The Impact of Water Reservoirs on Biodiversity and Food Security and the Creation of Adaptation Mechanisms

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Abstract—Problems of food security and the preservation of reserved zones in the region of Central Asia under the conditions of the climate change induced by the placement and construction of large reservoirs are considered. The criteria for the optimum placement and construction of reservoirs that entail the minimum impact on the environment are established. The need for the accounting of climatic parameters is shown by the calculation of the water quantity required for the irrigation of agricultural lands

Keywords—Reservoir, Central Asia, food, reserved zones, adaptation, agriculture.

I. INTRODUCTION

THE problem of food safety is important for all countries and at all times. Maintaining food safety is necessary not only from economic but also from social and political perspectives. A state that does not provide food independence cannot feel safe in the modern world. The modern situation has aggravated the problem of food safety, which is characterized by inconsistent processes in the global economy. On the one hand, food consumption is increasing in developing countries, and on the other hand, an economic and financial crisis has caused a slump in both food production and peoples' incomes in these countries [1].

Among the crises that the world has faced, climate change poses the most serious threat for all natural-economic systems, including water and land resources. Increased air temperatures and reduced precipitation combine to exacerbate the dryness of the climate. Most of Central Asia experiences arid environmental conditions, in which poor deposits, excessively low humidity, a high intensity of evaporation and excess solar radiation are characteristic. The sharp growth of the population, which has exceeded worldwide rates, has led to serious concern in the countries of Central Asia. Population growth has caused processes of economic intensification that have led to an increased pressure on water and land resources [2].

The food products manufactured in Tajikistan face many serious difficulties caused mainly by the growth of the population, the country's mountainous topography, and the limited farmlands available for grain crops and livestock

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because of steep slopes and unproductive microclimates. The average mean arable land per person of 0.14 ha is low compared with the global average of 0.26 ha/person. The degradation of the land, which has occurred as a result of the breaking of traditional norms of land tenure, such as the cutting down of woods and degradation of pastures, together with other processes, such as soil erosion, torrential rain events, flooding, soil salinization and desertification, have promoted an annual reduction of the volume of foodstuffs produced [3], [4].

One way to achieve minimum food safety in the vulnerable countries of the region is the development of new lands and the escalation of the production of agricultural products. In Tajikistan, for example, 800 Th. ha of suitable land is available for irrigation. An elementary analysis shows that approximately 0.2 ha/per of land is necessary for Tajikistan (in 2015, this number will result in between 650 and 850 Th. ha) to achieve an average regional indicator of the specific area of irrigation per capita. However, for this purpose, it is necessary to place in operation 10 Th. ha of newly irrigated land annually, and the possibility of such an expansion of the irrigated lands in Tajikistan is unlikely [5]. Nevertheless, another economically more favorable and ecologically useful solution to the given problem is an increase in the efficiency of the irrigated lands and water use. Increasing the efficiency of water use is a two-fold problem that entails both increased soil fertility and productivity and decreased water use. Thus, increasing the efficiency of water use is a complex problem in Tajikistan [6].

II. ECOLOGICAL & IRRIGATION AND ENERGETIC CRITERIA FOR RESERVOIR CONSTRUCTION

The use of hydropower in agriculture is one of the key basic branches of the economy of the Republic of Tajikistan, which possesses major stocks of hydroelectric power. The total annual potential resources from water-power engineering projects amount to 527 Bln. kWt·h, of which only approximately 5% has been realized to date [7]. The existence of this large potential supply of power has led to plans for the construction of a number of hydroelectric power stations, accompanied by reservoirs, in the near future. These plans are reflected in the development strategy of the energy branch of the Republic of Tajikistan Government. Hence, when planning agricultural development in areas adjoining water reservoirs, it is necessary to consider that water reservoirs influence localized thermal and radiative balances that in turn alter the

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climatic characteristics over the reservoir and its adjoining lands. The meteorological conditions affected by the water reservoir will, in most cases, be transformed into a coastal zone, including an area several hundred meters around the reservoir, outside of which the intensity of the influence of the climatic conditions of the reservoir sharply decreases. However, in the dominant wind direction, the climatic influence of reservoirs can extend to 10 or more kilometers.

