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The proceedings present 21 papers from 9 countries of the Asian region dealing with water, biodiversity and environmental problems in Asia and offering way for their solurion and sustainable development. The main focus is on the role of academic science and international cooperation in resolving conflict, legal and economic issues of environmental management under climate change. Adaptation of nature and society to climate change, Biodiversity under environmental changes, Problems of water use in Asian region, Socio-economic and environmental problems of the development of Asian regions and Mechanisms for sustainable development of Asian regions are discussed.

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Table of contents

Would Climate Change Bring Only Negative Impacts to the Ecosystem and Human Life Condition? A Speculation on It's Positive Side

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Introduction

Climate change and its impacts on our environment and human life conditions are surely the defining issue of our era. Hence, it is no wonder that world research community has carried out enormous scientific investigation and socioeconomic studies during the last several decades generating numerous publications about the causes, progress, impacts and applicable policies associated with climate change and global warming.

In this regard, however, most investigators suggest that future human life will be significantly affected mainly due to ecosystem transformation, sea level rise, increased epidemic disease spread, water shortage, etc.

However, the author thinks differently. Surely, there will be certain negative impacts as mentioned above. However, this is the author's proposition that there would be some positive effects caused by global warming and climate change, particularly in the regions of East Asia and Russian Far East where most of parts are rather cold region compared with other parts of the world. For example, opening of arctic sea route and acceleration of economic development in Russian Siberia in these days would not be possible without global warming and climate change.

In addition to this observation, most scientific publications which dealt with such negative impacts like decrease of crop production, loss of biodiversity, and/or ecosystem transformation limited their discussion largely to qualitative speculation. For this reason, in the presenting paper the author would like to discuss what the real impacts of global warming and climate change are in our region, particularly in the field of agriculture and forestry, by presenting some real data which have been collected in South Korea during the last several decades.

The Trend of Global Warming and Climate Change in Korea

Well known IPCC report(2007) clearly demonstrates that the global average air temperature has steadily increased ever since the start of industrial revolution in mid 19^{th} century as shown in Fig. 1. The increase of temperature was particularly significant over the last half a century, so the rate of warming averaged in this period was nearly twice that for the last 100 years showing the range 0.13℃ ± 0.03℃ per decade.

On this temperature increase, however, IPCC report described that effects of urbanization and land use change on the global temperature record were negligible (less than 0.006°C per decade over land and zero over the ocean) as far as hemispheric- and continental-scale averages are concerned. In fact, the real but local effects of urban areas were fully accounted for in the land temperature data sets used for drawing Fig. 1. IPCC report also mentioned that urbanization and land use effects are not relevant to the widespread oceanic warming that has been observed.

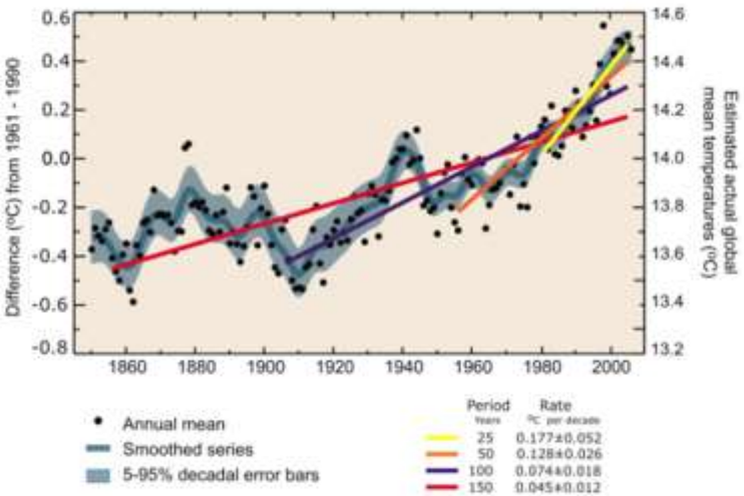

Fig. 1. Annual global mean observed temperatures(black dots) along with simple fits to the data. The left hand axis shows anomalies relative to the 1961 to 1990 average and the right hand axis shows the estimated actual temperature(°C). Linear trend fits to the last 25(yellow), 50(orange), 100(purple) and 150 years(red) are shown, and correspond to 1981 to 2005, 1956 to 2005, 1906 to 2005, and 1856 to 2005, respectively.

Comparing with this trend of global warming, however, Korea's recent temperature records show a very rapid increasing as illustrated in Fig. 2. The 10-year average temperature steadily increased from 12.1℃ to 12.8℃ between 1970 and 2010 showing most dramatic increase in the last decade. The rate of Korea's average temperate increase during the last 40 years was 0.27℃± 0.05℃ per decade(KMA, 2011), far exceeding the rate of global trend reported by the IPCC.

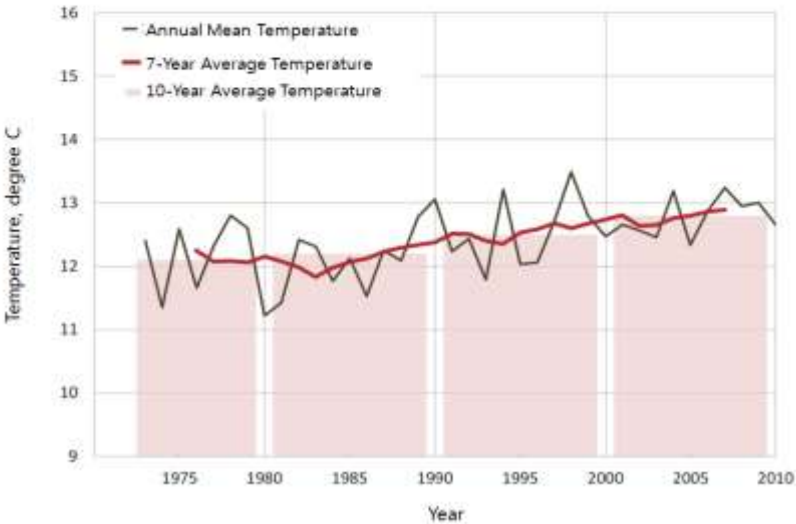

Fig. 2. Recent trend of annual average temperature increase in Korea(1973~2010).

This rapid increase of temperature in Korea would be caused mainly by the increase of greenhouse gases. In fact, Korea's background CO2 concentration increased by 3 ppm per year recently(MOE, 2011) and this increase rate is more than twice of global CO2 increase rate since 1970s. Rapid increase of population from 32.2 million in 1970 to 49.8 million in 2010 as well as rapid economic development and subsequent rapid increase of fossil fuel consumption during the same period would also affect such rapid increase of greenhouse gases.

Other factors such as accelerated urbanization and land cover change would have significant influence on Korea's climatic change. Furthermore, distinct geographical surroundings also may affect Korea's climatic change. Located alongside the Pacific and the Eurasian continent at mid latitude, Korea is regarded as one of few countries easily affected by both continental and oceanic climates.

Global warming also affects regional climate change. In Korea's case, 10-year average annual precipitation were increased about 15%, from 1,180mm in 1970s to 1,359mm in 2000s, as seen in Fig. 3.

In summary, it is believed that Korea has experienced about 0.8℃ temperature increase during the last half a century showing twice of global average mainly because of very rapid population increase and economic development compared to other parts of the world. Korea's unique geographic characteristics sitting far Eastern part of Eurasian continent as well as nearby China's recent economic development would also affect such rapid greenhouse gas increase in the air causing accelerated temperature increase.

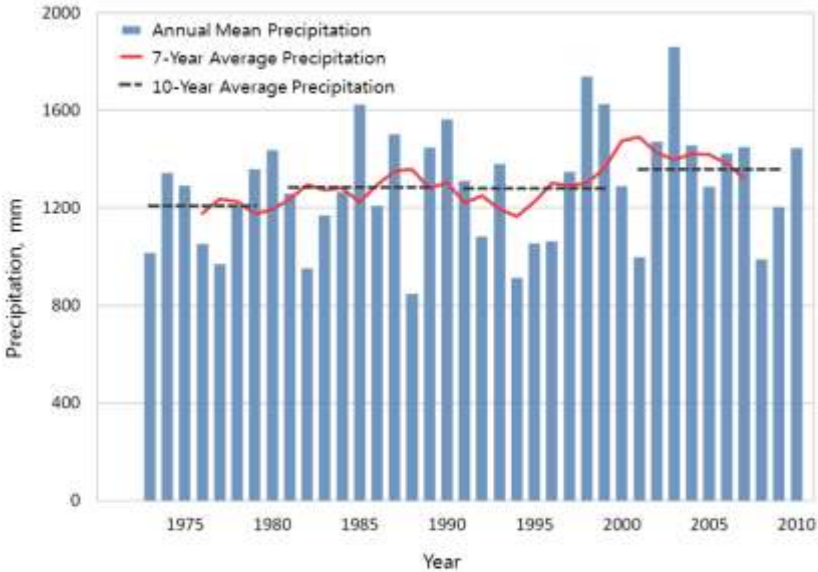

Fig. 3. Recent trend of annual precipitation increase in Korea(1973~2010).

This observation that Korea already has been through with significant global warming and climate change during the last half a century suggests that what Korea has experienced until now would serve as certain examples to other parts of the world in recognizing how significant the impacts of global warming and climate change will be for the next a couple of decades or more. The followings are some statistical analysis in the fields of agriculture and forestry in Korea.

The Impacts of Climate Change in Korea's Agriculture

Agriculture is highly dependent on specific climate conditions. Increases in temperature and carbon dioxide can be beneficial for some crops in some places. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Changes in the frequency and severity of droughts and floods caused by the global warming and climate change could pose challenges for farmers by significantly decreasing crop productivities.

In this regard, it seems the general consensus that higher temperature eventually reduce yields of desirable crops while encouraging weed and pest proliferation(IFPRI, 2009). Also, it is widely accepted that changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security(IFPRI, 2009).

Contrary to this generalized theory, however, Korea's agriculture business have enjoyed continued crop production increase during the last half a century. Here let's check the case of rice which is regarded most precious crop product in Korea dominating more than 90% of total grain production. Mainly because of nation's long history of rapid industrialization and urbanization rice paddy area has consistently decreased from 1.184million(M) ha in 1970 to 0.887M ha in 2010, showing about 25% reduction. However, annual rice production has increased about 25% during the same period from 3.907M M/T to 4.899M M/T as shown in Fig. 4.

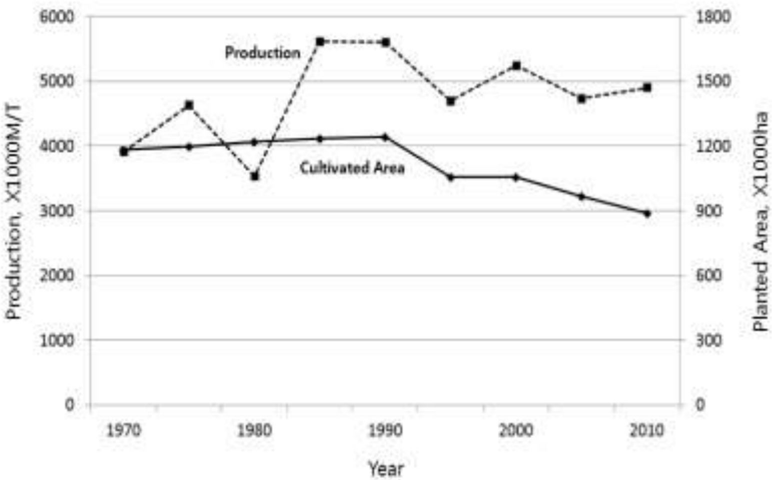

Fig. 4. Trend of rice production and rice paddy area change during 1970-2010 in Korea.

This amazing increase of rice production has surely been benefitted from changes in farming practices and technology development. Improvement of crop species, more use of fertilizers and pesticides, improvement of irrigation system, and increased agricultural mechanization all would have positive impacts on rice productivity.

In this regard, however, we may assume that global warming trend and it's subsequent climate change occurred in Korea during the last half a century would affect minimum impacts on rice production because if climate change impacts had been so serious as most scientists have speculated, such great productivity increase would never have been possible. Or, it might also be possible to assume that climate change would provide some positive effects on crop production in Korea. In fact, other crop productivities like wheat and soybean have also greatly increased, more than 60 % during the last 4 decades as shown in Fig. 5. Productivities of most fruit and vegetable products have also greatly increased.

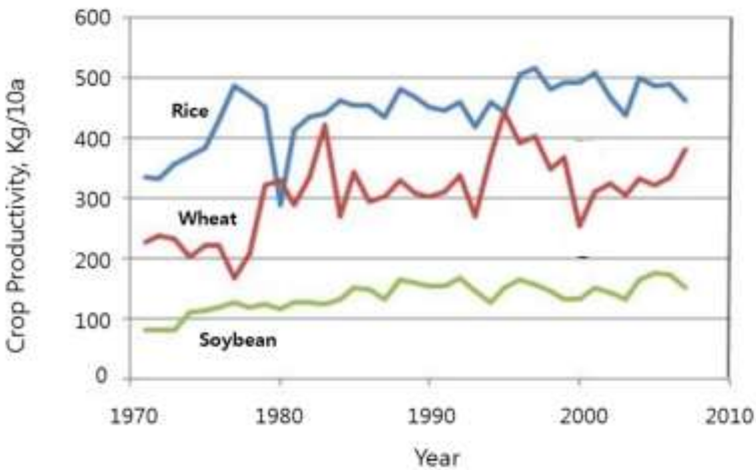

Fig. 5. Trend of major grain productivity changes during 1970-2010 in Korea.

In such countries like Korea, as climate becomes warmer, the possible growing period for outdoor crop is getting longer. The first day of frost would be delayed and the last day of frost is advancing, clearly extending the frost-free period. In Korea's case the first day of frost has been delayed by 2.9 days per decade while the last day of frost has advanced by 3.8 days per decade, extending the frost-free period by 6.7 days per decade(Fig. 6).

Such extension of frost-free period in combination with increase of precipitation during crop growing season as shown in Fig. 3 would provide some beneficial effects enhancing crop productivities in Korea.

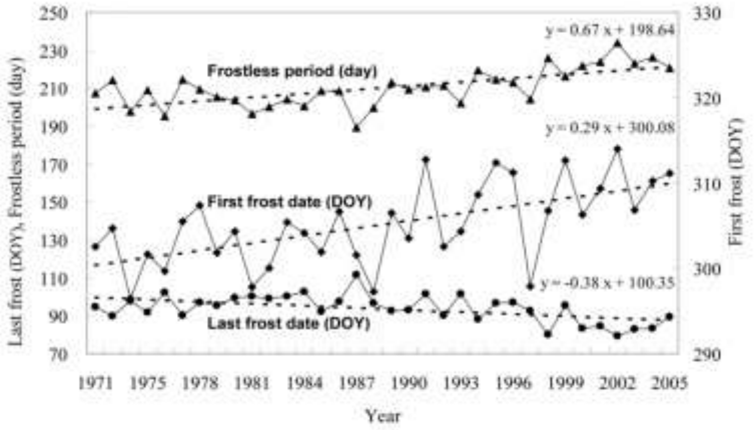

Fig. 6. Change of first frost day, last frost day, and frost-free period during the last 35 years in Korea(Shim et al., 2008)

In this regard, recent official report(Ministry of Environment, 2010) described that under the projected global warming according to the IPCC SRES A2 scenario the national mean GDD(Growing Degree Day) would increase by 10% from 4,432 of the present normal to 4,898 during the period 2011~2040, by 23% to reach 5,456 during the period 2041~2070, and by 8% to reach 6,093 during the period 2071~2100. In addition, the increasing trend will be much clearer at high altitude cool regions than in plain regions where the GDD is sufficient, affecting changes in agroclimatic zone and cropping systems in Korea(Fig. 7). If this is true, the author suspects that Korea's agricultural business would enjoy more of positive impacts of global warming and climate change than suffer from them.

The impacts of Climate Change on Forestry in Korea

Comprising 64% of country land forests in Korea provide much valuable benefits in many ways like production of materials, absorption of carbon dioxide from the air, and generation of pure water, as well as conservation of biodiversity. As climate change has recently progressed, biodiversity in the forest ecosystem and affiliated systems of the ecosystem have been envisaged to be influenced to a great extent(Ministry of Environment, 2010).

In this regard, most researchers in Korea also agree on such a generalized view that climate change will severely affect the overall ecosystem mainly because of significant rise in temperature and change of precipitation patterns in the 21st century. For example, they reported that the flowering and leaf sprouting periods have shifted to an earlier time in recent days(Ministry of Environment, 2010).

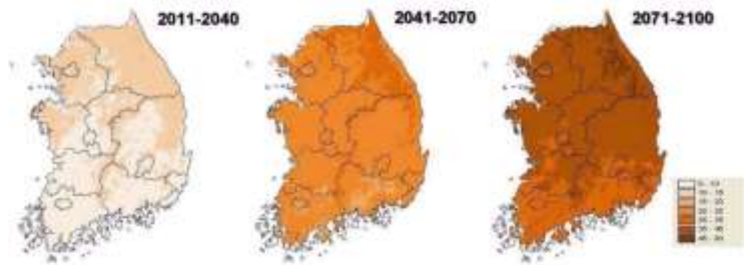

Fig. 7. Change of growing degree day(GDD; 0℃ for base temperature) under future normal climate projected by IPCC SRES Scenario(Kim & Yun, 2009)

However, the author also thinks differently. It is the author's speculation that Korea's long-term forestry records collected during the last half a century do not support the theory that the negative impacts of climate change on tree growth and biodiversity is significant.

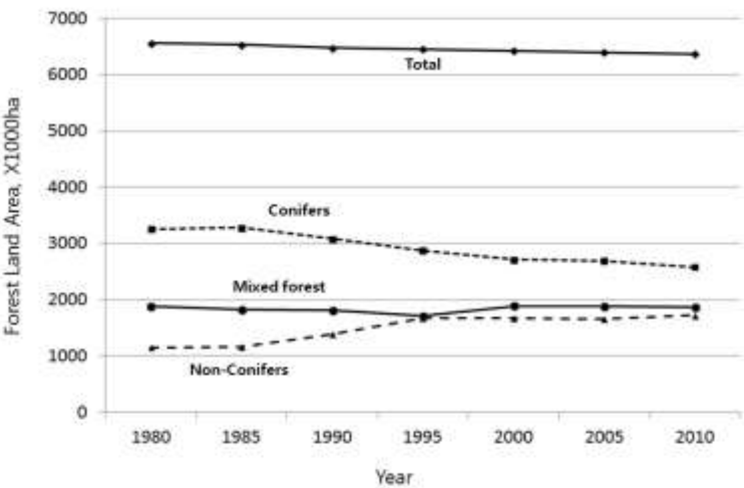

Fig. 8. Trend of forest land and forest type change during 1980-2010 in Korea

It would be true that Korea's forests are changing very rapidly and global warming and climate change have affected in some degree. For example, the size of conifer forests has continuously decreased recently while the areas of non-conifers and mixed forests were gained at the same time as shown in Fig. 8. Because conifers rather prefer cold weather while non-conifers generally like warmer and wetter weather this forest type change toward non-conifer forests would be a sure sign of recent climate change.

Like shown in agriculture, the total land size of forests in Korea is gradually decreasing mainly because of nation's rapid industrialization and urbanization, from 6.56million(M) ha in 1980 to 6.40M ha in 2010. However, the size of conifer forests mostly dominated by the pine trees has decreased almost 20% just within 3 decades, comprising from 49.6% in 1980 to 40.5% in 2010 among nation's total forests. In the same time, the size of non-confer forests has grown very rapidly, dominating 17.5 % in 1980 to 27.0% in 2010 of total forests.

However, changing forest types would show only a part of big picture that has been affected by global warming and climate change in these days. During the same period, Korea's forest growing stocks in terms of total amount and amount per unit area have greatly increased, more than 5.3 times and 5.4 times respectively, as illustrated in Fig. 9.

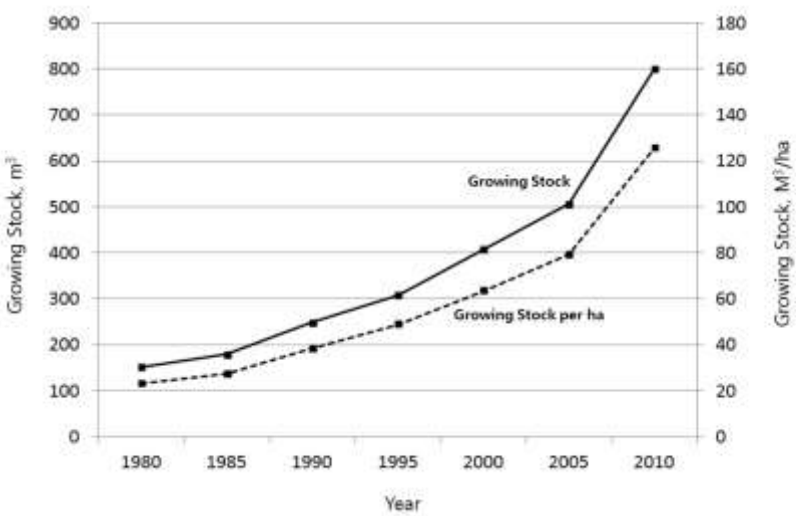

Fig. 9. Trend of total growing stock change in Korea's forestry during 1980-2010.

This enormous gain of stock growing would only be possible because most of Korea's forests are in the stage of rapid growing after centuries-long deforestation and forest abandonments. Also, massive introduction of financial capitals and new technologies like the forest protection from fires and pests, fertilization and mechanization in forest management, and extensive forest regeneration would greatly help such stock growth increases. However, in this regard, we must consider that such positive impacts from economic development and technological progress would be relatively small in forestry compared with the case of agriculture because the nation's total investment for the forest protection has always been very limited when compared with that of agricultural development.

Considering that forestry would have more impacts from climate change than agriculture we may notice some positive effects of global warming and climate change in the forests. For example, Fig. 10 illustrates the trend of forest pest occurrence since 1970 in Korea. As shown in the graph, 3 major forest pests in Korea, pine caterpillar, pine gall midge and fall web-worm, all were in the dwindling stages recently after massive proliferation in 1970s.

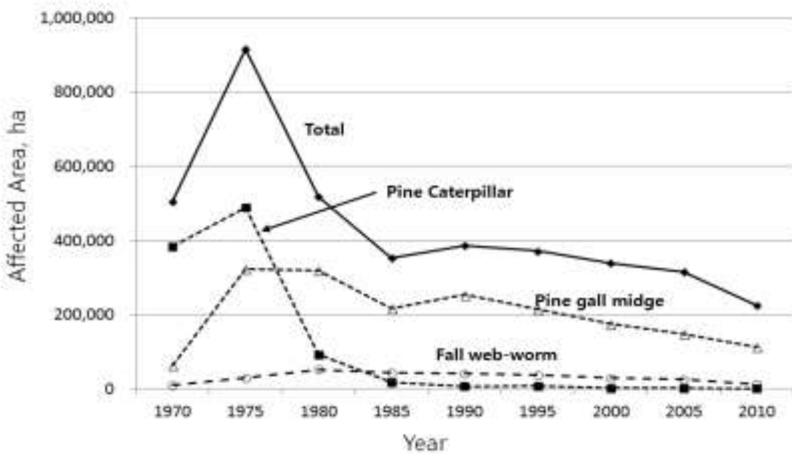

Fig. 10. Trend of forest pest occurrence in Korea's forestry during 1980-2010.

Needless to say, this phenomenon should be regarded as a result of good forest management practices in Korea, but with this observation we may develop such thinking that Korea's forests have grown bigger and healthier with less pest manifestation during the period of such rapid global warming and climate change which were usually recognized as increasing pest occurrence as described earlier.

Pine mushroom only survives under the pine trees and very sensitive to environmental factors. This mushroom is regarded as one of very valuable forest products in Korea and hence it's production has been well-documented. Here Fig. 11 shows the annual pine mushroom production in Korea since 1970. Significant fluctuations of annual production would represent how sensitive this species is but it's long-term production during the last 4 decades seems have not changed much. As discussed earlier, recent climate change consistently decreased the size of conifer forests reducing the number of healthy pine trees which serve as the nurturing ground for the mushroom. However, climate change would also bring more precipitation which is beneficial to the pine mushroom growth that prefers wet weather, particularly in it's autumn growing season.

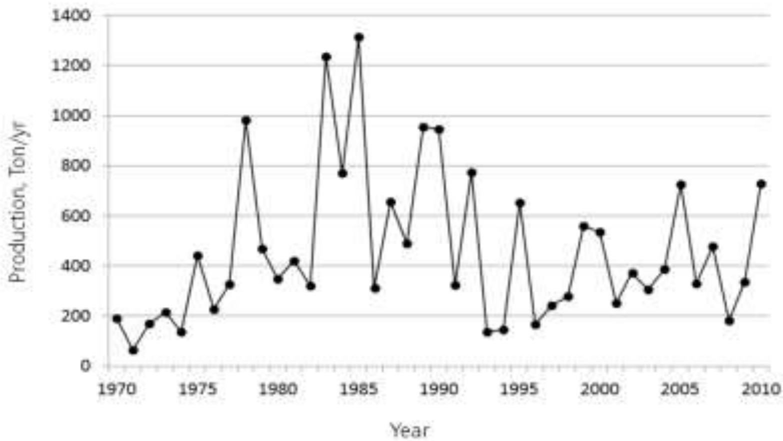

Fig. 11. Trend of pine mushroom production change in Korea's forestry during 1970-2010.

Conclusions

While there have been enormous publications discussing certain negative impacts of global warming and climate change, it is rather difficult to find out literatures that deal with some positive impacts of climate change. In addition to this, most of those publications, no matter either they are dealing with certain positive or negative impacts of climate change, seem lack of real data collected from the fields. Or, at best they usually discuss with data gathered based on microscopic observation rather than macroscopic perspectives.

In this regard, the author discussed what real impacts of climate change are in agriculture and forestry with the data obtained from the national statistical yearbooks of Korea. Because Korea's global warming and climate change trend during the last several decades has been regarded very rapid, a twice or more than world trends, our experience in those areas was expected to provide some clues useful in understanding what would happen in other parts of the world for the next a couple of decades or so.

Although both agriculture and forestry are generally regarded as very vulnerable to climate change Korea's agricultural and forest productivities have shown extensive growth in spite of such rapid progress of global warming and climate change.

Based on this observation, the author would like to conclude that we may have better chance for agricultural production and forest protection at least in the near future, particularly in such regions like East Asia and Russian Far East.

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Evolution of large water body ecosystem after decreasing of anthropogenic impact (in terms of Ladoga Lake).

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Ladoga is the biggest lake in Europe and an exclusive water supply source for Saint-Petersburg and many towns of Leningrad Region and Republic Karelia. Nowadays many regions of Russia have a fresh water shortage and it can increase in future. It is possible that Ladoga Lake water will be required for water supply of other regions.

Ladoga Lake water quality is a key factor which influences on a life of several millions people who live in the territory about 260 thousand sq.km. Some enterprises and organizations were influencing on Ladoga Lake ecosystem during several decades of the 20 century and significantly damaged it. There were signs of negative changes in Ladoga Lake at the end of 60th caused by development of economic activity in this place. The period since the beginning of the 1970th until the end of the 1980th was a time of ecological disaster. During this time Ladoga made a fast transition from oligotrophic condition into mesotrophic one. Certain areas got features of eutrophic reservoirs. The increasing of nutrients mainly by phosphorus and nitrogen entry into the lake stimulated phytoplankton mass extension. "Water blooming", caused by intensive development of cyanobacterium, was common for Ladoga Lake during the oligotrophic period. This phenomenon became more frequent and long-term with anthropogenic eutrophication increasing.

Eutrophication process attended with changes of several physical-chemical characteristics of the water. In particular, concentration of dissolved oxygen in hypolimneon periodically decreased. Transparency of the water reached earlier about 6-7 m; later it decreased on the average to 3 m. The "dead zones" without invertebrates of a benthos began to form in places of sewage influence. Such zones were adjoined by extensive polysaprobic areas without any typical representatives of the Ladoga fauna. A number of hydrobionts in benthos and plankton were characterized by morphological deformation due to Ladoga pollution. A big part of studied fishes had a high process of toxicoses: in the Volkhov bay about 70–80%, in the Svirsky bay 50–60%, in the mouth of the river of Vidlits 60%.

An activity of the Priozersk pulp and paper mill dumping sewage in the lake was suspended in 1986 by the Institute of Limnology initiative. As a result the ecological situation in the lake began to improve. The following economic recession and corresponding decrease in polluting load of the lake also led to improvement of its state. All this time the Institute of Limnology monitored different characteristics of Ladoga Lake with special attention to phosphorus and nitrogen. It is possible now to analyze Ladoga ecosystem evolution for the entire period, beginning from the intensive polluting press and till anthropogenic impact decrease.

According the researches results we can make such conclusions: water inflow and dissolved impurity to the lake from the rivers makes more than 85% of receipt part of Ladoga water balance and external load by polluting substances. About 90% of the general inflow arrives from three largest rivers: Svir, Volhov and Vuoksa. Carrying out of chemicals with rivers to the lake can be considered as an integrated indicator of environmental conditions and economic activity in the territory. A phosphoric load in Ladoga with river drain was about 6000–7000 t year^{-1} in the late 70th and beginning of the 80th. Nowadays about 3000 – 4000 t P year^{-1} (depending on water content of a year) arrives to the lake and about 50% of it is a natural component.

Critical load for surface water is defined by a number of polluting substances entry to the lake which don't cause harmful effect on sensitive components of water ecosystems, according to Hendriksen, etc. [6]. A critical load on a system water basin–reservoir is such level of substances come from outside that leads to achievement of allowable (critical) substances concentration level in water, ground deposits or biota [5].

Follenveyder [7] offered graphical view of differentiation between oligotrophic, mesotrophic and eutrophic lakes depending on inflow of water and phosphoric load. The diagram (fig. 1) has the name of Follenveyder. It can form a basis for approximate values determination of admissible phosphoric (Lp) and water (Lw) load. According this load the lake can be oligotrophic or eutrophic, in case of surcharge load.

Water load is a ratio of annual lake inflow volume to a water surface lake area. The result of researches [8] was the mathematical expression for calculation a critical phosphoric load (L_{kp}) on large cold water reservoirs with the slowed-down water exchange:

$$L_{kp} = 25L_w\,(1 + \tau_w^{0.5}),$$

where 25 is a critical concentration of phosphorus in a lake (in mkg • L^{-1}) during spring overturn, τ_w (per year) is the period of full water exchange in a lake.

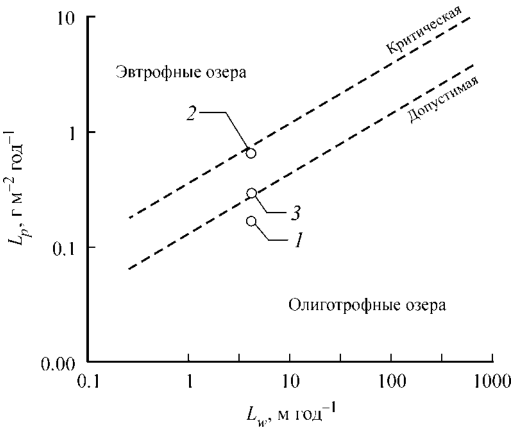

Fig. 1. The trophic status of lakes depending on phosphoric (Lp) and water (Lw) loads [7], and phosphoric load of Lake Ladoga in 1959–1962 (*1*), 1976–1982 (*2*), 1996–2001 (*3*).

In the next years the term "critical load" was used in relation to anthropogenic impact on water objects not only by phosphorus, but also by other chemical elements.

The mentioned method of critical load assessment is used for an average year in terms of water content. However it is necessary to pay attention to interannual fluctuations of water content for processes of anthropogenic eutrophication. Shallow water years can be determinate when lake is entered to eutrophic condition.

The critical phosphoric load on Lake Ladoga according to the Follenveydera-Dillon equation is 0.47 g of $m^{-2}year^{-1}$. It corresponds 8300 t $year^{-1}$ of phosphorus intake from the drainage basin to Lake Ladoga.

The external phosphoric load on Lake Ladoga in 1970th and beginning of 1980th years was 0.38-0.41 of $m^{-2}year^{-1}$, according to researches of the Institute of Limnology, Russian Academy of Sciences [3]. At this level of load, the lake was on the upper bound of mesotrophic conditions and corresponded to transitional level from mesotrophic to eutrophic level, according to Follenveyder's diagram. Phosphoric load was decreased to 0.32-0.35 $m^{-2}year^{-1}$ in 1984-1995 and reached permissible level 0.15-0.23 $m^{-2}year^{-1}$ in 1996-2010. Critical concentration of the general phosphorus in water of Lake Ladoga is 31 mkg l^{-1} [1], that corresponds to a critical load on the lake taking into account a sedimentation factor. This value is close to the concentrations observed in the late 1970. Reduction of phosphoric load on the lake led to decrease of its concentration in the lake water and to reduction of ratio values of general phosphorus critical concentration to its average contents (fig. 2).

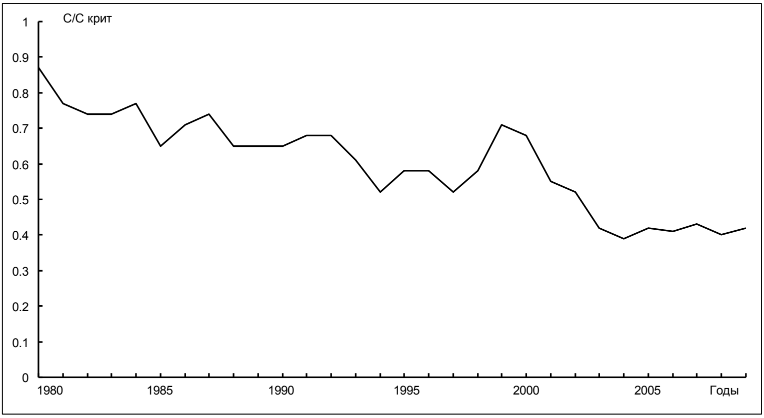

Fig. 2. Dynamics of concentration ratio of general phosphorus C to its critical contents $C_{(cr)}$ = 31 mkg of l^{-1} in Lake Ladoga.

Shilkrot [4] offered an assessment method of a maximum load on reservoir by the general nitrogen depending on average depth. According to this method the nitric load on the Ladoga Lake, which can lead to eutrophication, is 8 g of $m^{-2}year^{-1.}$The real nitric load on Ladoga, calculated by results of field studies, doesn't exceed 5 g of $m^{-2}year^{-1}$. There was no evidence of distinct trend changes in nitric load during all period of regular field studies.

The quantitative estimation, by methods of mathematical modeling show, that phosphoric load decreasing can't guarantee Ladoga productivity decreasing. In many cases an anthropogenic load decreasing is not a solution to return an environment into natural state or, at least, for prevention its further degradation. There can affect possible irrevocable biocenoses changes, an internal load from polluted ground deposits section and considerable inertness of large water system.

The average annual phosphorus concentration decreasing trend for the Lake Ladoga shows a possibility to keep its favorable ecological condition in the next years. At the same time researches results show that the lake restoration goes extremely slowly because of considerable inertness of intrabasin processes. There were some signs of the lake restoration only in

9–11 years after almost twice decreasing of anthropogenic load. Mainly these signs took place in areas with active hydrodynamic processes. Evolution of the Lake Ladoga ecosystem has a loop-shaped ("hysteresis") character. Return of the ecosystem to less trophic condition is attended by new formation of main reservoir community's peculiar features and characteristics. It defines absolutely a new stage of Lake Ladoga evolution. Some important hydrochemical and hydrobiological indicators (metals and phenols concentrations, phytoplankton and chlorophyll-a characteristics) were so far stabilized. Nevertheless, despite of the fact that many indicators were improved and stabilized, it was observed a decrease of transparency, bacterial plankton instability, a spurt of water flowering, appearance of toxic substances in water intakes, etc.

We can make a conclusion that the lake balance ecosystem is unstable. This fact is accompanied with economic activity increasing. Environment conditions of Ladoga Lake and its drainage area need to be permanently monitored. There is a necessity of tighten control of the lake conditions and constantly functional ecological support for current activities. This is important for timely taking measures to prevent negative changes in the lake ecosystem.

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Water and environmental problems of transboundary cooperation in continental Asia

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It is apparent that in the third millennium water becomes one of major resources that hampers potential development of many regions or causes inter-regional and inter-ethnic conflicts.

In this paper, we suggest dwell on three issues of transboundary cooperation in the field of water management

I. Problems of water supply and water distribution in continental Asia

By and large, Asia refers to the areas of water and environmental risk. Here, water resources are unevenly distributed: water resources are sufficient in the North (Asiatic Russia), whereas in Central and Southeastern Asia they are limited. This results in frequent epidemics and even water-related conflicts sometimes.

Pressing water-ecological situation is typical for almost all Asia countries, but it manifests itself differently in the "upper" and "lower" parts of the basins. Leaving aside the issue of "saving the Aral Sea", a significant deterioration of current water and economic situation has become obvious since the time of the USSR disintegration, the countries of which previously shared common transboundary basins and water infrastructure.

Unsolved problems of water allocation aggravates water shortage in the regions. Most of the water formed in the mountain regions of Tajikistan and Kyrgyzstan is consumed by Kazakhstan, Turkmenistan and Uzbekistan; still, there are no effective mechanisms for regulating the amount and mode of water use. For instance, 75.2% of the Syr Darya water falls on Kyrgyzstan, 2.7% of the Syr Darya and 74% of the Amu Darya on Tajikistan and 15.2 and 8.5%, respectively, on Uzbekistan [1]. Note that the "mountain" countries use less than 10% of total flow to cover their own needs; they seek compensation from partners, especially Uzbekistan with its 37.4% of the irrigated lands and about 45% of population of the post-Soviet Asian countries (PSAC).

Current imbalance in PSAC appears in water sector through growing competition in hydropower production and agriculture. It also creates a situation of "suspended disaster". With poor hydrocarbon resources, Tajikistan and Kyrgyzstan see the solution of the problems in the construction of large hydroelectric power plants (HPP, i.e. Rogun in Tajikistan, the Kambarata and Verhnenarynsk cascade in Kyrgyzstan). In water use, the so-called "plain" states stick to agricultural priorities. The situation is escalated, and implicit and explicit conflicts arise because of the construction of the unique Rogun dam (its height exceeds 300 m) in Tajikistan, promotion of the idea of building small HPPs and the expansion of irrigation systems in Uzbekistan. [2]

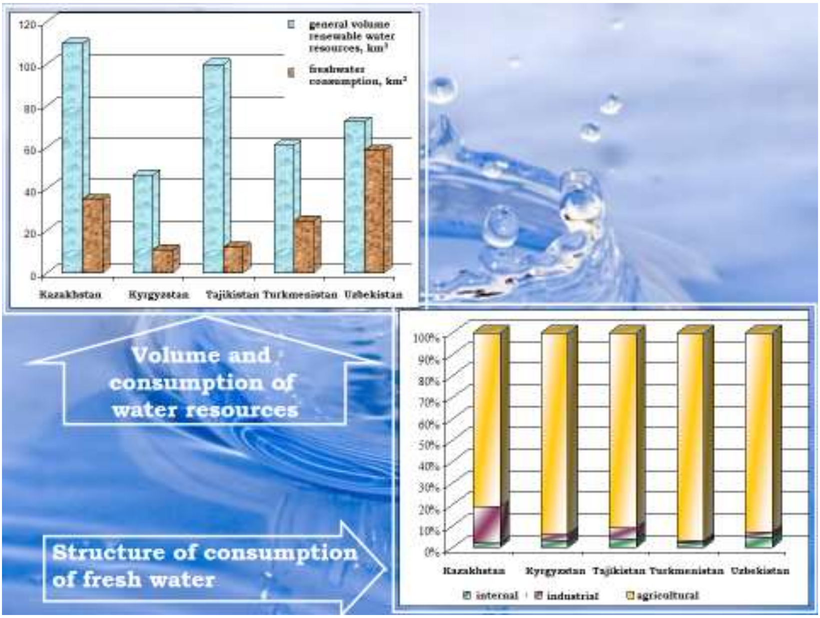

Fig. 1. Volume and consumption of water resources

The positive thing is cooperation of these countries with international organizations, though some "asymmetry" in the presence of representatives from Tajikistan and Kyrgyzstan at a conference in Tashkent, and on the contrary- the ones from PSAC in Dushanbe and Bishkek does exist. All this makes a productive discussion of water management, water-ecological and energy problems hardly feasible. Each country has its own arguments, but, in our opinion, the only way out is institutional one, namely through the development and strict observance of international agreements regulating water use and water resources allocation in the transboundary basin of the Aral Sea [3].

II. China's role in current water-ecological balance of Asia

At present, China acts both as a “hydrodonor” and as a “hydropump” of the region where rivers Brahmaputra (Matsang-Tsangpo in Tibet), Indus (Sindhu is called in Tibet), Mekong (Lancang-Dzachu in China), Hongha - "Red River" (Lishehe-Yuantszyan in the PRC), etc. originate. The growing economy of China requires more resources, including water ones.

The development of neighboring countries largely depends on the economic and geopolitical behavior of China that shows interest in river energy development in the Aral Sea basin. China is ready to back the construction of both large and small diversion HPPs, which being environmentally and seismically friendly would contribute to local development of Tajikistan and Kyrgyzstan. Options for financing the construction of HPPs on rivers outflowing from the Kyrgyz Tien Shan Mountains and then flowing in China are also discussed [4,5].

Interests of Kazakhstan and China meet in the context of "Aral" problem,i.e. when the hydroelectric plants of "mountain" states supported by China infringe upon the interests of partners from the "plain" countries. In addition, Kazakhstan is a "secondary" user of water resources of 23 transboundary rivers outflowing from China. Nowadays, the most tense situation is observed in the Irtysh basin. In 1999-2005, Xinjiang province withdrew 1.12 km^3 from Kara-Irtysh or 11.4% of upstream flow of R. Irtysh, in 2010- 2011 it was about 3.0 km^3 (over 30%), and in the near future it will reach about 4 km^3 or 40% of total water flow [6]. At present, there is moderate water shortage in R.Kara-Irtysh but soon it may become critical making a negative effect on the downstream territories of Kazakhstan and Russia.

In Kazakhstan and China, the problem of legal status and environmental safety of transboundary rivers remains unsolved; there are no mechanisms for controlling water intake in China. Moreover, China refuses to sign the UN treaty "On the Water" ratified by Russia and Kazakhstan in 1993. In 2001, the Agreement between and by the governments of Kazakhstan and China on "Cooperation on transboundary rivers conservation" was signed (12.09.2001, Astana). To do that, a joint commission on the conservancy of transboundary water resources was established, and some agreements between Kazakhstan and China were reached [7,8]. Being a good performer, China is very cautious in taking any commitments. Kazakhstan actively participates in various international debates, but mostly as a "third party", not vested to make decisions. Often, Kazakhstan fulfills its commitments inadequately.

Water interests of Russia and China meet in the basins of rivers Irtysh and Amur, where the issues of water allocation and water quality are topical.

III. Water management problems (actual and potential) in the transboundary Irtysh basin, a site of our direct interests

The Irtysh basin covers the territory of four states. Unfortunately, Russia receives the Irtysh water after China and Kazakhstan and does not participate in coordination of water-related issues. China opposes the Russia's participation in R.Irtysh negotiations.

To solve the problems of transboundary cooperation, the Russian-Kazakhstan commission for joint use and protection of transboundary waters (including working groups for the basins of rivers Ishim, Irtysh, Tobol, Ural, Bolshoy and Maly Uzeni) were established [10].

