THE IMPACT OF WATER RESERVOIRS ON BIODIVERSITY AND FOOD SECURITY AND CREATION OF ADAPTATION MECHANISMS

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Abstract

Problems of food security and preservation of reserved zones in the region of Central Asia in the conditions of the climate change induced by placement and construction of large reservoirs are considered. The criterion of an optimality of placement and construction of the reservoirs providing the minimum impact on environment is established. Need of the accounting of climatic parameters is shown at definition of the water quantity for the agricultural lands irrigation

Keywords: Reservoir, Central Asia, Food, reserved zones, adaptation, Agriculture

Introduction

The problem of food safety is important for any country and at any time. The maintenance of foods is necessary not only with economic but also from social and political positions. The state that is not providing food independence cannot feel safe in the modern world. The modern situation has aggravated a problem of food safety that characterized by rather inconsistent processes occurring in global economy. On the one hand, is an increase in consumption of the foodstuffs in developing countries with another is an economic and financial crisis that has caused slump in production and population incomes.

Among calls that the whole world faced climate change poses serious threat for all natural-economic complexes including of water and lands resources. The air temperature rise at reduction of precipitation conducts to strengthening of the climate dryness. The most part of the Central Asia is in arid environmental conditions, for which poor deposits, exclusively low humidity, high intensity of evaporation and superfluous solar radiation are characteristic. Sharp growth of the population concerns serious calls in the countries of the Central Asia, which exceeds world rates. Population growth has caused processes of an intensification of economy that have led to increase of technogenic loading on water and land resources.

The food products manufacture in Tajikistan already faces many serious difficulties caused mainly prompt growth of the population, mountain topography, limitation of farmlands accessible to grain crops and livestock because of abrupt inclinations both high eminences and improper microclimates. The average mean arable land on the person makes 0.14 ha on the person who at comparison with global average 0.26 ha/person is low enough. Besides degradation of the lands - proceeding as a result of infringement of norms of land tenure, cutting down of woods, degradation of pastures, together with other processes, such as a soil erosion, events of a torrential rain, flooding, salting soils and desertification promote annual reduction of volume of articles of food.

One of ways of achievement of the minimum food safety in the vulnerable countries of region is development of the new lands and escalating of manufacture of agricultural products. In Tajikistan, for example, are available to 800 Th.ha of the suitable lands for irrigation. the Elementary analysis shows that for achievement of an average regional indicator on the specific area of an irrigation per capita about 0.2 ha/per it is necessary for Tajikistan to 2015 will master to 650-850 Th.ha of the lands. However, for this purpose it is annually necessary to place in operation 10 Th.ha in of the new irrigated earths. However, such possibility of expansion of the irrigated lands in Tajikistan while is absent. However, another economically more favorable and ecologically useful decision of given problem is an increase of efficiency of the irrigated lands and water. Increase of efficiency of water is a two-uniform problem – increase of fertility of soil and productivity at economy of water. Increase of efficiency of water is a complex problem in Tajikistan.

Ecological & Irrigation and Energetic Criteria of Reservoirs

The hydropower with agriculture is one of key basic branches of the Republic of Tajikistan economy that possesses inexhaustible stocks of water - power engineering. Total annual potential resources of water - power engineering make 527 Bln. kWt·h and now are used only on 5 % [I. Normatov, G. Petrov, 2005]. The fact of presence of large supplies of water - power engineering testifies about coming in the near future building a number of hydroelectric power stations with reservoirs. It also reflected in Strategy of development of power branch of the Government of the Republic of Tajikistan.

Hence, at planning of development of agriculture in areas adjoined to water reservoirs it is necessary to consider fact that water reservoirs promote transformation of thermal and radiating balances that in turn causes changes of climatic characteristics over a reservoir and territories adjoining on it. The meteorological mode under the influence of a water table will most essentially be transformed usually in a coastal zone and in several hundreds meters from it, then intensity of the such influences sharply decreases. However, in a direction of dominating winds the remote climatic influence of reservoirs can extend to 10 and more kilometers.

Researches of change of a temperature mode of water on length of the river after the expiration from reservoirs shows that influence of large reservoir on water temperature are most significant: distinction in daily and decade sizes of water temperature before and after a reservoir reaches 8-12°C. The greatest difference of average monthly water temperatures in tail water of reservoirs before and after a construction of reservoirs to fit to November-January and for the Vakhsh River is equal 4.2-3.4°C. Thawing influence of waters dumped from large reservoirs proceeds 8 months and cooling four month (February-May). Thus thawing influence on length of the large rivers traced on distance in 1.74 times more (209 km) than at dump of cooled waters (120 km) [I. Normatov and al., 2010].