Through impoundment and increased residency times, dams alter water temperatures and chemistry, which in turn influence the rates of biological and chemical processes. Dams create barriers to the upstream-downstream movement of nutrients and organisms, thereby affecting physical and biological exchange processes. They also alter the timing and magnitude of the downstream fluxes of water, sediment, and ice, which modify biogeochemical cycles and the resulting structure and function of aquatic and riparian habitats. As dams occasionally collapse, they also present a risk to the built environment and downstream ecology [8].

The physical, biogeochemical, and biological processes occurring within a reservoir can affect the temperature and chemical composition of the water leaving the system to such an extent that its quality upon release no longer resembles that of the inflows. The degree to which water quality is affected on a daily, seasonal and/or annual basis depends on factors such as the surface to volume ratio and depth of the reservoir. Other factors include the geology and soil geochemistry of the surrounding catchment, the latitude of the reservoir, the rate and magnitude of sedimentation, the magnitude and timing of incoming flows and their residency time, and the level of biological productivity in the reservoir [8].

The water of a deep reservoir in temperate climates typically stratifies, with a large volume of cold, oxygen-poor water in the hypolimnion. Analysis of temperature profiles from 11 large dams in the Murray Darling Basin (Australia) indicated differences between the surface water and bottom water temperatures of up to 16.7 °C [9]. If the cold bottom water is released to maintain river flow, it can cause adverse impacts on the downstream ecosystem, including fish populations. Under a worst-case scenario (such as when the reservoir is full or nearly full, the stored water is strongly stratified and large volumes of water are released to the downstream river channel via bottom-level outlets), depressed temperatures can be detected 250-350 km downstream [10]. The operators of Burrendong Dam on the Macquarie River (eastern Australia) are attempting to address thermal suppression by hanging a geotextile curtain around the existing outlet tower to force the selective release of surface water [11,12].

Studies of changes in water temperature along the length of the river after discharge from reservoirs show that the influence of large reservoirs on water temperature is substantial: the daily and decadal scale change in water temperature before and after a reservoir is constructed, can reach 8-12 °C. The greatest difference in average monthly water temperatures in the tail water of reservoirs before and after the construction of a reservoir occurs in November-

January, reaching 4.2-3.4 °C in the Vakhsh River. The warming influence of the waters discharged from large reservoirs lasts for 8 months and the cooling influence for four months (February-May). Thus, the length of the warming influence of large rivers is 1.74 times greater (209 km) than the cooling influence of the discharged waters (120 km) [13].

At present, to define the efficiency criteria for a hydropower station (HPS) with a reservoir, a method based on the analysis of key parameters of the HPS construction, such as the capacity and output of electricity by the HPS in relation to the area occupied for building the HPS, is widely applied. The relation between the capacity and electricity output is used as an index of the ecological-economic efficiency of the HPS per hectare of the land used for the construction of the HPS (Table I).

TABLE I
ECOLOGICAL-ECONOMIC EFFICIENCY OF THE CONSTRUCTION OF AN HPS WITH A RESERVOIR

Index efficiency of HPS	Capacity to the Area (MWt/ha)	Power output to the Area (TWt/ha)
Annual value for HPS with area of groundless 100 Th. ha	0. 123	0.406

Based on the data presented in Table I, we estimated the efficiency of the existing Nurek HPS and the Rogun HPS, which is planned for near-future construction, both of which include reservoirs (Table II).

TABLE II
ESTIMATION OF THE EFFICIENCY OF THE NUREK AND ROGUN HPSS WITH RESERVOIRS

Name	$P, 10^2$	$W, 10^2$	S	A	M	Index of efficiency			
						P/S	W/S	P/A	W/A
Bratsk	4400	22.6	547.0	357.3	70.0	0.008	0.041	0.012	0.06
Charvak	600	20.0	4.6	2.7	9.18	0.13	0.436	0.225	0.75
Toktogul	1200	41.0	31.9	-	29.3	0.038	0.128	-	-
Nurek	2700	112	21.5	0.2	1.50	0.126	0.522	13.50	56.00
Rogun	3600	133	17.0	6.800	16.0	0.212	0.782	0.529	1.96

P=capacity of HPS (MWt); W=power output (TWt·h); S=area for building of HPS (Th.ha); A=area of wooded vegetation (Th.ha); M=migration of population (Th. Pers).

