontrollably to the lower reaches or breaks the dam, it can cause great losses in the downstream area and cause great economic damage in general [5, 6, 15].

In a recent study, some authors found that water resources are one of the most important components of community building, as many cities in the world are located near river basins and emphasized that rivers are formed from tributaries [1-4], and a part of the earth's surface separated from the neighboring river basin by a water separator is considered a river basin of this network. Flow length and flow density are characteristics of the river network. The total distance of rivers from the place of origin to the place of discharge is called its flow length. Flow density, expressed by the total length of tributaries in the basin per unit area, is an important feature of the river network. Flow density is closely related to several hydrological processes (infiltration, soil saturation, erosion, surface runoff and their interrelationships) that control flow and turbidity [2, 11-15].

2 Materials and methods

In 1970, a dam and a hydroelectric power station were built in the narrow Chorbog Gorge in the Chirchik Valley. Above the dam, the Charbog Reservoir was built in the Charbog (Brichmulla) basin (Fig. 1). The dam of the reservoir is made of stone and earth, the height is 168 m. The area of the reservoir is 40.3 km^2, the length is 22 km, the average width is 1.8 km, and the widest point is 10 km. The average depth is 49.4 m, the deepest part is 148 m, the length of the coast is 69 km. Recreation facilities have been built around the reservoir [7-10].

The reservoir was built to regulate the seasonal flow of the Chirchik River, to improve the water supply of 164,000 hectares of irrigated land in the Tashkent oasis, to generate electricity, and to improve the supply of drinking water to the city of Tashkent and its surroundings. The water capacity of the reservoir is 2,006 km3

The water reservoir is saturated by the Chotkal, Pskom, Koksuv rivers (96%), and more than 20 streams and rainfall [1-7].

95% of the water collected during the year is released through the water extraction facilities in the hydro-unit, the rest is spent on evaporation (0.5%), seepage (1m^3/sec).

Geographical coordinates of the dam are 41°38'01' N 69°56'49' E. According to long-term measurements of Chimgan weather station with an average temperature of 40°F in March, from 28°F to 97°F in April- June and up to 97°F in July-August. The precipitation varies from 21.25 to 5.15 mm during March and August [13-15].

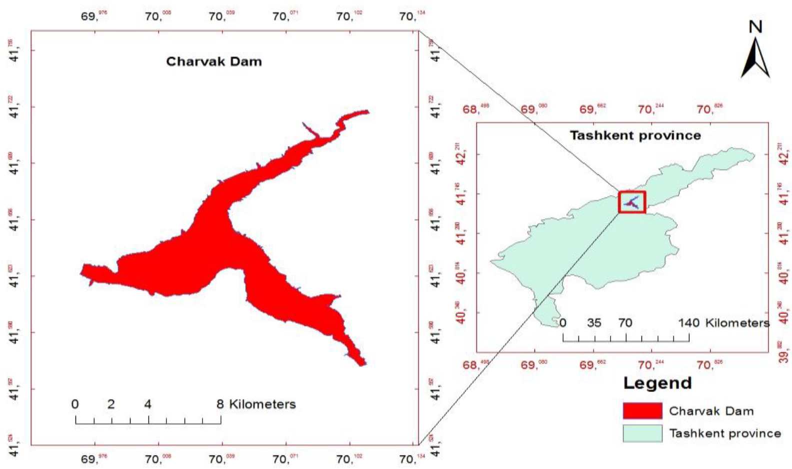

Fig. 1. Charvak reservoir.

Determination of the main characteristics of the flow based on hydrological monitoring data. For this purpose, general data on the Chirchik River (tributaries) entering the Chervok Reservoir or the tributaries directly flowing into the reservoir were used [1-5].

To calculate the main flow characteristics, the method of hydrological calculations, the method of calculating the main characteristics of the flow in the presence of hydrological observation data was used. Flow rate was studied, and when hydrological monitoring data are sufficient, determining the flow rate is easily determined by calculating the arithmetic mean value of the average multi-year water consumption data (Fig. 2)

$$Q_o = \frac{\sum Q_i}{n} \qquad m^3/sec$$

where: Q_i - annual water flow; n – number of observation.

