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The Method of Hydroecological Monitoring for Hydropower and Hydraulic Facilities of the Kashkadarya Region of Uzbekistan

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Abstract. The article is devoted to using the hydroecological monitoring methodology based on the created GIS systems for decision support systems in the Aral Sea basin. The object of the study is the hydropower and hydraulic structures of the Kashkadarya region of Uzbekistan. Comprehensive hydroecological monitoring of the Kashkadarya region was carried out using GIS (Geographic Information System), making it possible to create a series of digital maps. The methodology for conducting hydroecological monitoring consisted of a comprehensive analysis of the ecological and technical state of hydrotechnical and hydropower facilities. For the study, the developed geoinformation systems and digital maps were used, which make it possible to consider the features of hydropower and hydraulic structures, considering the relief, hydrography, and other factors. The study results make it possible to more reliably assess the hydroecological state of the objects and identify the main features of the things of study, their weak points. Specifically, the patterns and features of hydroecological processes in the Aksu river basin and their impact on hydraulic structures were established during the research. This will help water protection and water management organizations consider the hydroecological conditions for the reconstruction and construction of hydrological and hydraulic structures in the region under study.

INTRODUCTION

The main goal of our research is to show the advantages of the created method of hydroecological monitoring. One of the study's objectives is to analyze the state of water and energy resources and hydropower potential of the Aktepa HPP with recommendations for reconstruction, modernization and energy efficiency improvement. The main object of scientific research is all hydropower and hydrotechnical structures of the Kashkadarya region. For this, the method of hydroecological monitoring, developed in recent years, is used. One of the important strategic tasks currently assigned to the scientists and state bodies of Uzbekistan is to determine ways of more efficient use of natural energy resources for the agricultural and energy sectors of the economy of Uzbekistan. Under these conditions, for the construction and reconstruction of hydrotechnical and hydropower facilities, it must carry out hydroecological monitoring. Many scientific research studies on GIS-based monitoring of hydropower and hydraulic structures globally and Uzbekistan and other authors used to analyze the ecological situation [1-18]. For the first time, hydroecological monitoring was proposed in 2000 [19-21]. In the future, the technique was improved in the following works [22-24].

They consider the specifics (agrarian orientation in the development of the economy) and the peculiarity of the geographical location. There is an acute shortage of water resources. The priority directions in developing this sector of the national economy are water and energy-saving technologies and the effective use of hydraulic structures, hydroelectric power plants, and pumping stations. Therefore, geographic information systems and technologies will help designers reconstruct and construct new hydraulic facilities, hydroelectric power plants, and pumping stations. The operation of hydraulic structures should be considered closely connected with all systems

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included in the hydraulic unit. The function of hydraulic structures of reservoir units at the local runoff solves two main tasks: - to ensure the supply of water from the reservoir by the established consumption schedule and to maintain the unit's construction in working order. These tasks should be considered a single set of operational measures, thanks to which the unit of structures is operated for fish farming, water supply, water supply, hydropower, etc. In addition, at present, the efforts of many countries and organizations are aimed at solving issues of improving the operating modes of hydraulic structures in Uzbekistan. Special attention is drawn to hydroelectric power plants since the country's economic development is of paramount importance. The use of GIS makes it possible to consider the landscape and terrain, select the optimal construction sites, strengthen mudflow-prone areas, and predict landslides and landslides when designing works on the repair of old and construction of new hydropower and irrigation facilities.

METHODS

From the geographic information systems of the Department of Hydropower and Hydraulics used for hydropower and irrigation, we chose those that require attention to the physical and geographical factors, relief, influencing the conditions of reconstruction and modernization in the construction and design of hydraulic and hydropower facilities. The second factor is water consumption. The third factor is environmental.

In research work, information and communication technologies were used for a comprehensive analysis, according to the following plan:

1. Study of the distribution and levels of pollution in drainage and river systems adjacent to hydraulic structures of river systems, a study of the technical scheme of hydraulic and hydropower facilities (**MONITORING**).

2. Investigation of the peculiarities of pollution and analysis of pollutants dissolved in water to highlight the ecological situation in the adjacent territory, the peculiarities of technological schemes affecting the situation (**MODELING**).