For comparison, in Table III, the ecological-economic index values of the considered HPSs are compared with analogous indexes of other HPSs.

TABLE III
COMPARISON OF THE NUREK AND ROGUN HPS ECOLOGICAL-ECONOMIC INDEXES WITH THE OPTIMAL CRITERIA OF BUILDING OF HPS

Ecological-economic index efficiency of HPS	P/S (MWt/ha)	W/S (TWt/ha)
G	0.123	0.406
Bratsk HPS	0.008	0.041
Charvak HPS	0.130	0.436
Toktogul HPS	0.038	0.128
Nurek HPS	0.126	0.522
Rogun HPS	0.212	0.782

In Central Asia, with its climatic conditions, the selection of

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an appropriate geographical location for a reservoir is a challenge. The estimation of the extent of the influence of reservoirs in arid zones on the surrounding environment is possible using the coefficient $K_{sur.env}$ [14]:

$$K_{sur.env.} = \sum S_i / S_{oi} \cdot 100\% \qquad (1)$$

where $K_{sur.env.}$ is the coefficient of reservoir influences on the environment; S_i is the area of the territory under the influence of the reservoir, km^2; and S_{oi} is the area of the basin, km^2.

Calculations of $K_{sur.env}$ demonstrated that the value for the influence on the surrounding environment of the Kairakkum reservoir is 0.11, that of the Nurek reservoir is 0.144, and that of the Muminabad reservoir is 0.00195 (Table IV).

TABLE IV
COEFFICIENT OF INFLUENCE OF RESERVOIRS ON THE SURROUNDING ENVIRONMENT

Reservoirs	Kairakkum	Nurek	Muminabad	Golovnoy
K	0.11	0.144	0.002	0.0011

Note that small, upland reservoirs have a greater influence on the microclimate than reservoirs in plains areas. For large reservoirs, an identical pattern is observed. The influence of the Nurek reservoir is 1.31 times greater than that of the Kairakkum reservoir.

Apparently, the degree of influence of reservoirs on the adjoining land decreases as their size and volume decrease, and at the same time, the influence of the adjoining land on the reservoir increases. This pattern should be considered when planning the construction of new reservoirs in Tajikistan and during the planning of coastal development by the tourism industry seeking to create zones of rest with a greater set of recreation services.

To estimate the role of a reservoir in local climate conditions, the expression $\Delta P / \sigma_{sp.dif.}$ can be employed, where ΔP is an influence indicator and $\sigma_{sp.dif.}$ is the mean square deviation of the difference in the influence of a given indicator between two stations located within a distance of 10-20 km from one another.

When $\Delta P / \sigma_{sp.dif.} \geq 1$, the influences of the reservoir on the local meteorological conditions are essential. We use these criteria to estimate the role of the reservoirs as factors in the formation of the local meteorological conditions, the agro-climatic parameters of the coastal zone and coasts, and the thermics of the rivers in downstream reaches [15].

Until the Nurek reservoir was filled with water that was the same temperature as the Vakhsh River, the water upstream of the Nurek HPS dam (kishlak Tutkaul) exhibited almost no difference in temperature from the water up to 17 km below the dam (kishlak Sariguzar). With the filling of the Nurek reservoir (1972), a drop in the water temperature in spring (February-May) and an increased temperature in summer, autumn, and winter (July-January) in comparison with natural conditions were observed. This finding can be partly explained by the fact that reservoir was not at its maximum level when

water was discharged from its top horizon; only in 1980 did the reservoir reach its high surface level (HSL).