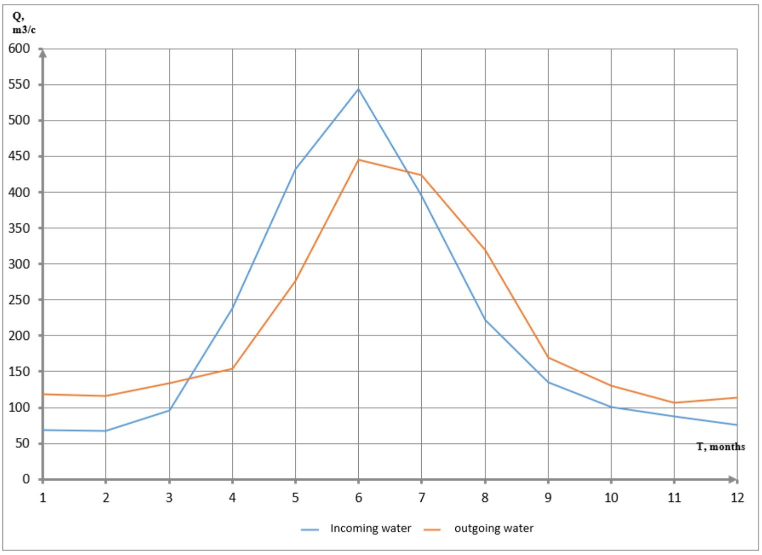

Fig. 2. Distribution of the average water consumption during the months of the water entering the livestock reservoir.

Due to the climatic, geomorphological, hydrogeological and other conditions of the river basin, the annual flow fluctuates throughout the year and over the years. Fluctuation of flow can be observed more especially in arid regions and mountainous regions. This situation can be clearly observed whether the river basin is large or small, that is, the smaller the area of the river basin, the sharper annual flow fluctuation is observed. These situations can be realized through GAT technologies [15].

ArcMap software was used to conduct gyrological analyses. Digital elevation model images with a resolution of 30m were downloaded from the USGS Earth Explorer website. These photos served as the main source of information, and the rest of the work was done [13-15].

3 Results and discussion

A digital elevation model image of the study area was downloaded from the USGS Earth Explorer website (Fig. 3). The model image was opened in ArcMap, the downloaded images were merged using the mosaic tool (Fig. 4), and the hydrology toolbar was opened.

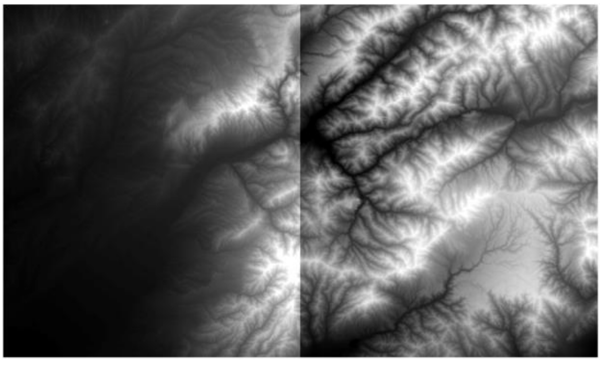

Fig. 3. Digital elevation model.

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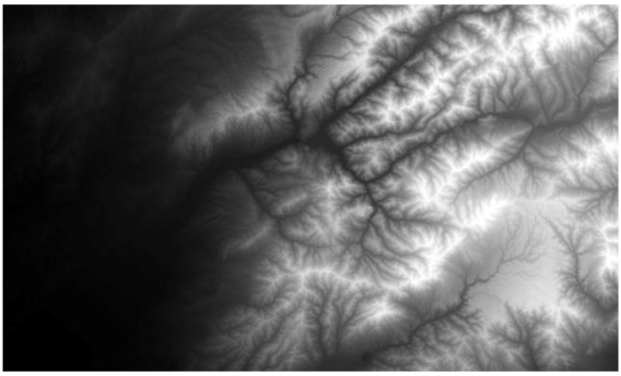

Fig. 4. Mosaicking operation.