At present for definition of efficiency criteria of the Hydropower station (HPS) with reservoirs is widely applied method based on the analysis of key parameters HPS construction such as capacity and out-put electricity by HPS in dependence of area territory occupied for building of HPS. As index of ecology-economic efficiency of Hydropower station is used relation of capacity and out-put electricity to the one hectares of the territory used for construction of HPS (Table 1).

Table 1. Ecology-economical efficiency of HPS with reservoirs construction.

Index efficiency of HPS	capacity to the area (MWt / ha)	power output to the area (TWt / ha)
Annual for HPS with area of ground less 100 th. ha	0. 123	0.406

By used of data presented on the Table 1 we made estimation efficiency now current Nurek HPS and planed in the near future construction of the Rogun HPS with reservoirs (Table 2).

Table 2. Estimation of the Nurek and Rogun HPS 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(T Wt·h); S- area for building of HPS(Th.ha); A-area of wood vegetation(Th.ha); M-migration of population(Th. pers)

For comparison in the Table 3 ecology-economic index of the considered HPS generalized with analogy indexes of other HPS.

Table 3. Comparison of the Nurek and Rogun HPS ecology-economic indexes with the optimal criteria of building of HPS.

Ecology-economical 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

G: annual for HPS with area of ground less 100 th. ha; P: capacity of HPS; S: area for building of HPS.

In the Central Asia Region with its inherent climatic conditions, choice of place and the geographical location for building of the reservoirs is one of actual problems. Estimation of the influence degree of reservoirs in Arid zones on surrounding environment it is possible by use of coefficient $K_{sur.env}$ [Murtazaev U I., 2005]:

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

where, $K_{sur.env.}$ - Coefficient reservoir influences on environment; S_i -area of the territory under influences of reservoir, km^2; S_{oi} – area of basin, km^2.

Calculations of the $K_{sur.env}$ demonstrated that factors of influence on surrounding environment of the Kairakkum reservoir is 0.11 and the Nurek reservoir – 0.144 and for Muminabad reservoirs is 0.00195 % (Table 4).

Table 4. Meaning of surrounding environment influences coefficient.

Reservoirs	Kairakkum	Nurek	Muminabad	Golovnoy
K	0.11	0.144	0.002	0.0011

It is possible to notice that influence of small premountainous reservoirs on the microclimate above than the plains. For large reservoirs observed identical picture. Influence of Nurek reservoir in 1.31 times above than Kairakkum reservoir.

Apparently, the degree of influence of reservoirs on an adjoining land decreases at reduction of their sizes and volume and at the same time return influences of the adjoining land increases to the reservoir. This feature should be consider at creation of new reservoirs in the Tajikistan and at development of schemes of building of coasts by recreation establishments, creation of zones of rest with a greater set of recreation services.

For an estimation of the role of the reservoirs as local climate formation factor it is possible to use the next attitude $\Delta P/\sigma_{sp.dif.}$, where ΔP – influence indicator, $\sigma_{sp.dif.}$ – Middle square deviation differences of the deposition one of indicator by two station located on the distance 10-20 km.

At $\Delta P/\ \sigma_{sp.dif.} \geq 1$- influences of the reservoir on formation of the concrete meteorological condition is essential. Some criteria we used at estimation role of the reservoirs as factor of formation of the local meteorological condition and agro climatic parameters of the coastal zone and coasts and thermic of the rivers in down beefs [V.M. Shirokov, P.C. Lopukh, 1985].

Up to filling Nurek reservoir by water temperature of the Vakhsh River water in upstream Nurek HPS dams (kishlak Tutkaul) practically not differences from its values on distance up to 17 km below the dam (kishlak Sariguzar). With filling of the bowl Nurek reservoir (1972 year) in spring (February-May) were observed drop temperatures of water and rising in summer - autumn - winter time (July-January) in comparison with natural conditions. The last explain partly by the fact that water take away from the top horizon of the reservoir at its unachieved filling up to High surface level (HSL) which has occurred only in 1980 years.

