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Integrated model of effective distribution of water resources in a transboundary river basin Ile based on a prediction model: a Literature review and ideas.

Abstract: The resources of the Ile River are the most important source of fresh water from Lake Balkhash. However, nowadays the situation with the use of resources of the transboundary Ile River with China remains unresolved. According to experts, the increasing withdrawal by the Chinese side and the deterioration of water quality in the Ile River could lead to an environmental disaster in the Balkhash basin. In this regard, the development of an integrated model for the optimal distribution of water resources of the transboundary Ile River will be an actual solution. In this article, we consider effective methods and solutions to water problems in Transboundary Rivers, as well as analyze the advantages and disadvantages of each method and their possible application for the Ile river basin.

Keywords: transboundary rivers, Ile, projection pursuit model, prediction model, gray wolf optimization, optimization of water resources distribution, hydrological model.

1. Introduction. For Kazakhstan, the use of water resources of Transboundary Rivers is a special and rather serious topic. Over the past 15 years, there has been a tendency towards a reduction in the natural resources of surface water in Kazakhstan [1]. Kazakhstan considers the solution of the problem of Transboundary Rivers as one of their priority tasks. According to experts, the implementation of the PRC's ideas will violate the existing water supply regime and will hit industry and agriculture in the northeastern and central regions of the Republic of Kazakhstan [2]. But the most important thing is that the environmental situation in the zone of Balkhash lakes can greatly deteriorate, which is able to repeat the tragedy of the Aral Sea here [1]. In this regard, the development of an intellectual model for the optimal distribution of water resources of the transboundary Ile River will be an urgent solution. This article discusses two successfully applied methods to solve the problems of water distribution:

1) The method of the regional climate model in combination with the physical hydrological model (WEHY-Watershed Environmental Hydrology Model) [3];

2) an integrated distribution model for optimizing water resources based on a forecasting model — the gray wolf optimization method (PPMGWO-Projection Pursuit Model and Gray Wolf Optimization) [12].

The research methods analyze input data, topography processing, land use, model calibration and validation, assessment of hydrological conditions, the advantages of the two models and their possible application for the Ile catchment.

Based on these two effective models for solving the problems of the distribution of water resources in the catchment areas, in this article we will build a hybrid model that can be applied to the catchment of the Ile River.

2 Research methods. The first method is the WEHY model of the watershed hydrology (WEHY), which was used for the Tao catchment [3]. According to the results obtained, it can be seen that this model is successfully used today to assess and analyze the distribution of water resources on the Tao River [3]. The WEHY model was implemented based on information on topography [10], soil and land use / coverage, which was obtained from global satellite data [6]. The input information for the climate model is global reanalysis data (ERA-20C) [7], which are then dynamically reduced using the regional climate model [5] and then introduced into the hydrological model for reconstruction of hydrological data [11]. Atmospheric data [8] consist of ERA-20C [7] reanalysis data on a reduced scale with eight different variables: 1) precipitation, 2) air temperature, 3) wind speed, 4) shortwave radiation, 5) longwave radiation, 6) pressure, 7) mixing coefficient, 8) geopotential height [4].

Using the approved WEHY model, it is possible to reconstruct hydrological data on the watershed, based on their input data obtained because of building the WRF-Weather Research and Forecasting Model [8]. The calibrated and tested WEHY model can be used to predict future water supply from the catchment under atmospheric inputs from future climate forecasts of global climate models [3].

Along with reconstructing the data, this approach allows simulating the corresponding atmospheric and hydrological variables; therefore, an analysis of these variables may reveal the causes of the reported results, although the determination of the cause-effect relationship may be complicated by the nonlinearity of atmospheric and hydrological processes [9]. Finally yet importantly, the results of this study have an exact time resolution (hourly), the application can be used to assess hydrological risks, such as floods and droughts [3].

The second method is the innovative integrated model PPMGWO [12] for optimizing the use of water resources in the transboundary river basin, which is integrated using the forecasting model (PPM) [14] and the gray wolf optimization method (GWO) [13]. The PPMGWO model is designed to optimize the distribution of water resources in transboundary river basins [12]. This study was applied to the Songhua River Basin and 25 control units as examples, taking the PPMGWO model proposed in this study to distribute the amount of water. In this study, 15 indicators of the distribution of water resources in transboundary river basins and regions are selected, which is consistent with reality [16].

The main principle of the PPM model is to project high-dimensional data into a low-dimensional subspace through a certain combination, reflect the structure or characteristics of the original high-dimensional data by minimizing the projection index, and analyze the data structure in low-dimensional space in order to realize the goal of studying and analyzing large data [15]. PPM can be used in the distribution of the amount of water, and the procedure of its algorithm consists of 5 steps [15]: 1) Assessment of the dimensionality of the data; 2) Build the function of the projection indicator; 3) Build the objective function of the projection; 4) Optimize the function of the projection indicator; 5) Calculate the cost of the projection.

The Gray Wolf Optimizer (GWO) is a simulation of hunting activities in a pack of wolf packs, leadership in clusters; prey environment and location of victims are three main types of behavior of hunting gray wolves [13]: 1) Cluster leadership; 2) the environment of the victim; 3) Hunting behavior.

The procedure for implementing the water distribution of the PPMGWO model can be generalized as follows: 1) build a system of indicators for the distribution of water quantity and normalize indicators; 2) determine the objective function; 3) initialize the parameters; 4) to obtain the spatial position of the victim based on the above procedure of the GWO algorithm [13]; 5) get the result of the distribution of the amount of water of each control unit.

Obviously, the PPMGWO model takes into account both the environmental justice of industrialized cities and the sustainable development of agricultural cities [13] [15]. The simulation results show that the amount of water that can be distributed in all controls shows a general tendency to increase with reasonable and equal operation and use of water resources [12].

3 Results of the study. Having analyzed two effective models for solving the problems of catchment areas, we can build a model that will be applied to the water resources of the Ile River. A feature of this model is that it considers both global climatic influences [3] on the Ile River basin and the use of water resources for various purposes (agricultural activity, urbanization, etc.) [17]. The first WEHY model uses atmospheric, hydrological and climatic data from 1970. The peculiarity of this model is that with the help of these data we can see statistics of precipitation, melting glaciers, changes in climate data, which directly affects the volume of water in the river basin, as well calibrated data can be used to predict future water supply from a catchment under atmospheric inputs from future climate forecasts of global climate models. In the second model, we see that here indicators are selected that relate to human factors, such as the ecological state of the studied area, the area of the agricultural industry, the population, the volume of water consumption, etc. The advantage of this model is that it projects high-dimensional data into a low-dimensional subspace through a certain combination [6], which allows to obtain a more accurate result with a minimum deviation from large data, also controls the rational use of water resources, an effective increase in the efficiency of water resources use and future industrial water reuse rate increase [12].

4 Conclusions. Our task is to implement the above hybrid model in the Python program using the current data of the Ile River. We can restore global data [4] using the Google Earth Engine program, which has had a Data Set since the 1970s. With the successful completion of this research work, our hybrid model in the future will allow us to show changes in the volume of the Ile River water predict and manage adverse events like drought, pollution, etc., and demonstrate the rational and efficient exploitation of the use of water resources.

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