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

Parviz I. Normatov

Tajik Technical University
10 acad. Radzabovich Ave., Dushanbe, 734042, Tajikistan
zar.rakhimov@mail.ru

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

I. INTRODUCTION

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

Among calls which the whole world has faced climate change poses a serious threat for all natural-economic complexes including water and land resources. The air temperature rises 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 which 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 by 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 per person which 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 the ways of achievement of the minimum food safety in the vulnerable countries of region is developing new lands and escalating manufacture of agricultural products. In Tajikistan, for example, people 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 irrigation per capita about 0.2 ha/per it is necessary for Tajikistan to master to 650-850 Th.ha of the lands in 2015. However for this purpose it is annually necessary to place in operation 10 Th.ha of the new irrigated earths. And such possibility of expansion of the irrigated lands in Tajikistan while is absent. Another economically more favorable and ecologically useful decision of given problems is increasing the efficiency of irrigated lands and water. The increase of water efficiency is a two-uniform problem: the increase of soil fertility and productivity at economy of water. Thus increase of efficiency of water is a complex problem in Tajikistan.

II. ECOLOGICAL IRRIGATION AND ENERGETIC CRITERIA OF RESERVOIRS CONSTRUCTION

The hydropower with agriculture is one of the key basic branches of the Republic of Tajikistan economy which 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 5 % [1]. 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 is 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 the 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 hundred meters from it, and then the intensity of 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 is the most significant: distinction in daily and decade sizes of water temperature before and after a reservoir reaches 8^{o}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^{o}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 is traced on distance in 1.74 times more (209 km) than at dump of cooled waters (120 km) [2].

At present for definition of efficiency criteria of the Hydropower station (HPS) with reservoirs is a 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. Index of ecology-economic efficiency of Hydropower station is used as relation of capacity and out-put electricity to the one hectares of the territory used for construction of HPS (Table I).

TABLE I 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 Groundless 100th. ha	0. 123	0.406

By using the data presented on the Table I, we made estimation efficiency now current Nurek HPS and planed in the near future construction of the Rogun HPS with reservoirs (Table II).

TABLE II ESTIMATION OF THE NUREK AND POGUN 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 the comparison in Table III, ecology-economic index of the considered HPS are generalized with analogy indexes of other HPS.

TABLE III COMPARISON OF THE NUREK AND ROGUN HPS ECOLOGY ECONOMIC INDEXES WITH THE OPTIONAL 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 groundless 100 th. ha; P: capacity of HPS; S: area for building of HPS;

In the Central Asia Region, 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 is possible by use of coefficient $K_{sur.env}$ [3]:

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

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

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

TABLE IV MEANING OF SURROUNDNG ENVIRONMENT INFLUENCES COEFFICIENT

Reservoirs	Kairakkum	Nurek	Mumina-bad	Golovnoy
K	0.11	0.144	0.002	0.0011

It is possible to notice the influence of small pre-mountainous reservoirs on the microclimate above than plains. For large reservoirs is observed identical picture. Influence of Nurek reservoir is 1.31 times larger than Kairakkum reservoir.

Apparently, the influence of reservoirs on an adjoining land decreases with the 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 considered when creating new reservoirs in Tajikistan and also in the 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 is influence indicator, $\sigma_{sp.dif.}$ is middle square deviation differences of the deposition, one of the 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. These criteria we are 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 also thermics of the rivers in down beefs [4].

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). By filling the bowl Nurek reservoir (in the year 1972) in spring (February-May), we 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 1980s. Since this year, influence of the Nurek reservoir on change of a thermal mode of the Vakhsh River water has been traced most precisely on 17 km of the river downwards from Nurek HPS dams up to hydrological post Sariguzar. The greatest differencein average monthly temperature of water before and after a construction of the reservoir on the hydrological post Sariguzar (4.2 ^{o}C) is observed in November-December. In process of removal from a dam, this temperate difference decreases to 1.2 ^{o}C. The influence of small channels reservoirs on change of water temperature on length of the river are traced on in significant distance (Table V).