In 1980, the influence of the Nurek reservoir on the thermal conditions of the Vakhsh River water began, which is traced most precisely to 17 km of the river downstream from the Nurek HPS dams up to the Sariguzar hydrological station. The greatest difference in the average monthly temperature of the water before and after the construction of the reservoir for the Sariguzar hydrological station (4.2°C) is observed in November-December. During discharge periods, this difference decreases to 1.2°C. The influence of small-channel reservoirs on the change in water temperature along the length of the river can traced for a considerable distance (Table V). Thus, the change in the annual distribution of the average monthly values of the water temperatures below large reservoirs for a specified time interval is not due to a change in the annual mean air temperature but, rather, is influenced by the discharge of water from the reservoirs. However, according to the data of the "Nurek" meteorological station, the average monthly temperature decreased after construction of the Nurek HPS (Fig. 1).

TABLE V
AVERAGE MONTHLY TEMPERATURES OF VAKHSH RIVER WATER BEFORE AND AFTER BUILDING OF THE NUREK RESERVOIR

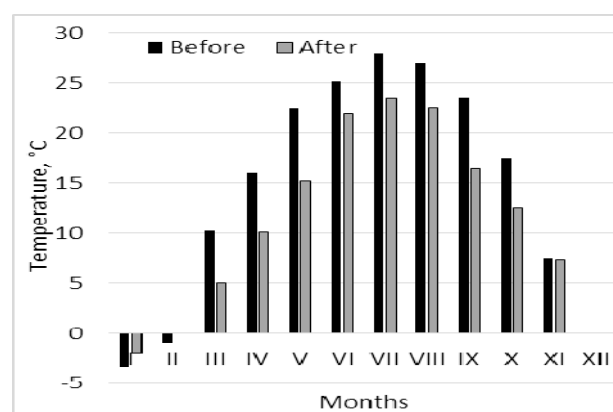| River-Post	Period	Month							
		I	II	III	IV	V	VI	VII	VIII
Vakhsh Tutkaul	1946 1967	2.6	4.3	7.6	11.0	12.8	14.3	15.0	14.9
Vakhsh Sariguzar	1967 1971	2.0	4.0	8.1	11.5	13.2	14.4	15.0	14.9
Vakhsh Sariguzar	1972 1980	5.4	3.9	5.5	10.0	13.0	14.9	15.9	16.0
Difference		-3.4	0.1	2.6	1.5	0.2	-0.5	-0.9	-1.1

Fig. 1 Average monthly temperature before and after building of the Nurek reservoir

III. IMPACT OF RESERVOIRS ON IRRIGATION REGIME FOR AGRICULTURE

To determine the potential influences of climate change on agro-climatic resources, we analyzed the climatic parameters of three districts with developed agricultural sectors (Dangara, Fayzabad and Yavan) adjoining the Nurek reservoir. For this

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purpose, data from the hydrometeorological stations (HMSs) located in these areas were used. Data on the temperature dynamics and relative humidity of air and the atmospheric precipitation for the years 1968-2000 were used. The evaporation and humidity coefficient were calculated (Table VI).

TABLE VI
AVERAGE MONTHLY TEMPERATURES OF VAKHSH RIVER WATER BEFORE AND AFTER BUILDING OF THE NUREK RESERVOIR

Hydropost	Index	Years	
		1968-1972	1995-2000
Dangara	T (°C)	15.3	16.4
	H (%)	57.0	56.9
	F (mm)	570.5	598.5
	I (mm)	1196.7	1438.0
Fayzabad	T (°C)	13.2	15.4
	H (%)	61.6	55.2
	F (mm)	709.0	675.4
	I (mm)	1013.0	1258.8
Yavan	T (°C)	17.2	16.9
	H (%)	47.2	50.4
	F (mm)	677.4	677.3
	I (mm)	1630.8	1567.5

T=temperature; H=humidity; F=precipitation; I=evaporation

The data presented in Table VI demonstrate that for 32 years (1968-2000), the average annual temperature increased 1.0-1.5 °C, which led to a 3-6% decrease in the relative humidity and a 10-26% increase in evaporation on an annual basis and of 12-30% in the period May-September. However, in the Yavan district, the dynamics of the changes in the listed parameters has had the opposite tendency: the temperature of the air and evaporation decreased by 0.5%, 7.2%, respectively, and the relative humidity and evaporation increased 7.2% and 10%, respectively.