3. Combining the methods used, taking into account all anthropogenic and physical-geographical factors and the influence of hydraulic and hydropower structures (**SUPPORT FOR DECISION-MAKING**)

Over the past twenty-five years, the author has developed geographic information systems based on GIS for various research purposes [19–24]. When carrying out projects, the authors used the methods and experience of leading foreign specialists from the Institute for the Study of Environmental Systems of the University of Osnabrück (Germany) and the International Technology Centers (Yokaiichi and Tsukuba, Japan), in which the author improved his skills. At that time, a large project existed at the German Institute to study the hydroecological situation of the Elbe River, where the focus was on the use of GIS technology (http://elise.bafg.de). Experience in the European project Intas "Restoration and management options for water and Tugai ecosystems of the northern delta of the Amu Darya River" project was used (project Intas Aral Sea Project Call 00-1039 Ecosystems on the Northern Amudarya Delta Region http: //www.usf.uos.de/projects/aral/ The two priority areas most concerned with the issue of water conservation of the Amudarya river resources are monitoring of hydraulic structures and water quality. A series of digital maps were created on the territory of Uzbekistan with hydraulic and hydropower facilities. In our studies, the Kashkadarya region is considered in more detail. In addition, a digital map can be used to obtain the technical characteristics of the reservoir and hydroelectric power station (Figure 1-2). For the successful operation of a hydroelectric power station, it is required to analyze the initial data (relief, geology, hydrology, etc.), to know the structures of structures, the possibilities of application and the technology of their construction, to master the methods of calculating the selected facilities, to predict the consequences caused by their construction and operation.

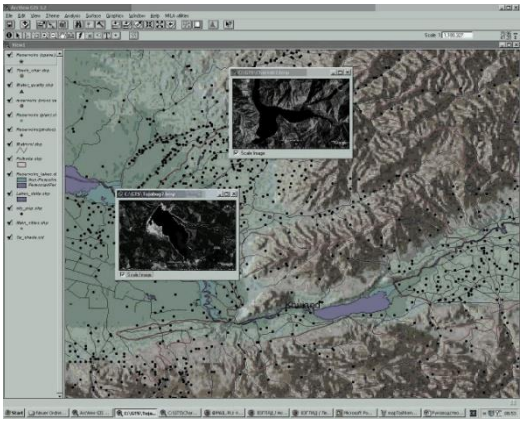

FIGURE 1. An example of using GIS to study hydraulic structures; for instance, after hovering the cursor over a reservoir, you can immediately get a satellite photograph, where you can find out in detail the configuration of the water reservoir or their technical data.

FIGURE 2. Satellite image of the features of the relief of the Tuyamuyun water reservoir.

In each hydroelectric power plant, there will be individual differences and hydroecological problems requiring different solutions. The study of water resources by river basins includes several blocks:

a) Collection and processing of information. This is a computer data bank, schematic maps, GIS-system (Geographic Information System).

b) Forecasts of changes in pollutants in the water of the river basin of rivers.

c) hydroecological mapping.

When creating a hydroecological monitoring system, three main factors were considered: collector and drainage wastewater, industrial wastewater and municipal wastewater. The pollutants themselves are divided into separate groups to move on to regulating their content, with the obligatory consideration of the environmental and economic assessment of water protection measures.

RESULTS AND DISCUSSION

An analysis of hydraulic and hydropower structures was carried out using information and communication technologies based on the obtained methods [19-24].

The first work analyzes the state, water energy resource and hydropower potential of the Aktepa HPP with recommendations for reconstruction, modernization, and energy efficiency improvement.

The second work examines the state of the waterworks of the Tyuyaumuyun reservoir, as well as the state of the existing reversing canals, the possibility of filling them with water volumes, and recommendations for the use of pumped storage power plants.

For hydroecological monitoring, the Gissarak reservoir (Figure 5) was selected, with seasonal regulation with a full capacity of 170 million m³, a useful capacity of 162 million m³. Particular attention is paid to the hydroelectric power station; the station is attached to the dam of the Gissarak hydroelectric complex, created in 1988 to accumulate water for irrigation. Operates on irrigation releases from the reservoir.