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

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

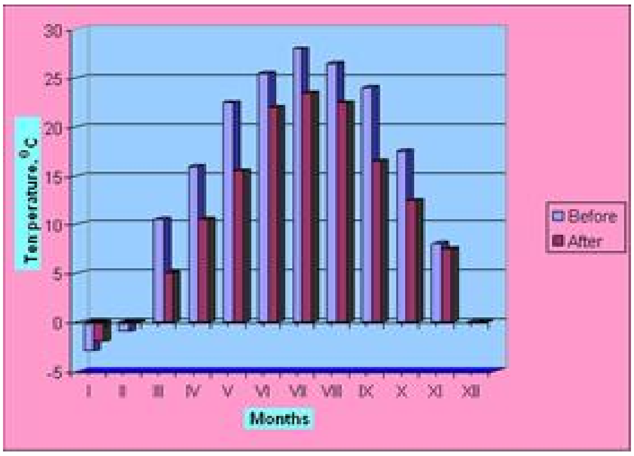

Figure 1 Average monthly temperature before and after building of the Nurek reservoir

III. IMPACT OF RESERVOIRS ON IRRIGATIONREGIME OF AGRICULTURE

For establishing 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 years 1968-2000 were used. The evaporation and humidity coefficient were defined by calculation (Table VI).

TABLE VI SUMMARY OF METEOROLOGICAL INDEXES IN EACH DISTRICT

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 the Table VI demonstrates that for 32 years (1968-2000) the average annual temperature has raised 1.0-1.5°C that has led to a decrease of the relative humidity about 3-6 % and an evaporation increase about 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 an opposite tendency: the temperature of air and evaporation decreases accordingly 0.5 and 7.2 % and relative humidity and factor of humidifying raise 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 developing regime of the irrigation, the parameters of meteor condition are usually considered for all period of supervision. But it conducts 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 irrigation regimes are 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. But data presented in Table 6 show that for last 20 years evaporation in a valley has decreased almost 300 mm (17 %) and the quantity of precipitation has increased 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 are made more 60 mln.m^3.

IV. SEDIMENTATION OF RESERVOIRS

The analysis of the research result of the filtration characteristics at irrigation by the clean water and water with the weighed sediments shows that 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) decrease from 1000 g/s to 82 g/s in 1980 years. Nurek reservoir almost completely besieges the weighed sediments of Vakhsh Rivers (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
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 the development of the technical project on calculation of the suspended load has been carried out. The prognosis of reservoir sedimentation for period of 11 years is given in the project.

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

On the estimation of the Institute of Mathematics of AS of Tajikistan, additional value of tributary sediment from Komsomolobad to Nurek reservoir is 4 mln. t.

Thereby the sediment flow Vakhsh River at the input in Nurek reservoir in condition average on waterless of year can be evaluated as 60-65 mln. t. The calculation carried out to take above estimation into consideration demonstrates that by the sixth year of constant exploitation useful volume of the reservoir will decrease to 200 mln. m^3 and by the 11th year - to 650 mln. m^3. Table VIII presentes the initial forecast sedimentation of Nurek reservoir. Under its formation was accepted that the process of sedimentation conditionally began in 1978 and its intensity at the first five years was 40 mln. m^3 per annum but in all following years - 90 mln. m^3 per annum.

TABLE VIII PROGNOSES OF NUREK RESERVOIR SEDIMENTATION (REDUCTON 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 is established that in connection with increase of temperatures, it is necessary to expect maintenance of longer vegetative period of agricultural crops. Intensity of air temperature increase 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 average to 10-20 %. It is 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 is reduced to an estimation of passage by them of phonological phases.

V. IMPACT OF RESERVOIR ON THE "TIGROVAYA BALKA" RESERVE

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 dependent "units" which could be kept in zoos and botanical gardens, and the equilibrium community has developed within millennia, in 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, they were supported by annual spring-summer floods and all lakes of reserve were filled with water. After construction of the Nurek HPS with reservoirs natural floods have stopped. It has led to gradual reduction of the water level in lakes of reserve and full drying of lakes Blue and Kabane.