We believe that in this situation, one should proceed from reality: China will not take less water than now, most likely its water intake will be increased. Kazakhstan also cannot reduce the amount of river flow not having extra sources of surface fresh water. Therefore, the situation with transboundary rivers flowing through China and Kazakhstan (and running through the Russian territory), will remain complicated despite the agreements reached [9,10].

The involved countries make the proposals how to solve these problems. For instance, Kazakhstan considers the following projects:

1. water replenishment of R.Irtysh;
2. dilution of industrial effluents.

The first project implies the diversion of runoff of R.Tikhaya flowing through Kazakhstan and Russia and entering R. Katun. This project, discussed for more than 20 years already, is very ambitious and intricate. It is planned to construct the hydraulic pressure tunnel of 4.5 km long and of 3 m wide from the Katun basin (Altai Republic of the Russian Federation) to the Bukhtarma basin (East Kazakhstan). Water transfer of 2 km^3 /yr is projected. In place of water level drop (605 m), the Belokatunskaya HPP and a reservoir with the capacity of 1.25 bln km^3 is built. [11]

The second project deals with turning rivers Ak- Kaba and Kara-Kaba outflowing from the ridges of Katonkaragay region in Kazakhstan then running through the Chinese territory and falling into the Black Irtysh. It is proposed to turn rivers at the boundary and to direct their flow to the Black Irtysh in Kazakhstan by means of a 20-km tunnel. Thus," the problem of water scarcity" will be solved but for a while.

To solve its own water-related problems, the Russian side suggests some water projects for consideration . The first is aimed at the construction (nearby Omsk city) of a channel type dam and the reservoir to store water and then uniformly feed R.Irtysh. Alternatively, the creation of a series of underwater man-made rapids to provide rise in water level by reducing the river speed was proposed [12]. Currently, the project on the construction of the Krasnogorsk hydroelectric complex at a 1813 km from the Irtysh mouth and 1 km upstream the oil refinery is being realized. According to the project, the reservoir will ensure the maintenance of the water level of R.Irtysh near Omsk city, especially in low-water years. Spillway dam will allow to maintain the reservoir level at any point of reference. The influence zone of a low-head dam should extend up to 60-65 kilometers upstream R.Irtysh, 23 km – R.Om'. The maximal level rise will be marked near the dam (3 m), while the minimal (1 m) in the opposite side of the reservoir. In the vicinity of city Omsk, water level in R. Irtysh is expected to be 1.5 - 1.8 m higher as compared to the current, extremely low one [13]. Probably, the realization of this project would solve water problems in Omsk, but hardly preserve the river ecosystem and provide sustainable water supply in the basin, since the demand for water in Kazakhstan [14] and China [15] increases and effective institutions of regulation are absent.

Finally, it may be said that

1. The territory of continental Asia is characterized by a great natural diversity; it is differentiated by territorial distribution, quality and demand for water resources. Lowland areas with high population density and economic potential face acute shortage of water resources, especially drinking water.

2. Transboundary rivers are the key areas of international cooperation where manifestation of problems is most prominent. The international community, particularly in Europe, North America, etc. has gained a positive experience in dealing with such problems. In Asian countries, the institutional forms of cross-border cooperation have not developed yet. Still, China, Tajikistan, Kyrgyzstan and some other countries have not signed neither the Helsinki Agreement of 1992 and 1996, nor other water-related legal acts.

3. Implementation of the methodology for strategic water management focused on the rational use of water and preservation of aquatic ecosystems for future generations can serve the basis for the integrated management of water complexes in transboundary basins of contiguous countries.

4. Operational management of water facilities should be carried out in accordance with Common Schemes for Conservation of Transboundary

Water Objects, the coordination of annual water management plans for all major hydraulic structures and daily schedules of water discharge.

5 Water resources conservation is an essential factor for sustainable development of almost all Asian countries that must be considered when working out the strategies for their development, including international cooperation.

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Modern adaptation approach of water consuming branches to climate changes and degradation of glaciers

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Abstract: It is known that the main waterways of Central Asia are Transboundary and respectively in relationship of the upstream and downstream countries of rivers the question of quantity and quality of waters are dominating. It is caused in distinction of interests in irrigational (the lower reaches countries) and power aspects of waters of the Transboundary rivers. One of such Transboundary rivers is Zeravshan River which waters are used mainly for an irrigation of agricultural lands of Uzbekistan. Zeravshan River Basin in the territory of Tajikistan is characterized by limitation of farmlands (about 20 Th.ha) but with sufficiently rich hydropower resources. Continuous monitoring of the water resources condition is necessary for planning of development of basin by the account of power and irrigational interests.

The present article is devoted to more detailed analysis and estimates of the prompt degradation of glaciers of the basin, quality of the Zeravshan River waters and formation of floods by essential economic damages and definition of adequate possibility measures for their mitigation. For this purpose meteorological data of Agency of hydrometeorology of Tajikistan, methods of the chemical analysis of waters of the river and statistical data of the Ministry of Emergency Situations of Tajikistan were widely used. In most cases the problem of water quality of the Zeravshan River consider in organic communication with activity of the Anzob Mountain-concentrating Industrial Complex (AMCIC) in Tajikistan. Results of comparison of the analysis of waters have shown about absence of essential pollution of waters of the Zeravshan River by wastewaters of the Anzob mountain-concentrating industrial complex but are changed under the influence of collector drainage water of irrigating basin zone and wastewater of Samarqand, Kattakurgan, Navoi and Bukhara cities of Uzbekistan

Keywords: Glacier, flood, agriculture, Hydropower, pollution, mountain.

1. Introduction

In the Aral Sea Basin on the territory which is located five states, water resources are used basically for irrigation and water-power engineering. These water users demand different modes of regulation of a river drain. In interests of water-power engineering – the greatest development of the electric power and accordingly use larges parts of an annual drain of the rivers in winter the cold period of year. For irrigation the greatest volume of water is required in the summer during the vegetative period. Regulation of a river drain is thus carried out by the large reservoirs. Thus all largest hydroelectric power stations are constructed in the countries of a zone of the drain formation - in upstream the rivers Amudarya and Syrdarya – in Kyrgyzstan and Tajikistan and the main areas of the irrigated lands are located in states of the down stream of the rivers – Kazakhstan, Turkmenistan and Uzbekistan [1].

Among calls which the whole world faced it is climate change which poses serious threat for all natural and economic complexes including water and land resources.

In condition of Central Asia the issue of assessing the present and estimated changes of glaciations have a basic importance for two reasons [2]:

- glaciers are clear indicators of the natural environment reaction to the climate changes: the rate of average annual temperature increase by less than 1.0 ^{o}C a century was enough for the glaciations in the mountains of Central Asia to be reduced by more than a third;
- it is equally important to estimate the impact of the present glacier ice retreat on the characteristics of river drain and water resources.

The Glaciers of Tajikistan occupied about 6% territories of the country and to make an important contribution in water flow formation of the Amudarya River - the largest waterway of the Central Asia and Aral Sea Basin.

Annually in average 10-20 % of the large rivers drain formed at thawing glaciers of the Tajikistan and in dry and hot years the contribution of glaciers to water resources of the same rivers in summer can reach 70%. Getting warmer in high-mountainous areas of Tajikistan (Pamir, Zeravshan and Gissar-Alay) corresponds to regional and global tendencies of the climate change and stimulated appreciable changes in glaciers. The estimation of influence of global climate change on glaciers of Tajikistan has shown that for all period of observation since 1930 years the total area of glaciations of the Tajikistan was reduced approximately to one third.

The accounting of change of climatic factors (temperature and evaporation reduction, increase in a precipitation and humidity) gives to economy of water for an irrigation of agriculture lands about 2000 m^3 per ha.

The presented examples clear are demonstrated about necessity of development of scientifically reasonable mechanisms of adaptation of all components of an ecosystem to climate changes.

The paper is devoted to the analysis of a condition of glaciers of a river basin of Zeravshan and development of modern approaches on a sustainable development of a river basin taking into account interests of hydro power and irrigation

Zeravshan is Transboundary River in Uzbekistan and Tajikistan - length of 877 km, the area of basin of 17.7 Th. km^2. The average expense of water 162 m^3/sec. Originates from the Zeravshan glacier in mountain knot between Turkestan and Zeravshansk with ridges the river is fed basically with glaciers and snow. Therefore the greatest drain in it is necessary for the summer (July, August), during the cold period of year Zeravshan bears not enough water. In the summer water in the river muddy, gray-steel color, in the winter pure and transparent. On territories of Republic Uzbekistan near to the Samarkand city the Zeravshan River is divided into two sleeves – Akdarya and Karadarjua. Earlier Zeravshan ran to Amudarya River but now loses the waters in desert Kyzyl Kum, forming two deltas – Karakulsk and Bukhara. The total drain of the Zeravshan River Basin on the periods 1932-1962 and 1962-1991 make is accordingly 146.26 and 145.03 km^3 [3]. The water of the Zeravshan River on the Republic Uzbekistan territory is distributed basically on following areas: Samarkand-70.2 % (at irrigated area of 67 %), Navoi-13.1 % (at irrigated area of 16 %), Dzhizak-7.4 % (at irrigated area of 8.6 %), Kashkadarya- 9.3% (at irrigated area of 7.8 %) [4]. From the total water intake of the Zeravshan River (4834 mln.m^3) to the Republic of Tajikistan to come only 253 mln. m^3 (5.23 %) [5].

2. Materials and Methods

By our preliminary researches it was established that in the Zeravshan River Basin water and power and ecological aspects become more actual in connection with appearance of the following problems:

- prompt degradation of glaciers of the basin;
- formation of floods by essential economic damages.

The present article is devoted to more detailed analysis and estimates of the above-named problems and definition of adequate possibility measures for their mitigation

For this purpose meteorological data of Agency of hydrometeorology of Tajikistan, methods of the chemical analysis of waters of the river and statistical data of the Ministry of Emergency Situations of Tajikistan were widely used.

3. Results and discussion

3.1 Glaciers of the Zeravshan River Basin

3.1.1 Zeravshan. The glacier is located on the Zeravshan and Turkestan ridges joints and gives rise to one of the main rivers of the Central Asia – Zeravshan River. It is dendrite glacier by length of 27.8 km, the area 38.7 $км^2$ and with inflows 132.6 $км^2$.The tongue of the glacier takes place on 2810 m above sea level. Moraines of the Zeravshan glaciers occupy 10 $км^2$ and with inflows 24 $км^2$ areas. Observation of the Zeravshan River water discharge are begun from the end of a 19th Century on the Dupuli Hydropost and since 1927 years are begun detailed observation of the Zeravshan glaciers.

3.1.2 Rama. The glacier is located on a southern slope of the Turkestan ridge in upstream of the Zeravshan River in narrow rocky gorge. It is a valley's glacier by length of 8.9 km and the area 22.3 $км^2$. The end of the tongue of the glacier takes place on 3500 m a. s. l. and is covered by the moraine 3 $км^2$. As well as all other glaciers of the Zeravshan River Basin the Rama glacier recedes.

3.1.3 Tro. The glacier is located on the southern slope of the Turkestan ridge in sources of Zeravshan River. A glacier is valleys by length of 3.0 km and the area 2.2 $км^2$. The tongue of the glacier takes place on 3920 m. a. s. l. and buries in a final moraine. Observations of the glacier are begun in 1959.

3.1.4 Dikhadang. The glacier is located in the Zeravshan River Basin on northern slope of the Zeravshan ridge. The glacier is valleys by length of 2.2 km and the area 2.0 $км^2$. Dikhadang glacier is covered by a moraine 0.3 $км^2$. The tongue of the glacier is located on 3600 m a. s. l. Observation of the glacier are begun in 1959.

3.1.5 HGP (Hydrographic party). The glacier is located on northern slope of Hissar Mountains in the Saritag River Basin running to Lake Iskandarkul. The length of a glacier is 1.16 km by the area 0.54 $км^2$and average width of 0.47 km. The glacier end lies at height of 3320 m. a. s. l. The first observations on a glacier are spent in 1968 and in 1971-1974 periods on a glacier every summer worked complex glacial expedition. For last 16 years (1990 - 2006 years) a glacier has receded on 35-55 m (Fig.1) annually the average its speed has made about 3 m per year though in the eightieth years of the last century it has made about 8 m annually. Shooting of a cross-section structure has shown that the glacier has not changed almost, and recedes only from a final part. Thus, the nearest decade's disappearance does not threaten glacier HGP.

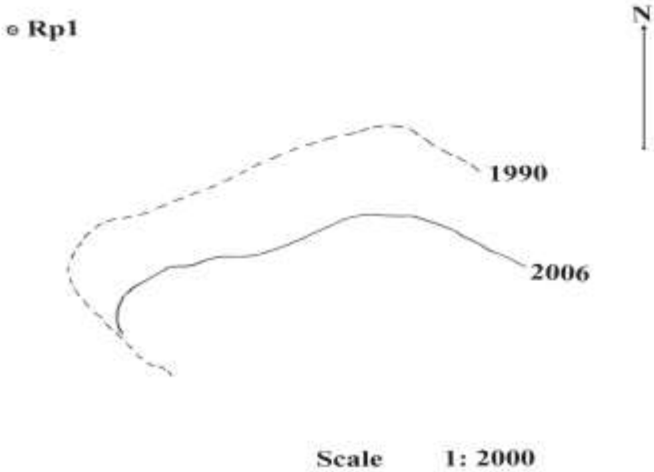


Fig.1. Deviation of the Hydrogeography Party glacier.

The question of Climate change influence on the glaciers state very actually in the Zarafshon River Basin (Table 1 & 2).

3.2 Hydroenergy potential of the Zeravshan River Basin

It is necessary to notice that for the Republic of Tajikistan is perspective the energy potential of waterways of the Zeravshan river basin which according to [5] makes – 11.8 Bln. kWt·h. Potential hydropower resources of some inflows of the Zeravshan River present on the table 4.

In the presence of such rich energy potential suspended to the Zeravshan River Basin in Sogd area huge deficiency of the electric power is observed - 3-4 Bln. kWt·h /year which is covered by import of the electric power from the Republic of Uzbekistan. The intensive grows of the Tajikistan population, presence of the large file of the fertile but not mastered lands suspended to upstream of the Zeravshan River demands principal processing of economic use of the Zeravshan Rivers scheme. The mutual combination of interests of upstream and downstream countries of the Zeravshan River is quite achievable by building of the cascade of Hydropower station (HPS) with regulation of the river drain.

Table 1. Dynamics of change of the Zeravshan River Basin glaciers.

Name	Periods	Deviation	Deviation	Note
Zeravshan	1927-1961 1961-1976	280 980	65	In the period 1927-1976 From ice set free the area 1.19 km^2
Rama	1929-1948 1948-1975 1976-1989 1989-1991 1929-1975 1976-1991	320 356	4 9 15 60	From ice set free the area 0.12 km^2 From ice set free the area 30.0 km^2
Tro	1976-1988 1988-1990 1990-1991	18 60 23	1-2 30 23	
Dikhadang	1977-1991 1990-1991	180 60	13 60	
HGP	1968-1976 1982-1990 1989-1990	18 63 12	2.2 7.9 12	

Source: Tajik Hydrometeorology Agency

Table 2. Possible changes of the Zeravshan River Basin glaciers for the period to 2050

Name of Glacier	**Reduction**		
	Length (km)	Area (km^2)	Volume (%)
Zeravshan	4.0-5.0	25-30	30-35
Rama	1.5-2.0	3.0-3.5	25-30
Tro	0.5-1.0	1.0-1.2	30-35
Dikhadang	1.2-1.5	1.0-1.5	more 50
HGP	Completely will thaw to 2030 years		

Source: Tajik Hydrometeorology Agency

It causes some discontent of Republic Uzbekistan connected by that realization of programs on development of a hydropower potential of the river by building a number of the water reservoirs leads to deficiency of water in vegetation period of agricultural crops.

Table 3. Potential hydropower resources of some inflows of the Zeravshan River [6]

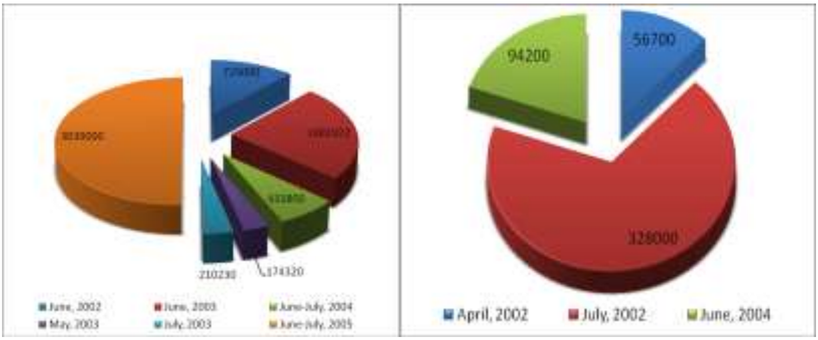
Name	Length, m	Average annual discharge, m^3/sec	Average annual power, Th. kWt	Average annual production, Mln. kWt·h
Sarmad	22.6	1.52	9.15	80.2
Artuchdarya	17.14	1.26	8.65	75.8
Magiandarya	68.4	10.3	76.5	670.0
Shing	14.2	5.89	20.0	176.0
Fondarya	24.5	61.1	396.0	3470.0
Tagobikul	19.8	2.83	17.1	150.0
Hasorchashma	12.4	1.70	10.8	94.2
Pindar	12.3	1.64	12.8	112.0
Dzijikurut	17.4	1.59	14.9	130.0
Gaberut	10.1	0.84	4.14	36.3
Iskandardarya	20.4	21.1	106	927.0
Saritag	34.0	13.5	68.5	560.0
Pasrud	28.4	4.68	13.8	121.0
Turo	12.7	2.07	10.1	94.0
Yarm	11.1	1.48	11.1	97.2
Demunora	19.6	3.0	24.1	210.0
Jindon	18.8	1.61	12.1	105.0

The cardinal solution of the conflict situation between an irrigation and water-power engineering is the greatest their joint development by building of new HPS with reservoirs. For water-power engineering it means increase in production of cheap and ecological pure energy and for an irrigation – increase of depth of long-term regulation of a drain and water security of already mastered lands, and also possibility of development new. At presence of several HPS with reservoirs the top reservoir can work only in power mode, the bottom reservoir of the same volume can regulated a drain up to restoration of its natural regime. Especially it can provide drain regulation in interests of irrigation. At presence not two but many quantities of HPS with reservoirs the situation even more will improve [1].

Thus, the analysis of the above-stated material is demonstrated that the solution of a problem of balanced use of two aspects, namely use of a hydroenergy potential of the Zarafshon River with full satisfaction of requirements of agriculture on water demands the deep feasibility report leaves on a plane of bilateral negotiations of the adjoining countries. It seems to us that at the present stage in Global climate change by the most important monitoring and a behavior estimation hydro- and meteorological parameters of the Zeravshan River Basin to climate changes which allows to plan and adapt development and water-power engineering and agriculture taking into account forthcoming values of volume of the rivers water on immediate prospects is.

3.5 Ecological and social-economical estimation of the flood impacts in Zeravshan River Basin

Among all the regions of Tajikistan 93 % of territory which borrow mountains in the Zarafshon River Basin the formation of floods is observed most often (almost 7% of the total across Tajikistan) and their average number in a year reaches 150. More than 300 thousand inhabitants live in the Zarafshon River Basin located in the Ajni and Penjikent regional centers. The local population is affected almost annually with great economic losses (Fig.2, 3).

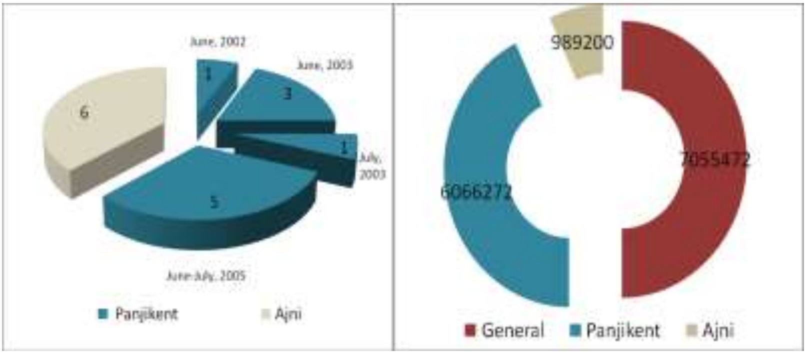


a) **b)**

Fig. 2. Economical damage of the floods in Penjikent (a) and Ajni (b) district (US Dollars).

Conclusion

It is established that in the conditions of Global climate change and its influence on all components of an ecosystem to become actual a problem of development of adequate and modern methods of adaptation of human activity to cataclysms of climate. In agriculture first of all substantial increase of efficiency of irrigation water and a farmland and wide involvement of biotechnology for selection high-efficiency and steady against stressful situations of grades is necessary. In the hydropower production direction this effective placement of hydropower station with reservoirs and stability of dams.



a) **b)**

Fig.3. Total human victims of flooding in Ajni and Penjikent districts (person)(a) and total economical damage of Ajni and Penjikent districts in results of floods (2002-2005)(b)

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Black Carbon: A New Twist to the Climate Change

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Abstract: Soot is a major particulate matter (PM) emitted to the atmosphere by incomplete combustion of hydrocarbon fuels. Soot is not a pure substance, and consists of many different polymerized carbons. Depending on the radiation emissivity, graphite-like carbon with an emissivity closed to that of the black body is called black carbon (BC) whereas amorphous carbon with a much lower emissivity is called brown carbon (BrC). If soot is emitted, it can affect the global climate mainly through the following three paths, (1) BCs absorb the solar radiation to heat up the ambient air mass for a climate warming effect, (2) BrCs act as nuclei for the cloud formation to block the solar energy influx for a cooling effect and (3) BCs and BrCs settle on the ice or snow surface to reduce the surface albedo to absorb more solar energy leading to the accelerated ice/snow melting for a warming effect. Because soot affects the global climate while being very short lived, it is often classified as a short-lived climate forcer (SLCF).

Currently, a group of atmospheric scientists, mostly from USA, begin to claim that BC is the second most important climate forcer with radiation forcing ranging from 0.3~1.2W/m^2, only to CO_2 with radiation forcing of 1.6W/m^2. On the other hand, overall radiation forcing for PM is estimated to be -1.3~-1.4W/m^2. Soot-emission-per-capita being very much independent of the industrial activities, regulating BC, separately from overall PM emission, will greatly increase the climate-response burden of the under-developed countries, which goes against the so-called climate justice.

However, we must note that BC cannot be selectively controlled from soot. Therefore BC's warming effect cannot be treated separately from BrC's cooling effect. In addition, soot emitted from the developed countries would be much more BC-loaded than that from the developing countries since BC tends to be formed in the combustion processes with higher temperatures and pressures. Before heading into the global regulation, we have to understand the way to quantify the BC and its climate effect while we still have to keep our focus on the CO_2 reduction efforts and soot emission reduction as an atmospheric pollutant.

Finally, we also have to pay attention to the soot emission in the arctic region, where soot settled on ice or snow can significantly accelerate the arctic ice melting. In particular, Russia possessing a significant arctic soot emission inventory from the gas flares and forest fires, she have to play a

key role in understanding SLCF's climate effects and the way to reduce soot emission in order to mitigate the atmospheric pollution and climate change.

1. What Is Black Carbon ?

Black carbon is a part of soot, mainly formed by incomplete combustion during any combustion processes, ranging from domestic fire, natural combustion processes such as forest fire, gas flare in the energy development to combustion associated with power generation [1]. Soot is made mainly of polymerized carbon formed in oxidizing-radical deficient combustion environment. However, soot is not a pure substance so that its definition and physical properties are not unique. Soot is a very dark substance. Nevertheless, depending on the soot formation mechanism, the soot tends to exhibit the physical properties (in particular optical properties), as depicted below.

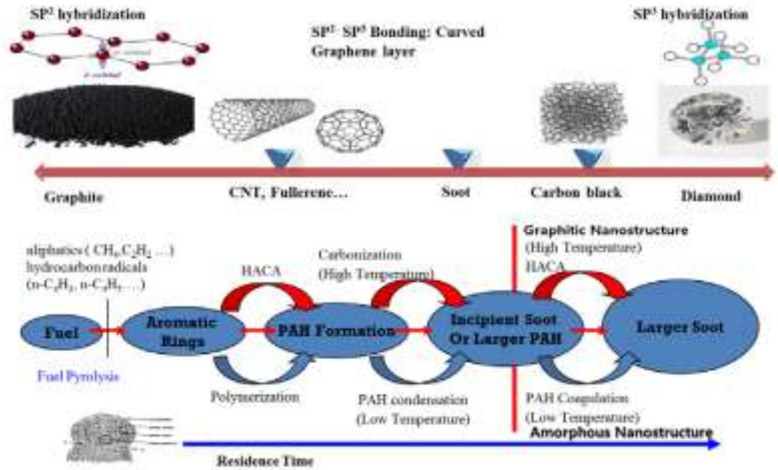

Fig. 1. Schematics of Soot Formation Mechanism and Corresponding Physical Properties

The Soot formation mechanisms can be divided into two, namely low-temperature mechanism and high-temperature mechanism. If soot is formed in a high-pressure and high-temperature environment, the HACA (hydrogen abstraction and carbon addition) mechanism leads to a graphite-like soot structure, which tends to behave like a black body due to the free electron pair in the SP2 bonding. On the other hand, in a lower-pressure and temperature environment, coagulation of PAH leads to an amorphous soot structure, the reflection index of which is much lower than that of black body. Depending on the radiation reflection index, the graphitic soot can be called black carbon (BC) and the amorphous soot can be called brown carbon (BrC) although there is no clear border line between BC and BrC, which is one of the main sources of the black carbon controversy.

If BC and BrC is a classification of soot depending on the optical property, there exists a chemical counterpart associated with the evaporation characteristics. When soot is heated up to 500℃ (the actual number varies depending on the analysis practitioners), a fraction of soot evaporates. Then, the residual part is called elemental carbon (EC), and evaporated part is called organic carbon (OC). In the real-world practices, in which the physical analyses are done much more rarely than the chemical analyses, EC is usually treated as BC. It should be here noted that EC is not exactly BC although EC and BC are closely related. Moreover, BC is seen as an important short-lived climate forcer (SLCF) mainly because of its radiation properties.

2. Black Carbon as a Short-Lived Climate Forcer

The roles of black carbon on the climate change have gained a great deal of attention in the past decade mainly because the issue was pushed forward by USA. Unlike other gaseous climate forcers, soot, of course including BC, has a typical lifetime of order of week since it will be easily washed away by rain. Therefore, BC as well as soot or PM is often classified as short-lived climate forcer (SLCF).

Soot or PM's contributions to the climate change can be viewed in three effects below

1. Cooling effect : PM may play a role of nucleus in the cloud formation to reduce the solar radiation into to the earth surface, consequently resulting in the cooling effect
2. Warming effect : BC, acting as a black body, absorbs solar radiation and eventually heats the ambient atmosphere, leading to the warming effect
3. Surface albedo effect : PM (regardless of BC or BrC), settled on snow or ice, will reduce the snow/ice surface albedo to absorb more solar radiation input, and will accelerate the ice or snow melting, which will lead to the warming effect, particularly in the arctic region.

Traditionally, PM's contribution to the global warming has been known as a negative feedback since the cooling effect by PM is much greater than the warming effect by BC. However, recently a group of US atmospheric researchers begin to isolate BC's effect from the overall effect of PM, so as to claim that BC is the second most global-warming substance only to CO_2. Furthermore, they suggest that emission reduction of BC is more effective in climate change response than reduction of CO_2 emission. However, these claims are surely based on the biased scientific data.

First, as mentioned in the previous subsection, there is no clear scientific definition for BC, and the current emission inventory is tabulated from the EC measurement data rather than the direct soot optical measurement data since the measurement efforts for the BC's radiation properties, which are directly correlated to its warming effect, scarcely exist. Furthermore, in any soot emission sources, BC is emitted as a part of soot, so that it cannot be separated from soot. Consequently, there is no method for selective measurement as well as selective control method of BC from soot so far. Therefore, isolating BC's warming effect from soot's overall atmospheric feedback is unrealistic.

Secondly, BC's inventory by region is quite different from CO_2 emission inventory. The annual per capita CO_2 emission, ranging from 20tCO_2/yr/person in USA to less than 1tCO_2/yr/person in the poorest countries can differ by an order of magnitude between the developed and developing countries. However, the annual per capita BC emission differs only by a factor of 2 or 3 depending on the region as shown in Fig. 2. Moreover, the dominant emission source in the developing countries is identified to be open biomass (perhaps wild fire or domestic fire) while that in the developed countries is transportation sector where high-performance diesel engine prevails. But recalling the soot mechanism outlined in Fig. 1, BC denoted in Fig. 2 is actually EC, which may not be seen as graphitic soot, the physical structure more closely related to BC. Consequently, BC inventory from the developing or under-developed countries may be significantly overestimated since BC from the residential biofuel is not likely similar to the graphitic soot.

3. Climate Effects by Black Carbon

So far we have discussed the uncertainties of BC as a SLCF, associated with its definition and inventory. However, the main issue is its feedback to the global climate system, which will be separately discussed for atmospheric interaction and snow/ice surface albedo effect in the following subsections.

3.1 Atmospheric Interaction of Black Carbon

Black carbon's atmospheric interaction, i.e. the cooling and warming effects, is discussed here. Since BC's atmospheric interaction is a solid-gas interaction, its interaction pathway is quite complicated. This can be easily seen from the fact that each research group still emphasize or neglect different interaction pathway since we are still not capable of fully understanding the precise interaction pathway. Nevertheless, the current research results can be grouped into three sub-categories, namely (1) low BC impact case, typically seen from the IPCC's 4th assessment report (AR4) [3], (2) high BC impact case, typically seen from the result of Ramanathan and Carmichael [4], and (3) medium BC impact case, seen from the result of the Hansen group [5].

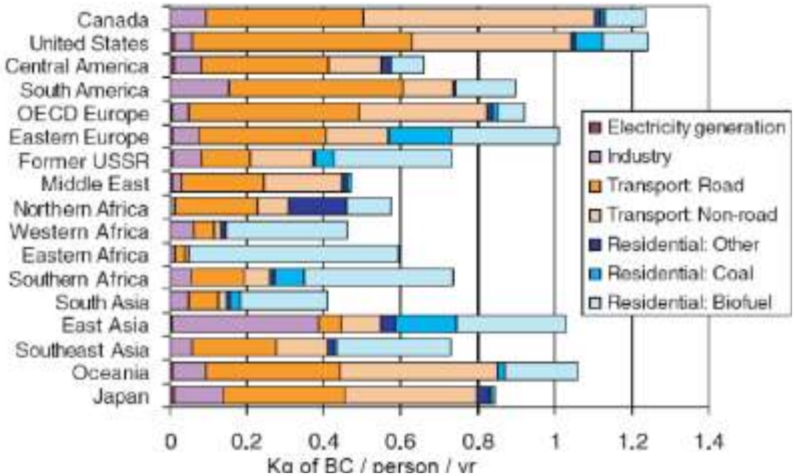

Fig. 2. Sectoral BC emission by region [2]

Figure 3 shows the BC and overall PM effects in terms of the radiation forcing (W/m^2) for the low and high impact cases. IPCC AR4, corresponding to the low BC impact case, exhibits that the BC's radiation forcing is estimated to be close to $0.1W/m^2$, which is less than 10% of the radiation forcing of CO_2 that is estimated to be $1.6W/m^2$. On the other hand, the Ramanathan and Carmichael, corresponding to the high BC impact case, estimate the BC's radiation forcing to be close to $0.9W/m^2$, a value nearly 60% of the CO_2's radiation forcing. This high BC impact case, along with the inventory data in Fig. 2, is the main scientific foundation for the USA's claim that the urgent global control of BC is more effective than CO_2 control. However, it should be noted that the PM's overall radiation forcing (including BC's warming effect) is estimated to be -1.3 and - $1.4W/m^2$ for low and high BC impact cases respectively, showing little difference in the PM's overall climate impact. In the high BC impact case, it was assumed that the radiation reflection index is of bi-modal distribution, i.e PM being either perfect black body or reflection body. Consequently, the BC's warming effect and OC's cooling effect are maximized together with the overall PM effect similar to other predictions. Moreover, the high BC impact case overlooked that physical separation (as well as selective control) of BC and BrC from the emission sources is a technically daunting challenge, thereby resulting in the erroneous conclusion that calls for the global BC emission control ahead of the CO_2 control to mitigate the climate change.

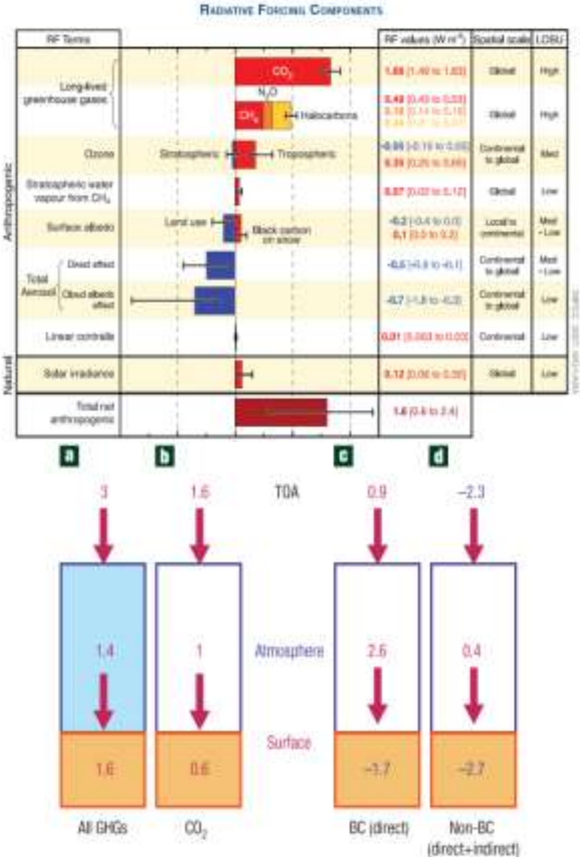

Fig. 3. Radiation forcing for BC, PM and other climate forcers from IPCC AR4 [3] and Ramanathan and Carmichael [4].

On the other hand, the middle BC impact case is shown in Fig. 4, where the BC's radiation forcing is estimated to be 0.49W/m^2 (0.38W/m^2 from fossil fuel BC and 0.11W/m^2 from biomass BC), a value almost middle of the low and high impact cases, while the overall PM's radiation forcing is -1.32W/m^2, very close to the other results. Hansen et al. also pointed out that the BC effect cannot be isolated from the overall PM or soot effects. They instead estimated the radiation forcing to be 0.25W/m^2 for soot (fossil fuel), -0.22W/m^2 for soot (biomass burning), and -0.85 and - 0.5W/m^2 for aerosol direct and indirect effects. The emission control of soot, which is doable by the currently existing technologies, may result in the reduction of warming potential (for fossil fuel soot reduction) or in the reduction of cooling potential (for biomass soot reduction), provided that soot control does not affect the non-soot aerosol effects, which is another doubtful assumption indeed. At this moment, it remains as an open question whether the emission control of PM would contribute to mitigation of the climate change.

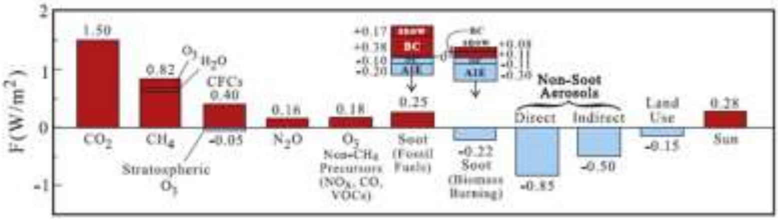

Fig. 4. Radiation forcing for each climate forcer [5].

3.2 Snow/Ice Albedo Reduction

Unlike the PM atmospheric interaction, which can contributes to positive or negative climate feedback, PM's role on the snow/ice surface albedo is always a negative feedback regardless of BC, BrC or dust once PM is settled on the snow or ice surface. In recent years, the surface albedo effect also attracts a great deal of concern mainly associated with the arctic warming that can be further accelerated by reducing the ice cover in the arctic region [6]. The arctic warming can have a farreaching impact on the climate system since it can significantly weaken the key climate regulating mechanisms such as the thermo-haline circulation (THC), the main ocean circulation driving force, and solar radiation reflection by the ice and snow cover.

In particular, the cold winter in the mid-latitude region is triggered by the warm arctic air mass, which can be easily predicted by the maximum melt area extent of the Arctic Ocean ice cover. This climate phenomenon can be interpreted as an inception of more abrupt nonlinear climate behavior rather than monotonic and linear global warming perhaps by the anthropogenic injection of the climate forcing chemical agents into the climate sphere. This is the main concern behind the suddenly gained interest on the snow/ice albedo effect.

PM-induced albedo reduction causes the snow to absorb more solar radiation, thus heating the snow/ice/land surface and warming the air above surface. Among PM, BC is most potent surface warming substance, however, other PMs, ranging from BrC to dust, nonetheless warms the surface. Once the snow or ice surface is melted by the heated surface, the resulting albedo is about 0.06 while the bare sea ice albedo varies from 0.5 to 0.7. Furthermore, the albedo of thick sea ice covered with snow can reach as high as 0.9. Therefore, BC, BrC or dust settled on snow/ice surface can produce a snowball effect on the surface melting process to drastically reduce the surface albedo to from melt-water ponds and warm the surface as well as the air above. Although there are many different physical mechanisms for arctic ice melting, such as simple global warming and intrusion of the warm current into the Arctic Ocean, a careful scrutiny on the arctic ice melting is urgently called for.

So far, the direct measurement efforts on the PM's arctic climate impact have been quite limited due to the difficult access to the region [7]. Although snow/ice albedo reduction caused by small impurity (PM/BC) could result in the dramatic change of Arctic climate through feedback acceleration, the direct and conclusive evidence that BC emission is one of main causes of the arctic ice cover reduction is yet to be established perhaps mainly because of yet limited research on the issue.

However, the future of BC's impact on the arctic ice cover is not optimistic since the BC emission inventory in the arctic region may drastically increase in the near future due to the increasing industrial activities in the region. The gas flare in the arctic energy development is already identified as a main soot emission source. The World Bank estimates that about 15~60 billion m^3 gas is flared in the northern Siberian gas fields, which are one of the largest flaring inventory in the world [8]. Such an increased human activity in the arctic region may cause direct soot deposition on the arctic ice and snow cover and give rise to a significant climate change feedback.

4. How to Deal with Black Carbon Debate

As discussed in the previous sections, the climate impact of black carbon is not yet a settled issue in that there is a huge gap of understanding between USA and other countries while the biggest gap exists between USA and China. However, we have to point out that the scientific claims made by USA have a number of flaws as below,

1. The definition of BC is not clear, so that the current BC inventory is also doubtful in that it is compiled from the EC measurement database. On

the other hand, the direct optical property measurement data, which are better related to the BC climate effect, are extremely limited.

2. For most climate predictions, the PM's overall radiation forcing is estimated between - 1.3 and -1.4W/m^2, showing a good and consistent agreement. On the other hand, the BC's radiation forcing, ranging from 0.1W/m^2 to 0.9W/m^2, exhibits an order-ofmagnitude difference. Such a large difference is perhaps attributed to the fundamentally doubtful assumption of arbitrary isolation of BC from the overall PM and the lack of physical understanding on how BC and PM interact with the various mechanisms in the earth climate system.

3. The claim made by USA that the immediate BC control is more effective than the CO_2 emission control is quite misleading. First, BC cannot be selectively controlled apart from overall PM, and the PM control itself is as complicated and expensive as the CO_2 control. Moreover, PM's lifetime is no longer than a few weeks, so that it possesses much less accumulating effect on the climate change than CO_2. In order to avoid the dire climate consequence in the future, the immediate CO_2 emission control is much more urgently needed than controlling any other climate forcers.

It is quite ironical that the high BC impact case was produced by a research group in the Scripps Institute of Oceanography (SIO), where Roger Revelle first established the scientific foundation of global warming by fossil fuel combustion. According to Naomi Oreskes [9], William Nierenberg, who succeeded the SIO directorship after Roger Revelle left University of California at San Diego (UCSD) a part of which is SIO, should be identified as a key person on "social deconstruction of the scientific knowledge." The phrase obviously mentions the so-called climate skepticism which is often supported by the powerful energy industries, most notably by those in USA.

In the International maritime organization (IMO) which is entitled to force the sectoral regulations, the possible regulation of PM and BC emission for the international shippings above the mid-latitude (40°N) has been discussed ever since USA and Norway proposed the regulation derived from the high BC impact case. However, introduction of the regulation is still unclear since many member countries necessarily do not agree with the scientific findings that the high BC impact case presents. On the other hand, the regulation of PM/BC emission in the arctic region needs be carefully considered since the arctic environment and climate system is quite vulnerable to the various anthropogenic contaminations.

The possible regulation of PM/BC emission in the arctic region is an issue of greater interest for Russia. Because of the decreasing ice cover in the Arctic Ocean, the arctic routes may open for the international shippings perhaps as early as in a decade. Then Russia would be in charge of maintaining a significant part of the arctic routes and protecting the ship's safety as well as the arctic environment. However, Russia also has the largest PM/BC emission inventory, including gas flares and wild fires in the regions adjacent to the Arctic Ocean. Russia is likely asked to mitigate the PM/BC emission near the arctic and Siberian regions prior to opening the arctic routes, as a precautionary measure to protect the vulnerable arctic environment and climate system.

Acknowledgement

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Current trends of temperature variations in the territory of Kazakhstan

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Abstract: *Using linear and polynomial approximation methods and Fourier analysis, time series of temperature at stations of Kazakhstan were analyzed. It was demonstrated that in the last decade, to the south of the fiftieth latitude atmospheric temperatures increase had stopped, and to the north, temperature began to drop. Decrease did not begin at the same time and it manifests in different ways.*

In recent years the problem of climate change has become one of the most pressing environmental problems discussed in the scientific world. In recent years, understanding of potential environmental and social impacts of global warming that have already been observed and is expected in future has markedly increased all over the world.

The problem of climate change on the territory of Kazakhstan has been explored by many researchers [1-3, etc.].

In [1] it was demonstrated that the warming, or rather, the process of climatic changes in temperature itself occurs in the territory of Kazakhstan not at the same time. Based on simultaneity of temperature changes the entire territory of Kazakhstan was divided into four zones, in each of which such change in temperature occurred in the last century in the same way (Fig. 1).

An explanation of the observed fact has also been given there. The temperature follows seminal changes in circulation. Since the territory of the Republic is vast, the prevalence of any type of circulation results in different consequences in remote areas of the territory. Thus, for example, the prevalence of C-type circulation according to [4] leads to a decrease in temperature below climatic in the Western Kazakhstan and above climatic in the Northern Kazakhstan. This is clearly demonstrated in [5].

There, in [1], it was also demonstrated for the first time that in the last decade of the past century temperature growth had stopped in the North-East of the country (Fig. 1, Pavlodar and Panfilov (Zharkent) stations). Therefore it was seen important to find out how temperature and precipitation have changed in the last 15-20 years. To do this, we used the time series of temperature and precipitation at the main (benchmark) stations for the period through the year 2012. Time series were approximated by a straight line, a sixth degree polynomial, and were also subject to Fourier analysis (frequency analysis) to detect long-period harmonic curves and their plotting using the scenarios for the next decades.

Figure 1 and Figure 2-5 demonstrate approximation results of temperature time series at some stations as a straight line and a sixth degree polynomial.