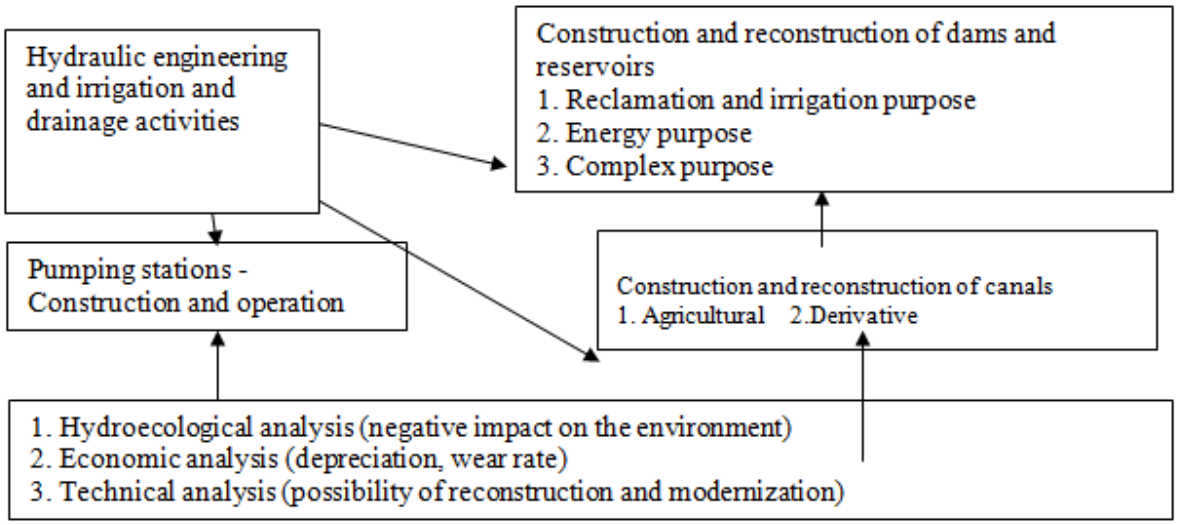

FIGURE 3. Block 2 - Hydraulic and main irrigation and drainage facilities

The methodology's experience was used in the development of criteria for the safe operation of hydroelectric power plants, pumping stations, and the development of hydrometric support. Below is a block of hydrotechnical monitoring for HPPs ((Figure 3-4) and indicators included in the block of hydroecological monitoring of HPPs.

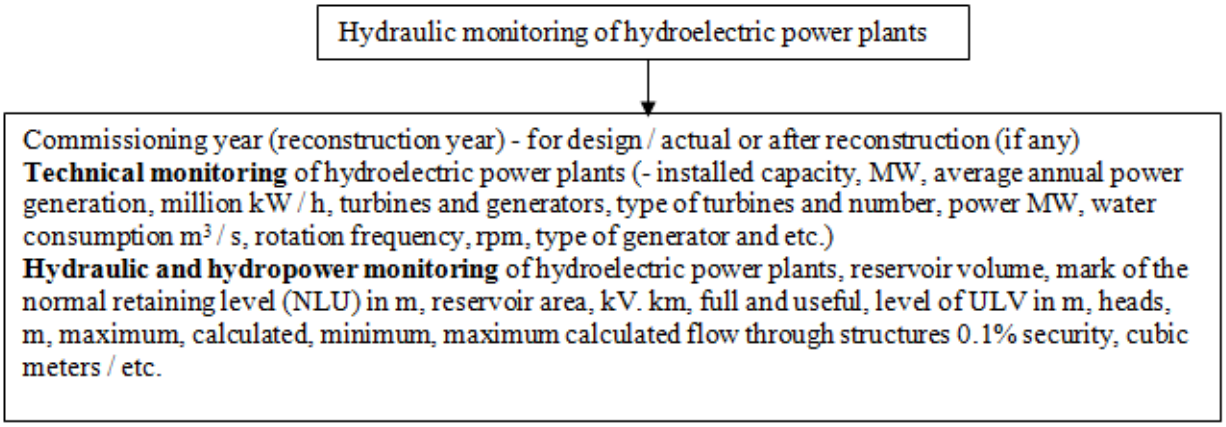

FIGURE 4. Integral indicators of hydrotechnical monitoring of HPPs

FIGURE 5. Satellite image of the features of the relief of the Gissarak reservoir.

In addition, the technical characteristics of the reservoir and hydroelectric power station can be obtained using a digital map.

Gissarak water reservoir:

type …… channel
total volume . ... 170 million m3
useful volume .... 161.6 million m3
Dam. type .... stone-earthen, with a core of loam
Material …… gravel-pebble soil
maximum height ..... 138.5 m
ridge length ..... 660 m
basement soils ..... clay shale and limestone
drainage .... drainage galleries
Outlet:
Type …… .. tunnel type.
design flow .... 200 m3 / s
gates ..... the outlet is equipped with 3 lines of gates flat wheel and other characteristics

We are leading integral indicators selected for hydroecological monitoring of hydroelectric power plants. The analysis is carried out in the main zones of hydraulic engineering and hydropower facilities:

1) In the area of the headwater of the reservoir;
2) In the area of the main hydraulic structures;
3) In the downstream zone of the watercourse