Now for maintenance of balance of water in reserve, sewage from farmlands is 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 is in need of being provided with pure water. It in turn demands development of alternative ways of water supply of the reserve by pure water to promote considerable improvement of a condition of flora and reserve fauna which is consist of the following works:

- To identify the impact of chemical pollution 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;
- To organize preliminary purification system of water inflow to the reserve by building of reservoirs.

It is known that fluctuations or change in one ecosystem component causes a number of collateral changes and other components. Change of a water mode and a chemical compound of waters bring in physiological changes in reserve plants due to the aspiration of plants' adaptation to the new created conditions. This process is 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 isn't excluded. 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 be transferred through food and by that to generate mass distribution of illness or an infection.

In 2007, a complex of works has been taken on inspection of territory of reserve and acceptance of measures which would allow improving 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 got is almost liquidated. Water on the cleaned channels and drains has directed to drying up lakes, and was filled with water; while in former years the natural waterway was supported 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 more safe; while earlier they often fell outside the limits protected territory.

In the autumn of 2008, reserve “Tigrovaya balka” had been executed for 70 years. By this anniversary the Government of Tajikistan had 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 had 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 %), the non-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 total area of reserve. In northern and southern part of reserve, they are available for 16 and 5 large and small lakes accordingly.

The water regime of soils of tugay-inundated biogeocenoses sharply differs from previous, firstly, the raised humidity of all soil thickness; secondly, the absence of influence of seasonal atmospheric humidifying as the regime here is 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 is accurately traced. Additional soil humidifying in tugay-inundated biogeocenoses provides high enough humidity of a soil profile throughout all year. The short drying of the top horizon is marked only in the middle of summer, at the moment of the greatest evaporation and moisture consumption on transpiration (to 5 %), the bottom horizons on contact to ground waters are allocated with the greatest moisten within all year, and limits of fluctuation of this contour (30 %) can serve as an indicator of dynamics of ground water level. So, at decrease of evaporation and transpiration, level of ground waters rises in the autumn and goes down in the summer. Close ground waters on the inundated terrace, continuously fed and freshened by river water, and also 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 are connected with coastal type of open communities of the grassy vegetation formed on young shallows and the bottom river terraces. Now territory of reserve occupies 25 Th.ha.

VI. 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.

REFERENCES

[1] I. Normatov, G. Petrov. “Use of Central Asia water resources in irrigation and hydropower: conflict of interests or mutually beneficial collaboration”., J. Water Resources of the Central Asia, vol.2, pp. 24-29, 2005.

[2] I. Normatov, U. Murtazaev and N. Nasirov. “Creation of adaptation mechanisms: the key to more cost-effective and environment-friendly water management”, IAHS Publ. Red Book 338. pp. 74-76, 2010.

[3] V. M. Shirokov, P.C. Lopukh. “Features of development of the nature of small reservoirs (on an example of artificial Reservoirs of Belarus)”. J. Geography and natural resources. vol.1, pp. 40-49, 1985.

[4] Murtazaev U I. Diss. Evolution of natural complexes of Reservoirs of Tajikistan and their influence on adjoining Landscapes.Dushanbe, pp. 322, 2005.

[5] P. I. Normatov – “Development of Information systems in regulation of water energy relations between countries of Central Asian transboundary river basins”, Joint IAHS & IAH Convention a symposium, IAHS Publ. 331 (Proceedings of JS.4), Hyderabad, India, pp. 494-499, 2009.

[6] P. I. Normatov, A. S. Kodirov, N. Shermatov – “*Mathematical modeling and prognosis of the main river of Tajikistan water discharge and optimization of hydropower station with reservoirs*”, 2nd International Scientific Conference “Energy and Climate Change”, 8-9, Greece, pp. 72, 2009.

Parviz I. Normatov was born in Dushanbe city of the Republic of Tajikistan on 6 February, 1989. He is a PhD Student of the Tajik Technical University in Dushanbe city of Tajikistan. The major field study of him is water resources management and application of information technology to monitor risk assessment, water objects and environment.