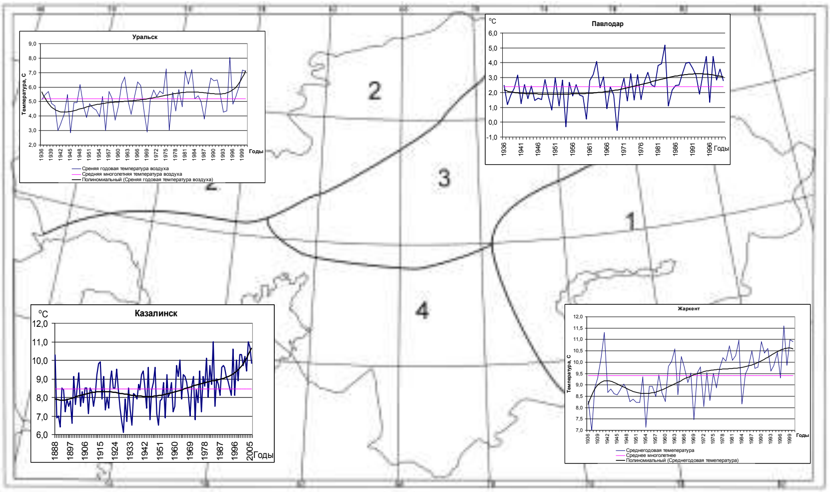

Fig.1. Results of territorial zoning of Kazakhstan based on the nature of temperature changes in the XXth century.

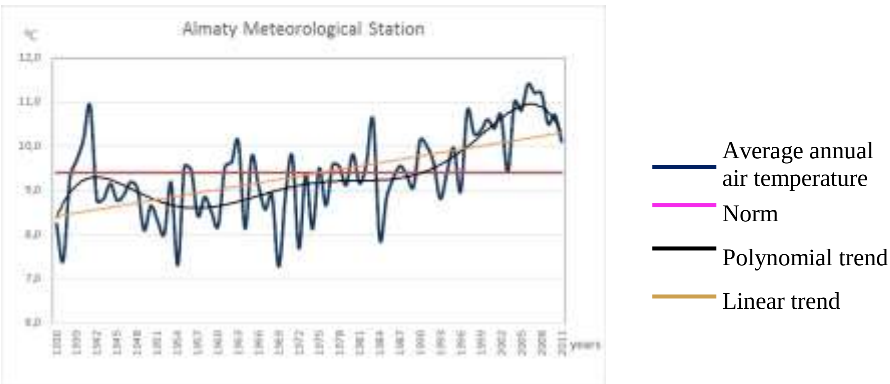

Fig. 2. Time variation of air temperature at Almaty MS (°C)

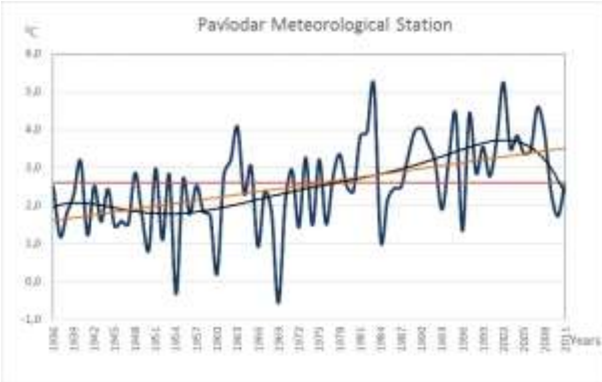

Fig. 3 Time variation of air temperature at Pavlodar Meteorological Station (Indications according to Figure 2)

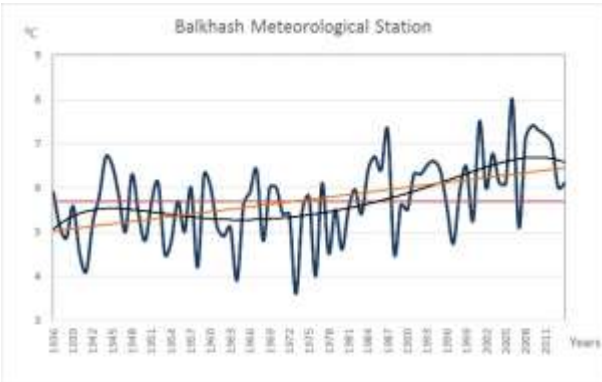

Fig.4 Time variation of air temperature at Balkhash Meteorological Station (Indications according to Figure 2)

You can see that the linear trend at all stations is positive, despite the addition of data to the time series for the last decades. This is understandable. Linear trend is a very conservative value, by its definition, [6,7]; only when temperature drops by an amount of warming which occurred, the trend will become zero, and after that a further drop of temperature will be negative. Because warming has lasted for more than half a century with different intensity, it will change its sign in half a century only, if fall of temperature indeed takes place. In the meantime, decrease in the trend will take place within a computation error; the accuracy of this decrease for the above reason will not be confirmed any time soon.

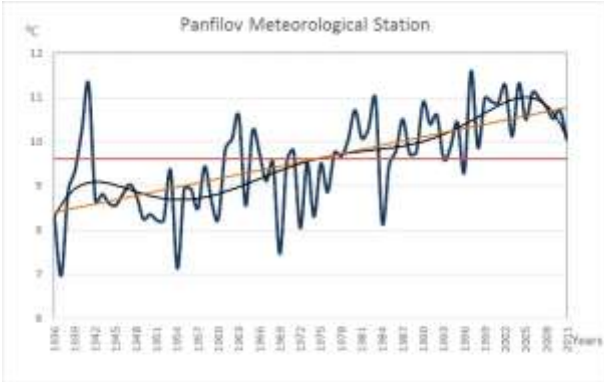

Fig. 5 Time variation of air temperature at Panfilov (Zharkent) Meteorological Station (Indications according to Figure 2)

You can see that the linear trend at all stations is positive, despite the addition of data to the time series for the last decades. This is understandable. Linear trend is a very conservative value, by its definition, [6,7]; only when temperature drops by an amount of warming which occurred, the trend will become zero, and after that a further drop of temperature will be negative. Because warming has lasted for more than half a century with different intensity, it will change its sign in half a century only, if fall of temperature indeed takes place. In the meantime, decrease in the trend will take place within a computation error; the accuracy of this decrease for the above reason will not be confirmed any time soon.

The advantage of polynomial approximation method is its high sensitivity to changes in dispersion and local mean along the time series [6,7, etc.]. As a result, based on polynomial approximation data, it is possible to determine cyclical fluctuations of varying duration in the time series in a rather reliable way. In our case, the way we used a polynomial approximation, identifies a Bruckner cycle and cycles that are close to it. In [1] it was based on these cycles identified in the temperature ranges, that territorial zoning of Kazakhstan had been performed.

The disadvantage of polynomial approximation method is also its advantage which is high sensitivity to local changes in the mean and variance. Fortunately, this disadvantage only appears on the ends of the time series [6,7, etc.]. We are of course interested in the end of series, i.e., reaction to changes of the end time. For example, Figure 1 shows that in Pavlodar in the late twentieth century, there had been a fall of temperature, recorded over a significant segment of time, and in Panfilov – over a short segment of time, that is, warming in Pavlodar is more reliable than that in Panfilov. In Uralsk, over a short time interval approximating line demonstrates significant warming. There has been a rise in temperature in Turkestan as well, but over a significant time interval. Consequently, the trend noted in Turkestan, is more reliable than that in Uralsk. Indeed, after the temperature time series lengthened by one and a half decades, approximating curve in Uralsk indicates fall of temperature (Fig. 4). At the same time, in Pavlodar, Panfilov (Zharkent) and Turkestan lengthening of temperature series did not result in changing the sign of the trend.

Thus, the situation is that for the purpose of timely decision-making on adaptation to climate change we must record the changes taking place as early as possible, and on the other hand, a linear interpolation method is not suitable for this, because it is very conservative. Polynomial interpolation method is unreliable because of its high sensitivity to changes in approximated values on the end of a time series and is overly sensitive to the inter-annual and other short-period fluctuations of the studied parameter, which is not a predictor of climate changes and requires a fairly long-term observation of the approximating line, to avoid errors in estimates.

Harmonics contained in the time series of the studied parameter, being temperature in this case, and identified using Fourier analysis are more trustworthy. This confidence is based on the following assumptions. Each harmonic discovered and identified in the original series is the result of impact of some factor that is known or is not fully known to us. The presence of harmonic indicates not only that there is such a factor, but also characterizes the intensity of effect (harmonic amplitude), and its frequency. There is every reason to expect that the influencing factor will continue in the future, and its effect will be the same as in previous years. The bases for these arguments (hypotheses) are the established facts of presence of diurnal and annual course harmonics in temperature series and simplicity of explanation thereof. As for harmonics with longer cycles, even though their source is not completely clear, the assumption that they are also affected by a specific source (or sources), which will continue in the future, also applies to them. Thus, harmonics have a certain physical interpretation and prognostic significance.

In this research we do not use spectral analysis. The advantage of Fourier analysis versus spectral analysis is that the detected harmonic is synchronized with the analyzed time series based on time, while spectral analysis only establishes the existence of a harmonic [7,8, etc.]. Therefore we will perform Fourier analysis of temperature series for some stations. We are going to use a modification of Fourier analysis, improved by A.V.

Babkin, allowing not only identify but also add up the most significant ones in view of the trend [9, etc.].

Fig.6-9 demonstrates the results of Fourier analysis of temperature time series for some of the most prominent stations.

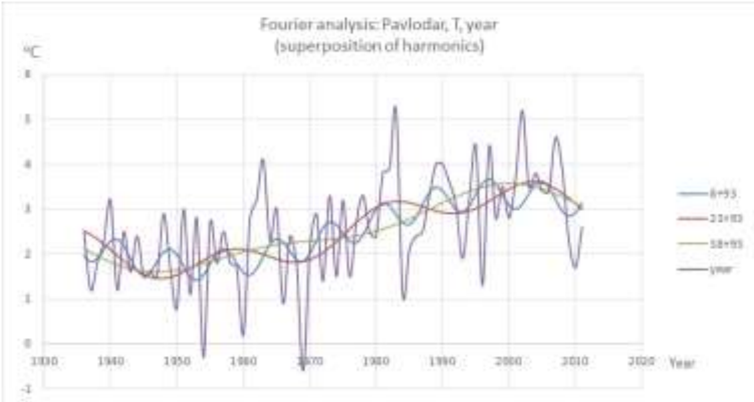

Fig. 6. Fourier analysis of temperature time-series at Pavlodar MS.

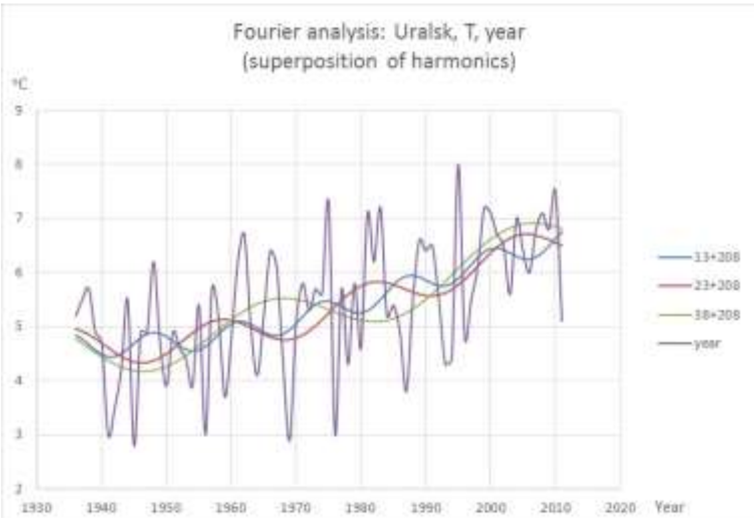

Fig. 7. Fourier analysis of temperature time-series at Uralsk MS.

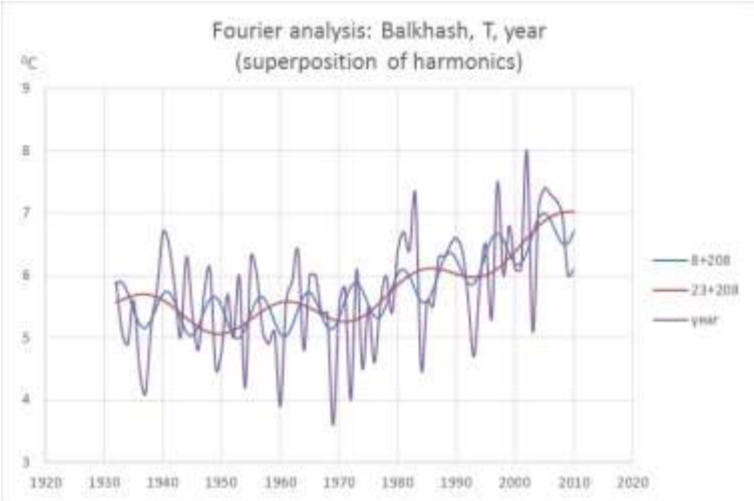

Fig. 8. Fourier analysis of temperature time-series at Balkhash MS.

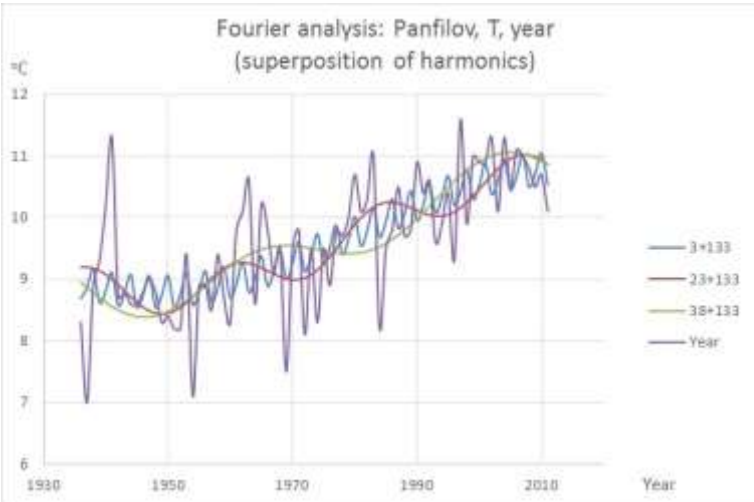

Fig. 9 Fourier analysis of temperature time-series at Panfilov (Zharkent) MS.

In Pavlodar, there are age-old harmonic (93 years), and 38 and 23 years-old harmonics. 38 and 23 years-old harmonics are summarized with the age-old (Fig. 7). It can be seen that 93+38 harmonics and 93+23 38 harmonics are in a phase of recession and the drop in temperature will continue for a long time, for a few decades.

Not at all of the stations the age-old harmonic is so well identified as in Pavlodar, but age-long or longer harmonics are present everywhere; we see harmonics of two hundred years or more as a situation, where the length of series and its structure are such that an age-old harmonic is distorted in favor of its best position through its extension.

In Uralsk, there are 38 and 23 years old harmonics present, which were separately added up with 203 years old harmonic. Decrease in amplitudes of 38 and 23 years old harmonics had just started. In the past century, it was not there yet (Fig. 8). It is evident that the two harmonics are in the process of amplitude decrease and in the coming years, temperature fall will continue.

In Kyzyl-Orda, Shymkent, Turkestan and Balkhash (Fig. 9), Panfilov (Zharkent) (Fig. 10) temperature drop has not started yet, but temperature rise had stopped.

Since we are not able to focus our attention to temperature time series analysis of all stations, please note that Bruckner (half-century) cycles are the most significant in terms of amplitude in the temperature series throughout the territory of Kazakhstan.

In general, throughout the area, the most noticeable drop in temperature takes place in the North-East of the Republic (Pavlodar, Semipalatinsk, Astana, etc.). The temperature drop is also observable in the North-West of the Republic (Uralsk, etc.). To the south of the fiftieth latitude the cooling has hardly started, but raise in temperature had stopped.

From [5,10,11, etc.], and others we know that macro-processes to the north and to the south of the fiftieth latitude differ significantly. As stated above, they differ over the western and the northern regions of the Republic.

Therefore, climatic changes of temperature throughout the territory of Kazakhstan are due to changes in planetary circulation.

Despite the above-mentioned lack of polynomial approximation, it must be admitted that this method in [1] has helped to identify Bruckner cycles in the temperature time series, and based on that to implement territorial zoning of the Republic. This was made possible because polynomial approximation method, with the exclusion of the series end, essentially performs the addition of the most significant harmonics, including trend.

The advantage of A.V. Babkin’s method has the advantage over polynomial approximation method only on the end of the time series, and also that, unlike polynomial approximation method, it comprises physical interpretation. Comparison of the results obtained by us now on the analysis of current trends of temperature change indicates that such changes take place in good agreement with regional characteristics noted in [1] and Buckner cycles stages in them.

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Fluctuations in Altai glaciers during instrumental observations (glacier Maly Aktru as a case study)

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Introduction

The most reliable studies of modern glacier fluctuations are based on evaluating the change in glaciers volume (Hagedorn, 2004). Since it is a challenging problem, fluctuations are generally measured by the retreat of glacier tongues. Unfortunately, the changes in ice balance and the rate of glacier response greatly influence the glacier tongue retreat that lasts for a few decades. We have tried to study the rate of volume change in glacier Maly Aktru and its response to variation in the average summer temperature in high mountains of Altai for the years 1952-2012. For this purpose, the instrumental observations of the Aktru glacier basin were made within the framework of the International Hydrological Decade (IHD), the International Hydrological Program (IHP) and the Program on glacier fluctuations monitoring.

Experimental data

In the course of IHP realization, S.A. Nikitin evaluated glacier volumes in the Aktru basin for the first time by using radar sensing (Galakhov et al., 1987).

With further development of portable devices and accuracy improvement in detection of glacier thickness, the Aktru glaciers were re-examined by means of profile sounding and more detailed topographic surveying of the glaciers area (Nikitin et al., 1997). The data are given in Table 1.

Table 1. The data on radar sounding of glacier Maly Aktru

date of sensing (years)	glacier area (km^2)	glacier volume (km^3)
1979 – 1982	2.85	0.264
1995 – 1996	2.84	0.245

The oldest large-scale maps (1:25,000) of the Aktru basin are dated the year 1961. They are constructed on the basis of aerial photography held since 1952. In 1978, R.M.Mukhametov and the researchers from Moscow State University performed photomapping of glacier Malyl Aktru. Using the data on aerophotography and photomapping, R.M.Mukhametov created a map of changes in the glacier surface (glaciers Maly Aktru and Kupol) occurred in 1952-1978 (Galakhov, Mukhametov, 1999). Re-photomapping of these glaciers was completed in 1983 by R.M.Mukhametov (Aref'ev, Mukhametov, 1996). In 1990, R.M.Mukhametov made re-photomapping of glacier Maly Aktru. This map was published after his death in the appendix to the monograph by V.P.Galakhov, A.N.Nazarov and N.F.Kharlamova (Galakhov, Nazarov, Kharlamova, 2005). In 2012, the researchers from IWEP SB RAS made an attempt of space stereoscopic survey of Aktru glaciers. However, the presence of clouds over the glacier tongue does not allow (at least now) to estimate reliably the change of the glacier surface for 1990-2012 based on topographic observations.

Discussion

Prior to discussion, let us consider the problem of conversion of volume change in glacier Maly Aktru into the balance resultant. In 1996, the ice factor (ratio of the firn basin area to the glacier tongue area) for glacier Maly Aktru averaged 1.5. The change in the glacier volume for the periods of observation occurred in the glacier's tongue: according to the measurements, the density of glacier ice was 0.9 g/cm^3 and the density of seasonal snow in the firn basin by the end of ablation - 0.45-0.50 g/cm^3 (Galakhov et al., 1987). Thus, to convert volume changes in glacier Maly Aktru into ice balance change we used factor of 0.8, i.e. an average with due regard for the area of the glacier tongue and the firn basin including firn melting which density is much higher than that of seasonal snow (Galakhov et al., 1987). Materials of instrumental observations allowed us to specify the periods of topographic surveys (published maps) and to assess the change in volumes of glacier Maly Aktru occurred in these periods (Table 2).

Table 2. Change in the Maly Aktru volume for the periods of topographic surveys published.

Period, years	Reference	Change in glacier thickness, m	Change in glacier volume, km^3
1952-1978	Galakhov, Mukhametov, 1999	+ 3,21	+0,009
1978-1983	Mukhametov, 1997; Aref'ev, Mukhametov, 1996)	-0,53	-0,0015
1978-1990	Mukhametov, 1997, surveying of 1990 by R.M.Muhametov	+0,90	+0,0026

In addition to the data on topographic surveying the glacier surface of Maly Aktru, we have the data on its annual ice balance for IHD and IHP periods (Galakhov et al., 1987) (1981-1986. (Galakhov, 2001)). The components of ice balance of glacier Maly Aktru are given for 1962 -1999 in the paper by Yu.K.Narozhnev (Narozhnev, 2001). Based on the data available, let us determine the rate ice balance change of glacier Maly Aktru depending on the average summer temperature in the glacier area. To do that, the observation data from the Karatyurek weather station (KWS), 2600 m asl) for the years 1940-2012 were used (Table 3).

Table 3. The rate of ice balance change of glacier Maly Aktru for the period of instrumental observations

Period of observation, years	Average summer temperature, °C (KWS, 2600 m asl),	Rate of change in ice balance, g /cm²/ year	Materials
1952-1978	5,51	+9,9	Topographic surveying
1978-1983	5,94	-14,2	Observations of ice balance
1978-1983	5,94	-8,5	Topographic surveying
1973-1986	5,68	-1,3	Observations of ice balance
1961-1978	5,68	-6,8	Observations of ice balance
1978-1990	5,51	+7,9	Observations of ice balance
1978-1990	5,51	+6,0	Topographic surveying
1990-1996	5,85	-9,4	Observations of ice balance

The obtained data on the surface change of glacier Aktru in 1952-1990 including the calculations of the glacier ice balance make it possible to estimate the influence of thermal regime on the rate of the glacier's ice balance change (Fig. 1).

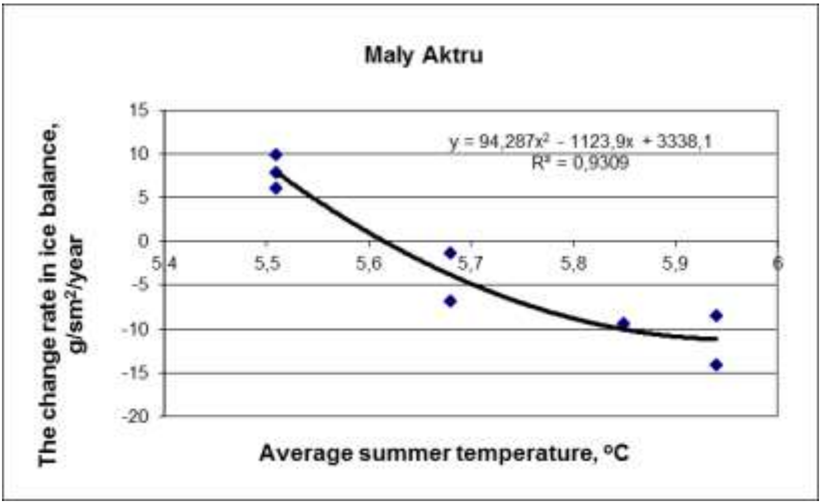

Fig. 1. Dependence of rate of ice balance change of glacier Maly Aktru on the average summer temperature (KWS, 2600 m asl).

Conclusion

Note that with glacier's tongue retreating throughout the whole period of instrumental observations, the glacier volume increased by almost 4%, and its mean thickness - by 3.5 m. The data from the KWS indicate that from 1997 to 2012 the average summer temperature increased by almost one degree as compared to the previous period (Fig. 2).

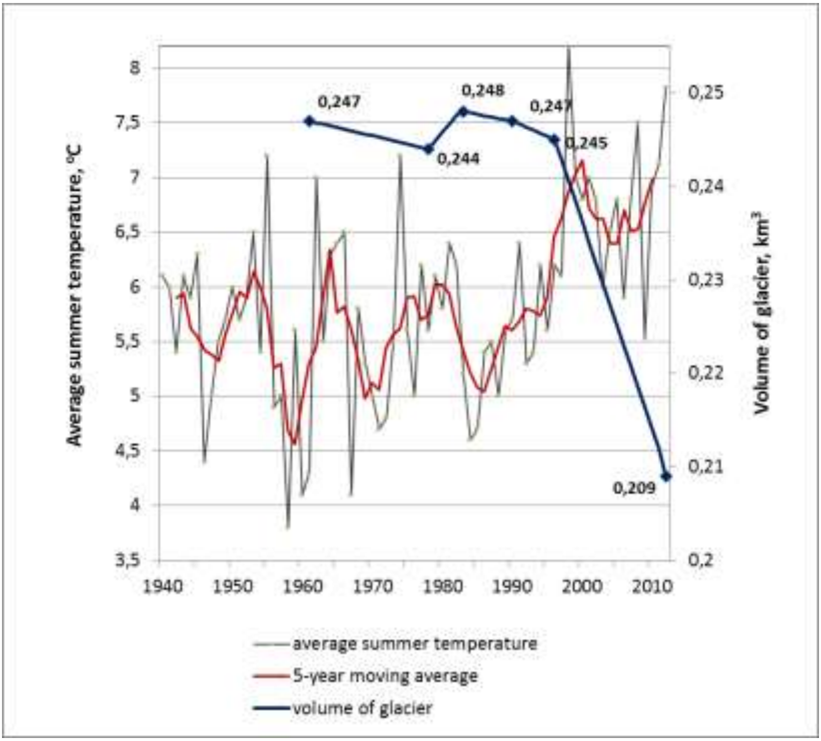

Fig. 2. Dynamics of the average summer temperature (KWS) and volume of glacier Maly Aktru

Thus, according to the data from the KWS, the average summer temperature for 1993-2012 is 6,67 ° C. Hence, over the last 20 years the glacier thickness would have decreased by 13 m, while its volume - by 0,038 km^3 that is 15% of the volume determined by radar surveying in 1996.

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Impact of Climate Change on Water Resources and Biodiversity of Iran

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Abstract: Iran is highly vulnerable to the adverse impacts of climate change. It is a country with 70% arid and semi-arid areas, limited water availability, low forest cover, liable to drought and desertification, prone to floods, high urban atmospheric pollution and fragile mountainous ecosystems. In this paper after a brief overview of climate variability and climate modeling, the impact of climate change on the crucial areas of water resources and biodiversity will be presented. Based on meteorological data of 1960-2005, the minimum and maximum temperatures, precipitation (the amount and the number of days with precipitation higher than 10 mm), wind speed, dew point temperature (as an indicator of humidity), cloudiness and daylight hours have been studied in seasonal and annual timescales. Climate modeling by two different models show that significant climate change will occur during 2010-2100. Modeling results indicate temperature and precipitation changes in the range of ±6°C and ±60%, respectively. Temperature rise not only increases evaporation and decreases runoff, but also accelerates melting snow that causes increased rate of runoff in winter and a corresponding decrease of runoff in spring. Modeling results also show that at a constant level of rainfall, an increase in temperature of only about 2 degrees creates a rise of 27.3 bcm in annual volumes of evaporation and transpiration. Furthermore, the results prognosticate that except for three provinces, runoff in most basins will decrease. Regarding the impact of climate change on biodiversity, generally accepted data and information have been taken from national documents such as National Biodiversity Strategy and Action Plan (NBSAP), since no official linkage is established between biodiversity and climate change. Iranian habitats support some 8,200 plants species of which 2,500 are endemic, over 500 species of birds, 160 species of mammals and 164 species of reptiles (26 endemic species). Rivers and wetlands including 22 international registered sites (By Ramsar Convention) with a total area of 1,481,147 hectares are considered as inland water ecosystems that are most valuable to climate change affecting biodiversity. The most important threatening factors to biodiversity are classified as follows: over exploitation of water resources and unsustainable development of agricultural development plans resulting in water scarcity so that inland water ecosystems are not functioning in a sound manner; over grazing and logging has reduced production of biomass in forests and

rangelands of the country; unsustainable land-use conversions creating large scale habitat degradation and fragmentation; hunting and trapping practices have a direct negative impact on the population of wildlife and aquatics resulting in declining genetic resources; extended use of fertilizers and pesticides caused severe poisoning and utrification of the environment and water bodies; and natural drought that strikes large areas of the country causing significant socio-economic and natural difficulties. At present Iran is losing its biodiversity at an alarming rate. There is no convincing report on the existence of the two big mammals, i.e., Persian lion and Caspian tiger from their natural and endemic habitats during the last 50 years. Asiatic cheetah, Persian wild ass, Persian squirrel and three species of sea turtles are among critically endangered species and on the verge of extinction. According to scientific evidence many plant species are under severe threat.

Keywords: Iran, Climate change impacts, Water resources, Biodiversity

Introduction

In the contemporary era, study of the impact of climate variability and change at different time and space scales on earth's natural system and humanity has become the outstanding global priority of the international community. Iran is highly vulnerable to the adverse impacts of climate change. Most parts of the country are arid or semi-arid, prone to drought and desertification; limited forests are liable to decay; water resources are scarce; sea level rise is a threat to very long coastal zones of the country; many urban and industrial areas are heavily polluted; and the country is mountainous with very fragile ecosystems. As a prerequisite to carry out the vulnerability and adaptation (V&A) assessment, a study on climate variability and climate modeling was undertaken to predict the future climate of Iran based on the historical record. Although V&A assessment was carried out for six different sectors including water resources, agriculture, forestry, human health, coastal zones and biodiversity, in this paper we focus on vulnerability of the water resources and biodiversity.

Climate Variability and Change in Iran

The aim of this study, which was carried out by the Climatological Research Institute of Iran's Meteorological Organization with close collaboration of the National Climate Change Office, was three fold. First, to expand the knowledge of Iran’s climate variability; second, to extend the knowledge beyond what has been achieved during the previous studies about the possible changes in the country’s climate due to human interference with the earth’s climate system; and, finally to provide the prerequisite for vulnerability and adaptation assessment in the sections mentioned above. To achieve these defined goals, the study has been divided in three main sections:

- Climate variability,
- Climate change projection,
- Downscaling.

Due to the limited space in this paper, downscaling will not be discussed here and the reader is referred to Iran's Second National Communication to UNFCCC.

Methodology

To define the country's climate, the data for the period of 1961-1990 is considered as the representative period in accordance with WMO recommendations. Then, the longest period of duration with the least information deficiencies, considering the gaps in the observations and the outcome of the data homogeneity will be adopted for the above-mentioned studies.

Climate change is evaluated by means of two LARS-WG weather generators and all outputs from the available GCMs in MAGICC-SCENGEN software in combination with different emission scenarios and climate sensitivities. To address the uncertainties the output of the adopted scenarios will be compared with each other and with the results of the climate variability study.

Climate Variability

To study the country's climate variability, differences in parameters like the minimum and maximum temperatures, precipitation (the amount and the number of days with precipitation higher than 10 mm), wind speed, dew point temperature (as an indicator of humidity), cloudiness and daylight hours have been studied in seasonal and annual timescales over the 1960-2005 time span. Accordingly, trend of maximum and minimum temperatures, precipitation, wind speed, daylight hours, dew point temperature, etc. were obtained in details as reported in the Second National Communication to UNFCCC (2011) and described briefly as follows:

Temperature: The study reveals that the increase in minimum temperatures is more widespread than the maximum temperatures. The discrepancies are remarkably higher in the large, heavily populated and industrialized cities. Due to the pattern of higher minimum temperatures, the daily temperature variability has reduced almost everywhere. The analysis of results shows that the temperature has risen between 2.5 and 5 degrees centigrade during 1960-2005. There are also cities with clear temperature descent rates. *Precipitation*: The southwestern part of the Caspian Sea, northwest and west of the country have experienced the highest rate of reduction in the amount of their annual precipitation. Also the number of days with precipitation higher than 10 mm, have reduced in the west, northwest, and southeast of the country. That number has increased in the other regions except in the southeast of the Caspian Sea.

Wind: During 1960-2005 the highest rates of decrease in wind speed are seen in central part of the country as well as the northeast.

Humidity: Variability of humidity was observed by changes in dew point temperature. It was shown that the dew point temperature is consistently decreasing in most parts of the country. However, in the north and northeast the dew point average is clearly ascendant. *Daylight Hours*: A rising rate pattern is visible everywhere throughout the country. The highest rate of increase is seen in the northwest of the country. *Cloudiness:* Cloudiness is another important factor in the climate system. The results show that the number of the days with clear skies changes between –12 to 12 per decade.

Climate Change Projection

The two models MAGICC-SCENGEN, Lars-WG have been used to project future changes in the country's climate at the regional scale while the PRECIS model has been used for projection in the local scale.

Climate Change Projection Using MAGICC-SCENGEN (HadCM2 and ECHAM4 Models)

The HadCM2 and ECHAM4 in combination with 18 available emissions scenarios have been utilized to project the changes in the country’s temperature and precipitation (as the main contributors to the formation of the climate) until the year 2100. Both GCMs predict a higher temperature nationwide with very little variation. According to HadCM2, the temperature will rise between 0.4 to 3 degrees centigrade, while the results of ECHAM4 suggest that the rise will be in the range of 0.5 to 4 degrees centigrade. However, there are remarkable differences between the projected changes in precipitation and its spatial distribution. According to HadCM2, the northern half of the country will see a rise in the amount of precipitation, while the southern half of the country will suffer a net loss in precipitation. Surprisingly, the projection changes using ECHAM4 and indicates that the northern half of the country will suffer from the loss of precipitation, while the southern part of the country will observe an increase in precipitation.

Climate Change Projection Using LARS-WG Weather Generator

This model was used to project the country's climate during 2010-2039 and to compare the results with observations during 1976-2005. The changes in the number of the dry, wet, freezing and hot days and extreme events like heavy and torrential rains as well as changes in temperature and precipitation have been examined. The results indicate that the amount of precipitation will on the average decrease throughout the country by 9% between 2010-2039, compared with the 1976-2005 period. However, the number of heavy and torrential rains will increase by 13% and 39% in the same period, respectively. Temperature projections show an average increase in the amount of 0.9 degrees centigrade and minimum and maximum temperatures will on average rise by 0.5 degrees centigrade. The rises are more pronounced during the cold season. The number of hot days in most parts of Iran will increase. The highest increase will occur in the southeast of the country by 44.2 days. The study has also revealed that the number of freezing days in most parts of the country will decrease. The highest decrease will occur in the northwest of the country with freezing days decreasing by 23 per annum. Study of the changes in the number of wet days during 2010-2039 indicates that it will increase in some areas in the northwest, center, south, east, and southeast of the country. In other parts of the country the number of wet days will decrease. The highest decrease will occur in the cold season. The study on the number of dry days shows an increase in many parts of the country. The highest rise at 36 days is expected to occur in the west and southeast of the country.

Water Resources

Potential Water Resources

Iran receives approximately 413 bcm of water from precipitation per annum, from which 296 bcm goes unutilized through evaporation and evapotranspiration. According to 2005 statistics the resources of renewable water are 130 bcm. Water supply and consumption by different sources are shown in Figures 1-3.

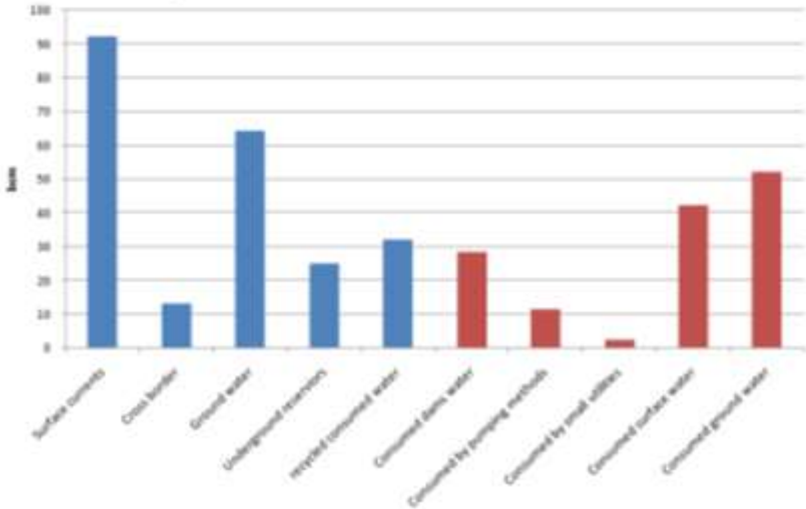

Fig. 1. Water Sources and Consumption Trends in Iran

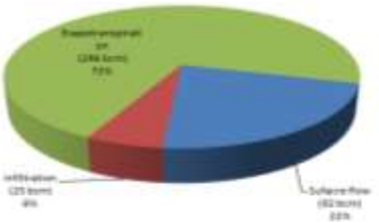

Fig. 2. Total Renewable Water Resources (130 bcm)

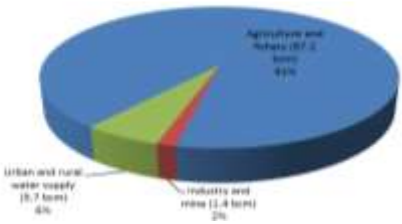

Fig. 3. Water Use in Different Sectors

Iran is located in the arid and semi-arid region of the globe with approximately 70% of the area in the dry and semi-arid region. In addition, in recent decades climate change has also adversely affected the country’s water resources. One of the consequences of climate change is increased frequency of floods that causes severe damage to water resources and is a major problem in water management. In fact, watershed degradation is an outstanding factor in the overall water crisis that has resulted in reduced production capacity of soil and water resources. Other consequences of climate change are the occurrence of severe and frequent droughts that cause reduced water resources for various uses and the loss of some water ecosystems. Average renewable water resources based on rainfall, vegetation, and other effective elements are about 130 bcm while the total accessible water with return flow is estimated about 111 bcm. Some 105 bcm of the total renewable water is contained by surface water. An estimated 25 bcm penetrates groundwater resources.

At present average renewable water per capita is about 1,900 cubic meters (2009), however, due to the increasing rate of population and the impacts of climate change, it is expected that the per capita water availability will be reduced to 1,300 cubic meter per capita by 2021. Regardless of the obvious differences in the country regarding water resources and the extensive arid area of Iran, this figure is much lower than the average rate in the country. Furthermore, the data of average per capita of water in the coming years forecasts Iran entering a new stage of water stress and scarcity.

Water, Sanitation and Protection of Environment

Providing safe and hygienic water for domestic use and hygienic discharge of sewage are very important for human survival and healthy living. By implementing water supply projects covering more than 98% of urban areas and near to 84 % of rural areas which is one of the basic national needs has been met to a considerable extent.

Around 32 bcm of industrial, municipal and agricultural wastewaters flow into both surface and ground water resources. In addition, the primary rivers within the country after crossing over plains and populated, economic and social centers are exposed to various pollutants and foster extensive environmental issues for the downstream plains. Thus, water management activities in this field are vital.

Water and Food Security

Based on recent statistics, some 70% of grains and about 90% to 100% of other crops and fruits are grown in irrigated lands. Various systems of water supply and water resources operation play different roles in providing food security. In addition, it is necessary to consider the drought management structure, in order to support the country’s food security in periods of drought. Hence, supporting drought management is increasingly vital for national food security.

Water and Climate

Climate Change Impact on Water Resources

Methods for assessing the impact of climate change on hydrology and water resources are categorized under three areas:

- Statistical analysis based on the past historical meteorological and hydrological records,
- Simulation study using climate change scenarios and basin-wide hydrological models,
- Simulation based on a macro-hydrological model that combines a general circulation model (GCM) and a hydrological model.

Climate Change Scenarios, Simulation and Their Impacts on Runoff

The results of the model record that the rise in temperature not only increased evaporation and caused decreased runoff, but also accelerated melting snow that causes increased rate of runoff in winter and a corresponding decrease of runoff in spring. Model results also indicate that at a constant level of rainfall, temperature increase of only about 2 degrees, creates a rise of 27.3 bcm in annual volumes of evaporation and transpiration.

General Circulation Models (GCM) Results and Their Impacts on Water Resources

In order to study the climate system and climate change on a global scale, general circulation models (GCM) are used.

Results of GCM models show that this model despite its limitations, including lack of hydrological parameters for a simplified model, heterogeneous spatial distribution of network data that is used as the input model and finally large scale model results, will most likely be the touchstone of future climate simulations.

Using MAGICC-SCENGEN model and downscaling the results to fit Iran's geography, rainfall and temperature conditions has been modeled until 2100. The calculations were performed for the IPCC scenarios HadCM2 -18 and the results of the model have been used to predict surface runoff.

All of the defined scenarios of GCM are used in this model. However, results of more appropriate scenarios for Iran's condition are shown in Tables 1-4. Using results of the GCM model as input data for the RAM model, a prediction is made for changes in thirty basins and runoff.

The model results show that:

- Increasing temperature caused increasing evapotranspiration and decreasing runoff,
- Increasing temperature caused a shorter snow melt period which results in a runoff increase in winter and decrease in spring,

- At constant rainfall, the annual evapotranspiration volume increased by about 27.3 bcm with increased temperature of only 2 degrees.

In general, based on the scenarios, Tshak-Bakhtegan and the Maharlu Basin will experience a probable 15.15% decrease in runoff while the Atrak Basin will witness a 7.24% increase. The greatest runoff decrease will be in the north provinces (Mazandaran and Qom) with 11.29% and the highest increase will be in the northeast's North Khorasan Province at 6.33%.

Table 1. Estimated Changes in Runoff (%) Due to the Projected Changes in Temperature and Precipitation in 30 Sub-basins of the Country.

Scenario / Sub-Basin	EMCONST	IS92A	IS92E	IS92F	K_1PC	K_1CON1
Aras	-2.52	-2.74	-2.92	-2.78	-2.42	-3.15
Atrak	4.81	7.24	5.60	5.41	4.65	-11.48
Bandar Abbas	-4.83	-5.21	-5.90	-5.69	-5.06	-0.30
Talesh-Mordab-Anzali	-3.22	-3.50	-3.78	-3.50	-3.05	-4.21
Tashak-Bakhtegan and Maharloo	-12.57	-13.80	-15.15	-14.82	-12.93	-5.67
Western border	-4.21	-4.67	-5.13	-5.02	-4.55	-1.96
Zohreh-Jarrahi	-5.67	-6.25	-6.90	-6.70	-5.94	-1.46

Table 2. Estimated Changes in Runoff (%) Due to Projected Changes in Temperature and Precipitation in Each Province.

Scenario / Province	EMCONST	IS92A	IS92E	K_1PC	K_1CON1
Mazandaran	-10.250	-9.324	-11.115	-9.036	-11.291
North Khorasan	6.326	3.812	4.480	3.776	-7.395
Qom	-4.860	-4.541	-5.433	-4.267	-3.128

Table 3. Maximum, Minimum and Average of Changes in Runoff (%) Estimated by Different Scenarios in Each Sub-basin.

Sub-Basin	Maximum	Minimum	Average
Aras	-2.18	-3.15	-2.57
Atrak	7.24	-11.48	4.30
Bandar Abbas and Sadig	-0.30	-5.92	-4.97
Talesh-Mordab-Anzali	-2.77	-4.21	-3.27
Tashak-Bakhtegan and Maharloo	-5.67	-15.15	-12.98
Western border	-1.96	-5.13	-4.40
Zohreh-Jarrahi	-1.46	-6.90	-5.89

Table 4. Maximum, Minimum and Average of Changes in Runoff (%) Estimated by Different Scenarios in Each Province.