Possible depth cuts in the photo were filled using the Fill tool (Fig. 5). The flow direction tool was used to determine the flow direction (Fig. 6). As a result, the flow direction was shown in 8 different colors: north, north-east, east, south-east, south, south-west, west and north-west.

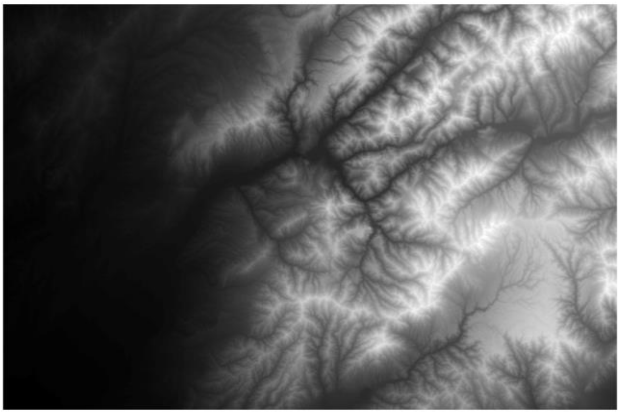

Fig. 5. Filling operation.

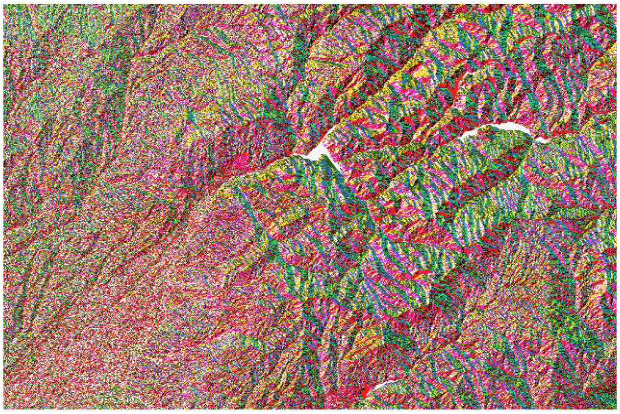

Fig. 6. Flow direction.

The data set obtained from the flow direction tool is entered as an input data set in the flow collection dialog box. In the study area, the tributaries with flow are shown in white color, and the areas that do not collect are shown in black color. Due to the very small number of tributaries, the data set values were divided into 2 classes. The classification method was changed from equal interval to manual, and values from 0 to 500 and values greater than 500 were separated into 2 classifications. Using the tool Raster Calculator, the values greater than 500 were calculated and the places where the new flow was collected were determined (Fig. 7). A watershed was created in the watershed we wanted to study (Fig. 8).

Then, the watershed point and flow direction data sets were entered into the watershed tool dialog box and a watershed polygon was created (Fig. 9). The flow patterns of the river were shown in sequence (Fig. 10). In this case, only the view of the water body was taken.

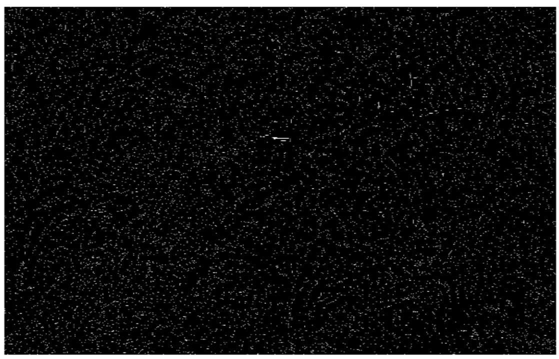

Fig. 7. Flow accumulation.