The reduction of evaporation during the vegetative period in the Yavan district reached 12.2%. In view of these climatic changes, it is necessary to take corresponding corrective measures in planning agriculture-related water use. Planning for the development of irrigation regimes typically considers meteorological parameters for all periods analyzed. However, this approach can lead to essential errors. Studies based on previously irrigated fields and prospective irrigation regimes that ignore the effects of global climate warming often do not consider the growing needs for water. In contrast, data on the Yavan valley recommended irrigation regimes resulting in the overuse of water resources. For example, the most recent recommendations for irrigation regimes for the valley are based on the annual average means of the humidity coefficient (0.35), which suggest that this valley is a drought-prone area. However, the data presented in Table VI show that for the past 20 years, evaporation in the valley has decreased by almost 300 mm (17%), the quantity of precipitation has risen by 70 mm (11%) and the humidity coefficient has risen to 0.45. Hence, the present irrigating norms for cultivation of the middle-fibrous cotton of 1100 m³/ha and 3000 m³/ha in the Yavan valley and Lucerne, respectively, are overestimated.

Calculations show that the unproductive losses of water in these two valleys exceed 60 mln.m³.

IV. SEDIMENTATION OF RESERVOIRS

The analysis of previous results on the filtration characteristics of irrigation by clean water versus water with the suspended sediments shows that prior to the construction of the Nurek reservoir, each m³ of Vakhsh River water contained up to 10 kg of sediments and that more than 100 t of sediments rich with minerals entered the agricultural fields annually. According to the Hydrometeorological Agency of the Republic of Tajikistan, the mid-annual discharges of suspended sediments in the Vakhsh River on the hydropost located on the kishlak Sariguzar—17 km below the Nurek HPS—since 1972 (the beginning of the filling of the Nurek reservoir) decreased from 1000 g/s to 82 g/s by 1980. The Nurek reservoir almost completely eliminated the suspended sediments from the Vakhsh River (Table VII).

TABLE VII
AVERAGE ANNUAL GRANULOMETRIC COMPOSITION OF THE VAKHSH RIVER SEDIMENT FLOW

Years	D (mm)					
	1-0.5	0.5-0.2	0.2-0.1	0.1-0.05	0.05-0.01	0.01-0.05
Komsomolabad						
1972-1976	1.43	7.05	8.6	15.3	37.0	18,0
1977-1987	1.53	7.11	8.7	14.9	37.2	17,9
Sariguzar						
1972-1976	0.63	1.77	3.9	8.7	47.3	22,1
1977-1987	0.72	1.94	3.9	9.1	48.2	21,5

The construction of the Nurek HPS dam was begun in 1961. Simultaneously with construction, a technical project investigating the suspended load was initiated. The prediction for reservoir sedimentation for a period of 11 years was included in the project.

For the period 1972-1989, the sediment flow of the Vakhsh River was measured in 1977 and 1980-1982 at Komsomolabad and in 1978 and 1985 at the Kishrog hydropost. In 1977 and 1985, the sediment flow measured at the Komsomolabad station changed in accordance with the change of the annual rainfall from 55.2 to 38.3 Mln. t at the station of Kishrog from 86 to 59 Mln. t.

Based on the estimation of the Institute of Mathematics of AS of Tajikistan, the additional value of the tributary sediment from Komsomolabad up to the Nurek reservoir is 4.0 Mln. t.

The input of sediment into the Nurek reservoir under average conditions for a dry year can be estimated at 60-65 Mln. t. The calculation demonstrates that by the sixth year of constant use, the useful volume of the reservoir would decrease by 200 Mln. m³ and by the 11th year by 650 Mln. m³. Table VIII presents the initial forecast for sedimentation of the Nurek reservoir.

During the planning for the reservoir, it was accepted that the process of sedimentation would conditionally begin in 1978, with an intensity of 40 Mln. m³ per annum for the first five years, accelerating to 90 Mln. m³ per annum in all

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subsequent years.