Province	Maximum	Minimum	Average
Ardabil	-2.19	-2.97	-2.59
Boushehr	-1.32	-7.33	-6.28
Charmahal Bakhtyari	4.76	-7.22	-5.60
Esfahan	-1.95	-4.21	-3.56
Hormozgan	-0.64	-6.83	-5.77
Ilam	-2.04	-5.50	-4.71
Khorasan-è-Razavi	5.41	-2.61	1.96
Khuzestan	0.79	-6.98	-5.62
Mazandaran	-8.10	-11.29	-9.51
North Khorasan	6.33	-7.39	3.46
Qom	-3.13	-5.43	-4.65
Tehran	-2.57	-3.52	-3.06

Furthermore, the examination of results show that:

- The greatest reduction of runoff is 38% in Karkheh and 36% in the large Karoon basin in the southwest,
- The highest increase of runoff is 12% in the Talesh and Anzali basins in the northern part of Iran,
- Of the 30 basins under study, in 25 cases, runoff decreased and in five cases it increased,
- Only three out of 30 provinces in Iran will have increased runoff and its related income.

Water and Energy (Adaptation)

Hydropower Plants

Electricity production from hydroelectric power plants has a vital role in the electricity supply of the country, especially in the peak hours of consumption. In Iran due to the special geographical conditions and existence of numerous large basins there exists good potential for expanding hydroelectric power plants. Hydropower generation potential of the country is about 50 Terawatt per hour including the estimated potential production of Karon Watershed at 30 Terawatt per hour, production potential of the Dez Basin at 9 Terawatt per hour and Karkheh’s potential production of 6 Terawatt per hour. The potential of other rivers is estimated at about 5 Terawatt per hour. In this respect, the regulatory capacity of water dams with hydroelectric potential at the end of 2008, was about 41 million cubic meters.

Potential of hydroelectricity generation is over 25,000 megawatts, of which 6,700 MW is being used. A 6,076 MW hydroelectric power plant is under construction with the completion of this project, hydropower generation capacity will increase twofold. In future the rate of runoff in some areas will be reduced, so the efficiency of the power plant of reservoir dams will be decreased. Therefore, the number hydropower plants should be increased. The mid-term plan for expansion of hydropower plants is shown in Table 5.

Table 5. The 5th National Development Plan for Hydropower Plants in Iran

Hydropower	Energy (giga watt/hour)	Power (MW)
2009	8065	17749
2010	758	1620
2011	1360	4870
2012	1330	2061
2013	263	490
2014	2998	5288

Biodiversity

Biodiversity as a dynamic and inseparable concept of ecosystems has been affected by climate change during the last century either directly or indirectly. Climate change directly impairs the functions of individual organisms (e.g. growth and behavior), modifies populations (e.g. size and age structure), ecosystem structure and functions (e.g. decomposition, nutrient cycling, water flows and species composition and species interactions) and the distribution of ecosystems within landscapes. Changes in disturbance regimes are good examples of the indirect impact of climate change on biodiversity. Although no systematic research has been conducted to show the linkage between climate change and biodiversity in the country, biodiversity national documents and scattered conservation activities have addressed climate change as an influential factor on biodiversity.

Methodology

Given the existing limitations in resources, the primary tools and methods used for studying vulnerability and adaptation of biodiversity to climate change have been based on academic study, expert judgment and individual meetings and interviews.

In general, no linkage is established even at a high level of policy making between biodiversity and climate change. National Biodiversity Strategies and Action Plan (NBSAP) is the most important national document regarding biodiversity conservation in the country. Although very limited, climate change has been addressed in NBSAP. This document proposed a comprehensive study to be accomplished and investigates inter-linkages of biological diversity and climate change in the country.

Although the Fourth National Development Plan (2004-2009) requested the government to implement the Biodiversity Conservation Action Plan, it seems that little action has been taken in this regard. The main reason for this might be lack of general awareness among the policy and decision makers of the impact of climate change on biodiversity in the country. Iran's second and third national reports to UNCBD (submitted in May 2001 and December 2005, respectively) confirm very limited actions were conducted in this regard. All this clearly implies that nationally produced data is very limited and studying vulnerability of biological resources to climate change is limited to internationally produced data and information.

To study the vulnerability of biodiversity to climate change, analogue overlapping of biodiversity resources with zoning maps of different climatic features has been used. National Protected Area System has been considered as the main biodiversity distribution model across the country. Unique and important wildlife habitats and ecosystems e.g. Hircanian forests, central sub-deserts (as the most important habitat for Asiatic cheetah and wild ass) have been considered as well.

Flora, Fauna and Natural Habitats

A large portion of Iran's territory is located in the Palaearctic realm and is considered as the center of origin for many commercially valuable plant species e.g. Medicago sativa or medicinal and aromatic herbs. The southwest has been characterized by Afro-tropical species, while the southeast has some species from the Indo-Malayan sub-tropical realm.

Iranian habitats support some 8,200 plants species of which 2,500 are endemic. Scientific evidence supports the presence of over 500 species of birds, 160 species of mammals and 164 species of reptiles (26 endemic species).

Wetlands and rivers are considered as inland water ecosystems. Investigations by the Department of Environment suggest that more than 100 big wetland sites are found nationwide. At this time 22 sites with a total area of 1,481,147 hectares are registered on the list of wetlands of international importance by the Ramsar Convention on Wetlands (Ramsar, 1971).

Wetlands are the most valuable ecosystems since they offer an abundance of ecological goods and services. Iran's wetlands play an important role in water balance and well-being of the natural environment, wildlife and human beings given the fact that most of the climate is dry or semi-dry. Out of 22 registered internationally important wetland sites in Iran, seven are mismanaged and included in the Montreux Record that is "a record of Ramsar sites where changes in ecological character have occurred, are occurring or are likely to occur".

More than 3,450 permanent and seasonal rivers are extant in Iran. These rivers are categorized within six main watersheds and 37 sub-basins. Long time measurements suggest that the largest portion of annual water discharge is into the Persian Gulf and Caspian Sea respectively while other four watersheds produce less water in terms of quantity but not importance. Rivers are the natural habitat for aquatic species, small animals, birds and specialized flora. They offer important and valuable ecological services as well.

There are some 12 million hectares of forests and 8,900 hectares of mangroves along the Persian Gulf coasts. Iran's forests are classified into five main categories as follows (Figure 4):

- Caspian broadleaf deciduous forests; consist of a rather narrow green belt in northern Iran with a current area of about 1.9 million hectares,
- Arasbaran broadleaf deciduous forests; are in the northwest of the country. They support many endemic species in an area of 120,000 hectares,
- Zagros broadleaf deciduous forests; consists mainly of oak trees from three main species. With an area of 5.5 million hectares. Zagros forests are located in the west of Iran,
- Irano-Touranian evergreen Juniper forests; almost all high mountains of the country outside the deciduous forests used to be covered by Persian Juniper (Juniperus polycarpus). Optimistically speaking, the area covered by this type of forest is about 500,000 hectares,
- Semi-savanna thorn forests; with an area of about 2 million hectares cover narrow bands in the west of the country and a wider belt in the south along the Persian Gulf and the Sea of Oman.

Rangelands cover some 55% of the total land area of the Country. While 8% out of 86.1 million hectares of Iran's rangelands are classified as excellent, 26% are favorable and 66% are classified as poor (Figure 5). Based on biomass production and grazing season, rangelands can be categorized as 1) summer rangelands; 2) winter rangelands; and 3) arid rangelands.

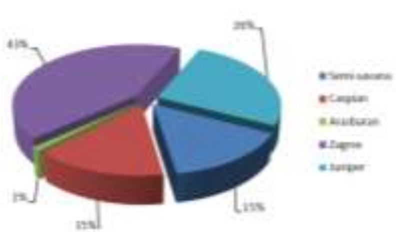

Fig. 4. Forests of Iran.

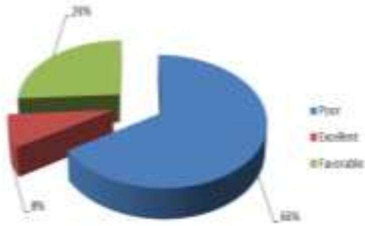

Fig. 5. Rangelands of Iran

Vulnerability Assessment

Current Situation

Past changes in the global climate resulted in major shifts in species ranges and marked a reorganization of biological communities, landscapes and biomes. The present global biota was affected by fluctuating Pleistocene (last 1.8 million years), concentrations of atmospheric carbon dioxide, temperature, and precipitation, and coped through evolutionary changes, species plasticity, range movements, and/or the ability to survive in small patches of favorable habitat (refuges). These changes, which resulted in major shifts in species ranges and marked reorganization of biological communities, landscapes and biomes, occurred in a landscape that was not as fragmented as it is today and with little or no pressures from human activities. Anthropogenic habitat fragmentation has confined many species to relatively small areas within their previous ranges, with reduced genetic variability. Warming beyond the ceiling of temperatures reached during the Pleistocene will stress ecosystems and their biodiversity far beyond the levels imposed by the global climatic change that occurred in the recent evolutionary past.

The current levels of human impact on biodiversity are unprecedented, affecting the planet as a whole, and causing large-scale loss of biodiversity. Current rates and the magnitude of species extinction, related to human activities, far exceed normal background rates. Human activities have already resulted in loss of biodiversity and thus may have affected goods and services crucial for human welfare. The outstanding indirect underlying human causes include: demographic; economic; sociopolitical; scientific and technological; and cultural and religious factors. The primary direct human drivers (proximate causes or pressures) include: changes in local land use and land cover (the major historical change in land use has been the global increase in lands dedicated to agriculture and grazing); species introductions or removals; external inputs (e.g., fertilizers and pesticides); harvesting; air and water pollution; and climate change. The rate and magnitude of climate change induced by increased greenhouse gases emissions has and will continue to affect biodiversity either directly or in combination with the drivers mentioned above, and might outweigh them in the future. Biodiversity resources in Iran are currently under severe pressure due to unwise use of natural resources as well as unsustainable development measures at different levels.

The most important threatening factors to biodiversity are classified as follows:

- Over exploitation of water resources and unsustainable development of agricultural development plans resulting in water scarcity so that inland water ecosystems are not functioning in a sound manner,
- Over grazing and logging has reduced production of biomass in forests and rangelands of the country,
- Unsustainable land-use conversions creating large scale habitat degradation and fragmentation,
- Hunting and trapping practices have a direct negative impact on the population of wildlife and aquatics resulting in declining genetic resources,
- Extended use of fertilizers and pesticides caused severe poisoning and utrification of the environment and water bodies,
- Natural drought that strikes large areas of the country causing significant socio-economic and natural difficulties.

At present Iran is losing its biodiversity at an alarming rate. There is no convincing report on the existence of the two big mammals, i.e., Persian lion and Caspian tiger from their natural and endemic habitats during the last 50 years. Asiatic cheetah, Persian wild ass, Persian squirrel and three species of sea turtles are among critically endangered species and on the verge of extinction. No scientific study has been conducted to determine extinct plant species but according to scientific evidence many species are under severe threat.

All these imply a very vulnerable situation in terms of biological resources and socio-economic conditions since these are two heavily inter-linked issues.

Future Situation

Generally speaking, Iran will experience a warmer and dryer climate during 2010-2039. It means that water demand will increase when rainfall is more limited. It could influence the timing of reproduction of animal and plant species and/or migration of animals, the length of the growing season, species distributions and population sizes, and the frequency of pest and disease outbreaks. Some species may move pole-ward especially migratory species or upward in elevation from their current locations. It is very likely that many species are already vulnerable to extinction.

The livelihood of many endemic and local communities, in particular, will be adversely affected if climate and land-use change lead to losses in biodiversity. These communities are directly dependent on the products and services provided by the terrestrial, coastal and marine ecosystems, which they inhabit. Urban populations will be affected directly and/or indirectly as well.

Vulnerability to Change in Precipitation

During 2010-2039 the average precipitation will decrease from 3% to 8%. This decrease will mainly occur in winter. It will result in less snowfall and less snow pack consequently. Water resources will decrease then and water scarcity threatens biological resources. Spatial deviation of precipitation suggests that huge portions of the Alborz and Zagros mountains will largely be affected and will result in less biomass and quality of forest and rangelands. Since the main portion of water supply of Iran is produced in these two mountain ranges, surface and ground water resources will be stressed. Many wetlands and other inland water ecosystems will be affected negatively which could lead to significant decrease in wildlife population.

Vulnerability to Heavy Rainfalls

As projected, the threshold for heavy and very heavy rainfall will increase. It is estimated that for heavy rainfall it will increase from 210mm to 237mm and for very heavy rainfall from 273mm to 378.8mm. It means that the number of floods will increase during 2010-2039. Heavy soil erosion and socio-economic catastrophes are expected.

Vulnerability to Change in Mean, Maximum and Minimum Temperatures

Mean temperature will increase in general during 2010-2039. This increase will be seen more sharply in winter (0.7°C) and autumn (0.6°C). The same pattern is seen in predictions of maximum and minimum temperatures. It reveals that wildlife species will shift to upper elevations to adapt themselves with this increase. It will cause a change in the habitat and behavior as well as limitation of territories and ecological niches. Temperature increase will result in shorter winters and early spring that will cause interruption in the reproduction schedule animal and plant species. Spatial zoning of departure rise suggests that in the northwest, a large area in the west and southwest will face the highest increase in mean temperature. It will occur is small spots of the northeast and southeast. Increase of water demand in these areas is a definite consequence that could especially affect the Urumiyeh Basin that is currently facing a crisis due to mismanagement of water resources. Coastal wetlands of the south are also susceptible to damage as well.

Vulnerability to Change in the Number of Hot Days

The number of hot days (days with maximum temperature over 30°C) will increase. When that occurs water stress will be very likely in plant and animal species. Temperatures over 30°C may also be beyond the tolerance range of some species. Almost the whole country will experience an increase in hot days but it will be more pronounced in the southeast, northwest and northeast.

Vulnerability to Change in the Number of Frost Days

The number of frost days (days with minimum temperature below 0°C) will decrease nearly nationwide and the country will experience this decrease but the northwest, south and southwest and northeast are more exposed to this phenomenon. Agro-ecosystems are in some ways dependent on frost days in winter. When the temperature falls below 0°C, many pests and diseases are destroyed while seeds, roots and other parts of plants will remain intact and safe in the next year.

Vulnerability to Change in the Number of Wet and Dry Days

A day is considered wet when the amount of precipitation is more than 0.1mm, while in a dry day recorded precipitation is less than 0.1mm. The number of wet days will decrease almost nationwide except for limited areas of the northwest and the south and more prominently in the west. The number of dry days will increase and this rise will be more significant in the west and southeast. All this reveals a general deficit of rainfalls in the west and southeast that will affect valuable habitats of the western forests, southeastern rivers and wetlands. The oak forests of the Zagros range, Mesopotamian marshlands, Hamoun wetlands complex and the Iranian crocodile are among the most threatened species and ecosystems.

Conclusion

The studies on the impact of climate change on Iran’s water resources and biodiversity carried out under the Second National Communication to the UNFCCC indicate that there is an urgent need for the Government of the Islamic Republic of Iran to develop national action plans for in-depth vulnerability assessment and adaptation plans, supported by the necessary legal, fnancial and institutional infrastructure.

Reference

1. Iran’s Second National Communication to the UNFCCC (November 2011).

Biodiversity of benthic invertebrates in lakes located along aridity gradient (lakes in the south of West Siberia as a case study)

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Introduction

For the past 30 years, in the Inner Asia the average annual air temperature has increased by 1.4 ° C, while the average annual precipitation remained almost unchanged [3]. These changes lead to climate aridization caused by increased evaporation and decreased evaporation-precipitation ratio. The lakes are accumulating elements of landscapes, their ecosystems are highly dependent on soil and geochemical climate-induced processes [6]. Benthic invertebrate communities are an important structural component of lake ecosystems; their composition and abundance depend on many environmental factors, including climate. Aridity gradient in various natural zones can serve as an indicator for predicting the impact of climate change on ecosystems of water bodies.

Material and methods

The communities of bottom invertebrates were studied in 2008 -2011 during the complex limnological field trips to lakes of the Ob-Irtysh interfluve. Altogether 25 lakes were examined. The material was collected and processed using standard hydrobiological methods [6]. A total of 150 quantitative and 40 qualitative samples were collected and analyzed. Dominant species were identified by their occurrence frequency [1].

The studied lakes are located in two natural zones and four sub-zones [7]. Lakes Kulundinskoye, Presnoye and a nameless one are in the dry steppe subzone; lakes Krivoye, Mostovoye, Uglovoye, Maloye Topol'noye, Peschanoye, Khorosheye, Bol'shoye Topol'noye, Krivoye, Khomutinoye, Kaban'ye - in the arid- steppe subzone; Gor'koye , Bol'shoye Ostrovnoye – in the moderately arid -steppe subzone; Mel'nichnoye, Ledoreznoye, Batovoye, Chernakovo, Lena, Verkhneye, Nizhneye, Pryganskoye, Pustynnoye, Bol'shoye - in the southern forest-steppe subzone.

Results and discussion

A total of 127 bottom invertebrate species of eight classes (Nematoda, Oligochaeta, Hirudinae, Bivalvia, Gastropoda, Phylactolemata, Crustacea, Insecta) were met in the lakes under study. The greatest number of the species was from the class Insecta, where Diptera dominated. Also, the insects Coleoptera, Ephemeroptera, Trichoptera, Odonata, Hetetoptera, Collembola, Lepidoptera were found.

According to the classification of surface water quality [3], the studied lakes from the dry sub-zone belong mainly to euhaline (salinity is within 25-140 g/l), from the dry-steppe and moderately arid- steppe subzones to alpha - mesohaline (1.5-18 g/l), from the south forest-steppe subzone to the oligohaline and alpha mesohaline (0.3-2.5 g/l) ones. Maximal species diversity of benthic invertebrates is observed in oligohaline lakes (1-13 species per sample, 5 on average). Minimal species diversity falls on euhaline lakes; here the number of species in the sample does not exceed two. It is evidence of general tendency towards the decrease in species diversity of aquatic organisms with the increase in salinity of inland waters [8].

The change in dominant and subdominant taxa of benthic invertebrates occurs from the southern forest to dry steppe. In the southern forest-steppe zone, dominant and subdominant taxa of benthic invertebrates are represented by Chironomidae, Coleoptera, Odonata, Ephemeropthera, Thrichoptera. In arid and moderately sub-arid steppe zones, the dominant taxa declines in number and the composition of benthic invertebrates changes. Here Chironomidae and Ceratopogonidae dominate. In the dry steppe, the dominant taxa are Ephydridae and Ceratopogonidae.

Change in the heat-moisture balance of the lake catchment strongly influences water mineralization that in turn has a significant impact on the taxonomic composition of aquatic organisms. Generally, salinity is accompanied by decrease in species number [8]. Our research shows that the greatest resistance to high mineralization is characteristic of typical inhabitants of brackish and salt water, namely larvae from the order Diptera: Ephydridae and Ceratopogonidae (0.55-140 g/l) [4]. Also great ecological plasticity is revealed for larvae Chironomidae and Coleoptera found in the salinity range from 0.384 to 25.4 g/l. Annelida (Oligochaeta and Hirudinae), Lepidoptera, Ephemeroptera, Trichoptera, Heteroptera were identified in lakes with water salinity exceeding 3.3 g/l.

To analyze the effect of the heat-atmospheric moisture ratio in the catchment area on the species diversity of benthic invertebrates, the average annual precipitation-evaporation ratios ($R_{p/e}$) obtained from the nearest weather stations located directly in the catchment area (for flowing water reservoirs it is upstream the river) or in the same latitude were used (Baevo: Mostovoye, Chernakovo, Lena; Blagoveshenka,Uglovskoe: Kulundinskoye, Presnoye, nameless; Volchiha: Uglovoye; Kamen'-na-Obi: Pustynnoye, Bol'shoye; Mamontovo: Gor'koye, Bol'shoye Ostrovnoye, Krivoye (Kasmala), Batovoye, Mel'nichnoye, Ledoreznoye; Slavgorod: Krivoye (Burla), Khomutinoye, Peschanoye, Khorosheye, Bol'shoye Topol'noye; Habary: Kaban'ye, Maloye Topol'noye, Verkhneye, Nizhneye) [9].

The analysis shows strong correlation between the moisture content and the total number of zoobenthos species (Nt) of the lakes with $R_{p/e}$ and the average value of the Shannon index (H). The Spearman's correlation between $R_{p/e}$ and H equals 0.93 ($p = 0.03$). We found the correlation between $R_{p/e}$ and Nt unreliable ($p > 0.05$). However, the accuracy of the approximation of the obtained power and exponential functions (0,5) indicates that they adequately describe the in-situ data of H and Nt with higher reliability of H (low line) (see Fig.1). Similar trends were previously described, but not confirmed by statistical methods [4].

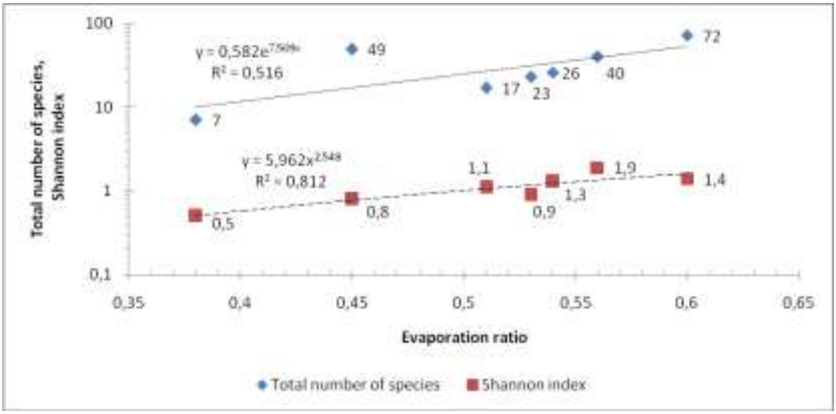

Fig. 1. Total number of species and mean species diversity (Shannon index) in lakes, the catchments of which are located in areas with different precipitation-evaporation ratio

Conclusion

1. A total of 127 bottom invertebrate species of eight classes were recorded in the lakes studied. Species diversity is maximal in oligohaline lakes of forest-steppe zone, the minimal - in euhaline lakes of dry steppe.

2. Dominant and sub-dominant taxa of zoobenthos, i.e. Thrichoptera, Ephemeropthera, Coleoptera, Odonata, Chironomidae are typical for the lakes of the south-steppe subzone, while for the moderately arid and arid-steppe these are Chironomidae and Ceratopogonidae. In the lakes of the dry steppe sub-zone Chironomidae are replaced by Ephydridae.

3. From the southern forest to dry steppe, the change in dominant taxa and the decrease in species diversity of benthic invertebrates are observed. Diminution of the evaporation-precipitation ratio in the catchment is accompanied by decrease in species diversity of zoobenthos (Shannon index) including total number of species.

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Environmental adaptation of brain shrimp Artemia sp.

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Brain shrimp *Artemia*, dwelling in hyperhaline waters, is an essential resource species of aquatic invertebrates. Major fishing saline lakes of West Siberia populated by parthenogenetic races of collective species *Artemia parthenogenetica* Barigozzi 1974 are located in Altai Krai, where production of *Artemia* cysts in 2000-2011 averaged 709 t/yr (Permyakova, 2012). Volumes of cyst harvesting vary greatly over the years. For example, in lake Bolshoye Yarovoye cist production ranges from 0 (2009) to 502 t (2007) that is evidence of sharp fluctuation in magnitude of *Artemia* population. With high anthropogenic load on *Artemia* population, it is necessary to specify the reasons of great variability in productivity of hyperhaline lakes: whether such variation in magnitude of *Artemia* population is typical for all animal populations or it is a result of excessive cysts withdrawal.

Phenomenal morphological changeability induced by environmental factors is characteristic of *Artemia* (Voronov, 1979). Most of important morphological features of *Artemia* are quantitative that according to Zhivotovsky L.A. (1991) may serve as biological "indicators" of the environment since they are related with adaptive properties. Shakin V. (1991) states that in order to survive, a living system adapts itself to extreme conditions via self-organization, mobilization, concentration on a few, but major factors of survival. The author suggests consider a degree of rigidity (i.e. coherence and organization of the system) as a quantitative measure of adaptation. Rostova N.S. (1999) proposed a heuristic approach to the problem of quantifying the similarity of correlation matrixes in different objects or conditions. Using the proposed method, we have studied features' interrelation in *Artemia* population from lake Bolshoye Yarovoye for several years. The results of this study are presented in the paper.

Materials and methods

Monitoring of *Artemia* population from lake Bolshoye Yarovoye was carried out in 2007-2011. Zooplankton was sampled in fixed points on 4 transects specified with GPS. The lake depth in each point of a transect was 2, 4, 6 and 8 meters. Concurrently with zooplankton sampling, we measured temperature, salinity and transparency of water at different depths. For sampling, the Apshtein plankton net and water bottle were used. Water transparency was defined with the use of Secchi disk, salinity - by refractometer, the brine temperature - by a mercury thermometer. The processing of samples was made in the laboratory using a binocular magnifier MBS-1 for identifying the population density and age structure. In 2007-2009, 3-4 sampling for the season and then once a year in 2010-2011 were performed.

The monitoring program involved the study of morphometric and meristic features of *Artemia*. Each year, we studied two samples of adult shrimps from spring-summer and summer-autumn generations numbered 60-160 individuals. Thus, we obtained the following measurements: total length (A), cefalotoracse length (B), abdominal length (C), ratio cefalotoracse length / abdominal length (D), length of furca (E), length right (F) and left (G) branch of furca, number of setae on the right (H) and left branch of furca (I), length (J) and width (K) of ovisac, ratio ovisac length / ovisac width (L) and the number of posterity on the ovisac (M). The data were processed using the methods of variational statistics (Schmidt, 1984, Rostova, 1999).

Results and discussion

Seasonal dynamics of *Artemia* population density in lake B. Yarovoye for the study period is presented in Fig.1. In 2007, the maximum density of the brine shrimp population is marked in the end of June – on average 26.2 th ind./m^3. The population was mostly represented by metanauplius. In three weeks, *Artemia* density decreased 16-fold or 1.8 th ind./m^3. Pre-mature and mature specimens, which gave rise to the second generation dominated. Rise in density of the second generation with metanauplius predominance averages 18.4 th ind./m^3 and falls on July 31.

In 2008, the first generation of *Artemia* reached its peak on June 19 and made up 38.0 in the north and 35.6 th ind./m^3 in the south part of the lake, respectively. Then, there was almost a month delay in *Artemia* development at the metanauplius stage. The appearance of the second generation was observed only on August 14. During the whole period of investigations we recorded the decrease in *Artemia* population density: July 22 - by 63%, August 14- more than 31%.

In 2009, the population density remained very low throughout the season (within 6.7 th ind./m^3).

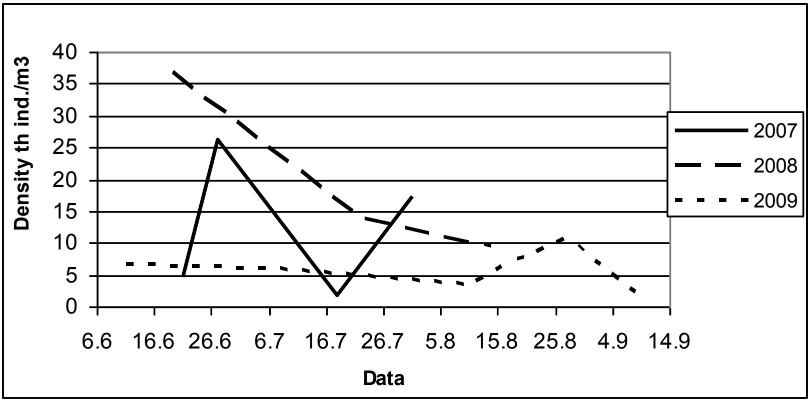

Fig. 1. Seasonal dynamics of population density of *Artemia* from Lake B. Yarovoye, 2007-2009.

Rise in number occurred only in the third generation that developed completely over a long warm fall: its density made up 10.6 th ind./m^3. The high number of population has recovered in 2010, when density reached 32.1 th ind./m^3 in the second generation Thus, the years of studying *Artemia* population in lake B.Yarovoye cover the development cycle, including heyday, recession, depression and abundance recovery.

Quantitative changes in animal populations result in qualitative ones. For instance, water vole has indigenous genetic rearrangements in its population during the depression phase (Kovaleva et al, 2011).

The analysis of morphological features of *Artemia* shows that annual mean values including brood sizes decrease from the spring-summer generation to the summer- fall one (Table 1). Variability of features was insignificant, except for meristic characteristics (i.e. number of setae on furka branches). Their number was always greater in the second generation; the variation coefficient reached 61%. The offspring number in the egg bag varied greatly as well. The features composing a body length (the length of the abdomen, cephalothorax) showed the least variability. Seasonal dynamics of variation coefficients was evident only during the period of population depression: variability of all traits of individuals from the second generation was generally higher than in the first one.

In the interannual aspect, we observed the decrease in average values of plastic properties and increase in their variability during the period of population depression. The increase in both mean values and variability characteristic of this period for meristic features was noted. During the rise in population number (2010), mean values of furka features were the least, whereas their variability - the highest.

Table 1. Mean values (x) and variation coefficients of (v) morphological features of *Artemia* from Lake B. Yarovoye

Feature		2007		2008		2009	
	Indicator	1*	2	1	2	1	2
A	X	13.48	11.42	13.55	9.92	12.39	11.89
	V	**10.90**	7.58	**11.66**	7.96	7.83	**14.46**
B	X	5.53	4.49	5.56	4.29	5.25	5.06
	V	**10.23**	8.60	**11.25**	9.32	7.51	**14.46**
C	X	7.94	6.93	7.97	5.63	7.15	6.84
	V	**12.93**	9.76	**12.65**	8.32	9.09	**14.90**
D	X	0.70	0.65	0.70	0.76	0.74	0.74
	V	**10.49**	5.86	6.44	**7.73**	6.10	6.16
E	X	0.38	0.35	0.33	0.25	0.32	0.30
	V	**17.89**	12.43	10.13	**12.43**	11.29	**18.86**
F	X	0.22	0.19	0.23	0.19	0.24	0.21
	V	15.01	**17.75**	14.14	**17.56**	16.36	**23.86**
G	X	0.23	0.19	0.23	0.19	0.24	0.21
	V	15.45	**19.96**	14.22	**16.67**	15.64	**21.97**
H	X	2.51	3.20	2.74	3.03	2.68	3.44
	V	**40.07**	33.31	44.17	**49.75**	34.54	**60.79**
I	X	2.47	3.23	2.75	3.05	2.69	3.40
	V	**44.56**	33.78	45.19	44.44	39.18	**58.43**
J	X	2.44	1.86	2.24	1.60	2.29	2.15
	V	**32.05**	11.41	9.65	9.70	8.88	**17.04**
K	X	2.28	1.76	2.20	1.50	2.24	2.13
	V	11.22	**12.97**	11.03	**13.18**	9.11	**19.86**
L	X	1.09	1.06	1.02	1.07	1.02	1.02
	V	**46.47**	7.27	6.34	**8.92**	4.97	**6.99**
M	X	100.47	44.94	83.10	40.36	102.82	79.11
	V	**36.85**	35.93	**38.03**	37.19	22.87	**58.51**

** - number of generation*

Coefficients of determination of features characterizing the level of connections in each feature are shown in Table 2. Most of the coefficients obtained in the years of high population and its decline is low (r2 <0,25). In the year of depression, the features' interdependence grows: almost all coefficients of determination increase to r2 = 0,25-0,49. There is no connection between variation and determination of traits. Among both fairly and strongly varying features, fairly and highly deterministic ones are met.

Table 2. The coefficients of determination (r2) of morphological features of *Artemia* from Lake B. Yarovoye

Feature	2007		2008		2009		Average	
	1	2	1	2	1	2	1	2
B	0.10	0.16	0.21	0.15	**0.31**	**0.31**	0.21	0.21
C	0.14	0.21	0.21	0.19	**0.30**	**0.31**	0.22	0.24
D	0.06	0.05	0.02	0.05	0.02	0.01	0.03	0.04
E	0.08	0.07	0.12	0.21	**0.31**	**0.34**	0.17	0.21
F	0.12	0.13	0.14	0.24	**0.28**	**0.30**	0.18	0.22
G	0.12	0.14	0.14	**0.26**	**0.28**	**0.31**	0.18	0.24
H	0.02	0.05	0.05	0.10	0.17	0.17	0.08	0.11
I	0.02	0.05	0.06	0.12	0.18	0.16	0.08	0.11
J	0.09	0.18	0.19	0.15	**0.30**	**0.30**	0.19	0.21
K	0.11	0.20	0.24	0.24	**0.36**	**0.35**	0.24	**0.26**
L	0.10	0.03	0.04	0.11	0.12	0.10	0.08	0.08
M	0.01	0.06	0.12	0.06	**0.26**	**0.32**	0.13	0.15

Comparative analysis of correlation matrixes of *Artemia* traits (based on an average coefficient of determination for each matrix that characterizes the system arrangement as a whole) indicates that every year the agreed variation of features increases in the second generation as compared to the first (Table 3). The organization of the correlation system of *Artemia* traits changed most impressively during the period of depression: not only the level correlation of features but also the structure of interrelations have changed**.** If for a matrix of the first generation (2007) the dendrite created by "maximizing the correlation path" was split into three pleiads, the for a matrix 2009 dendrite contained one pleiad of consistently varying features. Rigidness strengthening in *Artemia* living system is indicative of stressful habitat caused by natural factors. Thus, the question about natural or man-made reasons for decreasing *Artemia* population is solved.

It is of great interest to study the mechanisms of *Artemia* adaptation to extreme factors associated with high salinity (medium viscosity, temperature, amount of dissolved oxygen, composition and amount of food) and prompt population adjustment under changing environment. These populations should have high polymorphism. Levites E.V. (2005) believes, that polymorphism in offsprings produced without meiotic genome transformation is evidence of some other mechanisms ensuring variability. Author proposed the hypothesis on polytheny as a factor of variability supported by some studies to explain polymorphism in agamospermy progenies of plants.

Table 3. Mean coefficient of determination of features of *Artemia* from Lake B.Yarovoye for 2007-2011.

Year	2007		2008		2009		2010	2011
Generation	1	2	1	2	1	2	1	2
r^2	0.080	0.112	0.128	0.156	0.240	0.250	0.245	0.168

Thorough studies in population cytogenetics show that different groups of organisms have endoreproduction of cells in specific organs and tissues. Endoreproduction implies different processes leading to multiple increased number of chromosome sets in somatic cells (Anisimov, 1999). Mechanisms of genome multiplication are as follows:

1. chromonemal endoreduplication, when the number of chromosomes remains the same, but chromosomes become polytene ones;
2. abnormal mitosis leads to the asymmetric division of chromosomes and the appearance of haploids, triploids and aneuploids;
3. endomitosis is a multiple increase of chromosomes number in cells.

J.A. Freeman and R.B. Chronister (1988) showed that cells in developing A. franciscana SFB demonstrated tissue-specific differences in DNA content, as determined by fluorescence intensity of bisbenzimide-stained nuclei and by nuclear area. The authors concluded that the tissue-specific endopolyploidy was due to endoreduplication. For parthenogenetic races of Artemia from West Siberia aneuploidy, polyploidy and mixoploidy (a combination of cells with different valence core within the same organism) were revealed (Egorkina et al, 2008). In brine shrimp from the extremely saline lakes (Maloye Yarovoye - 280 g/l, Kuchukskoye - 320 g/l), a wide range of chromosome number with a high proportion of polyploid cells up to pentaploid was established. The most diverse chromosome numbers were found in Artemia from Lake B. Yarovoye with a low salinity level (up to 204 g/l). Apparently, the reason is that the lake is a deep thermally stratified body of water with a qualitative gradient of conditions for zooplankton habitat.

Probably, different ways of genomes multiplication in Artemia cells is the main mechanism of adaptation, genetic differentiation and ecological plasticity of populations. The significance of each genome multiplication process may vary depending on environmental conditions.

Conclusion

The consistent variability of morphological traits of Artemia from lake B.Yarovoye was studied in different phases of population dynamics. The population adapts itself to more severe environmental conditions (the second generation of each season, the phase of depression) through increasing the binding force and changing the interrelation structure of the features studied**.** Indices of determination of features allow us to understand the reasons (natural or anthropogenic) of decline in Artemia abundance.

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The diatom diversity in bottom sediments of the deep reservoir as an indicator of climate changes (Lake Teletskoye, Russian Altai as a case study)

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Abstract: The composition and abundance of diatom algae (Bacillariophyta) in layers with minimal and maximal number of frustules in bottom sediments of Lake Teletskoye from the underwater Sofia Lepneva Ridge were studied. The typical and rare representatives of diatoms in algae community of Lake Teletskoye were revealed. By and large,the composition of diatoms in various layers of bottom sediments does not differ greatly, it differs in number of frustules. The large amount of diatoms are cold-loving species, widely spread in waterbodies of the boreal zone. The total number of diatoms and the share of the cold-loving ones increase under cold snap and decrease with slight warming.

Keywords: *Lake Teletskoye, bottom sediments, diatoms, species composition, abundance.*

Introduction

The diatoms are microscopic unicellular organisms and the main group among algae in the most freshwater ecosystems. The diatom analysis being one of the priority bioindicative methods has a significant untapped reserve of information yet. Thus, there is a real opportunity to identify the criteria for assessing cumulative adverse impact on natural ecosystems as well as scenarios of transformation for these ecosystems in time and space.

Lake Teletskoye, the object of our study, is located in Altai Mountains in the south of West Siberia (51°31′45″N and 87°42′53″E). Its maximal depth is 323 m, the average one – 174 m. The lake is a canyon type reservoir of tectonic origin. The underwater Sofia Lepneva Ridge is situated in the crossing of meridional and latitudinal parts of Lake Teletskoye with top at the depth of 91 m (Selegei et al., 2001).

Material and methods

The bottom sediments were taken by the gravity corer from the top of underwater Sofia Lepneva Ridge in Lake Teletskoye in 2006. The length of the core was 1940 mm. The diatom data in the upper 0-1000 mm and low 1812-1940 mm of the bottom sediment core were analyzed.

The samples for diatom analysis were treated with 30% H_2O_2, heated during 12 hours at temperature of +60 ^{0}C and washed several times in distilled water by centrifugation. After washing, the cleaned diatom material was air-dried on coverslips and mounted in Canadian balsam. Diatoms were studied using Nikon H550L light microscope. All frustules met in the specimens were counted. The number of diatom frustules in specimens was converted to that per 1 gram of bottom sediments. The Key (1951) and Atlases (Khursevich, 1989; Hartley et al., 1996) of diatom algae were used for identification of species. The recent nomenclature was specified with modern phylogenetic system (AlgaeBase, http://www.algaebase.org/). The composition of diatoms and predominant species, the number of frustules in the layers with high and low abundance were revealed.

Results and discussion

The tanatocenoces in bottom sediments from the ridge reflect diatomcenoses developed during different periods of the lake history due to the underwater ridge situated in the crossing of meridional and latitudinal parts of the lake. In the studied layers the number of diatom frustules varied from 0.9 (135-140 mm layer) to 64.4 ml frustules/g (835-840 mm) with the average one of 22.9±0.78 ml frustules/g. The planktonic species *Aulacoseira subarctica* (O.Müll.) Haw. belonging to the group of cold-loving organisms dominated in the layers with high abundance of diatoms – up to 92.1 % of total number. The layers with less number of frustules (up to 5 ml frustules/g in other parts of lake sdediments) were rather rare: 135-140 mm– 0.9 ml frustules/g; 370-375 mm – 3.7; 375-380 mm – 3.2; 380-385 mm – 1.9; 385-390 mm – 1.1 ml frustules/g (Fig. 1).

In Lake Teletskoye the rate of sedimentation is 4-6 mm/year in the south near the main tributary of the lake, Chulyshman River, 1.41 mm/year in the maximal depth (Kalugin et al., 2000), and only 0.3 mm/year (0.45 mm/year including sediment moisture) on the underwater ridge (Kalugin et al., 2009). Therefore, the core of 1.9 m long reveals the sediments of the age of 4 thousand years. The 135-140 mm layer corresponds to the period of 1556-1539 when a slight warming during the Little Ice Age (1450-1850) was observed (Skabichevskaya, 2000). The layers of bottom sediments from 370 to 390 mm fit to the time period 706-772.

The number of diatom species in the studied layers of the core varied from 16 to 24, while in the layer with maximal abundance (835-840 mm) it was 44 species. The representatives of planktonic complex (*Stephanodiscus alpinus* Hust., *Cyclotella bodanica* Grun., *A. subarctica* и *Fragilaria arcus*

(Ehr.) Cl.) made up 21,5-56,8 % of the total number of frustules. All of them are typical for the lake algaecenoces and belong to the small- and medium-celled groups of the cold-loving species. In the layer with maximum number the value of planktonic forms was 85.3 % with predominance of *A. subarctica*. The plankto-benthic species (*Fragilaria construens* (Ehr.) Grun., *F. pinnata* Ehr., *Synedra vaucheria* Kütz., *Diatoma hiemalis* (Roth.) Heib., *Meridion circulare* (Grev.) Ag.) completed 2.3 or 19.7 % of total frustule number and were met in all core layers. The species *Synedra ulna* var. *danica* (Kütz.) Grun. – cosmopolitic, typical for eutrophic and lime-riched waters, mesohalobic, and *Tabellaria flocculosa* (Roth) Kütz.dwelling in peatlands mostly in the north and in the mountains, sphagnophilic, eutermic, oligosaprobic, acidophilic were not too often. The rate of benthic forms was 41.9 or 62.0 %; in the layer with maximum number of diatoms (835-840 mm) – 11.5%. *Cymbella ventricosa* Kütz., *Gomphonema olivaceum* (Horn.) Bréb., *Cocconeis placentula* Ehr., *Nitzschia angustata* (W.Sm.) Grun.were observed in all layers of the core, *Neidium productum* (W.Sm.) Cl. – oligohalobic, widely spread in the sediments of the freshwater and slightly salted waterbodies, and *Eunotia polydentula* Brun., a freshwater species, halophobic, cosmopolitic, living in slightly and medium acidic waters of peatlands and rarely in the mountain lakes.

Generally the composition of diatoms in various layers of the core taken from the underwater ridge with both maximal and minimal number of frustules does not differ greatly, but it differs in number of frustules. The large amount of diatoms are cold-loving species, widely spread in water bodies of the boreal zone. The total number of diatoms and the share of the cold-loving species increase under cold snap and decrease with slight warming.

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Floral Diversity and need for its Utilization in Nepal

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Introduction

Nepal is rich in biodiversity due to its vertical microclimatic zones ranging from tropical to alpine attributed by the altitudinal variation of the topography. The total area of Nepal is 147,181 km². Nepal's share of world's land is no more than 0.1% while its share in flowering plant species is over 2% (IUCN 1999). The country is ranked between 25th and 30th position in global contest and 11th position in the continental scale of biodiversity richness (Shakya, 1999). About 6000 flowering plants have been recorded in Nepal. In this relatively small area, more than 700 species of medicinal and aromatic plants (MAP's) have been reported, of which 250 species are endemic to the country.These plant species grow in all the ecological regions starting from tropical, subtropical, temperate and sub-alpine regions of the country. Sporadic research and studies have been carried out on different aspects of medicinal plants. A large quantity of medicinal plants are collected from wild in Nepal and almost 90% of medicinal plants collected is exported to India raw form without any value addition.

Richness and Conservation

Although, the study on floral diversity of Nepal is going on, the richness in terms of species diversity and their share in global context is given in table 1.