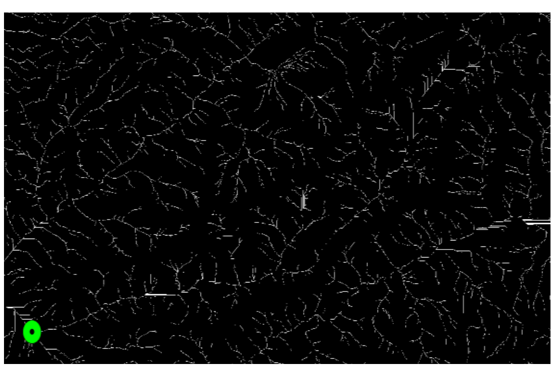

Fig. 8. Flow connecting point.

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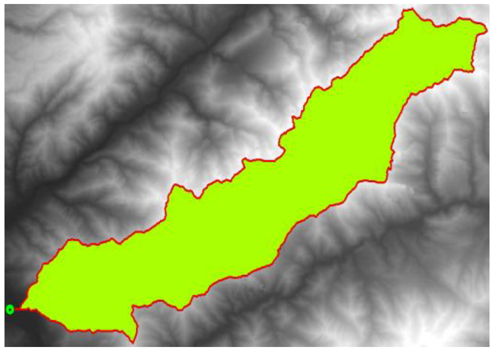

Fig. 9. River basin.

Fig. 10. Flow sequence.

The current density was determined (Fig. 11). Current density is divided into 5 categories and given separate colors.

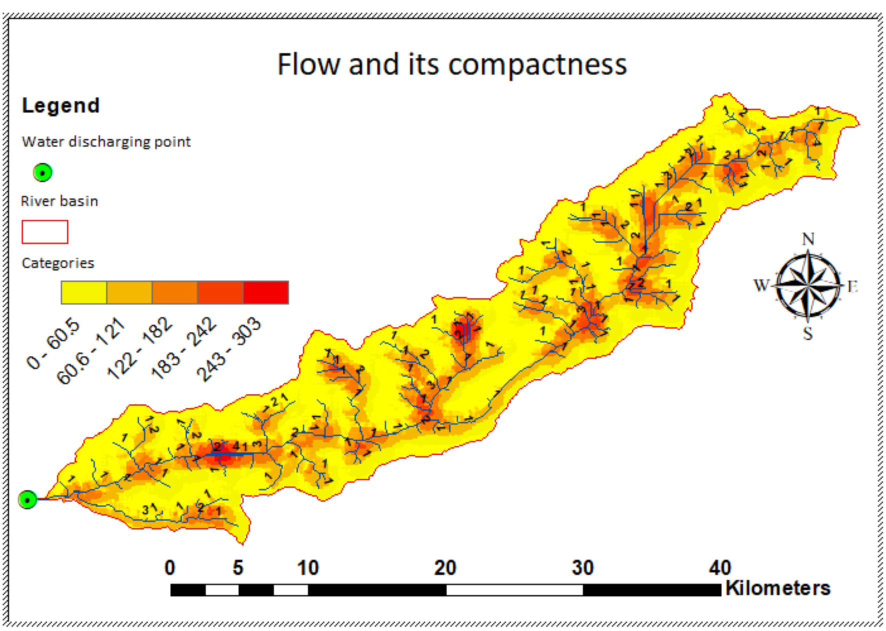

Fig. 11. Flow density

Flow length and density values were calculated (Table 1). The calculation results were performed on the basis of the data obtained on the basis of GIS technologies. We can see the processes in the reservoir basin in the case of Fig. 11, where the flow density decreases from the top to the bottom and is very sparse in some middle parts.

Table 1. Flow length and density

#	Flow length, km	River basin area, km^2	Flow density, l/km
1	297.7	392.5	0.76

4 Conclusions

Analysis of river basins using geoinformation systems is now widespread. Monitoring and evaluation of flow formation, flow length and density in river basins will help for efficient use of river basins and their sustainable management.

In the article, the river basin that feeds into the Chervoq reservoir was identified and its area was determined using the ArcMap program. Its area was 392.5 km^2. The total length of the river basin was calculated to be 297.7 km. Stream density was determined using the resulting river basin area and total stream length values. The current density was found to be 0.76. This indicates that the flow formation in this basin is good. Based on modern innovative GIS technologies, it is possible to remotely determine the area of water bodies and the conditions of flow formation.

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