Main indicators of hydroelectric power station monitoring

a) Cleaning of debris, flooded and floating objects (which is dominated by floating wood or plastic), is it necessary to reconstruct the trash grates, including the mechanisms for cleaning the grates;

b) Is it required to protect the shores from destruction: mechanical or biological (construction or reconstruction of protective and wave-damping structures, planting trees, shrubs, etc.) other measures to protect the shores from destruction (from the practical experience of the operation service);

c) water quality control - drainage water treatment, oily wastewater treatment, construction or reconstruction of existing treatment facilities, construction of sewage collectors, elimination of stagnant zones and shallow waters);

d) Combating flooding and waterlogging (bank embankments, impervious screens and curtains, drainage, etc.);

e) Ensuring the vital activity of aquatic organisms (fish, plankton and other aquatic organisms), which includes the creation and reconstruction of fish pass structures, deepening the water intake, pneumatic curtains, etc.;

f) Combating water bloom (aeration, etc.);

h) Prevention of pollution of water bodies during operation of hydroelectric power plants (purification of oily liquids);

i) Maintaining the natural regime of solid runoff in the downstream of the hydroelectric power station (washing the reservoir, mechanical removal of sediments, etc.);

j) Ensuring hydroecological safety in case of increased seismicity of hydroelectric power plants

(strengthening of landslide sections of the coast, reconstruction of spillway structures to reduce vibration of the base of the hydroelectric power station, increase the seismic resistance of structures and equipment, etc.);

k) Fight against blood-sucking insects (changes in the level regime, use of chemicals, breeding of insectivorous fish);

l) Measures to reduce the area of flooding of land (to enter the land into agricultural circulation, embankment and drainage of shallow waters.

Based on the joint use of GIS technologies and optimization models in the study of the ecological regimes of hydraulic structures and hydropower facilities, the following tasks can be solved:

- The establishment of theoretical patterns and features of the development of hydrological and hydrochemical processes in the basin of the river Aksu and the impact on the hydraulic structure;
- To propose several new methods of hydroecological mapping using GIS technologies.
- To develop mathematical hydraulic and hydrological models, reflecting the possibilities of improving the operating mode of hydraulic structures;
- Drawing up practical recommendations for solving various scientific and applied problems for environmental purposes and assessing natural resources

CONCLUSIONS

The analysis of the state of water and energy resources and hydropower potential of the Aktepa HPP was carried out with recommendations for reconstruction, modernization and energy efficiency improvement. Furthermore, studies of the ecological regimes of hydraulic structures and hydropower facilities were carried out based on the daily use of GIS technologies and optimization models.

The following tasks were solved:

- the patterns and features of the development of hydrological and hydrochemical processes in the Aksu river basin and their impact on hydraulic structures were established;
- several new methods of hydroecological mapping using GIS technologies have been proposed.
- mathematical hydraulic and hydrological models have been developed, reflecting the possibilities of improving the operating mode of hydropower and hydropower facilities;
- compiled practical recommendations for solving various scientific and applied problems of an ecological nature and assessing natural resources.

The following main scientific results were obtained:

1) Shows hydroecological and hydraulic engineering monitoring results using information and communication technologies on digital maps. They show permission to design and repair hydraulic and hydroelectric structures, considering the relief, hydrography, and other factors.

2) The obtained methodology makes it possible to assess the hydroecological and hydraulic engineering situation more realistically, considering their impact on hydraulic structures.

3) The obtained methodology of hydroecological monitoring will provide people with the opportunity to search for information for the development of environmentally safe operating regimes for hydraulic structures in Uzbekistan. In addition, water management organizations can use this system to plan and forecast the environmental situation in the Aral Sea basin.

4) This system can be seen as a scientific tool for a decision support system for decision-makers.

In addition, it is possible to use future work to solve the following auxiliary tasks:

1) Optimize the use of river and collector-drainage waters of the river basin (transport, tourism, fish farming, agriculture, etc.);

2) for forecasting floods and droughts;

3) improvement of the physicochemical and biological state of river waters;

4) Creation of various scenarios of water use, taking into account three main factors (physical-geographical, anthropogenic and socio-economic);

5) Predictive statistical and mathematical models, potentially valuable water resources calculation, and innovative project planning at the end of the study.

6) Substantiation and calculation of parameters of low-pressure pumped storage stations and inter-block reservoirs of hydraulic systems.

Information and communication technologies provide in the future a new, more modern, more effective, convenient and quick approach to the analysis of problems and the solution of problems facing humanity as a whole and a specific organization. Therefore, the hydroecological monitoring methodology should be used when justifying the operating parameters of multipurpose reservoirs. This is because, in design, the construction and operation of hydroelectric power plants, small hydroelectric power plants, nuclear power plants, water treatment, water supply, recreation, energy, etc.

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