Since this year began influence of the Nurek reservoir on change of a thermal mode of the Vakhsh River water which to be traced most precisely on 17 km of the river downwards from Nurek HPS dams up to hydrological post Sariguzar. The greatest difference of average monthly temperature of water before and after a construction of the reservoir on the hydrological post Sariguzar (4.2 °C) is observed in November-December. In process of removal from a dam, this difference decreases up to 1.2 °C. The influence small channels reservoirs on change of temperature of water on length of the river traced on in significant distance (Table 5).

Table 5. 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

Hence change of a course of annual distribution of average monthly values of water temperature below large reservoirs for a considered time interval not connected by change of annual means of temperature of air but is influence of reservoirs of the cascade. Although according to data of "Nurek" Meteorological station monthly average temperature after construction Nurek HPS goes down (Figure 1).

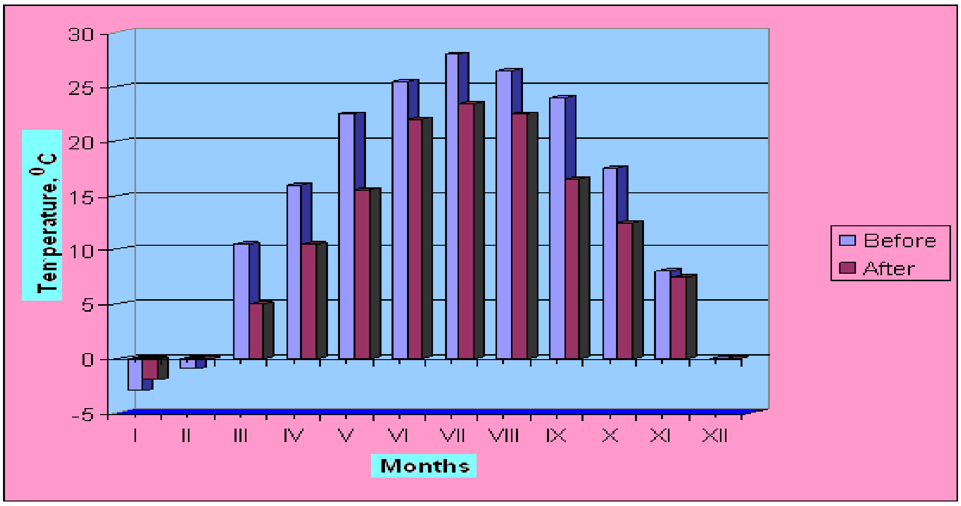

Figure 1 - Average monthly temperature before and after building of the Nurek reservoir

For establishment influences of the climate change on possible changes of agroclimatic resources we were spent the analysis of climatic parameters of three districts with developed agricultural branches (Dangara, Fayzabad and Yavan) adjoined to the Nurek reservoir. For this purpose data of Hydrometeorological stations (HMS) located in these areas have been used. Data on dynamics of temperature and relative humidity of air and atmospheric precipitations for 1968-2000 years used. The evaporation and humidity coefficient defined by calculation (Table 6).

Table 6. Summary of meteorological indexes in each district

Hydropost	Index	Years	
		1968-1972	1995-2000
Dangara	*T* (ºC)	15.3	16.4
	H (%)	57.0	56.9
	F (mm)	570.5	598.5
	I (mm)	1196.7	1438.0
Fayzabad	*T* (ºC)	13.2	15.4
	H (%)	61.6	55.2
	F (mm)	709.0	675.4
	I (mm)	1013.0	1258.8
Yavan	*T* (ºC)	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 on the Table 6 demonstrated that for 32 years (1968-2000) the average annual temperature has raised on 1.0-1.5ºC that has led to decrease of the relative humidity on 3-6 % and to increase evaporation on 10-26 % in an annual cut and 12-30 % in period May- September. However in Yavan district dynamics of changes of the listed parameters has the opposite tendency: the temperature of air, evaporation decreases accordingly on 0.5, 7.2 % and relative humidity and factor of humidifying raise on 7.2 % and 10 % accordingly.