Table 1. Floral diversity

Group of organism	Number of Species		Reference(s)	Nepal representation (%)
	Globally	Nepal		
Lichens	20,000	465	Sharma 1995	2.3
Fungi	69,000	1,822	Adhikary 1999	2.4
Algae	26,000	687	Baral 1995, Kattel & Adhikary 1992	2.6
Bryophytes	16,600	853	Mizutani et al 1995, Furukis Higuchi 1995	5.1
Pteridophytes	11,300	380	Iwatsuki 1988	3.4
Gymnosperms	529	28	Koba et al 1994, Akiyama et al 1998	5.1
Angiosperm	220,000	5,856	Koba et al 1994, Akiyama et al 1998	2.7
Medicinal plants	70,000	>2000	Manandhar 2002, Ghimire et al 2008, Baral & Kurmi 2006	-

IUCN – The World Conservation Union assists to prepare country report on Red Data List, CITES and CBD. The Conservation and Management Planning (CAMP) Workshops were designed by the

Conservation Breeding Specialists Group (CBSG) of IUCN. The objective of the CAMP Workshop is to determine the extent of existing and potential threats to the taxa being assessed and to propose plans for their conservation and management. It extensively uses the IUCN Red List categories and criteria for evaluation of the taxa. The CAMP Workshop held in Pokhara with technical support from the Medicinal Plant Specialist Group (MPSG) and Species Survival Commission (SSC) of IUCN assessed the Red List Categories assigned to the 51 medicinal plant taxa.

Table 2. Example of status of some Medicinal Plant species assessed at CAMP, Pokhara (IUCN)

S.N	Plant species/ Family	Threat status
1	*Pterocarpus marsupium* (Papilionaceae)	Critically Endangered
2	*Rauvolfia serpentina* (Apocyanaceae)	Critically Endangered
3	*Alstonia neriifolia* (Apocyanaceae)	Endangered
4	*Dioscorea deltoidae* (Dioscoreaceae)	Endangered
5	*Operculina turpethum* (Convolvulaceae)	Endangered
6	*Oroxylum indicum* (Bignoniaceae)	Endangered
7	*Alstonia scholaris* (Apocyanaceae)	Vulnerable
8	*Asparagus racemosus* (Liliaceae)	Vulnerable
9	*Butea monosperma* (Papilionaceae)	Vulnerable
10	*Curculigo orchoides* (Hypoxidaceae)	Vulnerable
11	*Piper longum* (Piperaceae)	Vulnerable
12	*Tinospora sinensis* (Memispermaceae)	Vulnerable

Source- Bhattarai et.al (2002)

Besides IUCN listing, few other species have been revealed to be categorized in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is a global mechanism to safeguard biological species from being extinct on account of the pressure arising from International trade of animals and plants, and their parts or products. It has categorized 13 species of plants of Nepal (see table 2) under appendix II and III. Species under Appendix II are categorized those species that are although not necessarily threatened, could become so if their trade is not properly controlled. Species under Appendix III can be permitted for expert if the exporting country issues an export permit.

Nepal being signatory to convention on biological diversity (CBD) and CITES is committed to implement their respective obligations. It has promulgated Forest Act – 1993. Six species of plants (*Nardostachys grandiflora*, *Rauvolfia serpentina*, *Cinnamomum glaucescens*, *Valeriana jatamansii*, *Taxus wallichiana* and *lichen spp*) are banned for raw export and 6 species (*Acacia catechu*, *Shorea robusta*, *Michelia champaca*, *Bombax ceiba*, *Pterocarpus marsupium*, *Dalbergia latifolia*) are banned for felling, transportation and export.

Table 3. List of plants of Nepal included in CITES Appendix

S.No.	Scientific Name	English Name	Appendix
1.	*Ceropegia pubescens*	Milkweed	I I
2.	*Cythea spinulosa*	Tree ferns	I I
3.	*Cycas pectinata*	Cycas	I I
4.	*Dioscorea deltoidea*	Dioscorea	I I
5.	*Orchidaceae*	Orchids	I I
6.	*Podophyllum hexandrum*	May apple	I I
7.	*Rauvolfia serpentine*	Serpentine	I I
8.	*Taxus wallichiana*	Himalayan yew	I I
9.	*Gnetum montanum*	Gneum	I I I
10.	*Meconopsis regia*	Himalayan yellow poppy	I I I
11.	*Podocarpus neriifolius*	Podocarpus	I I I
12.	*Talauma hodgsonii*	Magnolia	I I I
13.	*Tetracetron sinense*	Tetracentron	I I I

This highlights the need for conservation of such highly valuable resources for future generations because loss of these species will be the global loss.

Prioritized NTFPs identified for cultivation, conservation and development:

1. *Acorus calamus* L.
2. *Asparagus racemosus* Willd. *****
3. *Azadirachta indica* A. Juss.
4. *Dioscorea deltoidea* Wall.
5. *Phyllanthus emblica* L.
6. *Piper longum* L.*
7. *Rauvolfia serpentina* (L.) Benth.*
8. *Tinospora sinensis* (Lour.) Merr.*
9. *Aconitum heterophyllum* Wall.
10. *Aconitum spicatum* (Bruhl.) Stapf.
11. *Bergenia ciliata* (Haw.) Stearnb.
12. *Cinnamomum glaucescens* Nees*
13. *Cinnamomum tamala* (Buch.-Ham) Nees
14. *Dactylorhiza hatagirea* (D.Don) Soo*
15. *Gaultheria fragrantissima* Wall.
16. *Juglans regia* DC.
17. Lichens
18. *Morchella esculenta* Fr.
19. *Nardostachys grandiflora* DC. *
20. *Neopicrorhiza scrophulariiflora* (Penn.) Hong*
21. *Ophiocordyceps sinensis* (Berk.) Sung.
22. *Podophyllum hexandrum* Royle
23. *Rheum australe* D. Don
24. *Rubia manjith* Roxb. ex Fleming
25. *Sapindus mukorossi* Gaertn.
26. *Swertia chirayita* Roxb. ex Fleming*

27. *Tagetes minuta* L.
28. *Taxus wallichiana* Zucc.*
29. *Valeriana jatamansii* Jones*
30. *Zanthoxylum armatum* DC.*

*Prioritized species for Agro-technology

Demand and supply aspect

The demand for herbal medicines in the world trade is growing day by day, which has resulted into increased pressure on regionally and globally important MAP diversity. In Nepal, pressure on such valuable resources is highly increased as harvesting of MAPs from the wild state has been the secondary source of income for the rural people. Great demand of various Nepalese medicinal and aromatic plants also exists for the Nepalese as well as foreign pharmaceutical companies.

The value of most economically important MAP's in world trade totals about US$ 11billion annually (Iqbal, 1995). Growth in the natural products market is in a range of 3 % to 20 % (Grunwald, 1994), which is on an average 3 to 4 times average national economic growth rates (Subedi, 1999). According to a study carried out by Asian Network for small scale Agricultural Bio-resources (ANSAB) during 1995/1996 approximately 42 thousand tons of NTFP, consisting of more than 100 different items were handled by about 100 entrepreneurs. This amounted to more than 1.5 billion Nepalese rupees (approximately $ 20 million) (Subedi, 1997). Such MAP products are exported to India, Sri Lanka, Germany, Pakistan, Tibet, Hong Kong etc. (Foreign Trade Statistics, MOF, 2000). About 90% of the total collections are exported to India.

Nepal has about 18 thousands community forests users groups (CFUGs) which are conserving forest of about 1700 thousands hector. More than 10 million people are involved in community forestry directly or indirectly and are united to the National level organisation – Federation of Community Forestry Association of Nepal (FECOFAN). The contribution of CFUGs in the conservation of forest in Nepal is commendable and has been recognised one of the success story in the worldwide. However they are not able to benefit from the sustainable utilization of medicinal plants widely grown /potential for growing in these community forests due to the lack of proper management system or organisation. The medicinal herbs which are simply exported to India in raw form could be sold at higher prices by applying simple value addition procedures and made sustainable utilization of biodiversity for the benefit of the society. Collection and trading of Yarsha Gumba (Cordiceps sinensis) haphazardly from the very specific area where it grows in nature, is one of the worst example of sustainable utilization of biodiversity – the wonderful gift of nature Nepal.

Table 4. Exports of some herbs by Volume (tons)

Cinnamomum bejolghota	1,898
Cnnamomum tamala	1,015
Saphindus mukurossi	708
Xanthoxylum armatum	626
Paris Polyphylla	324
Rheum australlae	240
Nardostachys grandiflora	158
Terminalia chebula	143
Swertia chirayita	123
Setakchini	103
Rubia manjiith	93

Table 5. Exports of some herbs by Value (NRs ‘000)

Paris Polyphylla	224,397
Zanthoxylum armatum	89,277
Cinnamomum bejolghota	58,752
Neopichrorhiza scrolifularia	47,289
Cinnamomum tamala	46,414
Swertia chirayita	28,746
Sapindus mukurossi	26,785
Rheum australae	22,912
Setakchini	22,093
Morchella esculanta	19,475
Nardostachys grandiflora	9,437

In conclusion there is a need of scientific research for domestication, scientific basis for collection from wild and development of or introduction of technology transfer for value addition of medicinal herbs of Nepal.

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The macrozoobenthos of the rivers, situated in the southern slopes of Greater Caucasus

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Introduction

The southern slope of the Greater Caucasus is rich in rivers. These water streams have all the properties, specific for mountainous rivers: the fast-flowing, low water temperature, oxygen-rich, etc. Also they have an important economic value as sources for water supply, irrigation, power supply, fisheries development. However, hydrofauna and zoobenthos of the rivers, situated in the southern slopes of Great Caucasus have not been studied properly. It is known that the macrobenthic organisms play an important role in the formation of the biological productivity of water basins. Also, these organisms are active in the biological purification of water, play a role of a natural indicator of water pollution by organic substances and serve as a link in the food chain in ecosystems.

Material and Methods

During the 2010-2011 years for the first time for Greater Caucasus in different habitats of Akhokhchay, Aksuchay, Bumchay, Demiraparanchay, Girdmanchay, Goychay, Vendamchay, Turyanchay rivers, situated on its southern slopes samples of macrozoobenthos were collected and analyzed. Methods of research conducted by Jadin [4]. In the rivers of the region 106 species of benthic organisms from 15 taxonomic groups were discovered.

Results and Discussion

Akhokhchay, being a right tributary of the Ayrichay river, originates on the southern slopes of the Greater Caucasus (2000 meters). The length of the river - 25 km, the area of the water basin 691 km^2, flows through Ismayilli [1,2,3]. The main part of the catchment area is formed by the storm waters. The streams and mud flows occur fairly often. During the observation period, the water temperature was 9.6-22.4 °C, pH — 7.1-7.4, oxygen regime was equal to 8.6-8.8 mg / lt. As a result of analysis of the materials collected from the rivers, 66 species of benthic organisms from 14 taxonomic groups were recorded. Molluscs are dominated in the biodiversity of macrozoobenthos (8 species). Minimal quantity of decapods and water fleas were observed (2 species of each taxon). The second place on species composition are occupied by dragonfly larvae. Other groups were represented by 3-6 species. The most common are the following species: *Costatella acuta*, *Anisus spirorbis*, *Valvata pulchella*, *Corbicula cor*, *Sphaerium lacustre*, *Ephemella igniita*, *Baetis rhodani*, *Caenis macrura*, *Ordella macrura*, *Notonecta lutea*, *Bidessus pusillus*, *Ecnomus tenellus*, *Limnophilus flavicornis*, *Leptocerus tineiformis*, *Oecetis furva*.

The total biomass of benthic organisms was equal to 0.17 gr/m^2, the quantity fluctuated between 54 specimens/m^2 (Table 2).

Akhsuchay originates from the southern slopes of the Greater Caucasus Mountains. The length of the river is 75 km, the total basin area — 631 km^2 [1, 2, 3].

During the observation period, the water temperature was equal to 14-25 oC, pH - 7.8-7.9 mg / lt. In the river 57 species from 14 taxonomic groups were found. The first place occupy the caddisflies (8 species). Other groups are represented by 2-8 species. Among these species the prevalent are the following: *Nais communis*, *Branchiura sowerbyi*, *Eiseniiella tetraedra*, *Piscicola geometra*, *Hydrobia longiscata*, *Ecnomus tenellus*, *Hydropsyche ornatula*, *Limnophilus flavicornis*, *Leptocerus tineiformis*, *Oecetis furva*, *Corixa punctata*, *Berosus spinosus*, *Procladius choerus* etc.

In the river, the biomass of benthic organisms was equal to 0,80 gr/m^2, number of animals — 121 specimen/m^2. The biomass of organisms ranged from 0,03-0,14 gr/m2 in taxonomic groups and 2-32 specimen/m^2 by the number of animals. According to the numerical dynamics and biomass the caddisfly larvae were prevailed (32 specimen/m^2; 0,14 gr/m^2).

Bumchay originates from the southern slopes of the mountain range of the South Caucasus (3400 meters high). Is a left branch of he river Turyanchay, the length of 51 km, the basin area 450 km. It flows through the territory of Gabala region [1,2,3].

During the period of study, the 60 species of benthic organisms from 10 taxonomic groups were recorded. The first place among the detected species was occupied by chironomids (9 species); the second — the larvae of dragonflies (8 species). The 7 species from each taxonomic group were occupied by oligochaetes, hemipterans and dipteran (Table 2). Other taxonomic groups are represented by 3-5 species. The most common species are *Branchiura sowerbyi*, *Lumbricillus lineatus*, *Eiseniella tetraedra*, *Costatella integra*, *Valvata pulchella*, *Hydrobia longiscata*, *Gammarus lacustris*, *Eylais hamata*, *Lestes sponsa*, *Baetis rhodani*, *Siphlonurus linnaenus*, *Cloen dipterum*, *Corixa punctata*, *Sigara falleni*, *Berosus* *spinosus*, *Tabanus sp.*, *Helius sp.*, *Stempellina bausei*, *Micropsectra praecox*, *Chironomus thummi*, etc.

The biomass of benthic organisms in the river reach 0,32 gr/m^2, size — 84 specimen/m^2. Biomass by taxonomic groups of organisms ranged from 0,03-0,08 gr/m^2, quantity — within 6-18 specimen/m^2 (Table 2).

Demiraparanchay originates in the southern slopes of the Greater Caucasus mountains (altitude 3850 meters). This river is one of the main sources for the formation of the river Turyanchay. It flows through the territory of Gabala region. Its length is 69 km, the area of the water basin — 596 km^2.

During the period of investigations the temperature of water were equaled 15.1-24.2 ºC, pH – 7.4-7.6, oxygen regime — 8.6-8.8 mg/lt.

The 45 benthic species from 45 systematic groups were recorded in this river. The larvae of caddis fly is dominated on the quantity of species (7 species). The other groups were represented by 1-5 species (table 1).

By the frequency of occurrence the species *Auloforus furcatus*, *Lymnaea stagnalis*, *Anisus spirorbis*, *Gammarus matienus*, *Agrion virgo*, *Anax imperator*, *Ecnomus tenellus*, *Hydropsyche ornatula*, *Leptocerus tineiformis*, *Oecetis furva*, *Hydrometra stagnorum*, *Velia rivulorum*, *Colymbetes fuscus*, *Limnochironomus tritomus*, *Endochironomus dispar*, etc. were prevailed.

The biomass of benthic organisms in the river were equaled 0.51 gr/m^2, the quantity — 111 specimen/m^2. By the quantity and biomass the chironomid larvae (20 specimen/m2, 0.08 gr/m^2) were dominated (table 2).

The Girdmanchay river originates from the 1 km on the Southern-East of the Babadag pass (2900 km). It connects with Kura river from the left side by the use of artificial canal. The length of river is 88 km, the water basin is equaled 727 km^2. The mineralisation of water equals 560 mg/lt, with sulfur-natrium chemical composition.

During the period of observations the 55 benthic species were recorded. By the quantity of species the larvae of caddis fly are dominated. The other groups are represented by 1-5 species (table 1). By the frequency of occurrence the species *Nais elinguis*, *Lymnaea auricularia*, *Ancylus fluviatilis*, *Corbicula fluminalis*, *Pontogammarus robustoides*, *Ecnomus tenellus*, *Hydropsyche ornatula*, *H.instabilis*, *Leptocerus tineiformis*, *Oecetis furva*, *Gyrinus minutus*, etc. were prevailed.

Table 1. The quantity of macrozoobenthos of Southern Slopes of the Great Caucasus on taxonomic groups

№	Taxonomic groups	Rivers								
		Total quantity	Akhokhchay	Akhsuchay	Bumchay	Demiraparanchay	Girdimanchay	Goychay	Vandamchay	Turyanchay
1	Oligochaeta	7	6	5	7	3	4	4	3	5
2	Hirudinea	6	5	2	-	-	1	2	2	3
3	Mollusca	12	8	4	3	5	3	8	6	4
4	Ostracoda	3	3	-	-	-	3	2	2	-
5	Amphipoda	7	4	3	2	3	5	4	3	2
6	Decapoda	3	2	2	-	2	2	2	1	3
7	Hydracarina	4	2	2	-	-	2	2	1	2
8	Odonata	8	5	6	6	4	4	7	6	8
9	Ephemeroptera	10	7	6	8	5	6	8	7	4
10	Trichoptera	8	6	8	5	7	7	8	7	3
11	Hemiptera	7	5	4	7	3	3	5	4	2
12	Coleoptera	10	4	4	6	4	5	8	7	5
13	Dipteral	8	3	4	7	3	4	5	4	3
14	Chironomidae	11	6	5	9	5	4	9	8	6
15	Ceratopogonidae	2	-	2	-	1	2	-	2	-
	Total:	106	66	57	60	45	55	74	63	50

The biomass of benthic organisms was equaled to 0.27 gr/lt, the quantity — 80 specimen/m^2 (table 2).

The Geychay river originates from the Southern slopes of the Great Caucasus (altitude 1980 meters), connects with the Kura river from the left side by the use of artificial canal. It is distinguished by high water level in comparison with the other rivers, that flow from the Southern slopes.

During the period of studies the temperature of water was equaled 12.3-21.8 ^{o}C, pH 7.4-7.5, the oxygen regime — 8.1-8.4.

The 72 species from the 13 systematic groups were recorded in the river (table 1). By the species quantity the chironomid larvae (9 species), molluscs, the dragonfly larvae, caddis flies, coleopteran were dominated (8 species from the each taxonomic group).

Table 2. The quantity and biomass of rivers in south slopes of Great Caucasus (specimen/g·m^2)

№	Taxonomic groups	Rivers							
		Akhokhchay	Akhsuchay	Bumchay	Demiraparanchay	Girdimanchay	Goychay	Vandamchay	Turyanchay
1	*Oligochaeta*	-	-	-	-	12 / 0,04	-	-	-
2	*Mollusca*	18 / 0,04	26 / 0,10	18 / 0,08	10 / 0,05	20 / 0,08	40 / 0,20	22 / 0,10	–
3	*Amphipoda*	6 / 0,01	14 / 0,04	8 / 0,02	18 / 0,07	9 / 0,03	28 / 0,10	–	21 / 0,04
4	*Decapoda*	–	2 / 0,12	–	3 / 0,14	–	4 / 0,21	–	–
5	*Odonata*	–	20 / 0,08	–	10 / 0,04	–	–	16 / 0,03	24 / 0,07
6	*Ephemeroptera*	12 / 0,03	32 / 0,14	20 / 0,08	8 / 0,02	14 / 0,04	–	30 / 0,08	26 / 0,06
7	*Trichoptera*	20 / 0,07	14 / 0,06	12 / 0,03	20 / 0,06	–	12 / 0,04	6 / 0,01	–
8	*Hemiptera*	–	10 / 0,04	–	5 / 0,01	18 / 0,06	–	–	–
9	*Coleoptera*	–	–	12 / 0,04	5 / 0,01	7 / 0,02	–	–	12 / 0,04
10	*Diptera*	6 / 0,01	3 / 0,01	–	12 / 0,03	–	14 / 0,07	20 / 0,08	28 / 0,08
14	*Chironomidae*	2 / 0,01	–	14 / 0,07	20 / 0,08	–	30 / 0,10	–	11 / 0,02
	Total:	64 / 0,17	121 / 0,80	84 / 0,32	111 / 0,51	80 / 0,27	128 / 0,72	94 / 0,30	112 / 0,31

The next place were occupied by damselfly larvae (7 species) and hemipterans (5 species). By the frequency of occurrence the species *Lymnaea auricularia, Costatella acuta, Corbicula cor, Coenagrion scitulum, Lestes sponsa, Agrion virgo, Ecnomus tenellus, Hydropsyche ornatula, H. instabilis, Oecetis furva, Notonecta lutea, Gerris lacustris, Hydroporus planus, Tabanus sp., Tipula sp., Cryptochironomus defectus, Ch.thummi, Einfeldia pagana, Limnochironomus nervosus, Endochironomus tendens, Microtendipes chloris*, etc. were prevailed.

The biomass of benthic organisms in the river was equaled to 0.72 gr/m^2, quantity — 128 specimen/m^2. The molluscs were prevailed in quantity (0.72 gr/m^2). By sistematic groups the biomass and quantity of organisms was equaled to 0.07-0.02 gr/m^2 and 4-40 speciment/m^2 accordingly (table 2).

Vandomchay is the right branch of the Goychay river, connect with the Kura Kura river. The length is 98 km, area of basin — 629 km^2.

During the period of investigations the temperature of water was equaled 13.4-19.6 ^{o}C, pH — 7.1-7.2, oxygen regime — 8.9-9.0 mg/lt.

The 61 species of benthic organisms from 15 systematic groups were recorded in the river. The chironomid larvae (8 species), dragonfly and caddis fly larvae, coleopteran (by 7 species from the each taxonomic group) were dominated. The other species were represented to 1-6 species. By the frequency of occurrence the species *Auloforus furcatus, Lymnaea auricularia, Corbicula cor, Valvata pulchella, Gammarus lacustris, Palaemon elegans, Sympucna fusca, İschnura elegans, Ephemella ignita, Caenis macrura, Cloen dipterum, Laccophilus hyalinus, Gyrius minitus, Hydrous piceus, Lymnophilia sp., Ephydra sp., Procladius choerus,* etc. were prevailed.

The biomass of benthic organisms in the river was equaled to 0.30 gr/m^2, quantity —94 specimen/m^2. The dragonfly larvae (30 specimen/m2) and molluscs (0.10 gr/m^2) were prevailed on quantity and biomass, accordingly (table 2).

Turyanchay is the left branch of the Kura river, flows through the territories of Gabala, Ujar, Agdash and Zardab regions. The length of river is 180 km, the area of water basin — 1840 km^2 [1,2,3].

It is originates from the Southern-West slopes of the Bazarduzu mountain (3680 meters altitude).

During the period of observations 50 species of benthic organisms were recorded. By the frequency of occurrence the species *Nais communis,* *N.elinguis, Lymnaea auricularia, Corbicula cor, Coenagion concinnum, C.scitulum, Agrion virgo, Ephemerella ignita, Baetis rhodani, Ecnomus tenellus, Hydropsyche ornatula, Leptocerus tineiformis, Chironomus thummi*, etc. were prevailed.

The population changes of benthic organisms in the river was fluctuated. The biomass and quantity of organisms were equaled 0.02-0.08 gr/m^2 and 10-28 specimen/m^2 accordingly. The total biomass of benthic organisms was equaled 0.31 gr/m^2, quantity — 112 specimen/m^2.

Also the distribution of benthic organisms in sabrobic zones was investigated by Makrukhin A.V. [5], Semenov V.P. [6], Tankevitch P.B. [7]. The 86, 12 and 8 species from 106 studied species were defined, as olygosaprobic, β-mesosaprobic and other groups, accordingly.

It is known, that the development of benthic organisms in rivers is changed in accordance with season and water velocity. As follows from the table 1, the molluscs (12 species), dragonfly larvae (10 species), coleopteran (10 species) and other groups (2-8 species) were represented in the river. It should be noted, that the findings are very encouraging for fish-breeding (trouts) development in the region.

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Effects of climate change on water resources in Turkey

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Abstract: Based on monitoring data and climate projections, scientists highly agree that water resources have the potential to be strongly affected by the climate change in the long-run. However, there is no consensus about the degree of the impact of human activities on climate change.

Turkey, that is located in the temperate zone is a relatively large country (780,000 km^2) with considerably high environmental gradients such as changes in elevation, a high biogeographical diversity and several climate zones that differ from each other (such as the very wet climate of the Eastern Black Sea Region with more than 2000 mm annual precipitation compared to dry climate of the Central Anatolia less than 300 mm annual precipitation). Data analyses conducted by several independent and institutional studies revealed that Turkey's territory will be under a relatively strong climate change impact in the next 90 years. As of the first decade in this century Turkey was classified as a water stressed country. Higher temperatures and less precipitation may increase the pressure on Turkey's freshwater resources even more. We present a digest of the present situation of Turkey's water resources with a focus on their vulnerability to climate change and the solutions to this problem. This paper discusses the management options to deal with climate change and how these management options can be integrated with the solutions of other problems related to water resources such as water allocation for domestic, industrial and agricultural sectors, prevention of deterioration of aquatic ecosystems in Turkey.

Keywords: Climate change, water budget, water crisis, hydrological modelling, sectoral allocation of water

Introduction

Based on monitoring data and climate projections, scientists highly agree that water resources have the potential to be strongly affected by the climate change in the long-run (Erturk, 2011). However, there is no consensus about the degree of the impact of human activities on climate change.

Turkey, that is located in the temperate zone (between latitudes 36°N-42°N and longitudes 26°E-45°E) is a relatively large country (780,000 km^2) with considerably high environmental gradients such as changes in elevation (Figure 1), a high biogeographical diversity (Figure 2) and several climate zones that differ from each other (Figure 3), such as the very wet climate of the Eastern Black Sea Region with more than 2000 mm annual precipitation compared to dry climate of the Central Anatolia less than 300 mm annual precipitation. Considering these facts, different regions of Turkey are expected to be affected on different levels by the climate change.

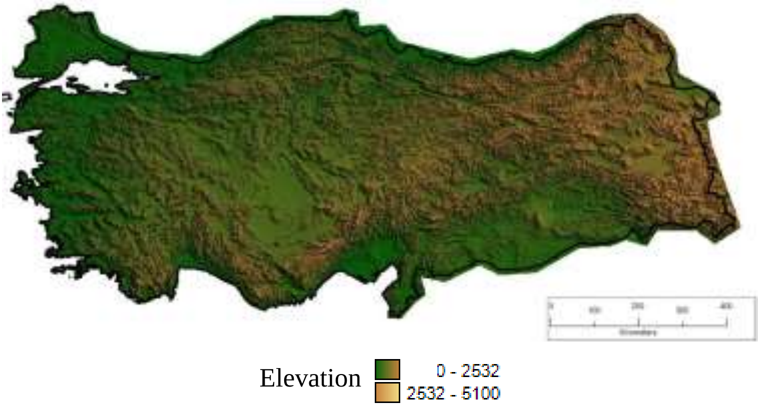

Fig. 1. Topographical Map of Turkey

Fig. 2. Main watershed boundaries overlaid on biogeographical map of Turkey

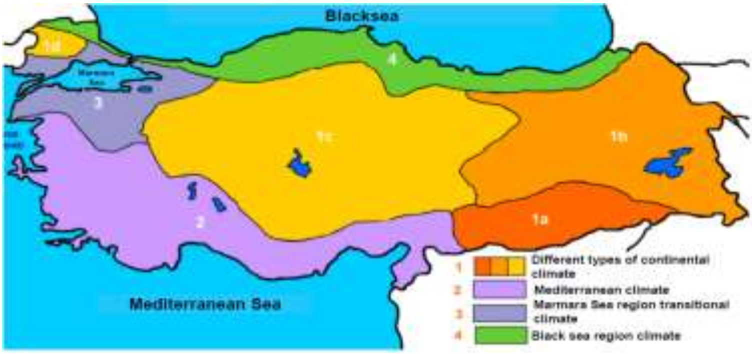

Fig. 3. The main climate zones is Turkey

Data analyses conducted by several independent and institutional studies revealed that Turkey's territory will be under a relatively strong climate change impact in the next 90 years. (Figure 4-5) Several studies, including downscaling global circulation models (GCMs) have been conducted in Turkey by various research groups.

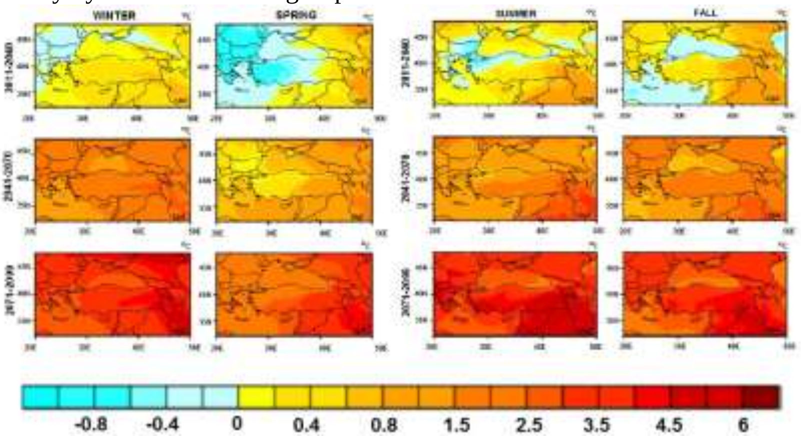

Fig. 4. Predictied temperature changes in Turkey (degrees Celsius) (Karaca and Dalfes, 2008)

Other researchers (such as Özhan, 1985; Bayazıt and Avcı, 1997) analyzed water budget of Turkey, however did not publish the amount of water transported by different hydrological processes. Such an estimation of Turkey's water budget with major components was conducted by the State Hydraulic Works of Republic of Turkey (DSI), based on data from the years 1951 to 2000 (Figure 6).

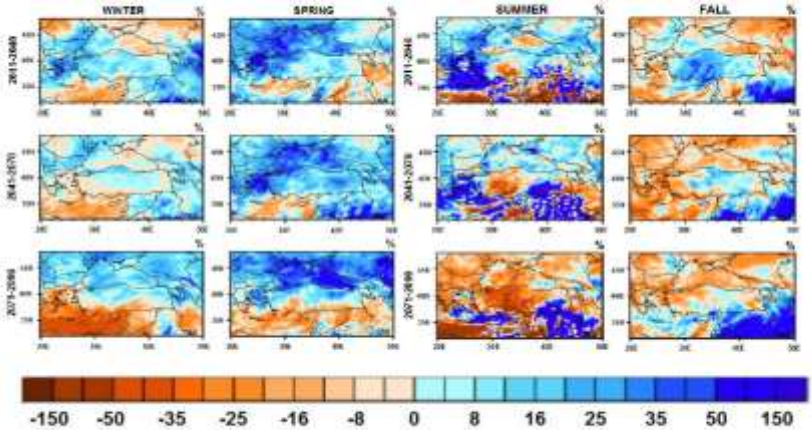

Fig. 5. Predicted precipitation changes in Turkey (Percentage) (Karaca and Dalfes, 2008)

When Turkey's water budget is examined, Turkey's mean annual precipitation was 643 mm between the years 1951-2000. This equals annually to 501 billion m^3 of water in average. 158 billion m^3 of this amount is mixed up in rivers and lakes as surface water. When the economic and technical requirements are taken into consideration, it is seen that the annual available amount of water is 112 billion m^3. According to the data of General Directorate of State Hydraulic Works (DSİ), in Turkey 11 percent of water is used in industry sector, 15% is used for domestic purpose and 74% is used for agricultural purpose. In consideration of 2008 figures, annually 34 billion m^3 water was used for irrigation, 7 billion m^3 water was used for domestic water, and 5 billion m^3 water was used for industry. The water consumption in Turkey, which is 46 billion m^3 in total, corresponds to 41% of Turkey's overall water potential (DSI, 2009).

As of the first decade in this century Turkey was classified as a water-stressed country. Because of the geographical location of Turkey, the country has gone through moderate meteorological arids in 6-year periods; and severe meteorological arids in 18-year periods (ORSAM, 2013). Turkey's total land area is 78 million hectares; 28 million hectares of which can be classified as cultivable land. The calculations of General Directorate of State Hydraulic Works show that 8.5 million hectares of land can be irrigated in terms of technology and economy. Today 5.42 million hectares of the irrigable land is open to irrigation (ORSAM, 2013).

As of the first decade in this century Turkey was classified as a water-stressed country. Turkey is divided into 25 watersheds in line with its hydrological features (Figure 7).

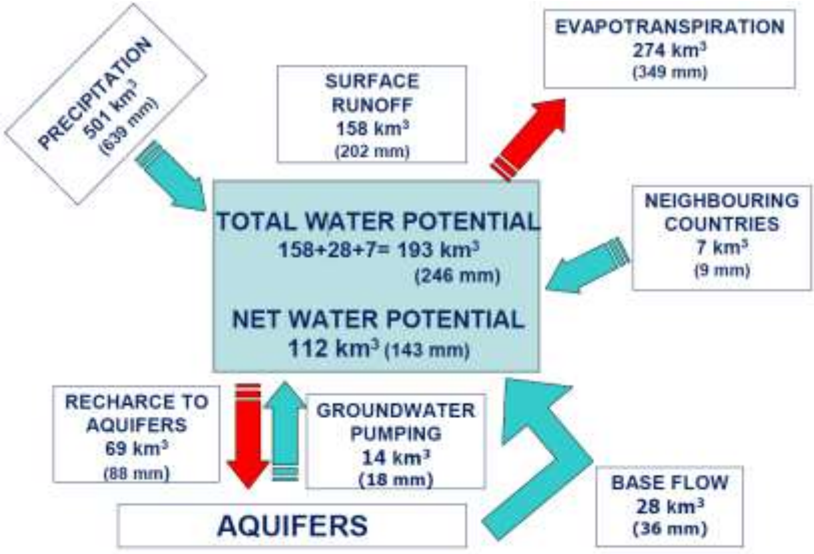

Fig. 6. Water budget of Turkey as estimated by the State Hydraulic Works

Fig. 7. Watersheds of Turkey

The water potential of Turkey is 192 billion m^3. Possessing 28.4 percent of Turkey's potential, Euphrates and Tigris Basin is the largest basin both in terms of the surface area and its water potential; and it exceeds the country borders. The other trans-boundary basins from northern to southern are Çoruh River Basin, Aras River Basin, Orontes (Asi) River Basin; and in west Maritza (Meriç) River Basin. These basins occupy an important position in Turkey's international relations because of their trans-boundary characteristics (ORSAM, 2013).

Table 1. Attributes of Turkeys Watersheds

No	Watershed name	Area (km^2)	Annual precipi-tation (mm)	Annual runoff (m^3/s)	Annual runoff (Billion m^3)	Annual runoff (mm)	Percent of runoff (%)
1	ERGENE	49 482	604	203.06	6	129.42	3.49
2	MARMARA	24 100	729	161.19	5.08	210.93	2.77
3	SUSURLUK	23 765	712	131.26	4.14	174.18	2.25
4	KUZEY EGE	9 032	624	43.93	1.39	153	0.75
5	GEDİZ	17 118	603	34.44	1.09	63.45	0.59
6	KÜÇÜK MENDERES	7 165	727	17.16	0.54	75.54	0.29
7	BÜYÜK MENDERES	24 903	664	63.28	2.00	80.13	1.09
8	BATI AKDENİZ	22 615	876	225.47	7.11	314.41	3.87
9	ANTALYA	14 518	1 000	405.96	13.0	881.83	6.97
10	BURDUR	8 764	446	7.94	0.25	28.58	0.14
11	AKARÇAY	8 377	456	8.09	0.26	30.44	0.14
12	SAKARYA	56 504	525	159.29	5.02	88.9	2.73
13	BATI KARADENİZ	29 682	811	296.65	9.36	315.18	5.09
14	YEŞİLIRMAK	36 129	497	167.43	5.28	146.14	2.87
15	KIZILIRMAK	78 646	446	164.15	5.18	65.82	2.82
16	KONYA ENCLOSED	56 554	417	191.53	6.04	107	3.29
17	DOĞU AKDENİZ	22 484	745	299.94	9.46	421	5.15
18	SEYHAN	20 731	624	211.07	6.66	321.08	3.62
19	ASİ	25 241	816	65.65	2.07	82.03	1.13
20	CEYHAN	21 222	732	206.29	6.51	306.55	3.54
21*	FIRAT-DICLE-Euphrates River	120 917	540	1 002	31.61	261.43	17.21
	FIRAT-DİCLE-Tigris River	51 489	807	744	23.45	456	12.77
22	DOĞU KARADENİZ	24 022	1 198	566.23	17.86	743.35	9.72
23	ÇORUH	19 894	629	201.81	6.36	319.92	3.47
24	ARAS	27 548	432	151.06	4.76	172.92	2.59
25	VAN ENCLOSED	15 254	474	95.32	3.01	197.07	1.64

* Euphrates and Tigris leave Turkey as two different rives, however since both join together before discharging to Gulf of Persia, as Shatt al-Arab they were considered as a single watershed.

In 1989, Malin Falkenmark prepared and index pointing out the oppression of the population on the water resources by correlating the overall population and the overall amount of the water resources of the countries, as well as by considering the requirements of the natural system.

The threshold values that are called as the "Falkenmark Index" is a frequently used index defining the oppression on the water resources. According to this index, the minimum domestic water requirement per capita on a daily basis was calculated as 100 litres; while the agricultural and industrial water requirement was calculated as 500-2000 litres per day. And the threshold value was defined as 1700 m^3 per capita on annual basis. It was stated that in case of falling below of this value the water stress would emerge; below 1000 m^3 the country would go through a water scarcity; and when this figure falls below 500 m^3 on annual basis chronic water scarcity would be gone through that could lead to great problems within the country (ORSAM, 2013).

Higher temperatures and less precipitation may increase the pressure on Turkey's freshwater resources even more. Yıldız et al (2007) estimated the variation of in river flows using trend analysis (Figure 8).

The sectorial water allocation in Turkey as provided by Eroglu et al (2007) is given in Table 2. As seen in Table 2, most of the water is allocated to irrigation. This is expected, since Turkey is geographically located on the semi-arid belt.

Table 2. Sectorial Water Allocation in Turkey (Ergolu et al, 2007)

Years	Total Water Consumption		Sectors		
	Billion m^3	% of water potential*	Irrigation	Domestic	Industrial
			%	%	%
1990	30.6	28.0	72.0	17.0	11.0
2005	40.1	36.0	74.0	15.0	11.0
2012	44.0	39.2	72.4	15.9	11.4
2030**	112.0	100.0	65.0	23.0	12.0

* Assuming a net water potential of 112 km3/year as given in Figure 6
** Estimation

Materials and Methods

Water budget analyses based on observed data are useful; however their predictive capabilities are questionable for most of the cases. As expected, procedures for estimation of the impact of climate change on water resources make considerable use of predictive techniques for water budget analyses, such as the hydrological modelling. In this study, Soil and Water Assessment Tool (SWAT) was used for hydrological simulations. SWAT that was developed by Texas University Department of Agricultural Engineering is known as a reliable hydrological model that produces reasonably accurate results even for ungauged watersheds. Hundreds of SWAT applications were reported by many authors, some of which cover an entire country (Faramarzi, 2009), regions that cover several countries (Schuol et al, 2008a) or even an entire continent (Schuol et al, 2008b).

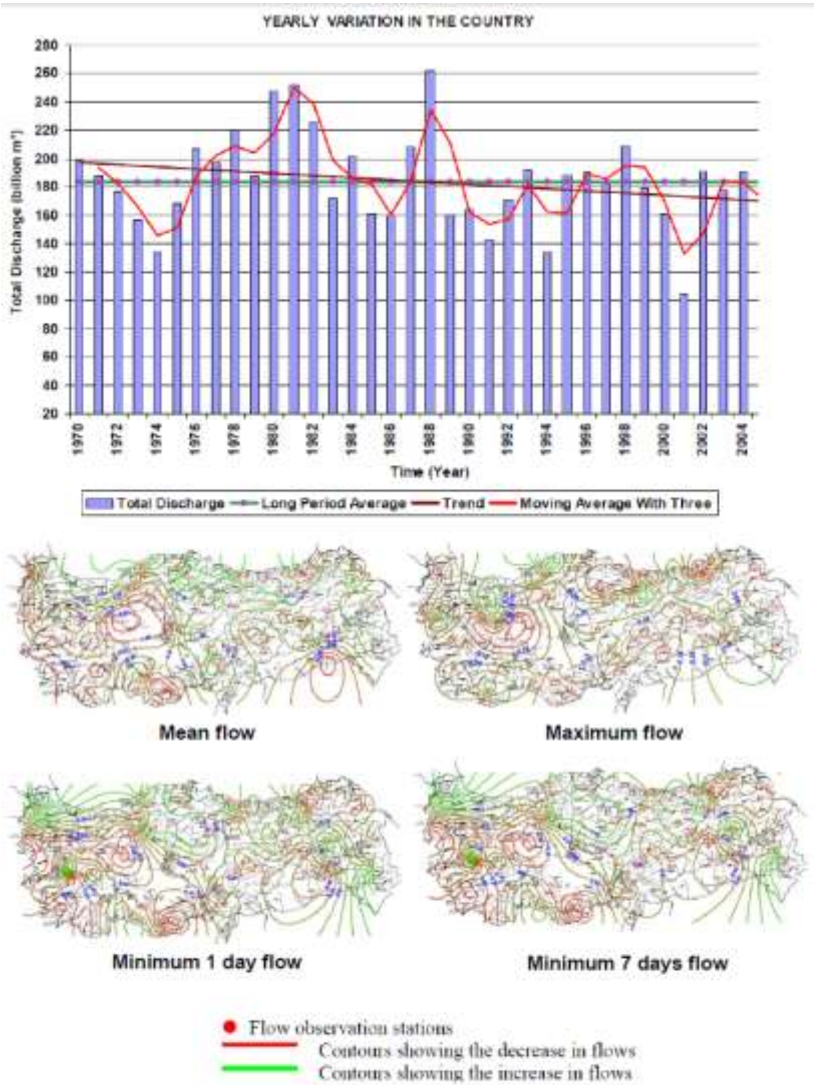

Fig. 8. Estimated variations in river flows in Turkey (Yıldız et al, 2007)

SWAT can be for water quality studies as well, so once the hydrological model has been setup and utilized for water budget analyses (such as the case in this study), a base for follow-up studies that are more related to water quality studies is already present. The hydrological processes as considered by SWAT are illustrated in Figure 9. The model considers the effect of plant growth on the hydrology as well.

SWAT subdivides a watershed into subbasins. The subbasins are assumed to drain into reaches that are considered river channels. There are also options to consider the lakes and reservoirs, ponds and wetlands. The subbasins are further divided into hydrological response units (HRUs), each having different land-use soil and geological attributes. In this study, a model for the entire Turkey was developed (Figure 10).