TABLE VIII
PROGNOSES OF NUREK RESERVOIR SEDIMENTATION (REDUCTION OF THE
FULL VOLUME)

Year	1978	1983	1988	1993	1998	2001
volume (km^3)	10.5	10.3	9.85	9.4	8.95	8.68

Early studies established that in connection with the increase in temperature, a longer vegetative period of agricultural crops can be expected. The intensity of increase of the air temperature and the increase in the stock of soil moisture in the spring will enable earlier spring sowing. Adhering to the mean annual starting dates of sowing without accounting for climate change will lead to a decrease in productivity of all agricultural crops. The displacement of sowing relative to an optimum for 5-10 days reduces productivity on the average by 10-20%. This decreased productivity is related to the fact that the most important period for the efficiency of crop growth occurs at air temperatures that are higher than the optimum. The influence of agro-climatic conditions on the rates of growth of agricultural crops can be reduced to an estimation of when each crop will pass through its phenological phases.

Understanding the forces exerted by large dams on local climate is key to establishing whether artificial reservoirs inadvertently modify precipitation patterns in impounded river basins. Using a 30-year record of reanalyzed data, the spatial gradients of atmospheric variables related to precipitation formation are identified around the reservoir shoreline for 92 large dams of North America. The large dams influence local climate most in Mediterranean and semi-arid climates, while for humid climates, the influence is least apparent. Clear spatial gradients of convective available potential energy, specific humidity and surface evaporation are also observed around the fringes between the reservoir shoreline and farther from these dams [16].

V. IMPACT OF RESERVOIR ON THE TIGROVAYA BALKA NATURE RESERVE

The Tigrovaya Balka Nature Reserve is a heavily forested area critical for the preservation of unique communities of flora and fauna. They species living in the reserve are not simply independent "units" that could be kept in zoos and botanical gardens but, rather, are members of a climax community that has developed over millennia, the infringement of which will lead to the irreversible degradation and disappearance of many species, as was the case with Turanian's tiger.

Until the settlement of the Vakhsh River and the building of the Nurek HPS, the vegetative ecosystems of the reserve were supported by annual spring-summer floods, and all the lakes of the reserve were filled with water. Since construction of the Nurek HPS and its reservoirs, the natural floods have stopped. This condition has led to a gradual reduction of the water level in the lakes of the reserve and complete drying of Lakes Blue and Kabane.

Now, to maintain the balance of water in the reserve, sewage from farmlands is input. Without the implementation of measures to prevent excess sewage from entering the reserve, even with small concentrations of salts, due to extremely high evaporation, the salinity of the soil and waters of the reserve will increase to fatal limits. There will be an intensification of processes of desertification and salinization that finally will change the heavily forested vegetation.

The present condition of the Tigrovaya Balka Nature Reserve requires the provision of uncontaminated water. In turn, the development of alternative means of supplying the reserve with water will considerably improve the condition of the flora and fauna of the reserve. Future studies should have the following objectives:
- To identify the impact of chemical pollution transition processes on environmental changes;
- To identify the impact of transition processes on changes in environmental standards and risk assessment criteria related to toxic elements;
- To review suitable remediation options;
- To develop methods of prioritizing urgent action areas (hot spots) within the boundaries of the "Tigrovaya Balka" reserve;
- To provide recommendations for risk management strategies to improve environmental conditions and water resources;
- To organize a preliminary purification system of water inflow to the reserve by building reservoirs.

Fluctuations or changes in one ecosystem component cause a number of collateral changes in other components. The change of the water dynamics and the chemical composition of waters cause physiological changes in the reserve plants due to the adaptation of the plants to the newly created conditions. This process is reflected in the food allowance and activity of the fauna and birds of the reserve. The potential mutation of species of plants, animals and other inhabitants of the reserve cannot be excluded. Considering the fact that the Tigrovaya Balka Nature Reserve is also a place of seasonal residence for migrating birds, the processes taking place in the reserve's flora and fauna can have far-reaching effects. In many areas, poachers have used the reserve as a place to hunt. The undesirable infections and illnesses caused by the adaptation of the inhabitants of the reserve to the disrupted natural conditions can be transmitted through food and thereby result in the mass distribution of an illness or infection.