Reduction of the evaporation in the vegetative period in Yavan district reaches 12.2 %. In view of climatic changes, it is necessary to bring corresponding corrective amendments in planning of the water use in agriculture. At development of regime of the irrigation, it is usually consider parameters of meteocondition for all period of supervision. However, it conducts to essential errors. On the old irrigated and perspective irrigation, files due to ignoring the process of global climate warming irrigation regime do not consider growing needs for water. On the contrary, on the Yavan valley files recommended regimes of the irrigation connected with over expenditure of water resources. For example, last specifications on regimes of the irrigation Yavan valley on annual average means of humidity coefficient (0.35) to the category of droughty areas. However, data presented in Table 6 show that for last 20 years evaporation in a valley has decreased almost on 300 mm (17 %) and the quantity of precipitation has risen on 70 mm (11 %) and humidity coefficient up to 0.45. Hence present irrigating norms for cultivation of the middle-fibrous cotton in Yavan valley is 1100m^3/ha and 3000 m^3/ha for Lucerne are overestimated. Calculations show, that unproductive losses of water only on two valleys made more 60 mln.m^3.

The analysis of the result of researches of the filtration characteristics at irrigation by the clean water and water with the weighed sediments shows that up to building of the Nurek reservoirs in each m^3 of Vakhsh River water contains up to 10 kg sediments and annually more 100 t sediments rich with minerals inflows to the agricultural fields. According to the Hydrometeorological Agency of the Republic of Tajikistan mid-annual charges of the weighed sediments of the Vakhsh River on the Hydropost located on the kishlak Sariguzar - 17 km below of the Nurek HPS since 1972 (the beginning of filling of Nurek reservoir) to decrease with 1000 g/s up to 82 g/s in 1980 years. Nurek reservoir almost completely besieges the weighed sediments of Vakhsh Rivers (table 7).

Table 7. 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
Komsomolobad						
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

D-diameter of particles in sediment flow

The Construction of the dam of Nurek HPS has started in 1961.Simultaneously with construction was carry out development of the technical project on calculation of the suspended load. In project given the prognosis of reservoir sedimentation for period of 11 years.

At the period of 1972-1989 years sediment flow of the Vakhsh River was measured in 1977, 1980-1982 on Komsomolobad and in 1978, 1985 on Kishrog Hydropost. In 1977 and 1985 years sediment flow measured on Komsomolobad station changed in accordance with change of wateriness year from 55.2 up to 38.3 mln. t on the station of Kishrog from 86 up to 59 mln. t.

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

Thereby the sediment flow of Vakhsh River at the input of Nurek reservoir in condition average on waterless of year can be evaluate in 60-65 mln. t. The calculation carry out with take into consideration above estimation demonstrated that by the sixth year of constant exploitation useful volume of the reservoir would decrease to 200 Mln. m^3 and to 11th year - to 650 mln. m^3. In the table 8 and presented initial forecast sedimentation of Nurek reservoir. Under its formation accepted that the process of sedimentation will conditionally begin in 1978 and its intensity at the first five years was 40 mln. mn^3 per annum but in all following years - 90 mln. m^3 per annum.

Table 8. 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

By early researches, it established that in connection with increase of temperatures it is necessary to expect maintenance of longer vegetative period of agricultural crops. Intensity of increase of temperature of air and increase in stocks of moisture in soil in spring will allow spending earlier spring sowing. Orientation to mean annual dates started of sowing without climate change will lead to decrease in productivity of all agricultural crops. Displacement of sowing relatively to optimum for 5-10 days reduces productivity on the average on 10-20 %. It connected by that the most responsible period of formation of efficiency of crops will pass at raised concerning optimum temperatures of air. Influence of agroclimatic conditions on rates of development of agricultural crops reduced to an estimation of passage by them of phenological phases.

Impact of Reservoir on the "Tigrovaya Balka"

The reserve "Tigrovaya balka" is the last on a planet to the greatest a reservation of unique community's of heavily forested florae and faunae. All kinds living in reserve represent independent "units" which could be kept in zoos and botanical gardens, and the equilibrium community that has developed within millennia, which infringement will lead to irreversible degeneration and disappearance of many kinds as was, for example, with Turanian's tiger.

Up to settlement of the Vakhsh Rivers and building of the Nurek HPS vegetative ecosystems of reserve supported by annual spring-summer floods and all lakes of reserve filled with water. After construction of the Nurek HPS with reservoirs natural floods have stopped. It has led to gradual reduction of a water level in lakes to reserve and full drying of lakes Blue and Kabane.

Now for maintenance of balance of water in reserve sewage from farmlands filled in. In a case, not acceptance of measures on prevention of a gulf of sewage in reserve, even at small concentration of salts in them, due to extremely high evaporation salinity of soil and waters of lakes of reserve will raise to fatal limits. There will be an intensification of processes of desertification and salting that finally will lead to change of the heavily forested vegetation.