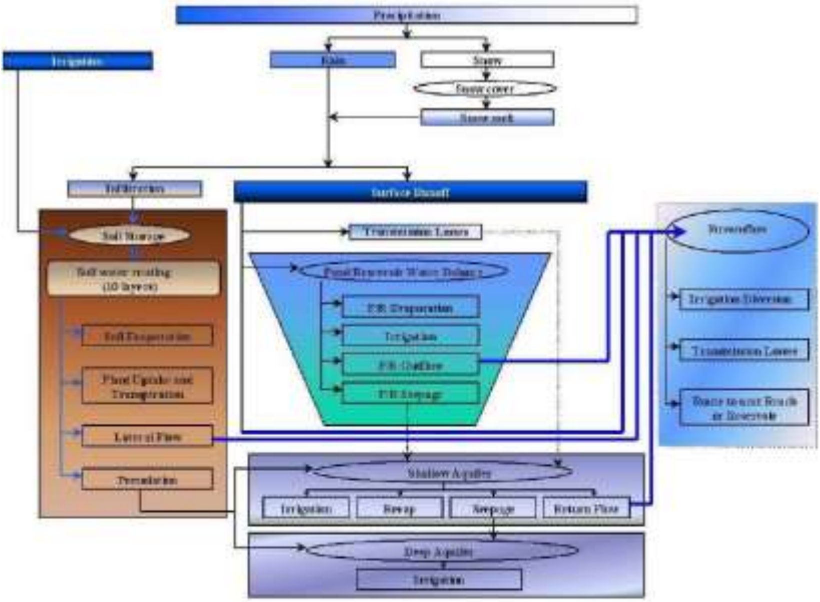

Fig. 9. Hydrological processes simulated by SWAT

The model consists of 914 subbasins and 12318 HRUs. As seen in Figure 10, the model covers most (95%) of Turkey's territory. To prevent the uncontrolled increase of model complexity, a threshold area of 500 km^2 was chosen. In other words, any independent subbasin that is smaller than 500 km^2 was not considered in our study for modelling. This is the reason, why the coastlines were not exactly reproduced by the watershed delineation process. However, these deviations were considered to be acceptable for the accuracy of the water budget simulations needed in this study, which aims to give a general overview for the water budget of Turkey.

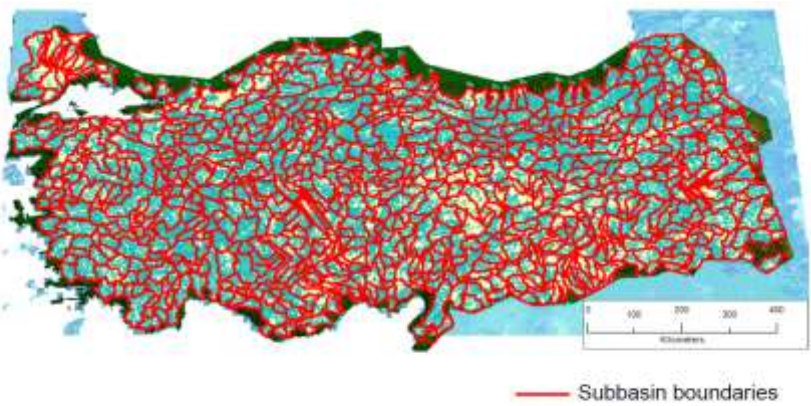

Fig. 10. Hydrological Model for Turkey

Building a hydrological model for an entire country is a complex task that needs extensive data. In this study, we used global data sets. The topography was obtained from SRTM (Space Radar Topography Mission) data sets. Land use and soil data were obtained from Food and Agricultural Organization (FAO) global data sets, meteorology data was obtained from weather database available at: http://globalweather.tamu.edu/. The National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR) was completed over the 31-year period of 1979 through 2009 for the meteorological data.

The MWSWAT interface (freely available by www.waterbase.org) was used to generate the necessary input files, whereas SWATLab (Erturk, 2013) was used to manipulate the SWAT inputs for fine tuning and for processing the model outputs. The simulations were setup for the years 1979-2009, where the years from 1979 to 1989 (end of year) were considered as the warm-up period.

The simulation results for the years 1990-2009 were averaged over time and compared with the water budget of Turkey from State Hydraulic Works (DSI) as provided in Figure 6. As of model validation, we tuned our model, until it reproduced the water budget of Turkey as estimated by DSI. Years 1990-2009 were used as base years. This model setup will be referred as the base scenario hereafter.

After the model validation was completed, three simulations for three scenarios corresponding to 60 years in the future (2070's) were run. In all scenarios; temperatures were assumed to increase 3°C in the winter, 2°C in the spring, 5°C in the summer and 4°C in the autumn.

Scenario 1 is a general climate change scenario assuming that precipitation will increase 20% in the winter and spring, will decrease 40% in the summer and will not considerably change in the autumn.

Scenario 2 assumes that the precipitation will not considerably change in any season.

Scenario 3 is the worst case scenario assuming that the precipitation will decrease 20% in all seasons.

The years from the base simulations (20 years from 1990 to 2009) were used for scenario simulations, after the relevant meteorological model input time series were updated due to the assumed climate change in the scenarios. Water potentials and major water budget components were estimated for all scenarios. In all scenarios, water from the neighbouring countries was assumed to be constant, as estimated by DSI. The land use was assumed to be constant as well.

Results and Discussion

The summary of the spatially and temporally averaged simulation results from SWAT for the years 1990-2009 are given in Table 3 and Table 4. As seen in Table 3, the simulation results for the base years are close to the water budget estimations of DSI. The small differences not exceeding 10 percent are due to the fact that the estimation approaches were different and that we did our analyses based on the years 1990 to 2009, whereas DSI's analyses were based on the years 1951 to 2000.

Table 3. Comparison of the Simulation Results with the Major Water Budget Components Estimated by DSI

Water budget component	Estimated by DSI	SWAT simulation results	Difference
Precipitation (mm)	639	692	8%
Surface runoff (mm)	202	194	4%
Base flow (mm)	36	34	6%
Evapotranspiration (mm)	349	319	9%
Net inflow into the aquifers (mm)	88 -18=70	68	3%
From neighbouring countries (mm)	9	9*	-
Total water potential (mm)*	246	236	4%

*Not calculated by SWAT, used for water potential estimation only

Table 4. Estimated Averaged Monthly Variations of Water Budget Components by SWAT Simulation

Month	Precipitation	Snowfall	Surface Runoff	Base flow	Evapotrans-piration
	(mm)	(mm)	(mm)	(mm)	(mm)
January	76.41	37.34	20.58	2.16	9.28
February	83.08	34.53	36.97	1.88	14.77
March	86.29	20.40	47.08	2.83	29.20
April	77.17	2.51	27.41	4.62	42.09
May	58.42	0.07	10.80	5.76	52.39
June	26.53	0.00	3.50	4.29	49.45
July	14.46	0.00	1.27	2.75	31.47
August	14.84	0.01	1.01	1.85	19.11
September	26.94	0.05	2.10	1.42	20.52
October	63.70	2.05	8.31	1.62	23.43
November	77.20	14.99	13.60	2.12	17.74
December	89.12	31.84	22.08	2.30	10.10

Since the base years do not correspond to real years in the scenarios, the sequential model results related to these years were considered as random variables in our analyses and are presented as cumulative density functions rather than time series (Figure 11 and Figure 12).

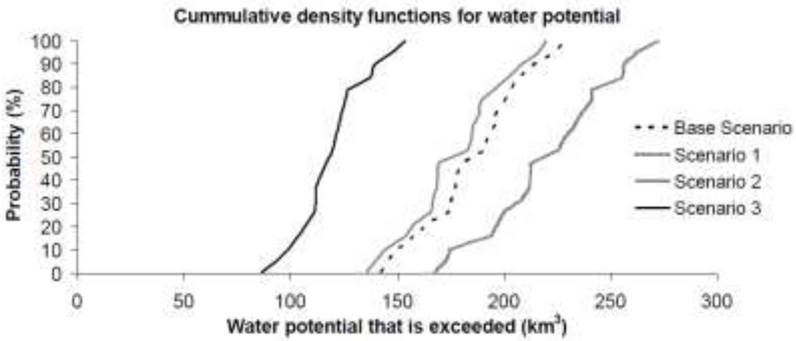

Fig. 11. Estimated water potential for different scenarios

The water budget components for three different scenarios are given in Table 5. As seen in Table 5, there is a considerable increase of Turkey's water potential in Scenario 1. This is due to the fact that, winter and spring precipitations were increased by 20% in this scenario. Even though summer precipitation was decreased by 40%, the overall potential water budget has increased. This result is due to the fact that Turkey, as a temperate semi-arid country receives most of its precipitation in winter and spring.

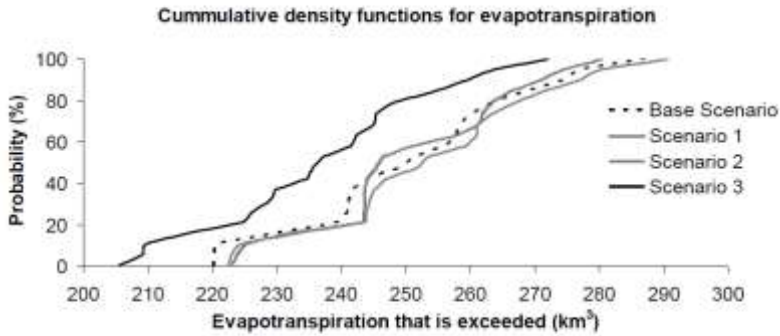

Fig. 12. Estimated evapotranspiration for different scenarios

In scenario, 2 there is a slight decrease of the water potential of Turkey. Also the surface runoff has decreased and evapotranspiration has slightly increased.

In the third scenario, which is the "worst case scenario" in our study, the water potential of the country decreased drastically. The averaged annual total water potential is only slightly over today's net water potential as estimated by DSI.

Table 5. Major Water budget components of Turkey for Different Scenarios

Water budget component	Base scenario	Scenario 1	Scenario 2	Scenario 3
Precipitation (mm)	692	763.40	692	553.60
Surface runoff (mm)	193.76	231.39	183.00	122.90
Base flow (mm)	33.55	40.77	34.45	19.89
Evapotranspiration (mm)	319.10	319.10	323.10	301.80
Net inflow into the aquifers (mm)	67.89	81.99	70.15	46.17
From neighbouring countries (mm)	8.93	8.93	8.93	8.93
Total water potential (mm)	236.24	281.09	226.38	151.72
Difference of total water potential from base scenario	-	+19%	-4%	-36%

Evaluating the annual water budgets gives some insight to the future, but the temporal distributions of different water budget components within a year are important as well. Analysing the change of these distributions may answer questions such as "will the dry months get more dry and/or the wet months get more wet?" or "will the flood risks increase?" or "what about base flow that sustains our rivers in the dry season?". The averaged monthly values for the water budget components are given in Figure 13.

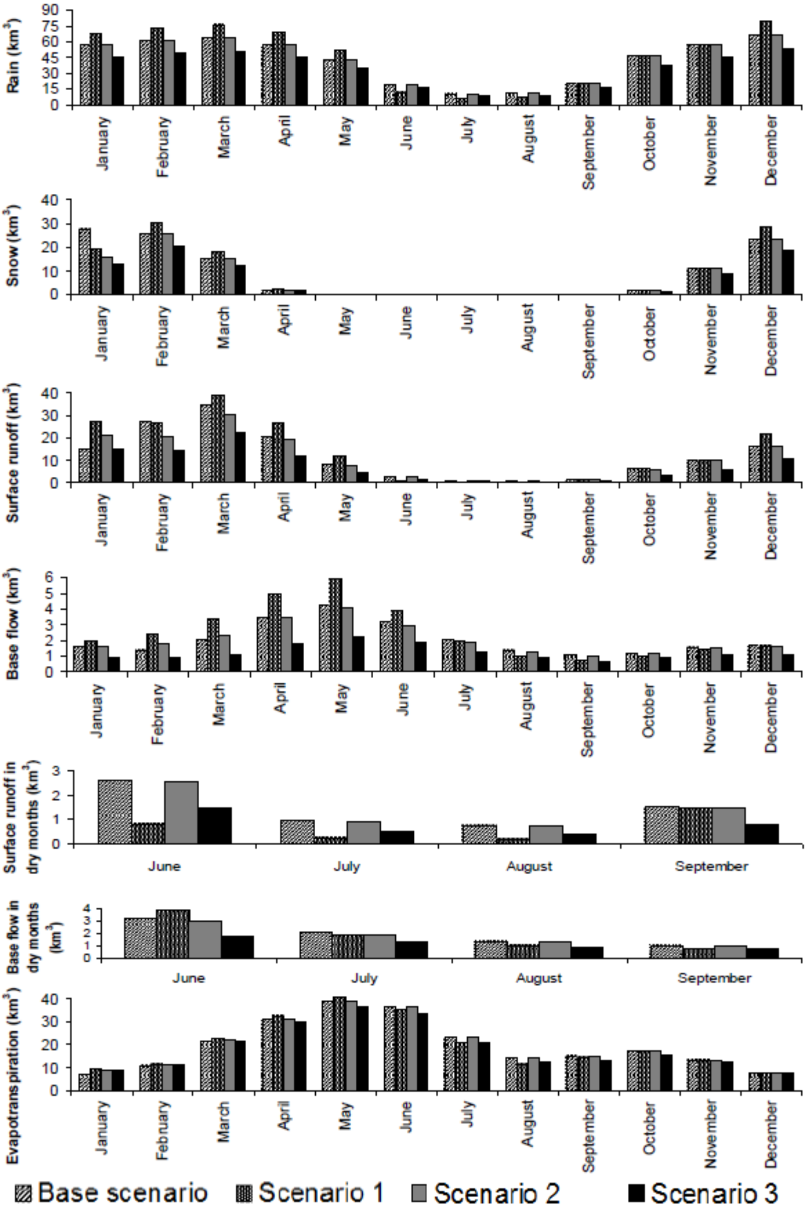

Fig. 13. Averaged values of monthly water budget components

As expected, in Scenario 1 water potentials have increased considerably in the winter and the spring months. Surface runoff has increased in these months as well as in the late autumn. Base flow increased from January to June and decreased in the other months. On the other hand, it is important to point out that the surface runoff and the base flows have decreased in the dry months so that Scenario 1 represents the driest summer months, even drier than the worst case scenario (Scenario 3). If the climate change would end up as in Scenario 1, wet months would really get wetter and the dry months would get drier.

Scenario 2 was designed to investigate the effects of temperature increase alone so that the precipitation was kept as the same in base scenario. As seen in Figure 3, the water budget components vary slightly from the base scenario for almost all months as well as all water budget components except evapotranspiration that has increased because of the increased temperature explaining the slight decrease in all other water budget components. It is however important to point out that our model does not (yet) include lakes and reservoirs at this stage and therefore evaporation from free water surface, that may increase the total evapotranspiration is not accounted. At this stage, such type of water losses is considered as one of the reasons for the difference between the total and net water potential.

Scenario 3 was the worst case scenario to investigate the combined effect of temperature increase and precipitation decrease. The total water potential of the entire country decreased drastically. All components of the water budget in all months have decreased. It is interesting to point out that the decrease of water yield in dry months is less than in Scenario 1, whereas the decrease in summer precipitation was the most severe one. Considering this fact and that the temperature increase alone hadn't a strong effect on the water yield as in Scenario 2, we concluded that the effect of precipitation change on the total water potential is more important than the effect of temperature change.

The monthly simulation results discussed above gave important hints related to temperate and semi arid characteristics of Turkey's hydrology. Bearing in mind that two of the three scenarios ended up with dry seasons getting drier and that the corresponding months are mostly in the growing season of crops, it is possible to conclude that the irrigation water demands in Turkey are likely to increase.

Besides being located in temperate and semi-arid region, Turkey has also another important characteristic which is its size. Turkey is a large country with considerable regional differences. Therefore, the Turkey's 25 watersheds are expected to be affected differently from climate change. Our discussions were related on the water potential of the entire country, in other words on a water budget spatially averaged over Turkey's territory. Since the model developed in this study is spatially discretizised as subbasins and hydrological response units, it is also possible to estimate the water potentials of Turkey's 25 watersheds. For this purpose, SWAT subbasins were overlaid to the boundaries of Turkey's 25 watersheds (Figure 14). SWATLab was utilized to transfer data from model outputs to geographical user interface readable format to calculate Turkey's 25 watersheds total water potentials for all three scenarios (Figure 15 and Table 6). As expected, different watersheds are affected differently. Strongest climate change effects were estimated for the watersheds that are located in Central Anatolian Plain followed by the watersheds located in the Mediterranean climate zone. The effects on the eastern Turkey and Black Sea region were weaker.

Fig. 14. SWAT subbasins overlaid to watersheds boundaries of Turkey

The model that was setup as an initial effort in this study is capable of producing more results such as daily time series, erosion etc., but at this stage of setup and validation, those results would be premature to present in this paper. Some of the enhancements needed for more detailed model based analysis related to the effect of climate change on water resources in Turkey are listed below:

- Enhancement of model validation with more stream gauge time series and better parameter estimation as well as determination of model reliability utilizing sensitivity and uncertainty analyses

- Setting up the model with more detailed land use data that include a more precise crop pattern and forest assemblages, as well as including more precise information related to agricultural operations
- Include lakes and reservoirs as well as reservoir operations
- A more detailed model setup related to aquifers and more precise geological information
- Linking to downscaled global climate model (GCM) or regional climate model (RCM) results utilizing more advanced techniques
- Linking or coupling with a land-use change model so that land use changes as a response to climate change could also be simulated
- Including water quality and ecology issues.

After hydrological and sectorial analyses as well as planning studies to wastewater management, following sectorial water allocations were proposed for the 25 watersheds of Turkey until 2040 (Figure 16). This period is the so called “master plan period” whereas our preliminary model results for 2070’s could be used to analyze the “second master plan period”.

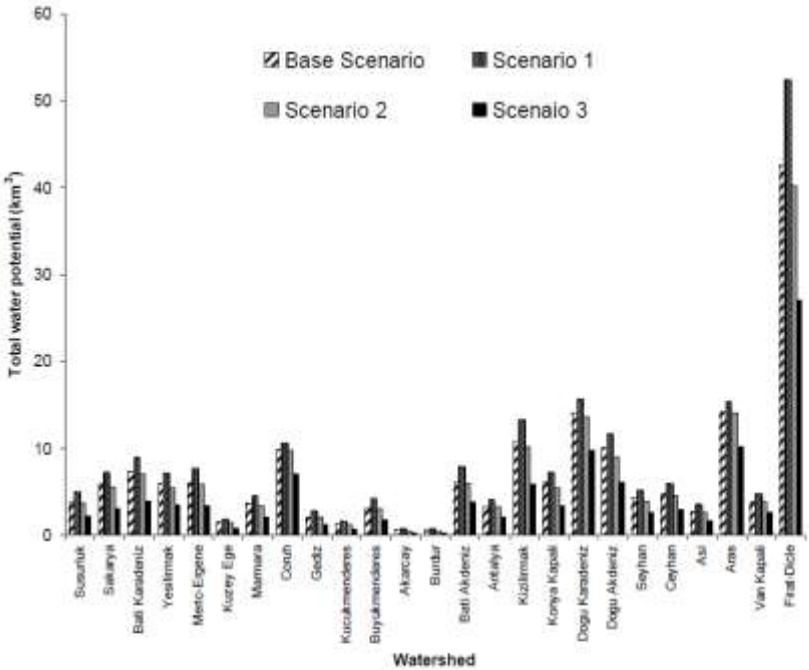

Fig. 15. Simulated total water potentials of 25 Watersheds of Turkey

Table 6. Estimated changes in total water potentials of 25 Watersheds of Turkey (%)

Watershed	Scenario 1	Scenario 2	Scenario 3
Susurluk	29.00	-4.30	-44.47
Sakarya	21.48	-7.64	-47.32
Bati Karadeniz	20.77	-2.39	-46.45
Yesilirmak	21.79	-6.74	-40.30
Meric-Ergene	29.46	-2.34	-44.22
Kuzey Ege	28.05	-0.93	-39.09
Marmara	25.47	-3.74	-43.19
Coruh	8.01	-0.71	-27.31
Gediz	30.09	-2.54	-41.52
Kucukmenderes	32.75	-0.12	-40.77
Buyukmenderes	30.68	-2.22	-42.30
Akarcay	21.98	-12.07	-49.35
Burdur	31.39	-8.00	-47.47
Bati Akdeniz	29.17	-0.73	-37.63
Antalya	25.54	-3.14	-38.46
Kizilirmak	22.25	-6.21	-45.55
Konya Kapali	18.13	-10.47	-44.28
Dogu Karadeniz	11.18	-1.81	-30.83
Dogu Akdeniz	17.87	-9.08	-37.90
Seyhan	17.78	-8.96	-38.59
Ceyhan	23.59	-3.88	-36.92
Asi	29.38	-0.17	-37.22
Aras	8.96	-0.52	-28.13
Van Kapali	20.59	-1.65	-32.20
Firat-Dicle	23.05	-5.65	-36.60

As it is seen from the figure, each watershed there are different predictions about the sectoral distributions usually based on sectoral developments rather than climate. However, successful climate change adaptation depends not only to effective national regulations, but also on the extent to which water management can be integrated into sectoral policies (such as domestic and industrial water consumption, agriculture, energy, etc.) and environmental policies (such as biodiversity, coastal and marine environment).

Conclusions and Recommendations

In this study, water potential of Turkey was analyzed with a focus on its vulnerability to climate change. Concluding remarks and final recommendations are given below:

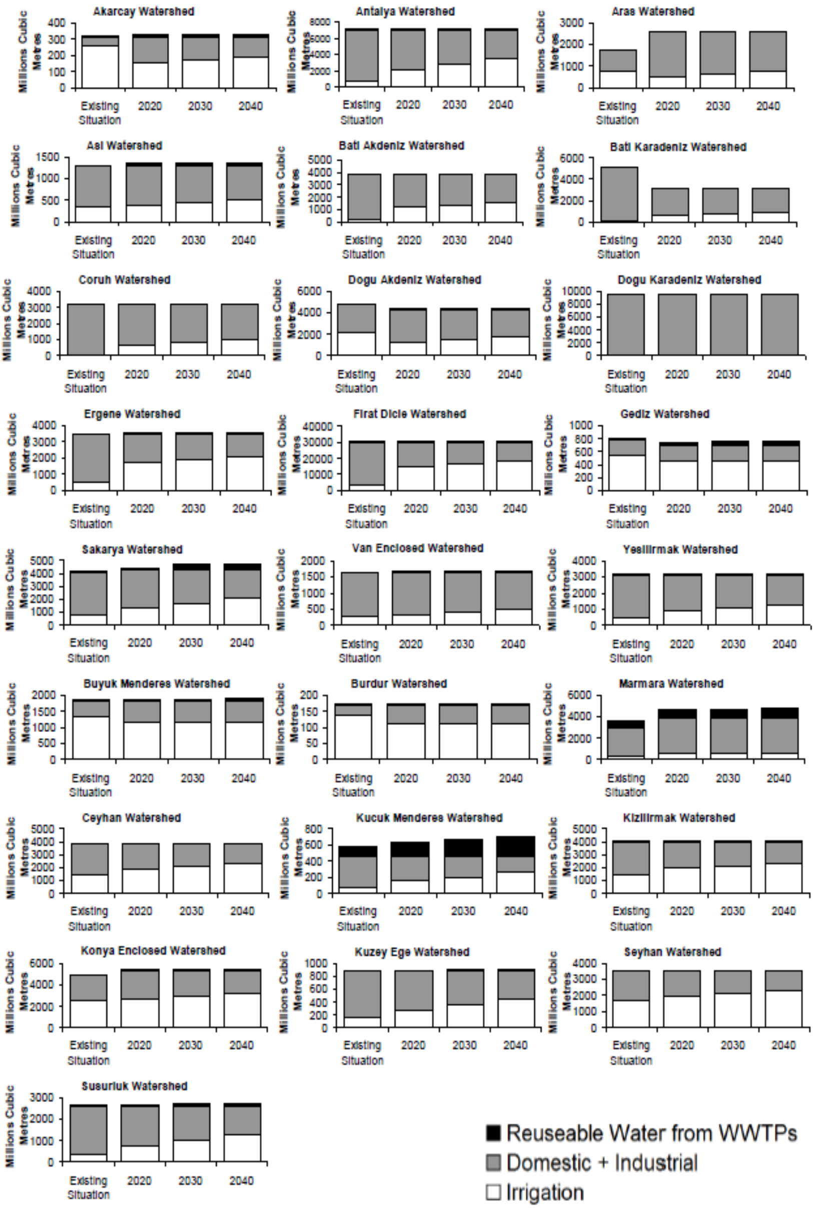

Fig. 16. Proposed sectorial water allocations for 25 watersheds of Turkey until 2040

- Measures for adaptation to climate change is dependent on local and regional characteristics. Geographically Turkey has very different climate, topographic, demographic characteristics.
- In conclusion, during the development of policies and water management plans, it is inevitable to take into account of effects of climate change on water resources. Nevertheless, increasing water stress, flood and drought events occurred in the past accelerated the measures taken for adaption to climate change in Turkey. Equitable allocation and efficient use of water between sectors is essential. In addition to reducing the consumption of water, alternative water resources such as reuse of treated wastewater, desalination, rainwater harvesting and use of gray water should be also evaluated depending on the conditions in each watershed.
- In Turkey, losses through water distribution networks in urban areas exceed 40%. To ensure the water security in urban areas with less water extracted from the natural resources these losses and leakages should be reduced.
- Good agricultural practices such as changing to less water demanding crops, efficient irrigation techniques, etc. should be promoted. In Turkey, considerable amount (72%) of the net water potential is used for irrigation (Table 2). According to predictions experts estimate that this number could be dropped to ~65% by the year 2030. We however, suggest a further decrease to ~55% in 2050s based on our analyses and model predictions.
- Our simulation results indicated that there is a high standard deviation between the total water potentials of several years. However, the groundwater storage is more stable than the surface water storages. Good groundwater management practices, optimized over the entire country can save storage to be utilized in crisis situations such as extreme drought for several years. We should keep in mind that the response of groundwater is slow to climatic conditions but once this storage is depleted its recovery will take decades. Therefore, aquifer management and restoration practices should be initiated now and not when (and if) the climate change may have already depleted the usable water potential of the country.
- As can be seen, there are numerous measures including preparatory measures (such as intensified monitoring activities, forecasting and warning systems) ecosystem-based measures (such as implementation of a green infrastructure, protection and restoration of water-retention areas), behavioral/managerial measures (Capacity-building, knowledge transfer and public awareness), technological measures (such as

industries using clean technologies) and policy approaches (enhanced institutional framework) that can be taken and for each watershed.

Acknowledgements

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Hydrology and management of the terminal lakes in the central Asia

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Introduction

Hydrological feature of the arid zones of the Central Asia is difference between natural conditions of the runoff formation area of the river and area of the lake location where this river flows in. In these natural conditions a large quantity of terminal lakes can be arisen, and these lakes have a specific hydrological regime. They are fed mainly by rivers, annual runoff of which is characterized by high coefficient of variation coupled with very high coefficient of autocorrelation. This feature of river runoff leads to quasi-cyclic fluctuations of lake water level which is typical of Caspian Sea, Issyk-Kul, Balkhash and Chany Lake, Toreyskiye Lakes in Transbaikalia, Lake Hulun Nur in the China and other closed lakes in Central Asia. Water level variations of the terminal lakes in the arid and semi-arid zones are good indicators of climate changes.

Study of hydrological characteristics of terminal lakes are very important task both from scientific and practical point of view because water resources of these lakes are used for different purpose of water industry. In this paper the approach to stochastic modeling of hydrological regime of the terminal lakes is considered taking into account not only natural variability but anthropogenic impacts also. An assessment of possibility to manage a lake water level was carried out by example of two terminal lakes – Chany Lake and Hulun Lake.

General Characteristic of the Study Objects

Hulun Lake is freshwater lake situated on the Barga Plateau, in the northern part of Inner Mongolia (PRC). Lake is named by Dalai Nur in Mongolian and by Dalainor in Russian. The hydrographic network of the lake watershed includes the systems of the rivers: Khalkhyn Gol, Orshon Gol and Kherlen, as well as Lake Buir. Lake Hulun is connected with the Argun river by the Mutnaya channel (Fig. 2). The lake is fed by the Kherlen and Orshon Gol rivers, and by a number of small streams (1.76 km^3/year) as well as by atmospheric precipitation (0.58 km^3/year). The evaporation from the lake surface and runoff from the lake via the Mutnaya (the part of this channel located in China named by Xinkaihe) channel are estimated as

2.33 km^3/year and 0.14 km3/year respectively. More detailed information presented in Table 1.

Table 1. Sample statistic parameters of the main hydrometeorological characteristics of the Hulun Lake

Characteristic	Parameters			
	Mean	Coefficient of variation C_v	Coefficient of asymmetry C_s/C_v	Coefficient of autocorrelation R(1)
Inflow, km^3	1.22	0.35	2.5	0.52
Evaporation, mm	684	0.07	4.0	0.57
Precipitation, mm	335	0.44	3.0	0

Lake Hulun is an almost closed reservoir, with relatively complicated mechanisms of water level fluctuations. In the beginning of the 20th century a significant increasing of the lake size was occurred – the lake length has grown from 30 km to 75 km in 1926 [Murzaev, 1952]. Present degradation of the water level of the Hulun Lake was started in 2000. During eight years water level dropped and reached 541.45 m in 2007 (decreased by 3.35 m), and the water surface area reduced from 2293.6 to 1800 km^2.

To avoid negative impact of the lake level degradation on the lake ecosystem, to prevent eutrophication of the lake and decreasing of the lake mineralization, as well an reduction of floodplain landscapes if water level will rise again, the project of the water transfer from the Hailar river to the Hulun Lake was suggested. It is supposed that during 5–15 years after the construction of the canal the water level in the lake will stabilize at an elevation of 544.8 m. Once this level is reached, the water transfer from the Argun river will be turn to water transfer from Lake Hulun via the Xinkaihe (Mutnaya) channel to Argun river back. It was specified in project that lake water level is need to maintain within the range of ±20 cm of the designed level.

According to project of water transfer, the canal will divert approximately 1 cubic km of river water to the Hulun Lake per year. The annual runoff of the Hailar river is 3.5 km^3/year (1.5 km^3/year in low flow years) in the place where the head of the canal is constructed, therefore the canal will receive up to 60–75% of the river runoff. Flow capacity of the canal is estimated at 70–93.6 m^3/s. The project stipulates that the water from the Hailar river will transfer in proportion to the available water resources and will not exceed 28–30% of the mean annual discharge of the river. The canal should be operated in a warm period (from May to November). A water losses from the canal (seepage through the bottom) are estimated as 20% of the total volume of diversion water flow [www.arguncrisis.ru].

Fig.1. Hydrographic scheme of the Argun' river. Borders: (1) Argun' river basin, (2) state border.

The Lake Chany is situated in the south of the West Siberia, Russian Federation. It drains an area of 27 340 km^2 and covers an area about 1500 km^2. The water surface area of the lake depends on the wet or dry climate cycling, the depth of different parts is varied from 1,4–1,9 to 4,8–8,5 m [Savkin et al, 2005]. Kargat and Chulym rivers are the main tributary of the Lake Chany.

The Lake Chany is the largest terminal lake in the Ob-Irtysh interfluvial region without drainage. Lake Chany has irregular shape and consists of two main parts – Lake Bolshie Chany including three main pools and Lake Yarkul, and Lake Malye Chany (Fig. 2). All this parts are connected each other by channel and small flow path. The water level of the lake dropped sharply in 1967-68 years and fish kill in the lake was caused by. To rise up the lake level by reducing the evaporation from the water surface lake, the largest Yudinsky Pool (water surface area in 60-ties was 700 km^2) was separated from the main part of the lake in 1972 by several dams. Statistic parameters of annual time series of the main components of the lake water balance were estimated by method of moments (see Table 2).

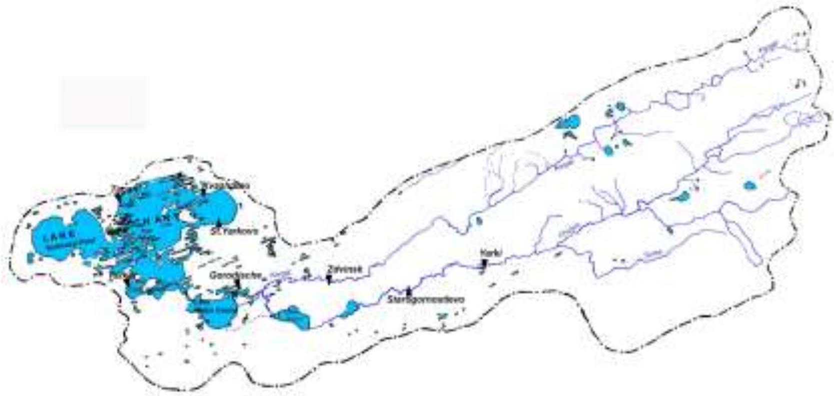

Fig. 2. Lake Chany watershed

Table 2. Sample statistic parameters of the main hydrometeorological characteristics of the Chany Lake

Characteristic	Parameters			
	Mean	Coefficient of variation C_v	Coefficient of asymmetry C_s/C_v	Coefficient of autocorrelation R(1)
Runoff, m^3/s	12,6	0,93	1,9	0,48
Precipitation, mm	342	0,22	4,5	0,11
Evaporation, mm	541	0,10	1,1	0,35
Water level (1934-1972), m BS	106,2	0,19	4,8	0,90
Water level (1973-2006), m BS	106,18	0,1	1,3	0,81

The main purpose of Chany Lake level management is to keep optimal water level and salinity from the fisheries, agriculture and hunters point of view. This optimal level was determined as 107.5 m BS.

So, for both lakes (Chany Lake and Hulun Lake) it is very important to develop stochastic models to be able forecast both annual and seasonal variability and make assessment of efficiency of the lake level management [Bolgov, Frolova, 2012; Bolgov, Korobkina, 2012].

Method of Investigation

Because of a forecasting of climate and flow changes for the foreseeable future can be given only by stochastic models of the water balance components and due to complexity of water resources models, the most acceptable method of investigation is simulation technique.

So, the probabilistic forecast of the terminal lake water level was carried out on the base of well known dynamic lake water balance equation and Markov stochastic models of the fluctuations of water balance components – runoff, precipitation and evaporation:

$$\frac{dh}{dt} = v(t)/S(h) - e(t), \qquad (1)$$

where $v(t)$ is water inflow [m^3/s], $e(t)$ represents difference between precipitation and evaporation, averaged on the lake area [m], $S(h)$ is the lake area [m^2].

Simulation of synthetic series of water balance components of the lake is carried out on the base of joint (two-dimensional) distribution of random variables. A bivariate probability density function constructed as bilinear series expansion using orthogonal polynomials in the form of explicit definition through the moments of weight function have been used to simulate annual inflow to the lake. For this case the Log Pearson Type 3 distribution and distribution of Ktritskyi and Menkel were introduced as weight function. It appears that application of LP3 distribution as marginal distribution is useful because of much more saving computational algorithm are created as compared with using of Ktritskyi and Menkel distribution.

Results of the Stochastic Modeling

Assessing of the consequences of the Hailar river flow transfer project. The consequences of the implementation of water management measures by the Chinese side within the Hailar river basin influencing the flow regime of the Argun river on the site of state border crossing were assessed through simulation calculations. The model of the water economy system represents a set of nodes, reservoirs and canals connecting the individual nodes. The input processes are: 1) inflow to Lake Hulun, 2) the runoff of the Hailar river in the water intake site, 3) evaporation from the surface of Lake Hulun, and 4) atmospheric precipitation on the lake water surface. The main hydraulic and morphometric characteristics of the system include: 1) a dependence of the area of Lake Hulun on the water level, 2) a dependence of the runoff from the lake on the water level in the lake, and 3) the flow capacity and the operating mode of the water transfer canal. The management criterion for the lake (for the water level in it) is provided by the value of deviation of the level from the mean.

An important part of the water economy system that includes terminal lakes is irrevocable water consumption. As a matter of fact, in our case the scenarios of development of the water economy system the scenarios of increases in irrevocable water consumption in the river basin.

Analysis of the results from the simulation experiments shows that for a substantial water consumption increase in the Chinese part of the Argun river basin, the consequences for the hydrological regime can be significant. An examination of the different variants of water consumption revealed the following features. If the regime of the lake is managed without taking into account the increase in water consumption, the negative impacts of this project on the flow regime of the Argun river will be minor. Some decrease of the river runoff is possible for the first five years until the lake is being impounded to reach the designed water level. The variants concerning the increase in water consumption within the Lake Hulun watershed are characterized by a considerable influence on the Argun runoff, because the runoff of the Hailar will be used to compensate the increase in irretrievable losses of water concerned with industrial development. The worst variant arises in the case of the PRC program of water economy construction within the Hailar river basin will develop in full measure. The maximum flow in summer which provides the inundation of the Argun river floodplain may decrease by 30–40% during low-water years. Such a conclusion is based only on taking the irreplaceable losses into account. Calculations showed that the water transfer to Hulun Lake would lead to an obviously unsteady regime of the Lake water level fluctuations (as well as of the runoff regime of the Argun river) during the first 10–15 years of its impounding. During this period, decreasing of the runoff of Argun river will be much more substantial than it will be after Lake water level is stabilized in the range of projected values. Impounding of the Lake up to projected elevation will take about 14 years. As Lake will be filled up, the volume of water transfer will decrease from 1.1 to 0.2–0.3 km^3/year in 14–15 years (see Fig. 3). Operating regime of the water management system (Lake with canal) will stabilize during 12-15 years from the start of the operation one.

Possibility of the Lake Chany water level management. A series of the Lake Chany water level probabilistic forecasts for hypothetical scenarios of the water management in the watershed, including operation of spillway on the lake as well have been performed. Figure 4 demonstrates cumulative distribution function (separately for Yudisnskyi Pool and Lake Chany) for the six scenarios of water use in the lake watershed (Table 3). Water level in the lake is controlled by spillway, several regimes of operation of which have been considered in the model for managing Lake Chany at high water level.

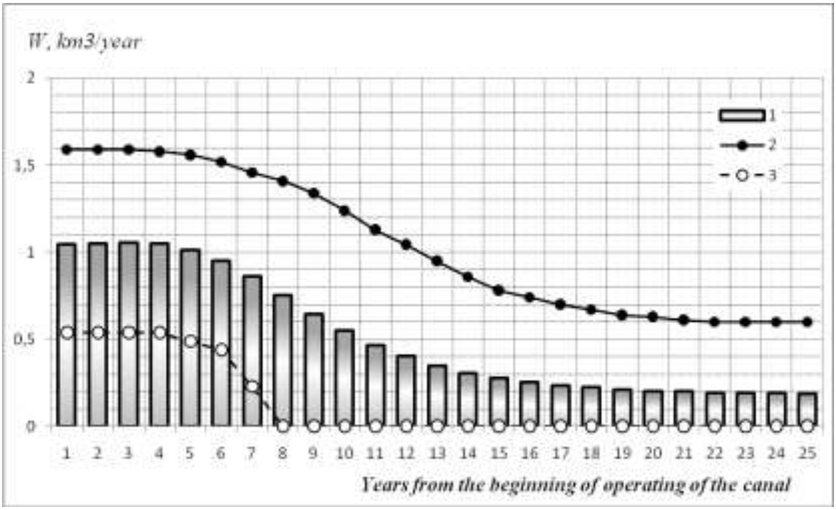

Fig. 3. Forecating volume of water transfer by the canal Haylar-Hulun Lake per year (with confidence interval 10% and 90%)

The results demonstrated that taking into account water discharge through spillway from the lake to the Yudinsky Pool leads to a marked reduction in mean annual values of the lake water level in the low probability range (2-3% or less). However, the operation of the spillway does not give stabilization of the lake level fluctuations inside a narrow range of values. To stabilize the lake level the water transfer from other watershed(s) as well as reconstruction of the existing hydraulic facilities (first of all, spillway) have to be considered.

Table 3. Water management scenarios in the Lake Chany watershed for the water level forecasting

1	Outflow regulator (orifice, spillway…)	crest level is 107,5 m
2	Outflow regulator (orifice, spillway…)	crest level is 106,5 m
3	Withdrawal	5% from the mean annual inflow to the lake
4	Withdrawal	10% from the mean annual inflow to the lake
5	Water transfer from other river basins	5 m3/s (if water level in the lake is less than 107,0 m BS level)
6	Water transfer from other river basins	10 m3/s (if water level in the lake is less than 107,0 m BS level)

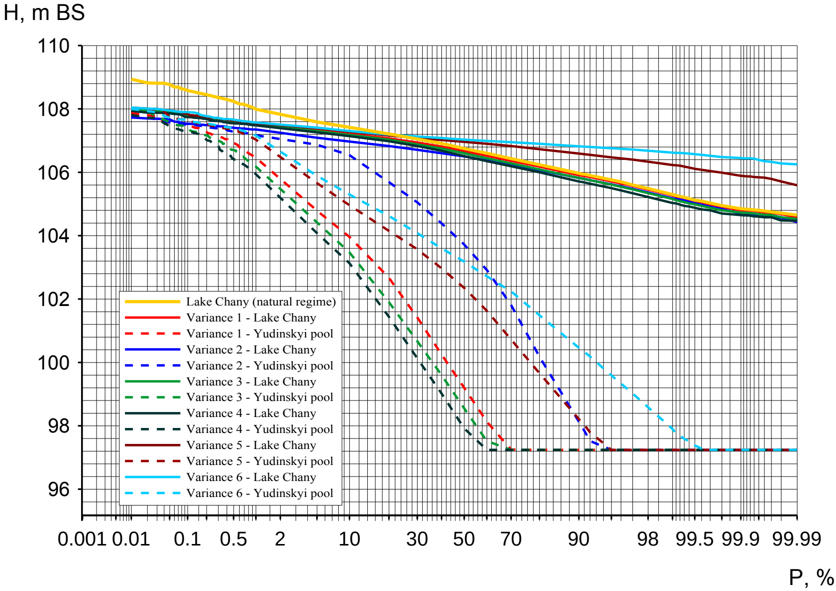

Fig. 4. Cumulative distribution function for the six scenarios of water use in the Lake Chany watershed

Conclusions

1. An assessment of the consequences of the implementation of water economy measures in the Hailar river basin for the runoff of the Argun river (in the site of intersection river with state border between the RF and PRC) was carried out by simulation model. It was showed that in result the maximum value of runoff of the Argun river in summer can decrease by 30– 40% in low flow periods. During first years of the Lake Hulun impounding, decreasing of the runoff of Argun river will be much more substantial than it will be after the Lake water level is stabilized in the range of projected values. Operating regime of the water management system (Lake with canal) will stabilize during 12-15 years from the start of the operation one.

2. The model calculations and water level forecasting for the Lake Chany executed for some water use scenarios showed that for a given operating conditions of spillway, water levels will fluctuate in rather big interval. To stabilize the lake level the water transfer from other watershed(s) as well as reconstruction of the existing hydraulic facilities (first of all, spillway) have to be considered.

Acknowlegement

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Water Resources in the south of West Siberia under global climate changes

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Introduction

Undoubtedly, the global increase of air temperature has an effect both on the World Ocean and the surface water. Over a period from 1976 to 2006 (30 years), the warming of the air temperature over Russia was 1.4ºC (Malinin, 2009). The interannual variation of the World Ocean level shows a pronounced upward trend of about 200 mm for past 180 years (Shiklomanov, 2008). A sinusoidal harmonic of the World Ocean level in reference to the trend line with the points of transition in 1882 and 1954, and the current positive sinusoidal branch is observed. The phase of the upward branch gives a steeper local linear trend for the period from 1954 to 2000 as compared to the general trend of increase of epy World Ocean level in 1860-2000.

The need to assess the water content due to climate change poses the following research objectives: 1) to identify the nature of variations in precipitation in West Siberia over the last 2000 years; 2) to reveal the existing discharge trends in the area under study over the past decades, and 3) to simulate the surface runoff in taiga and forest-steppe zones of West Siberia under different scenarios of weather variation.

Objects of research

For each of the tasks within the south of West Siberia (Fig. 1) the following objects of research were selected:

- For the reconstruction of precipitation in the south of West Siberia – Lake Chany;

- To assess the change in the discharge in the south of West Siberia over the past decades (by 69 hydrological stations on the rivers of the Ob-Irtysh basin with long series of observations of daily and monthly mean discharge);

To simulate the surface runoff formation a typical bogged catchment of River Vasyugan (Maisk village) in the taiga zone and atypical for the territory of Great Vasyugan Mire the catchment of River Kargat (Zdvinsk village) situated in the forest-steppe zone were selected.