In 2007, a set of tasks for inspection of the territory of the reserve, and certain measures were undertaken to improve the delivery of water to the reserve ecosystem. These measures include clearing an overgrown natural channel, building a channel for a supply of fresh water bypassing dams, and building a pumping station, among other measures. The systematic clearing of channels has proceeded since 2008. Despite an insignificant difference in the levels of the northern and southern parts of the reserve, the development of bogs in the north, where wastewaters were historically discharged, has almost ceased. The water in the cleaned channels and drains has been directed into a drying-up lake, which has been filled

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with water, as in former years when the natural waterway was supported by regular floods.

At the direction of the Tajikistan government in 2007, the reserve has been increased by 21 thousand ha. The added territories improve the protection of ecosystems such as tugayes and adjoining deserts. Additionally, the increase in the reserve has facilitated the natural movement of animals; previously, they often left the limits of the protected territory.

In the autumn of 2008, the Tigrovaya Balka Nature Reserve had been in existence for 70 years. At this anniversary, the government of Tajikistan made the decision to increase the area of the reserve by 100 thousand ha. However, before becoming part of the reserve, these areas were used as a cattle pasture and for fuel gathering, which led to the degradation of grasslands and a total disappearance of the *Haloxylon* woods. *Haloxylon* restoration is ongoing in the reserve.

Now, the reserve area encompasses more than 47 Th. ha. Taking into account the transferred lands of the former collective farms and the intercollective-farm enterprises (1.3 Th. ha), the total area of the reserve comprises 50.9 thousand ha, including a wooded area of 24.1 Th. ha (47.4%), a non-wooded area of 26.8 Th. ha (52.7%) and a light forest, glades, mountains area of 8.0 Thousand ha (14.1%). Bogs and waters occupy 21.4% of the total reserve area. In the northern and southern parts of the reserve, 16 and 5 large and small lakes are present, respectively.

The water regime of the soils of tugay-inundated biogeocenosis sharply differs from the previous regime. First, there is increased humidity at all soil depths; second, the influence of seasonal atmospheric humidity is almost nonexistent, as the regime here is defined by additional humidity at the expense of the shallow (1-2 m) levels of groundwater. The water and salt regimes of the soils define the formation and seasonal development of vegetative cover. In deserted biogeocenosis, the seasonal development of vegetation has been accurately traced. Additional soil moisture in tugay-inundated biogeocenosis provides sufficient humidity for the soil profile throughout the year. The brief drying of the top horizon occurs only in the middle of summer, during the period of greatest evaporation and moisture consumption by transpiration (to 5%). The bottom horizons in contact with groundwater are provided with the greatest moisture throughout the year, and the limits of fluctuation of this parameter (30%) can serve as an indicator of the dynamics of the groundwater level. Thus, in the autumn, when evaporation and transpiration decrease, the level of groundwater rises, whereas it falls in the summer. The shallow groundwater on the inundated terrace, which is continuously fed and freshened by river water and by periodic floods in recent times, provides the vegetation of the reserve with moisture throughout the year. The ecological conditions also include a long summer drought, which causes extremely low relative humidity. These contrasting relationships of the soil and atmospheric humidity characterize the living conditions of the tugay vegetation. In the initial stage of development, tugay woods are connected with coastal open communities of grassy vegetation formed on young shallows and river-bottom terraces. Presently, the territory of the reserve includes 25 Th. ha.

VI. CONCLUSION

A review of the literature clearly shows the influence of reservoirs on the formation of the local microclimate, the landscape, habitat conditions and the physicochemical properties of water flows. However, the extent of this influence on various components of the environment differs and is primarily defined by the sizes and locations of the reservoirs. The main factor increasing the coefficient of influence of reservoirs is the surface area of the water body, the volume of water and the height of the dam. The essential change in the water temperature of the Vakhsh River after the construction of a reservoir is revealed. Meteorological data established a decrease in the temperature of the district after the construction of the Nurek reservoir. A reduction of the volume of the reservoir by more than 17% for the period 1978-2001 was observed. Thus, studies have established that mitigation of the impact of the changes in microclimate that are induced by reservoirs on the environment and the production of agricultural products can be achieved by developing effective mechanisms of adaptation and by carefully selecting the locations of future water reservoirs.

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