The present condition of the "Tigrovaya Balka" reserve needs in providing with pure water. It in turn demands development of alternative ways of water supply of the reserve by pure water promotes considerable improvement of a condition of flora and reserve fauna that consist from next works:

- To identify the impact of chemical pollution transition processes on real 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) at the territory of “Tigrovaya Balka” reserve;

- To derive recommendations for risk management strategies in order to improve secure environmental conditions and water resources;

- Organization of preliminary purification system of water inflow to the reserve by building of reservoirs.

It known that fluctuations or change in one of ecosystem components causes a number of collateral changes and other components. Change of a water mode and a chemical compound of waters occur physiological changes in reserve plants due to aspiration of plants to adaptation to the new created conditions. This process automatically reflected on a food allowance and activity of fauna and birds of reserve. Process of a mutation of kinds of plants, animal and other inhabitants of reserve did not exclude. Considering that fact that the reserve “Tigrovaya balka” is also a place of seasonal residing of birds of passage processes proceeding in flora and reserve fauna can extend on huge territories of globe. In most cases, poachers transform reserve into a hunting place. Undesirable infections and the illnesses caused by adaptation of inhabitants of reserve to the broken natural condition can transferred through food and by that to generate mass distribution of illness or an infection.

In 2007 year has been spent a complex of works on inspection of territory of reserve and acceptance of measures which would allow to improve water delivery of an ecosystem of reserve. These measures include clearing overgrown natural a channel, building of the channel for a supply of fresh water bypassing dams, building of pump station etc. The systematic clearing of channels has proceeded in 2008. Despite very insignificant difference in level of northern and southern parts of reserve — bogging in the north where exhaust waters were almost liquidate. Water on the cleaned channels and drains has directed in drying up lakes — and it filled with water, as in former years when the natural waterway was support by regular floods.

At the initiative of the Government of Tajikistan in 2007 the “Tigrovaya balka» reserve area has been increased by 21 Thousand ha. The added territories allow providing complex protection of ecosystems – as tugayes and adjoining deserted. Besides, the reserve increase has made natural moving of animals by more safe – earlier they often fell outside the limits protected territory.

In the autumn of 2008 to reserve “Tigrovaya balka” was execute 70 years. By this anniversary, the Government of Tajikistan has made the decision on territory expansion on 100 Thousand ha. However before joining these deserts were used for a pasture of cattle and fuel gathering that has led to degradation of complexes of grassy plants and a total disappearance of haloxylon woods. For their restoration, the Reserve began to spend haloxylon landing.

Now the reserve area makes 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) now the reserve total area makes 50.9 Thousand ha, including the wood area of 24.1 Th. ha (47.4 %) and not wood – 26.8 Th. ha (52.7 %) and a light forest, glades – mountains - of 8.0 Thousand ha (14.1 %). Bogs and waters occupy 21.4 % from the n reserve total area. In northern and southern part of reserve are available 16 and 5 large and small lakes accordingly.

The water regime of soils of tugay-inundated biogeocenoses sharply differs from previous, first, the raised humidity of all soil thickness; secondly, absence of influence of seasonal atmospheric humidifying as the regime here defined, basically, by additional humidifying at the expense of close (1-2 m) levels of ground waters. The water and salt regime of soils defines formation and seasonal development of a vegetative cover. In deserted biogeocenoses, seasonal development of vegetation accurately traced. Additional soil humidifying in tugay-inundated biogeocenoses provides high enough humidity of a soil profile throughout all year. Therefore, in the autumn, at decrease in evaporation and transpiration, level of ground waters rises and goes down in the summer. Close ground waters on the inundated terrace, continuously fed and freshened by river water and in recent times periodic floods, provide vegetation of reserve with moisture within round year. The originality of ecological conditions consists also that the long summer drought causes very big dryness of air. These contrast relations of soil and atmospheric humidity characterize living conditions of the tugay vegetation. Tugay woods in the initial stage of the development connected with coastal type of open communities of the grassy vegetation formed on young shallows and the bottom river terraces. Now territory of reserve occupied 25 Th. ha.

Conclusion

Thus as a result of the carried-out researches it is established that mitigation of impact of change of a microclimate induced by reservoirs on environment and production of agricultural products can be carried out by development of mechanisms of adaptation and an optimum choice of a place of construction of water reservoirs

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