Fig. 1. Location of objects under study: West Siberia, the Ob-Irtysh basin, Lake Chany, Great Vasyugan Mire, Glacier Maly Aktru (Gorny Altai)

Background

Task 1

The basis for modeling precipitation in Lake Chany was formed by the long-term study of the reconstruction of fluctuations of its mirror for the last 2000 years with a 50-year time step conducted by the Institute of Geology and Mineralogy SB RAS (Zykin *et al.*, 2009). For simulation, we used the equation of water balance for individual water basin. The results of estimation of annual precipitation variation by the fluctuation of the Lake Chany water table were compared with the ones obtained with sporo-pollen spectra (Klimanov *et al.,* 1987). The calculation of the thermal regime and precipitation is based on the simulation model of glacier balance previously developed by the IWEP (Galakhov, 2001).

Task 2

The State Hydrological Institute was engaged in the study of water discharge variation due to climate warming. The complex statistical analysis was used to study the dynamics of the spring, summer-fall and winter discharge of large, medium-size and small rivers of Russia as well as the intra-annual discharge distribution (Shiklomanov, 2008). Currently, the foreign practice in hydrology has been also focused on the study of trends in water flow occurring due to the climate change. For instance, the trends of seasonal, average, minimal and maximal water flow were analyzed for natural river basins of Canada, similar to those in West Siberia (Adamowski & Bocci, 2001; Burn & Hag Elnur, 2002; Cunderlik & Burn, 2002; Pilon & Yue, 2002; Whitfield & Cannon, 2000; Yue *et al.*, 2002; Zhang *et al.*, 2001).

Task 3

The modeling of surface runoff in the catchments with clear boundaries of watersheds is based on the water-balance equation with consideration for precipitation, evaporation, runoff, water loss and changes of moisture capacity in the area (Giants, 1964).

Methods

Task 1

To assess changes in annual precipitation in the south of West Siberia, the results of paleolimnological reconstructions of water levels of Lake Chany were used (Galakhov, 2011).

The change in thermal regime (the magnitude of cooling) was defined with the use of a simulation model for calculating the ice balance components of the Maly Aktru glacier based on the climatic conditions (i.e. temperature of the warm period) dependence of the glacier tongue location. The values of a warming period were calculated by the extension of an ancient forest boundary compared to the modern one.

The assessment of cooling in the second half of the Holocene was based on determining the position of the moraine complexes and their radiocarbon dating. The evaluation of the warming period was made by the position of the upper forest boundary and by radiocarbon dating as well. The radiocarbon dating of organic debris (wood and peat) sampled in the moraine complexes and in lacustrine sediments located ahead of the moraines was performed using QUANTULUS 1220 in the laboratory of Cenozoic Geology and Paleoclimatology of the V.S. Sobolev Institute of Geology and Mineralogy, SB RAS. The results of dating were used to estimate the time of moraine complexes formation with regard to the time of the glaciers response to the cooling period and the time of the glacier's tongue advancement up to the moraine complex (Galakhov, 2001).

Task 2

For analytical presentation of scenario forecast based on linear trends, the approximate equality of discharge, calculated from the series of observations Q_0 (m^3/s), and the average value of series of the calculated linear trend Q_0^T (m^3/s) was used.

Task 3

For modeling of a surface runoff in the swampy catchments, a simulation model of a water balance is used (Galakhov & Belova, 2008). For the rivers with clear boundaries of watersheds, water balance (including water loss) is calculated by the Velikanov's formula (Velikanov, 1964): $X - E - POT - Y = W$, where X – the average precipitation in the basin, mm; E – the average (for the basin) evaporation, mm; Y – runoff, mm; POT – the average (for the basin) water loss, mm; W – the change of precipitation in the basin, mm.

Data

To carry out the climatic research we used the baseline climatological data sets from the (All-Russian Research …, 2012) as well as the mentioned above reconstruction of water table fluctuation of Lake Chany conducted by the Institute of Geology and Mineralogy (Zykin V.S. *et al.*, 2009).

Results and Conclusions

Task 1

When modeling the water balance of Lake Chany, the variation of precipitation in the region over the past 2000 years was calculated. To determine the periodic dependence of series, the spectral analysis based on the Fourier one-dimensional transformation was used. The main frequencies contributing significantly to the periodic behavior of the whole series were identified. The curve calculated with the selected periods is shown in Fig.2.

The current upward positive sinusoidal branch on the graph of precipitation originated in the first half of the 20th century (1910), and the extremum of the function is forecasted by the year 2100. The existing trend will be observed up to the last quarter of the 21st century.

The study of glacier fluctuations in the alpine Altai allows the graphing of thermal variations in the warm season of the appropriate time period (Fig. 3). Similar to the precipitation series, the spectral analysis based on the Fourier one-dimensional transformation was used to reveal the main harmonics. On the graph, the average annual temperature fluctuation has a slightly larger oscillation than the one for precipitation, but the local situation within the last and the present century is also distinguished by a growing positive trend. The inflection point of the function of air temperature fluctuation falls on the early 20th century and, according to the forecast, a positive extremum is expected by the year 2170. Last year (2012) was within the quasi-linear upward trend; in the future, the temperature increase will take place with a decrease in the growth rate.

Rise of air temperature and precipitation, taken as a whole, influences the formation of the surface runoff in the south of West Siberia.

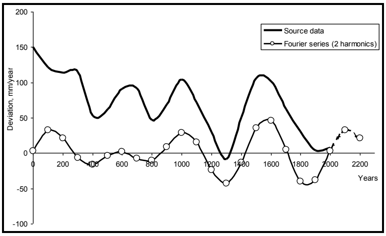

Fig. 2. Precipitation fluctuation in the south of West Siberia (mm/year) for the last two thousand years (based on the results of paleolimnological reconstructions of Lake Chany)

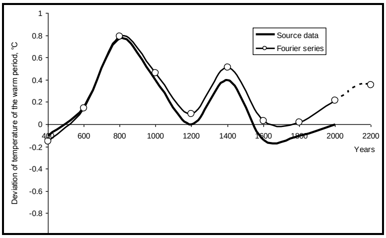

Fig. 3. Deviation of temperature of the warm period from the mean (°C) in the south of West Siberia for the last two thousand years (based on the glacier fluctuations in the alpine Altai)

When making a hydrological forecast the term “scenario”, i.e. a plausible and often simplified description of events in the future, based on the consistent set of assumptions about driving forces and key relationships, was used. The basic requirement in scenario forecast is the maintenance of the current long-term trend in the annual flow in the rivers under consideration. This condition is acceptable for a 10 – 20 year forecast, as the surface runoff is mostly subject to precipitation fluctuation, which currently shows a quasi-linear upward trend.

Task 2

The analysis of changes in water content of rivers involved the processing of data from hydrological gages with full observation period of at least 50 years. Using the residual mass curves of discharge modular coefficients for each series, the calculation of representative period including the full cycles of water content was determined. Based on the results of the forecast, the following zones of discharges change are identified in the area under study (Fig. 4):

Zone 1 (–). By the year 2030, the decrease of discharges in rivers Anui (–2.2 % / 10 years), Katun (6.2 % /10 years), Biya (0.54 % /10 years) will lead to a decrease in the discharges of Ob River at the Fominskoye water gage by 3.1% as compared to 2010.

Zone 2 (+). By the year 2030, the increased discharges of the left tributaries of the Ob, in particular, river Aley (0.40% / 10 years) and river Charysh (0.85% / 10 years) leads to the increased discharges in Ob River by

1.1% (Barnaul water gage) and 1.2% (Kamen-on-Ob water gage) as opposed to 2010.

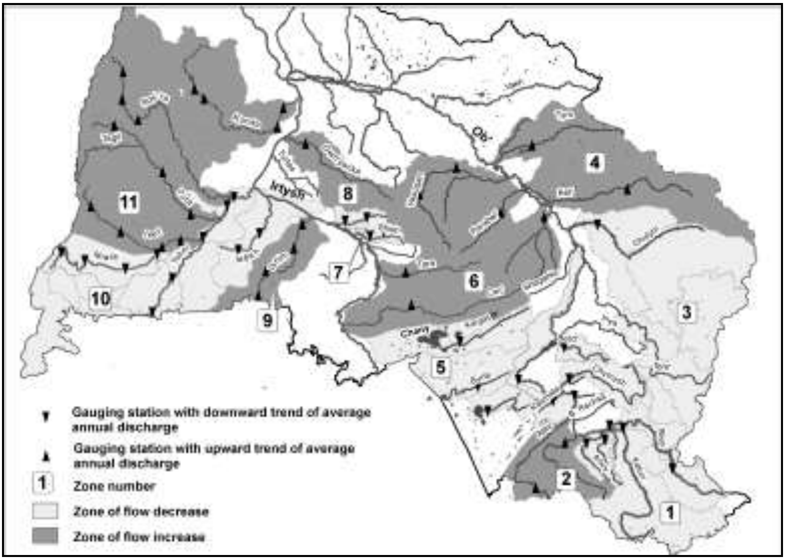

Fig. 4. Schematic map of changes in rivers discharge in the south of West Siberia

Zone 3 (–). Right-bank tributaries of River Ob with decreasing discharges (rivers Chumysh, Berd, Tom, Chulym) produce the decrease in discharge of Ob River at Kolpashevo water gage by 3.1% as against 2010.

Zone 4 (+). Right-bank tributaries of Ob River, rivers Ket' and Tym, show the increasing discharges. By the year 2030, the relative increase will make up 0.5% and 1.3%, respectively.

Zone 5 (–). The left tributary of Ob River, river Kasmala, and the rivers of the Ob-Irtysh interfluve (rivers Kulunda, Burla, and Kargat) will show the discharge decrease by 5.2%, 3.15, 0.85, and 3.9%, respectively, for 10 years.

Zone 6 (+). Within the Great Vasyugan Mire a steady increase in the discharges takes place. This area demonstrates the maximum relative change of the discharge by the year 2030: river Om – 11.5% (south-west), and river Parabel' – 11.0% (east).

Zone 7 (–). Right tributaries of the Irtysh, Rivers Shish and Tui, will reduce water content at a rate from –0.9 to – 3.1% for 10 years.

Zone 8 (+). The right tributary of river Irtysh – river Demyanka (its catchment area is a forested territory (50%) and wetlands (30%)) has a 5.4% increase discharge every 10 years.

Zone 9 (+). Running through the Russian territory river Ishim – the left tributary of river Irtysh, increases its water content by 6 –7% every 10 years due to its forest–covered and wetland basin. From the Russian-Kazakhstan border up to Omsk and Tyumen regions, forests cover 62% and bogs – 8% of the total basin area of 27 000 km^2. The river site from the Tyumen region up to the river's mouth near village Orekhovo (the catchment area is of 20 000 km^2) is forested by 45% and waterlogged by 30%.

Zone 10 (–). According to the forecast, left-bank tributaries of river Irtysh in the forest-steppe and steppe zones of river Miass (waterlogged by 5% or less), river Tobol (waterlogged in selected sites by 7 – 16%) and adjacent river Vagai running in the taiga zone will reduce their discharge.

Zone 11 (+). Tributaries of the left-bank Irtysh from the taiga zone will increase their water content (tributaries of river Tobol are rivers Iset', Sos'va, Tura, and river Konda – a tributary of river Irtysh).

Task 3

To study the conditions for surface runoff formation in wetlands, the following basins were considered: a typical bogged catchment of river Vasyugan (village Maisk) in the taiga zone, and atypical for the territory of the Great Vasyugan Mire the catchment of river Kargat (village Zdvinsk) situated in the forest-steppe zone. Alternative balance calculations of the runoff in the model basins were performed for several years: a long-term average annual year by water content, and the years with scenario changes in temperature and precipitation regimes.

The flow simulation in the rivers of taiga and steppe zones of Great Vasyugan Mire under different scenarios of meteorological parameters with the use of the water balance equation clearly shows that precipitation, not air temperature, has the most significant effect on the surface runoff. At warming of 1°C, the runoff is reduced by 7-12%, and at warming of 4°C – by 43%. A 50% reduction of precipitation will result in 80% decrease of the surface runoff, while a 50% increase in precipitation will lead to a twofold increase in the runoff.

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VIII.76.1.1 "The study of surface runoff formation processes and the development of information and modeling systems for operational forecasting of hazardous hydrological situations on the large river systems of Siberia".

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Trace elements in suspended matter of Altai surface water

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Introduction

Today, some topical issues of water management remain unsolved; among them are the insufficient information on the trace element composition of surface waters and biogeochemical conditions in the catchment area as a factor determining physical properties and chemical composition of surface waters.

It is common knowledge that most of chemicals in the river flow is associated with suspended matter, the mass of which in the annual river runoff is approximately four times greater than that of soluble compounds [1]. The transported suspended matter serves as a natural collector that contributes to removal of heavy metals from solution and prevents their entering into living organisms.

The research objective is to study the content of suspended matter in rivers of Altai with due regard for biogeochemical characteristics of river basins as well as suspended trace elements in the surface waters during different hydrological periods.

Objects and methods

We studied small- and medium-size rivers of the North, Northeastern, East, Northwestern and Prealtay provinces of Altai [2] as well as the main types of soils from accumulative and transaccumulative landscapes in the catchment areas.

Water sampling was carried out in the river mouth during the summer low-water period in the summer of 2007, 2010 and during the spring flood of 2010. The samples were collected in a clean plastic bottles, filtered through a membrane filter, preserved in HNO_3 (2 ml per 0.5 liters) according to [3] and transported in dark containers.

The content of trace elements (As, Cd, Cu, Fe, Mn, Ni, Zn, Pb, Cr, Co, V) separately in the filtrate and in the solid phase was estimated by the Chemical-Analytical Center of IWEP SB RAS using the atomic absorption spectrometry with electrothermal atomization (SOLAAR M-6). Statistical data were processed by means of standard methods [4]. Ecological - biogeochemical evaluation of elements' content in suspended matter was based on their comparison with soil Clarke by A.A. Beus (cited in [1]) and with world average values [5].

Results and discussion

The concentration of trace elements in the studied suspension varies substantially (Table 1). Generally, the statistical distribution of values is log-normal. Zn (200 fold) and Cd (100 fold) demonstrate maximal variability, Fe (6 fold) and V (8 fold) - minimal one.

Table 1. Variation-statistical parameters of metal content in suspended matter from Altai rivers for the period of low water in summer, mg/kg (n = 33)

Element	Limits of fluctuation	$X_{average} \pm x$	C*v*	Xgeoch	Suspended matter in world rivers [5]
Cadmium	0.77 – 79.2	**21.1** ±3.2	89	14.1	3.2
Chrome	14 – 189	**108** ±7	40	108	the data are not available
Cobalt	3.1 – 27.4	**17.5** ±1.0	33	18.3	the data are not available
Copper	45.3 – 1016	**345** ±45	76	310	98
Iron	18001 – 76829	**31140**±2240	42	31695	77900
Manganese	53 – 2693	**710** ±99	81	532	1650
Nickel	66 – 1698	**509** ±75	86	444	76
Lead	14 – 467	**193** ±23	69	160	3.2
Zinc	6.6 – 1395	**535** ±93	102	287	343
Vanadium	44.7 – 138	**80** ±4	28	83.5	the data are not available

It is believed that the mass ratio of soluble compounds to suspended solids in the river flow depends on the structure of soil and vegetation cover: the more forest phytocenoses (preventing mechanical erosion) present, the less suspension is removed by the surface and interflow (G. Herard, 1956, op. to [6]). Indeed, in the rivers of the Northeastern province (in the catchments of which the mountain forest landscapes with brown mountain-forest and mountain-taiga soils prevail), total suspended matter is much less (1.2 to 18 mg/l) than in the rivers of the North (3.6 - 130 mg/l), Northwestern and Prealtay provinces (1.4 - 500 mg/l); here, black soils (mostly plowed) dominate.

According to our results, the concentrations of Cd, Cu, Pb, Ni in the suspended matter (mg / kg) exceed the world average ones [5], whereas the content of Fe and Mn is lower (see Table 1).

It is apparent that the suspended matter of rivers is not just mechanically grinded rock material; it is a result of its specific transformation [6] determined by a ratio of mean element concentration in suspension to its Clark in the continental Earth crust (*Fr*). In opinion of V. Dobrovolsky (1998), the ratio of heavy metal concentrations to their Clarkes increases in suspended matter most of all. For *Fr* calculation, Clarke concentrations of A.A. Beus were used (1976, cited in [6]). Values of *Fr* in suspended matter from the Altai rivers, make it possible to specify four groups of elements: 1) elements, *Fr* values of which are close to 1(Fe, Mn, V); 2) elements, the content of which in river suspensions exceeds the Clarke ones 2 - 4 times (Cr and Co); 3) elements, *Fr* of which vary within 11- 32 (Cu, Zn, Pb, Ni) and 4) elements, the concentration of which in river suspension 100 fold exceeds the average one (Cd).

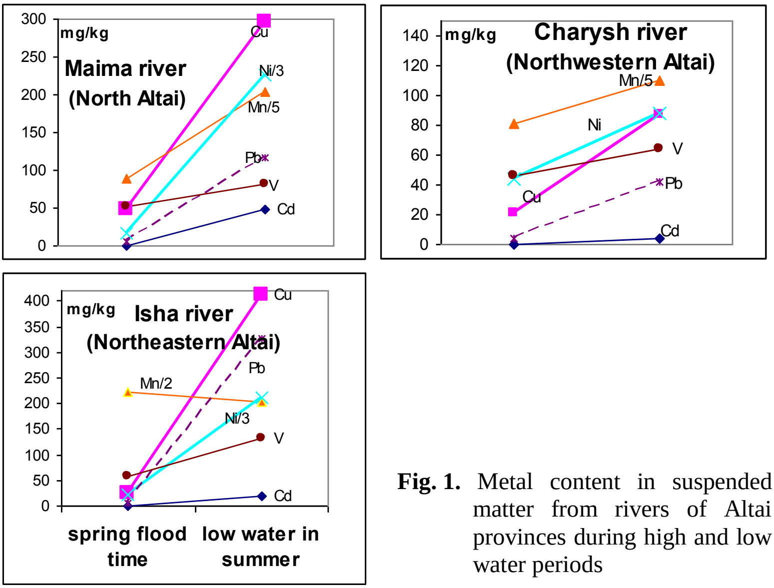

Fig. 1. Metal content in suspended matter from rivers of Altai provinces during high and low water periods

Dobrovolsky V. states that removal of large quantity of heavy metals attached to dispersed weathering products is one of the mechanisms for protection of land organisms from their excess [1]. With increased (relative to MPC) content of dissolved cadmium (1 class of the hazard) [6], the highest *Fr*, probably, supports this mechanism and demonstrates the process of withdrawal of extra metal concentrations from a biological cycle of the studied rivers.

It was found that the content of suspended metal forms in the waters of the Northeast Altai are significantly lower than in rivers of other studied provinces. For instance, in rivers of the Prealtay province the insoluble forms of Fe reach 9250 μg/l, Mn - 590 μg/l, Cu - 26 μg/l, V - 49 μg/l , and in rivers of the Northern Altai the concentration of Zn makes up 114 μg/l and Ni - 35 μg/l. For reference, in mid and downstream of R. Ob', the content of soluble Fe does not exceed 2039 μg/l, Mn - 89.6 μg/l, and concentrations of Co and Zn are much lower [7] than those in the rivers studied.

The comparison of chemical composition of suspended matter in different hydrological periods is indicative of higher metal content in summer than during spring flood time (Fig. 1). In the summer low water period, fine fraction (largely saturated with heavy metals due to its greater sorption ability) prevails in suspended matter. Because of high flow velocity during the high water period, physical processes in the water column dominate over the biogeochemical ones; hence, the particles much larger in size but chemically less saturated are involved in water migration. Due to coarse-grained particles, the amount of suspended matter increases several times, though the content of trace elements remains low.

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The Role of Institutional Factors in Facilitating Trans-boundary Cooperation: Methodology Notes

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Recent years have changed geopolitical priorities of the Russian Federation in favor of substantial strengthening of its eastern vector. This process is logically determined by the growing economic potential of Asia Pacific, and also by the ambitions and capacities of other Asian countries. These changes in the geopolitical priorities have already resulted in the increased scale of interaction of Russia with its neighbors in Asia, and most probably this trend will continue in the near future. According to the Russian laws, an interregional collaboration should become a significant component of such an interaction. In this context, it is worth to mention that in many cases a fundamental background, still underestimated, exists for the expanding cooperation between many border territories since they belong to the internally and naturally integrated trans-boundary complexes.

The factor of trans-boundary nature of some geographic and socio-economic systems which is determined by the integrity of their natural structures and/or the unity of their socio-economic and cultural development is getting a new and important dimension in the current epoch of globalization. This factor can substantially impact the existence and future development of such specific spaces which are divided by the state borders. The phenomenon of the trans-boundary character provides natural and socio-economic objects with some new qualities. On one hand, the trans-boundary character of the natural objects may be interpreted as a background for the development of mechanisms of international and interregional cooperation. On another hand, it provokes new challenges anthropogenic on their nature.

One of the major results of the trans-boundary cooperation is represented by the fact of the existence of the trans-boundary regions. We believe that as compared with the border territories which can be interpreted as phenomena determined by the state border, and trans-boundary territories which exist in the framework of the integrated geo- and ecosystems, trans-boundary regions wherever they exist are the outputs of the political will and political design. The key factor when trans-boundary regions are shaped is a joint participation of the international actors in setting up the development strategies of the adjacent territories and a mutual aspiration to cooperate. Although trans-boundary regions are in a way, artificial phenomena which are developed in accordance with the schemes designed by the trans-boundary communities, step by step they receive real economic content and are functioning on the basis of specific institutional mechanisms.

In the meantime it should not be neglected that such kind of mechanisms requires some peculiar conditions to mature and cannot be created anywhere. Thus, from the theoretical point of view profound analysis of this complicated mixture of natural and civilizational trans-boundary factors can only be done by the means of an interdisciplinary research as the basic precondition for setting up the appropriate institutional structures.

The second aspect which is at least equally important is a study of the existing institutional framework for the trans-boundary cooperation. After classical approach of Thorstein Veblen, the institutional framework is understood here as forms of organization and means of development of the trans-boundary interactions. It incorporates the combination of laws, rules, codes of behavior, types of socio-economic relations and links. In other words, these are ways of social life in connection with the material surrounding of the existing society. In this sense the social institutes can be divided into formal, including instruments, means, regulating methods in some specific spheres of social life, such as laws, rules and regulations, and informal which are also impacting and structuring the actions provided by the formal social institutes. Respectively, the process of the institutionalization can be interpreted as a creation of mechanisms, systems and ways which provides for regulating certain spheres of the social life. This process should always be considered from the historical retrospectives since it has some specific phases in its development.

Although these are the formal institutes, primarily the legislation and the administrative system of institutions represented by the existing governing bodies which are mostly in the focus of those analysts who study international cooperation in the trans-boundary regions, the informal institutes should not be neglected as they deeply impact the formal ones. In some cases this is a merging of business structures and the public administration that makes formal institutes operate in a negative sense. The typical example of that is a development of forestry in Siberia and on the Far East. The wealth of forests on the East of Russia and proximity to the

Chinese border with its higher demanding economics requiring timber in the constantly growing quantities in the situation of mismanagement of this industry in the Russian Federation led to the depletion of the natural capital of the forests' ecosystems. There are a lot of publications illustrating the decisive role of the social institutions for the "resource curse" in Russia that is specifically addressed to oil and gas. On this reason we would support those experts who underline that the existing institutes in Russia are rather barriers and obstacles than stimuli for the regional development. This thesis can easily be illustrated with numerous and vivid examples from the recent economic performance of the East of Russia. In the context of these processes specific attention should be addressed to the environmental consequences of the interaction of factors of the first (the amount of natural deposits and the geographical location) and the second (social institutions) nature (after P. Krugman) in the eastern trans-boundary territories.

For further analysis the classification scheme of the World Bank can be suggested as a good methodology instrument. It is based on outlining three dimensions of the regional development which are characterized by the factors of the market accessibility, such as a density, a distance and a disunity. In the framework of such an approach the equalization of territories against basic indicators of the living standards, or their economic pulling up to the levels of the leading regions is presented as the process of the regional integration. Such factors and trends as agglomeration, migration, regional specialization and trade are interpreted as the key drivers of changes in the regions, both positive and negative. The authors of this concept have designed so called "empirical rule of the economic integration" which is based on the proper selection of instruments the governments and authorities have at their disposal and may use in a view of the three dimensions of the regional development.

At first it incorporates the formation of the social institutes which are neutral in terms of their territorial dimension. These are laws and regulations connected with the land, labor force, international trade, as well as such institutes which are dealing with education, health, water supply and sewerage systems, etc. which are to be funded from the state budgets. Secondly, these are such measures which may connect and integrate the territories. These are predominantly the infrastructural measures such as the construction of roads and airports, communication systems, etc. which provide for the movement of people, goods and ideas and make it easier and faster at all levels. Thirdly, these are measures which stimulate the development of specific territories, such as regional programs focused on poverty prevention, tax privileges and other preferences for concrete territories.

Without making conclusions on sufficiency of these measures it is worth to note that their appropriateness is well supported by a broad spectrum of examples. It is pointed out by the World Bank experts that the final success is conditioned by the utilization of all three kinds of means of regional growth since each of these instruments is designed to solve specific tasks at its own level. Most of the strategic development programs for the eastern regions of Russia contain predominantly the measures which stimulate the development of specific territories and thus belong to the third category of instruments of governing. Meanwhile, there is a lack of attention given to the measures which are to be neutral in a territorial respect. Such measures are seen as absolutely necessary for Russia in order to guarantee implementation of legislation, specifically, environment protection laws, providing equal access to resources including the land resources, for creating favorable conditions for business to all business actors and not to specific companies which operate at some specific territories, protecting population and business from violence and other arbitrary actions.

It should be pointed out that measures of the second group, first of all the development of infrastructure, are not always neutral to the regions. Rather often they are oriented at providing some privileges or favorable business conditions to some concrete companies and/or consortiums (e.g. the highway and gas pipeline “Altai”, East Siberian and Far Eastern (VSTO) gas pipeline, railroad Naryn – Lugokan in Zabaikalskiy krai, etc.). In other words they are focused on providing support to certain industries. Accepting significance of such projects we would like to underline that they do not embrace the whole scope of the tasks connected with the infrastructural development. The major objective of the institutes regulating territorial development is a securing of acceptable living standards equal to the average ones in the country. It is specifically acute at the moment for the eastern regions of Russia since the existing disparity is leading to the increasing population outflow from the region. In this context the effectiveness of such an institute as a private-public partnership, although understanding its importance and significance, should not be overestimated when setting up machinery for the solution of the key strategic tasks.

At the moment there are the indications that some demand for the improvement of the institutional infrastructure is demonstrated by the regional administrations, although it is still weak enough. The matter is that improvement of the institutions will certainly result in decreasing of the administrative rent. It is a reason why this process is always connected with the resistance to the institutional modernization. This issue formulates an important aspect of the research, and a study of the trans-boundary links and interactions and trans-boundary demand for the natural resources will be an important direction of such a research. It is well known that the resource orientation of the economic development is contributing to the decreasing rent in the resource sectors of the economy and to the increasing rent in the processing and innovative industries. This is why there is a risk that such advanced industries may be extruded from the economics of the trans-boundary territories, if the existing dynamics and the deepening of the raw materials industries orientation in the border regions will not be overcome. We believe that it applies not only to the eastern trans-boundary territories of Russia but to the western ones as well, as recent detailed familiarization of one of the authors with the economic processes in the trans-boundary Russian-Finnish Karelia region indicates. This is clear that the trans-boundary location may entail some negative consequences for the economic performance if remains unregulated. On the opposite side if the situation is duly conceptualized it provides with much more possibilities for effective utilization of the factor of border and trans-boundary location when generating joint operational strategies allowing transformation of the trans-boundary territories into real trans-boundary regions.

The analysis of the basic trends of the formal and informal institutionalization in the framework of the ongoing processes of socio-economic and socio-cultural interactions of the border territories at the interregional levels is seen as specifically important. In particular, it refers to the international experience of creating institutes of interregional cooperation in such trans-boundary territories as Euroregions. The issue is actualized by the fact that this model directly refers to the equalizing living standards of the population living across both sides of the state borders.

We assume that these methodological requirements should be a platform for planning and evaluating the development institutes, for example, such as Siberia and Far East Development Corporation. Modernization of the social institutes should be a basic precondition for the modernization of the economy as a whole. It does not mean, however, that it should go ahead of the economic modernization: the two processes may develop in parallel. But it is really important to understand whether the institutes of modernization are going on in a right way, and correctly assess the consequences of their development.

Thus, the analysis of the institutional basis of the trans-boundary interactions of the Russian regions with their neighbors including those of them which cooperate in the framework of the trans-boundary river basins has both theoretical and practical meanings. The key theoretical task is to identify whether the current processes are leading to transformation of the trans-boundary territories into trans-boundary regions or their status will most probably remain unchanged. The practical task is to elaborate appropriate recommendations leading to the optimization of the institutional structures in the framework of the concept of the trans-boundary regions. For some territories such as, for example, the Big Altai region, the perspective of institutionalization of the multilateral international and interregional dialogue should also be duly considered.

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Evaluation of water balance components and ecological condition of poorly studied transboundary river basins by isotope methods (by the example of basins of rivers Kyzyl-Suu – Pamir-Alay and Chu – the northern Tien-Shan)

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Abstract: Due to global climate change and the new system of water allocation and water use in Central Asia, there is an urgent need to reassess the water resources of poorly studied transboundary river basins as well as long-term forecast of mountain rivers water content. These are the following Central Asian river basins: Sary-Jaz, Aksai, Naryn, Chu, Kyzyl-Su, the upper reaches of Amu Darya and Syr -Darya, and others. However, these regions' basins have extremely poor network of gauging stations, moreover data for the last 30 years concerning hydrometric observations are not perfectly qualitative and reliable.

To solve this problem there was proposed in the 60-90's of the last century the use of isotope methods, well-behaved in many poorly studied river basins. Lack of the necessary instrumental base and funding of scientific developments based on the leftover principle still retard the development of isotope methods and their application in the hydrological practice in countries of Asian region. The problem can only be solved through the uniting the international efforts and preliminary studies of researchers in this area.

In 2009, between the KazNU, IWPEHP AS PT and IWP&HP NAS KR agreements on scientific and technical cooperation have been concluded, joint works with the use of isotope methods are carried out. In particular, in transboundary rivers, situated in the territory of our countries, Kyzyl-Su (Alay Valley) and Chu (Northern Tien-Shan) researches on isotopic composition of uranium in the water have been conducted. It was shown the wide range of application of $^{234}U/^{238}U$ ratio and its total content to estimate the ice and underground components in the supply of individual inflows, the

share of the last in the formation of water balance and control over water pollution in areas with uranium anomalies. These results are promising and suggest the need to organize continuous monitoring of uranium isotope parameters in the water to clarify and forecast water resources of poorly studied river basins as well as their ecological condition monitoring.

1. The Kyzyl-Suu River basin, a feed area of which is located in the Alai mountain area between ridges Zaalai (Pamir) and Alai (Tien Shan) on the territory of the Kyrgyz Republic, and on the territory of the Republic of Tajikistan it merges with the Muksu River, forming the Vakhsh river – a basin of the Amu-Darya River.

There is no reliable gauging station at the Kyzyl-Suu River, and for the region the question of the genesis of the individual components of the basin water balance, in particular, volume of the modern ice and groundwater flow remains unexplored. Therefore, there was made an attempt to show here the possibilities of the uranium-isotope method, well-proven in many places to address such problems [1-14].

At the Kyrgyz part of the basin in September 2012 there were tested 11 samples of the water for the uranium isotope composition in the places of the flow generation – in the upper and middle reaches of the Kyzyl-Suu River at the confluence of major tributaries (Fig. 1).

Fig. 1. The scheme of uranium isotope sampling of Kyzyl-Suu river water basin

The feed area of the Kyzyl-Suu River in the eastern part of the Alai valley is fully of spring genesis (samples 1-4). Glaciations in this part do not exist (Figure 2). The flow is formed by the long waters transit on bedrock and friable fragmental sediments of thick mass of the eluvial weathering crust on the bedrock substrate, the genesis of which is a tectonically stimulated. This friable fragmental cover is wrongly considered by other research workers as the ancient moraines of the Alai Valley [4, 5].

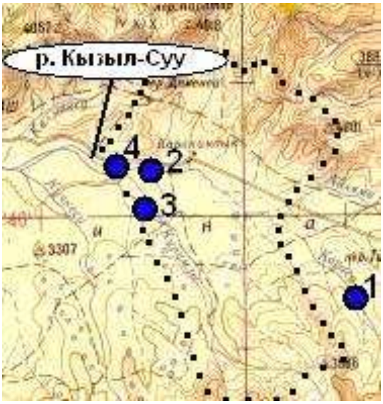

Fig. 2. The area of nourishment sources of Kyzyl-Suu river

In sampling places of the samples 5-7 the Sary-Mogol and Achik-Tash rivers flow in the Kyzyl Suu River. The sample 6 was taken on the right side of the Kyzyl-Suu River near (no more than 150 - 200 m) to the Sary-Mogol River outlet and can characterize an incomplete mixing of waters of the latter with the waters of the Kyzyl-Suu River. The Sary-Mogol and Achik Tash rivers are mainly fed by the glacier, because in the headwaters there are many large glaciers (Fig. 3).

Samples 8-11 were taken at the confluence of the major tributaries Altyn-Dara and Kok-Suu into the Kyzyl-Suu River. The Kok-Suu River has predominantly a glacial flow, as it can be judged by the relatively large area of glaciers in the headwaters of the basin of this river. There are the highest altitudes of Alai Mountain Range (Skobelev Peak -5200 m) and the largest glaciers. In the basin of the Altyn-Dara River the glaciation area is relatively not big (Fig. 4), so the flow of the river has an insignificant glacier component.

The isotopic composition of uranium in the tested water sources was determined in the Marie Curie Laboratory of Radiation Ecology of the Al-Farabi Kazakh National University. Radiochemical preparations include concentrating of uranium from 1 liter of water on ferric hydroxide, refining from hindering radiating elements by extraction with tributyl phosphate and by electro-deposition with infinitely thin layer onto steel disk. Measurements are performed by 8-chambered Alpha-ray Spectrometer manufactured by company «Canberra» (AlphaAnalyst, Canberra 7404) with software «Genie-2000» for processing of results. Evaluation of the flows in different parts of the river basin is made according to the data of $^{234}U/^{238}U$

ratio and total content of uranium in confluent flows with the help of isotopic dilution formula [4-6, 9].

The results are shown in Table 1 and on the uranium isotope diagram of the dependence of the excess ^{234}U from the total uranium content (Figure 5).

Fig 3. The area of Achick-Tash rivet outlet

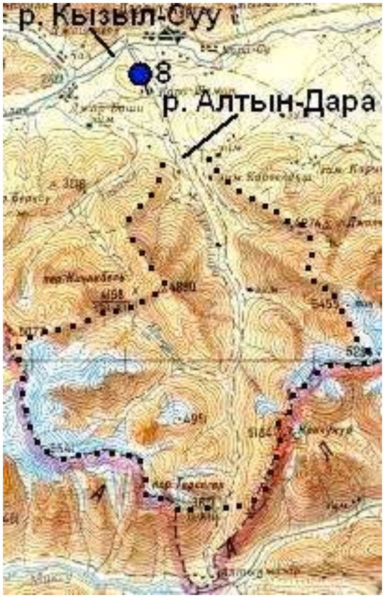

Fig.4. The area of Altyn-Dara river outlet

As it can be seen from the represented data, waters from different sources of the basin contrastively differ both in the total uranium content and the excess amounts of ^{234}U in them.

The minimum concentration of uranium was recorded in the springs, which feed the headwaters of the Kyzyl-Suu River (sample 1,3). A significant excess of ^{234}U in them ($^{234}U/^{238}U$ = 1.6-1.7) indicates that these waters before entering the surface has had a long-term contact with the bedrocks.

In the waters of the origins of the Kyzyl-Suu River itself there was detected a maximum excess of $^{234}U/^{238}U$ = 2.7 with increased uranium content compared to the spring waters. Therefore, these waters are formed as a result of long-term deep circulation in zones of cracking and crushing rocks [6-8]. The volume of the spring flow in this part of the basin, calculated by isotope dilution formulas [6, 7], reaches up to 10-15% if the

Kyzyl-Suu River flow in the western part of the investigated area before confluence of the Kok-Suu River will be taken as 100%. (Table 2).

Table1. Uranium isotopes in waters of Kyzyl-Suu river basin

Sample No	Place of sampling	^{238}U, Bq/l	^{234}U, Bq/l	$^{234}U/^{238}U$	C,10^{-6} g/l	$^{234}U/^{238}U$ x C, 10^{-6} g/l	Runoff portion, %
01	Spring in origin of Kyzyl-Suu river	0.007 ±0.001	0.012 ±0.001	1.7±0.2	0.56	0.90	
02	Upper of Kyzyl-Suu river	0.017 ±0.002	0.046 ±0.003	2.7±0.1	1.37	3.70	225±15
03	Spring in origin of Kyzyl-Suu river	0.010 ±0.001	0.017 ±0.001	1.7±0.2	0.81	1.38	110±5
04	Kyzyl-Suu river, lower than springs 1 and 3	0.015 ±0.001	0.033 ±0.002	2.2±0.2	1.21	2.66	335±15
05	Achik-Tash river, mouth	0.013 ±0.002	0.016 ±0.002	1.2±0.2	1.05	1.26	115±5
06	Kyzyl-Suu river in the area of Saru-Mogol outlet	0.013 ±0.002	0.020 ±0.002	1.5±0,.	1.05	1.58	
07	Kyzyl-Suu river after outlet of Sary-Mogol and Achik-Tash rivers	0.017 ±0.001	0.033 ±0.002	2.0±0.1	1.37	2.74	
08	Kyzyl-Suu river before the outlet of Altyn-Dara outlet The average value for samples 7 and 8	0.009 ±0.002	0.016 ±0.003	1.9±0.5	0.73	1.39	550±20
09	Altyn Dara river, mouth	0.021 ±0.004	0.031 ±0.004	1.4±0.3	1.70	2.38	550±20
10	Kyzyl-Suu river after outlet of Altyn-Dara river	0.017 ±0.002	0.030 ±0.003	1.8±0.2	137	2.47	1100
11	Kok-Suu river, mouth	0.033 ±0.003	0.037 ±0.003	1.1±0.1	2.67	2.94	

The waters of the Achik Tash River, according to the space photos and topographic maps (Fig. 3), as well as to the isotope uranium, are clearly of the glacial genesis: in the feed area of the river there are the largest glacial basin of Zaalai mountain range with the Lenin Peak (altitude - 7134 m) and the Lenin glacier (length - 17 km), within the measurement accuracy they have an equilibrium isotope ratio and a relatively low content of uranium.

Unfortunately, we were unable to test the uranium isotopic composition of the waters in the Sary-Mogol River outlet, and tested only waters of the

Kyzyl-Suu River down the confluence to the Sary-Mogol River. The decreased value of $^{234}U/^{238}U$ = 1.5 and of the total uranium in the sample 6 in comparison with the selected above (sample 4) waters of the Kyzyl-Suu River ($^{234}U/^{238}U$ = 2.2) indicates that the waters of the Sary-Mogol River, which, as well as the Achik Tash River of the glacial genesis (Fig. 3), should have the equilibrium ratio of uranium isotopes. Then, according to the same isotope dilution equations, the volume of these two tributaries flow does not exceed 20%.

Table 2. Genetic components of Kyzy-Suu river water basin (%)

Sample no.	Water source	I Glacier water $(^{234}U/^{238}U)_1$ = 1.3±0.3 C_1=0.6.10^{-6} g/l	II Solid rocks water $(^{234}U/^{238}U)_2$= 2.7±0.1 C_2=1.3.10^{-6} g/l	III Water of quaternary deposits $(^{234}U/^{238}U)_3$= 1.1±0,1 C_3=2.7.10^{-6} g/l
2	Kyzyl-Suu river origin		100	
1,3	Springs in the upper stream of Kyzyl-Suu river	85	15	
4	Kyzyl-Suu river lower than springs 1,3			
5	Achik-Tash river	80		20
6	Kyzyl – Suu river in the outlet of Sary-Mogol river	60	20	20
7,8	Kyzyl-Suu river before the outlet of Altyn-Dara river	60	35	5
9	Altyn-Dara river	30	25	40
10	Kyzyl-Suu river after outlet of Altyn-Dara river	40	35	25
11	Kok-Suu river			100

The largest inflow in the studied part of the basin is a river Altyn-Dara, waters of the latter are of mixed type of feeding according to the uranium isotope indicators. In addition to the ice waters, the underground waters also take part in feeding of the river, increasing the degree of disequilibrium of the even isotopes of uranium. To estimate the proportion of these waters, the additional uranium-isotope sampling in its basin is required. Applying the average values to samples 7 and 8 ($^{234}U/^{238}U$ = 2.0; C = 1.05.10^{-6}g /l) for waters of the Kyzyl-Suu River before confluence into the Altyn Dara River, we find the flow volume of the Altyn Dara River equal to (50 ± 20)%.

As follows from the uranium-isotope diagram (Fig. 5), the tested waters of the Kyzyl-Suu River basin are stacked in a triangle, the vertices of which can be served by the isotope ratios in the main feed supply of the investigated waters:

I – the ice waters with a minimum content of uranium (up to 0.5 – $0.6.10^{-6}$g/l);

II – the bedrock waters with the largest isotope shifts ($^{234}U/^{238}U$ = 2.7 - sample 2);

III – the waters circulating in the zone of active water exchange in destroyed deposits of the upper quaternary horizon with the equilibrium ratio of uranium isotopes, and with its increased total content (sample 11).

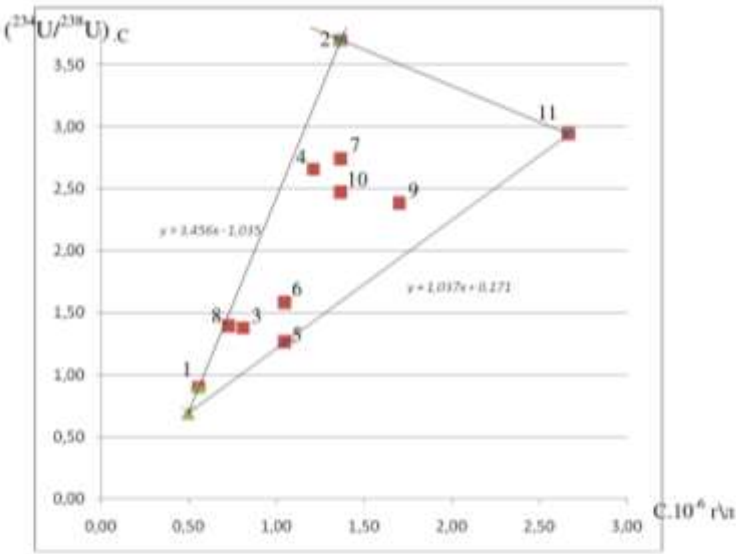

Fig. 5. Uranium isotope diagram of the waters of Kyzyl-Suu river basin

The remaining tested sources are a mixture of these three types of water in different proportions (Figure 5, Table 2).

Based on the obtained results it can be concluded that the uranium-isotope method is applicable to the study of both the genesis of individual sources of the Kyzyl-Suu River basin, and to the evaluation of their input in the formation of the river flow. Data on the ratio of isotopes of uranium are the first and preliminary in this region. They need to be continued with the detailed isotope uranium testing of the water of all tributaries, both surface and underground. This will allow valuing of the inflow rate in any part of the basin and its annual flow, if to rely on data from at least one gauging station in the basin.

2. The Chu River is formed by the confluence of Karahodjur and Kochkor rivers, which rise in high altitude parts of Tien Shan (the Kyrgyz Republic). The boundary with Kazakhstan goes along the river bed. Total length of the river is 1100 km with river basin area of 148 000 sq.km [15,16].

An isotopic composition of the uranium in waters of the Chu River basin has been previously studied by scientists of the Kyrgyz Republic in order to test a hypothesis about influx of the river into the lake Issyk-Kul in the past [17], to specify elements of the water balance in the area of forming the river basin flow [18-20], to trace and map underground flows in the Chu basin [10,21, 22]. The studies of the radionuclide content in the environmental objects of the Chu River has been performed since 2008 within the framework of the project of International Science and Technical Center K-1474 «Influence of the natural deposits of uranium and technological works on its mining & refinery onto environmental condition of the border areas of the Shu River valley of the Southern Kazakhstan and neighboring Kyrgyzstan» (2008-2012)»[10,11]. Places of uranium-isotope samplings in 2009-2011 years are shown in the fig. 6.

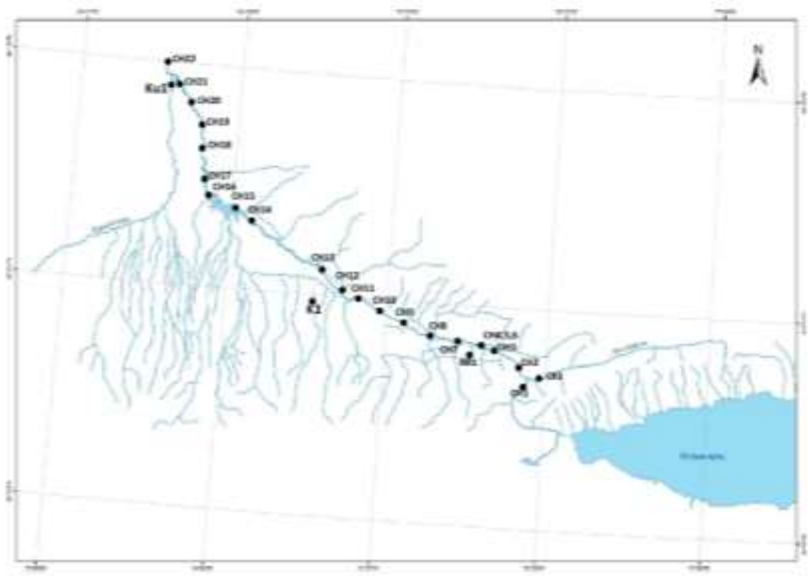

Fig. 6. Scheme of sampling in Chu river basin

We have made a generalized analysis on existing uranium-isotope data in the basin waters and have found a possibility of using of the Even

Uranium Isotope Ratio $^{234}U/^{238}U$ to access the flow volume of the surface and underground confluents of the Chu River in different parts of the studies. (Table 3).

Table 3. The average value of uranium concentration and $^{234}U/^{238}U$ ratio in waters of Chu river

Sampling area	Sampling Data	^{238}U, Bk/l	^{234}U, Bk/l	^{235}U, Bk/l	$^{234}U/^{238}U$	U, mkg/l
Chon-Kemin river, mouth	08.07.11	0,049 ±0,006	0,065 ±0,006	0,004 ±0,002	1,32 ±0,02	3,99 ±0,45
Chu river before outlet in Chon-Kemin river	08.07.11	0,114 ±0,009	0,178 ±0,011	0,006 ±0,004	1,561 ±0,02	9,27 ±0,76
Chu river after outlet in Chon-Kemin river	08.07.11	0,093 ±0,006	0,141 ±0,007	0,005 ±0,003	1,517 ±0,013	7,55 ±0,51
Chu river after eastern Big Chui Channel	08.07.11	0,094 ±0,008	0,142 ±0,009	0,006 ±0,004	1,511 ±0,017	7,60 ±0,66
Beginning of water outcrop in Chu river to the south of Tokmok town	08.07.11	0,099 ±0,005	0,150 ±0,006	0,005 ±0,002	1,505 ±0,011	8,04 ±0,43
Krasnaya rechka before outlet in Chu river	08.07.11	0,103 ±0,006	0,156 ±0,007	0,007 ±0,003	1,514 ±0,013	8,35 ±0,49
Average value for Chu river at sites:	*08.07.11*	*0,097 ±0,004*	*0,147 ±0,005*	*0,006 ±0,001*	*1,512 ±0,008*	*7,9 ±0,3*
Chu river to the south of Tokmok town	02.07.09	0,114 ±0,013	0,178 ±0,020	0,006 ±0,003	1,56 ±0,03	9,2 ±1,0
Chu river, Aukatty vill.	02.07.09	0,114 ±0,014	0,167 ±0,020	0,006 ±0,003	1,47 ±0,03	9,2 ±1,1
Chu river, Karasy vill.	02.07.09	0,119 ±0,014	0,189 ±0,022	0,009 ±0,003	1,59 ±0,03	9,6 ±1,1
Average value for Chu river at sites:	*02.07.09*	*0,116 ±0,010*	*0,178 ±0,015*	*0,007 ±0,002*	*1,535 ±0,02*	*9,3 ±0,7*
Chu river near Ken-Bulun vill.	08.07.11	0,099 ±0,006	0,145 ±0,007	0,006 ±0,003	1,455 ±0,013	8,01 ±0,52
Chu river before Norus river mouth	08.07.11	0,145 ±0,010	0,201 ±0,010	0,007 ±0,004	1,386 ±0,02	11,73 ±0,78
Norus groundwater flow by [5,6]					1,11 ±0,01	15 ±1
Chu river to the south of Milyanfan vill.	08.07.11	0,168 ±0,008	0,228 ±0,009	0,011 ±0,004	1,33 ±0,02	13,6 ±0,7
Chu river to the south of Milyanfan vill.	02.07.09	0,181 ±0,022	0,241 ±0,029	0,012 ±0,004	1,33 ±0,05	14,5 ±1,8
Average value for Chu river over 2009-2011		*0,175 ±0,007*	*0,235 ±0,008*	*0,011 ±0,003*	*1,33 ±0,01*	*14,0 ±0,6*
Chu river, Korday town	02.07.09	0,218 ±0,027	0,286 ±0,034	0,014 ±0,005	1,31 ±0,05	17,5 ±2,2
Chu river, Kasyk vill.	02.07.09	0,238 ±0,050	0,290 ±0,059	0,014 ±0,013	1,22 ±0,09	19,1 ±4,0
Chu river, Karasu vill.	02.07.09	0,182 ±0,017	0,257 ±0,019	0,013 ±0,008	1,41 ±0,03	14,6 ±2,3

Sampling area	Sampling Data	^{238}U, Bk/l	^{234}U, Bk/l	^{235}U, Bk/l	$^{234}U/^{238}U$	U, mkg/l
Average value for Chu river at sites:					*1,32 ±0,03*	*16 ±1*
Chu river, Kamyshanovka vill.	01.07.09	0,542 ±0,033	0,645 ±0,033	0,029 ±0,014	1,19 ±0,05	43,6 ±6,6
Chu river before Tasotkel storage reservoir	07.07.11	0,262 ±0,16	0,334 ±0,017	0,015 ±0,07	1,279+0,03	21,25 ±1,28
Sampling pit in Kamyshanovka vill.	01.07.09	0,820 ±0,022	0,930 ±0,022	0,086 ±0,010	1,13 ±0,03	65,9 ±7,6
Tasotkel storage reservoir	07.07.11	0,192 ±0,010	0,246 ±0,010	0,010 ±0,004	1,28 ±0,03	15,56 ±0,84
Dam at Tasotkel storage reservoir	07.07.11	0,236 ±0,014	0,305 ±0,015	0,015 ±0,006	1,30 ±0,03	19,14 ±1,13
Channel after Tasotkel storage reservoir	07.07.11	0,236 ±0,012	0,309 ±0,013	0,019 ±0,006	1,31 ±0,03	19,11 ±0,99
Chu river, after Tasotkel storage reservoir	07.07.11	0,249 ±0,017	0,314 ±0,018	0,013 ±0,007	1,30 ±0,03	20,18 ±1,41
Chu river, Novy Put vill.	07.07.11	0,247 ±0,014	0,319 ±0,015	0,016 ±0,006	1,29 ±0,03	20,03 ±1,11
Chu river, Novy Put vill	08.07.11	0,326 ±0,021	0,427 ±0,022	0,021 ±0,009	1,30 ±0,02	26,40 ±1,70
Average value in surface water of the site					*1,29 ±0,01*	*20 ±1*
Chu river before Kenes vill.	08.07.11	0,349 ±0,018	0,477 ±0,020	0,021 ±0,008	1,37 ±0,02	28,28 ±1,47
Artezian well, Kenes vill.	08.07.11	1,037 ±0,048	1,415 ±0,052	0,052 ±0,021	1,36 ±0,02	83,99 ±3,88
Chu river before outlet in Kuragatty river	08.07.11	0,488 ±0,032	0,678 ±0,035	0,032 ±0,014	1,39 ±0,03	39,52 ±2,60
Kuragatty river	08.07.11	0,277 ±0,047	0,395 ±0,052	0,012 ±0,020	1,40 ±0,04	22,39 ±3,80
Chu river after outlet in Kuragatty river	08.07.11	0,467 ±0,022	0,532 ±0,022	0,073 ±0,011	1,14 ±0,03	37,81 ±1,81

According to the analysis of water samples taken in July 2011, the isotope ratio $^{234}U/^{238}U$ and total content of uranium in waters of upper parts of the Chu River basin down the confluence of the Chon-Kemin River and before the pinchout of underflow in the area of Tokmok city, remain constant within the measurement accuracy, which does not contradict to previously received data [3-11] and differs noticeably from the same parameters in the waters of the Chon-Kemin river. It has made possible the evaluation of the flow volume of the latter in this area of the Chu River basin, which turned out to be equal to (30±5)%, and which corresponds to the hydrological data [2], and our previous data on isotopes of uranium [4-6].

The total content of uranium, as well as the excess amount of ^{234}U, increases slightly in the area between Tokmok city and Karasu village in the waters of the Chu River. It is evidently associated with the underground waters inflow from the cone delta side of the eastern rivers of the Kyrgyz mountain range, characterized by average isotope ratio ($^{234}U/^{238}U$) equal to 2 and total content of uranium not exceeding 1.10^{-5} g/l [6,7], i.e. the evaluated volume of the underground waters in feeding of surface waters of the Chu River in this area does not exceed 20%.

Then, downstream the Chu River in the area between Krasnaya and Chernaya rivers the excess amount of ^{234}U in the surface waters decreases significantly (from 1,54 to 1,33 at measurement accuracy of around 1%), and total content of uranium in them increases (from 9 to 16.10^{-6} g/l at measurement accuracy not more than 7%). Such a rapid change of the isotope ratio in this section is most likely associated with the inflow of the underground waters in central parts of cone delta of the Kyrgyz mountain range with decreased excess amount of ^{234}U (not more than 10%) and increased content of uranium ($1,5.10^{-5}$ g/l) [7, 8], as well as with the input of technogenic uranium from the Chernaya River. A volume of the underground waters inflow according to the isotopic composition of uranium in this area is (30±15)%.

Downstream the Chu River a total content of uranium in its waters increases to the concentration values higher than recommended by WHO, equal to 15.10^{-6} g/l. It may be associated with the pinch-out in the area of Tasotkel underground water-storage reservoir, enriched with uranium to the hazardous levels (10^{-4} – 10^{-5} g/l). The volume of the latter in feeding of surface waters may reach from 30 to 60%, which requires organizing continuous control of potable water quality in this area of the Chu River basin.

Thus, based on the analysis of data on isotope ratio of the uranium in surface and underground waters of the Chu river it is determined that:

- the volume of the surface inflow at the confluence of the Chon-Kemin River into the Chu River is 30±5%;

- the ratio of even isotopes of uranium $^{234}U/^{238}U$ in the areas of no significant underground waters inflow (Chon-Kemin city – Tokmak city – Ken-Bulun village – Karasu village; the area of Tasotkel water-storage reservoir) remains consistent at least during decades;

- the surface waters enrich with uranium along the river downstream due to the input of the underground waters;

- the volume of the underground component from the southern slopes of the Kyrgyz mountan range in the area between Tokmak city and Kordai city in feeding of the Chu River does not exceed 50%, and in the area of Tasotkel water-storage reservoir due to the pinch-out of uranium-enriched waters does not go less than 30%;

- The uranium anomalies, which are hazardous for potable waters, exist in the underground waters in the area of Kuragatty village.

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Monitoring and Analyses of Impact of the Industrial Complexes on Water Quality of the Central Asian Transboundary Rivers

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Abstract: In most cases the problem of water quality of the Zeravshan River consider in organic communication with activity of the Anzob Mountain-concentrating Industrial Complex (AMCIC). AMCIC is the mining enterprise for extraction and enrichment of complex mercury-antimony ores of the Dzhizhikrut deposit. It is located in a right-bank part the rivers Dzhizhikrut which are the left inflow of the river Jagnob (the river Jagnob is the right inflow of the river Fondarja which in turn is the left inflow of the river Zeravshan). For definition influence of the AMCIC on qualities of waters of the river Zeravshan were made sampling of water from the river in two points - on Fondarya and Pete Rivers is located accordingly before and after wastewater dams of AMCIC. Comparison of results chemical analyses have shown about absence of the factor of pollution of the river Zeravshan by wastewaters of industrial complex.

Keywords: pollution; waste dams; irrigation; transboundary

1. Introduction

In the Aral Sea Basin on the territory which are located five states, water resources are used basically for an irrigation and water-power engineering. These waterusers demand different modes of regulation of a river drain. In interests of water-power engineering – the greatest development of the electric power and accordingly use larges parts of an annual drain of the rivers in winter the cold period of year. For irrigation the greatest volume of water is required in the summer during the vegetative period. Regulation of a river drain is thus carried out by the large reservoirs. Thus all largest hydroelectric power stations are constructed in the countries of a zone of the drain formation - in upstream the rivers Amu Darya and Syr-Darya – in Kyrgyzstan and Tajikistan and the main areas of the irrigated lands are located in states of the down stream of the rivers – Kazakhstan, Turkmenistan and Uzbekistan [1]. Zeravshan (in up-stream - the Matcha river) the river in Uzbekistan and Tajikistan - length of 877 km, the area of basin of 17.7 th. km^2 and the average expense of water 162 m^3/sec. Zeravshan River originates from the Zeravshansk glacier in mountain knot between Turkestan and Zeravshansk with ridges the River is fed basically with glaciers and snow. Therefore the greatest drain in it is necessary for the summer (July, August), during the cold period of year Zeravshan bears not enough water. In the summer water in the river muddy, gray-steel color, in the winter pure and transparent. On territories of Republic Uzbekistan near to the Samarkand city the Zeravshan river is divided into two sleeves – Akdarja and Karadarjua. Earlier Zeravshan ran into Amu Darya but now loses the waters in desert Kyzyl Kum, forming two deltas – Karakulsk and Bukhara.The total drain of the Zeravshan River Basin on the periods 1932-1962 and 1962-1991 make is accordingly 146.26 and 145.03 km^3 [2].

2. Water quality control of the Zarafshon River

Water quality has become a global issue. Every day, millions of tons of inadequately treated sewage and industrial and agricultural wastes are poured into the world's waters. Every year, lakes, rivers, and deltas take in the equivalent of the weight of the entire human population—nearly 7 billion people—in the form of pollution. Every year, more people die from the consequences of unsafe water than from all forms of violence, including war—and the greatest impacts are on children under the age of five.

From the international level to watershed and community levels, laws on protecting and improving water quality should be adopted and adequately enforced, model pollution-prevention policies disseminated, and guidelines developed for ecosystem water quality. Standard methods to characterize in-stream water quality, international guidelines for ecosystem water quality, and priority areas for remediation need to be addressed globally [3].

Water relations between Central Asia republics during the Soviet Union time were regulated by "Complex Use and Protection of Water Resources Schemes" in Amudarya and Syrdarya basins.

The main purpose of working out basin "Schemes" was to define real volumes situated within the Amudarya and Syrdaya basins and available for using water resources. It was also providing their fair allocation among region republics, meeting all the water users interests. It should be noticed, that the number of important aspects were not considered and included in "Schemes", for the situation has greatly changed after 1980 (years of the last "Schemes" specification and completion of hydraulic range composition). Mainly it concerns the ecologic acquirements and sanitarian clears thrown into rivers and channels. Overusing basin water in irrigational lands planned as maximum use by “Scheme” resulted in exhausting water resources and appearing new problems. They are:

- deterioration of ecological condition, sometimes leading to ecological disaster in river lowlands of Aral basin;
- great pollution of river water with pesticides, herbicides, other harmful elements and increasing of water mineralization.

The problem of studying the water quality change and development of mechanisms of its control is still actual and concerns not only the separately taken country of Central Asia but all the states of the region.

For stabilization of an ecological situation in the region a number of measures is offered, for example, by Jalalov [4]. According to one of them it is necessary to make as a principle the limited water intake with some changes allowing the water users down the river flow to intake the greater water volume in percentage terms. The adoption of this limited water intake system, according to same Jalalov (2001), will allow regulating water intake from the rivers not only in view of irrigated lands, but also in view of water quality, degree of its mineralization. Nowadays one of the most polluted rivers of Central Asia is Zarafshan River. The capacity of this water is changed under the influence of collector drainage water of irrigating basin zone and wastewater of Samarqand, Kattakurgana, Nagoya, and Bukhara cities. Mineralization of water exceeds from origin to estuary from 0.27-0.30g/l to 1.5-1.6g/l. The most exceed of MC among heavy metals is observed in Cr and Zn. Moreover in Zarafshan river high contain of antimony was found out and it’s phenol pollution composes 3-7.5 MC [5]. Results of reduced chemical analysis of these materials indicate that mineralization of river's water changes within surveyed area from 0.3 to 2.7 g/1. Down the stream from mountains to Navoi meridian mineralization increases from 0.3 to 1 g/1 and then up to Bukhara oasis it reaches 2.6 g/1. In the same direction the chemical composition of water changes - hydrocarbonate ion decreases and sulphate ion increases. Mineralization level of collector-and-drainage water, broadly used within Bukhara oasis, is higher making 2.5-4 g/1. Lower mineralization (0.6 - 0.7 g/1) occurs in canals water taken from Amudarya River and used for irrigation and partially for potable water supply. According to the results of atomic absorption method the chemical contents of Zerafshan waters is closely related to the collecting points and varies extensively (mg.eqv/%): HCO_3^- :15.0-28.0; Cl^-: 11.74-27.0; SO_4^2-: 55.0-69.72; Ca^{2+}:27.0-36.79; Mg^{2+}:24.0-45.00; Na+K:28.0-36.82.It was defined that the HCO_3^- content is decreasing and the Cl^- and SO_4^{2-} are generally increasing from Navoi to Buchara [6].Now after the statement of Republic Tajikistan about the maximum use of hydropower potential of waterways of the Zeravshan river basin the question of water quality of the river Zeravshan though it existed throughout many years, in new coloring began to rise from Uzbekistan. Many consider a problem of water quality in organic communication with activity of Anzobsk mountain-metallurgical industrial complex.

3. Anzob Mountain-Concentrating Combine (AMCC) the mining enterprise for extraction and enrichment of complex mercury-antimonic ores of the Dzhizhikrut deposit. It is located in area Ajni in 13 km of a highway of Dushanbe-Khujand in a right-bank part the rivers Dzhidzhikurut which are the left inflow of the river Jagnob (the river Jagnob is the right inflow of the river Fondarja which in turn is the left inflow of the river Zeravshan). The Dzhizhikrut deposit has been opened in 1940 and in 1945-1959 intelligence works were spent and industrial expluatation has begun from 1954. The Dzhizhikrut deposit is located in the ore field area with the same name which is a part of the Zeravshan-Gissar mercury-antimonic belt. The main ore minerals are antimonite and cinnabar. Since 1966 1970 reconstruction of industrial complex was spent and for the purpose of prevention of hit of sewage of industrial complex to the river Dzhizhikrut river in village of Ravot (8-10 km from industrial complex) on left to river bank Jagnob was are built waste water dams**(WWD).** With 1970 on 1994 pipelines of sewage functioned normally, and since 1994 as a result of heavy rains pipeline pieces has been destroed. In 2009 the industrial complex has completely restored pipelines and now dams in the complete set and works in the established mode. We spent in 2010 a complex of physical and chemical analyses of quality of waters of the river Zeravshan and its inflows. Results of analyses are presented in tables 1-3 and on the Fig.1-3.

Table 1. Physical-chemical analyses results of Zeravshan river waters after WWD of AMCC

T, C	pH	NO_3	NH_4	PO_4	Cr(VI)	Cr(IV)	Hg	Sb	Cd	Zn
14.4	7.96	30.72	0	103.15	0.029	0	0	0	0	0.019
15.5	8.17	12.1	0	146.6	0.014	0	0	0	0	0.017
16.2	8.3	11.17	0	112	0.01	0	0	0	0	0.015
16.6	8.19	10.64	0	88.1	0.015	0	0	0	0	0.014
17.0	8.29	7.73	0	129.2	0.029	0	0	0	0	0.021
17.4	8.21	4.21	0	151.3	0.034	0	0	0	0	0.019
17.0	8.34	22.42	0	131.1	0.037	0	0	0	0	0.029

Table 2. Physical-chemical analyses results of Zeravshan river waters

T, °C	pH	Θ, µS/sm	mg/l								
			O_2	NO_3	NO_2	PO_4	NH_4	Pb	Zn	Sb	As
15.9	8.41	285	3-5	0	0	50	0	0	0	0	0
13.8	8.4	269	7	10	0	100	0	0	0	0	0
16.2	8.4	280	5	10	0	100	0	0	0	0	0
15.7	8.4	289	5-7	0-10	0	50	0	0	0	0	0
14.2	8.4	244	7	0-10	0	0	0	0	0	0	0
13.3	8.5	250	7	5-10	0	0	0	0	0	0	0
13.3	8.4	247	5-7	10	0	0	0	0	0	0	0
12.3	8.5	250	5	0-10	0	50	0	0	0	0	0

Table 3. Physical-chemical analyses results of Zeravshan river tributaries waters

Name	T, °C	pH	Θ, µS/sm	mg/l								
				O_2	NO_3	NO_2	PO_4	NH_4	Pb	Zn	Sb	As
Iskandarkul lake	10,0	8,6	182	10,5	0,0	0	5	0	0	0	0	0
Iskanderdarya	12,1	8,6	189	10,5	17,5	0	10	0	0	0	0	0
Yagnob	13,6	8,5	209	6,0	5	0	250	0	0	0	0	0
Sangiston river	16,0	8,3	209	5,0	10	0	100	0	0	0	0	0
Kishtudak	22,0	8,5	320	6,0	10	0	375	0	0	0	0	0

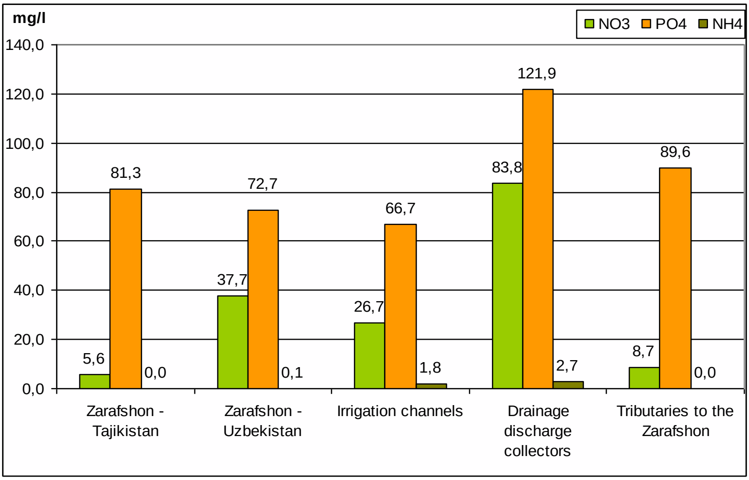

Fig. 1. Content of nitrate, phosphate and ammonium in waters of the Zeravshan River on the Tajikistan and Uzbekistan territory, waters from irrigation channesand drainage collectors in Uzbekistan and tributaries to the Zeravshan River

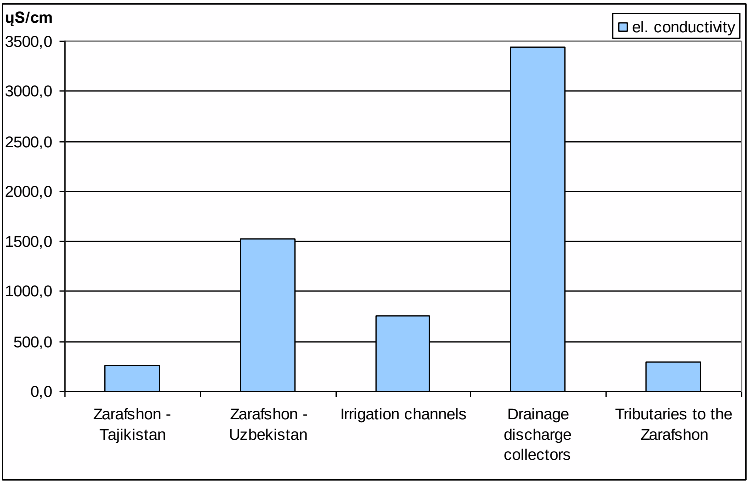

Fig. 2. Electrical conductivity of waters of the Zeravshan river on the Tajikistan and Uzbekistan territory, waters from irrigation channesand drainage collectors in Uzbekistan and tributaries to the Zeravshan river

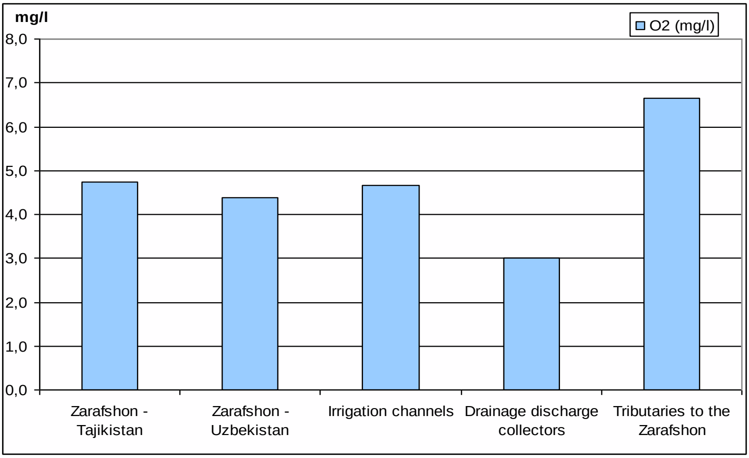

Fig. 3. Content of oxygen in waters of of the Zeravshan river on the Tajikistan and Uzbekistan territory, waters from irrigation channesand drainage collectors in Uzbekistan and tributaries to the Zeravshan river

Tables 1-3 and Fig.1-3 shows that in waters of the Zeravshan river and its inflows the maintenance, and as a last resort, excess of concentration of heavy metals of maximum permissible concentration isn't observed. For definition influence of the Anzob mountain-metallurgical industrial complex on qualities of waters of the river Zeravshan we were made sampling of water from the river in two points - on Fondarya and Pete is located accordingly before and after waste water dams of combaine. Comparison of results chemical analyses have shown about absence of the factor of pollution of the river Zeravshan by waste waters of industrial complex.

The penetrating comprehension of water importance in the region and social responsibility for steady water supply, for example, called immediate reaction of 5 Governments in Central Asia. In February 1992 there was founded Interstate Coordination Water Commission (ICWC). The foundation of ICWC in difficult and unpredictable post-Soviet time enabled the countries of the region to pass painlessly the period of water “anarchy”, to ensure equilibrium and consent in the region and has shown strategy of all countries to ensure today and in future mutual understanding and respect in fruitful cooperation.

It gives the ground to hope, that the problem of contamination and ascending of a degree of water arteries mineralization can be solved with the same success by creating (similar ICWC) Interstate Coordination Water Quality Commission (ICWQC). The structure of such organization is presented on the Fig.4.

Structural subdividing “The interstate experts” unite the leading technicians in valuating the quality and composition of waters from all five states of Central Asia. The main function of this body is to compare the republican experts’ information about water composition and to solve disputable questions by carrying out the independent expert appraisals of water quality of Transboundary Rivers. ICWQC Secretary appoints the stuff and sets terms of power of the interstate experts. In Information Center established in each country of Central Asia the water quality control statistics in industrial, agricultural, municipal sectors and Hydroposts are gathered, generalized and systematized.

Thus, the data concerning water arteries quality from each country come to Analytical Center of ICWQC. It should be noted, that after reaching the complete transparence of relative composition and quality of all water arteries in Central Asia the next stage is the development of mechanisms to encourage and take measures to the states polluting water environment. These problems together with other questions should be studied in ICWQC Secretariat for considering at Meeting of Central Asia Heads of Governments.

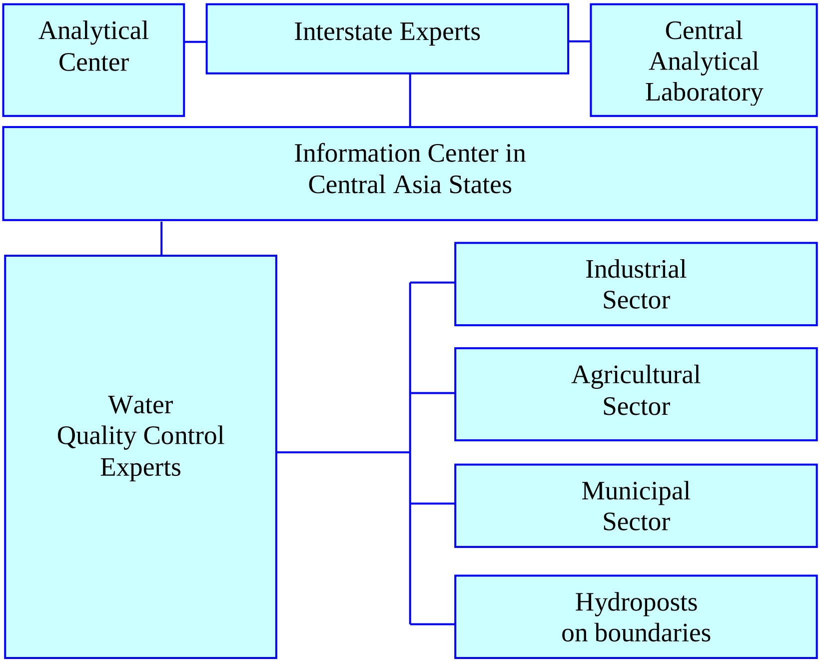

Fig. 4. Structure of the Interstate Coordination Water Quality Commission

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The development perspective of Hydropower resources of the Pyanj Transboundary River Basin

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Abstract: Pyanj River is Transboundary Rivers (on border of the Republic of Tajikistan and Afghanistan) the left tributary of Amu Darya in the Central Asia. The length of the Pyanj River is 921 km and the area of basins of 114000 km^2. It is formed by merge of the Pamir and Vahandarya rivers. The average discharges of water 1032 m^3/sec. At present time is used basically for irrigation.

Keywords: Transboundary; Central Asia; Afganistan; Hydroper resources; Agriculture; Hydrometeorological

1. Introduction

Water resources are a basis of hydropower of Tajikistan. The general annual potential hydropower resources in republic make up 527 Bln. kWt·h from which not less than 40-50 % are technically possible for development of the hydropower. More than 95 % of all electric power in republic is developed by hydroelectric power stations. In conditions of Tajikistan, the unique hydroelectric power stations constructed on the large rivers, flowing on deep rocky canyons, have not only hydropower, but also water-regulating and meliorative meaning. It is clear that the hydropower resources renewable and also are safe from the point of view of throwing other harmful substances in environment. All these properties do greater traditional hydroelectric power industry non-competition, in perspective, by an energy source in conditions of Tajikistan.

Water resources focuses, basically, on the large rivers – Vakhsh, Pyanj, Obi Khingoy and others. The specific saturation of potential water resources makes up significant size – 3682.7 kWt·h on 1 км^2 territories (the first place in the world), per capita 87800 kWt·h in a year (1-2 places in the world). However, last years of expense of irrational use shortage of the electric power is observed, that negatively influences on social and economic development of republic and well-being of population.In structure of manufacture of primary fuel and energy resources (PFER) in region the leading place occupies now organic fuel (table 1).

Thus about half of total amount of power resources to fit to the natural gas which basic stocks are concentrated in Turkmenistan and Uzbekistan.

The second place in structure of the primary energy carriers made by the states of the Central Asia, occupies oil, to 80 % of its extraction to fit to Kazakhstan. In power balance of Kyrgyzstan and Tajikistan the huge share to fit to hydroenergy. In structure of internal manufacture of primary fuel and energy resources (PFER) hydropower makes accordingly 82 and 96 %. However, in structure cumulative fuel-power balance of region the hydropower share is insignificant now (about 2 %).

Table 1. Structure of primary fuel energy resources production in Central Asia countries (%)

Country	Gas	Oil	Coal	Hydro	Total
Kazakhstan	16	50	33	1	100
Kyrgyzstan	2	5	11	82	100
Tajikistan	2	1	1	96	100
Turkmenistan	83	17	0	0	100
Uzbekistan	84	13	2	1	100

Pyanj River is Transboundary Rivers (on border of the Republic of Tajikistan and Afghanistan) the left tributary of Amu Darya in the Central Asia. The length of the Pyanj River is 921 km and the area of basins of 114000 km^2. It is formed by merge of the Pamir and Vahandarya rivers. The average discharges of water 1032 m^3/sec. At present time is used basically for irrigation.

On 27 April, 2005 between Governments of the Republic of Tajikistan and the Government of Islamic Republic Afghanistan is signed Agreement about cooperation in the field of joint development of hydropower resources of the river Pyanj and development of interstate transmission lines. On the river Pyanj the basic inflow of Amu Darya economically soundly building of 14 hydroelectric power stations by capacity from 300 MWt to 4000 MWt with the production of electricity of 86.3 Bln. KWt·h/year. By 2025 as a result of intensive development of water-power resources of the Pyanj river basin electric power development can reach level of 80 Bln. KWt·h/ year. The Amu Darya River in the length 2580 km, on the power stocks is considered the most important energy source of Afghanistan to components of 50 % of all resources of the country. Only economically effective hydropotential of the Amu Darya River makes 37.5 Bln. kWt from which 33 kWt to fit to Pyanj Rivers.

2. Pyanj River basin of Northern Afghanistan. River basins of Northern Afghanistan are located in the north of the central Hindu Kush ridge. Almost all rivers of northern Afghanistan originate from this mountain ridge and flow in northern and northwest direction. Hydrographically all northern river basins in the north Afghanistan belong to basin of Amu Darya. The Amu Darya basin area makes approximately 534740 km^2 and high-rise marks change from maximum in 7134 m a. s. l. on Pamir in the east where Amu Darya originates to minimum in 320 m a.s.l. Hydrographically the northern Afghanistan river basin is subdivided now on two basins units:

- Pyanj-Amu basin in the northeast, including the basic inflows of Kokcha and Kunduz;

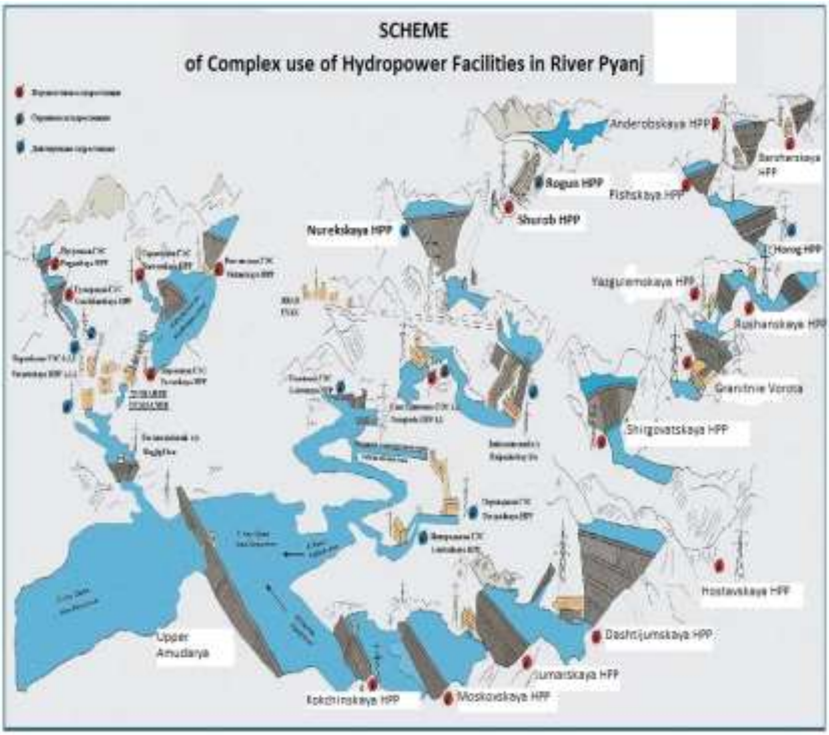
-Northern basin characterized so-called «blind rivers», that is the former inflows which already throughout several centuries don't run into Amu Darya, leaving the big desert Shortepa between a place of disappearance of these rivers in Dashti Shortepa and Amu Darya.

Table 2. Hydropower station on the Pyanj River [1]

Name	Capacity, MWt	Output, TWt·h/years	Head, m	Useful volume of reservoir (km^3)
Namangutskaya*	2.5	0.018	36	0
Barsharskaya	300	1.6	100	1.25
Anderobskaya	650	3.3	185	0.1
Pishskaya	320	1.7	90	0.03
Khorogskaya	250	1.3	70	0.01
Rushanskaya	3000	14.8	395	4.1
Yazgulemskaya	850	4.2	95	0.02
Granites gate	2100	10.5	215	0.03
Shirgovatskaya	1900	9.7	185	0.04
Khostovskaya	1200	6.1	115	0.04
Dastidzumskaya	4000	15.6	300	10.2
Dzumarskaya	2000	8.2	155	1.3
Moscowskaya	800	3.4	55	0.04
Kokchinskaya	350	1.5	20	0.2
Nijni-Pyanjskaya	600	3.0		

The current way of distribution of water of the Amu Darya River is based on Tashkent Agreement 1987 which regulates a water use share in Aral Sea basin – namely, water resources of Amu Darya and Sir-Darya – between five the Central-Asian countries till now without any account water division for Afghanistan. Now, water use in five states of basin is estimated as in Table 3.

All rivers originating from the Central mountain ridge Hindu Kush (Southern border of Amu Darya basin watershed) go down to northern plains located in basin of northern rivers of Afghanistan along the left coast of Amu Darya. The general Afghani area belonging hydrographically to the Amu Darya basin Includes northern basins and the Pyanj-Amu basin covering the area in 167473 km^2 from which 693 km^2 (basin Pyanj-Amu – 54 %) intensively drainages Afghani the rivers running into Amu Darya. Hence, a share of the Afghani territory in the Amu Darya basin makes 31 % or one third in comparison with other four coastal states. The considerable area of this Afghani territory, which most part make northern plains located on the left coast of Amu Darya, it is possible to irrigate (about 800000 ha), however now, by estimations, 385000 ha are irrigated only.



Source: The Ministry for Foreign Affairs of Tajikistan

By estimations (Indicators of world development, WB, Washington, 2001) it is expected that in 2010 the population of Afghanistan will reach somewhere about 35Mln. persons from which approximately 8 million (23 %) lives in Northern Afghanistan, being in regular intervals distributed, approximately on 4 million, in two basic parts of river basin (Pyanj-Amu and Northern basins). Population density in the irrigated territories located along the river of Amu Darya and its basic inflows is high 48 persons on км^2.

Table 3. Water resources of the Aral Sea Basin and Mid annual volume water use of Central Asia countries

Country of the Amu Darya River Basin	Mid-annual volume Water use, Mln.m^3	Share from the total Mid-annual volume Water use, %
Tajikistan	7500	11
Afghanistan	5000	7
Uzbekistan	33000	47
Kyrgyzstan	1500	2
Turkmenistan	23000	33
Total		100

The Department of Energy and water resources of Afghanistan has developed the concrete plan for development taking into account possibilities of the country available nowadays. About it the day before, acting in Volusi Dzhirga, the candidate for Ministers of Energy and water resources Mohammad Ismail Han has declared. Mohammad Ismail Han has informed that the Department of Energy and water resources taking into account necessary requirements have begun work in 3 directions. In particular, as he said, the ministry intends to carry out reforms for revival and improvement of system of water supply and a water management, to continue the national program of development of water sources, strengthening of coast of the rivers.

Till now from planned 3200 projects for five years realization of 1200 programs is finished, has informed fulfilling duties of the Minister of Energy and water resources of the Afghanistan: “Volumes of water stocks from 22 Mln.m^3 of water are finished to 24 Mln.m^3 that gives the chance to irrigate 330 Th. ha of the agriculture lands”. Now the Department of Energy and water resources of Afghanistan for the purpose of an estimation of water-supplies in the rivers and lakes of Afghanistan, and also an estimation of resources of water from deposits has established the equipment on 105 centers on control of water resources in 22 provinces of the country. In total it is about the country planned to establish such 177 centers. For five next years in branch it is planned to realize 2100 projects connected with water supply and an irrigation, having finished the areas of the new irrigated earths to 780 Th. ha.

The Department of Energy and water resources for the purpose of preservation of water resources and infrastructure creation plans to create 208 water basins, including 20 large, has specified fulfilling duties of the minister. These 20 largest water basins are planned to create in 5 water regions of the country. Among them such water tanks as the Kunarsk water basin, the Coma, Gamberi, Kal-e-Besh and et.al. European Union and

Afghanistan signed the agreement according to EU will allocate the financial help at a rate of 36 Mln.USD for improvement of water resources management in the north of Afghanistan.

According to Mohammad Ismail Han, the help most part will be directed on performance of the projects connected with use of resources of Amu Darya. The minister is assured that with realization of the projects planned by its department it will be possible to irrigate about 50 Th.ha of agriculture lands. Rational use of water resources can positively affect a standard of living of the majority of the population of the north of the country.

In 2006 the Minister of Energy and water resources of Afghanistan Ismail Khan has made a number of rigid statements concerning savings of water potential of the country. He considers that thanks to snowfalls annually in the country are formed 75 Bln.m^3 of water from which only 30 % are spent inside, and other part – leaves the Afghani territory in the form of the rivers and streams. For savings of water potential of the country the minister has suggested to construct dams, reservoirs and channels.

The project of development of water resources of the Pyanj River has been made in the USSR when in 1970 the Central Asian branch of the Hydroproject has developed "the Scheme of complex use of the Pyanj and the Amu Darya Rivers on a boundary site between the USSR and Afghanistan". This scheme has been confirmed in the USSR, but hasn't received realization because of difficult relations between the USSR and Afghanistan.

To 2020 year three planned basic irrigational projects will include in addition about 200 Th.ha of the irrigated lands, therefore the irrigation total area in the Afghani part of the Amu Darya basin will make approximately 600 Th.ha and therefore an annual maximum water intake from Pyanj, Amu Darya and Kokcha, Kunduz will make 6000 Mln.m^3.

2.1. Long-term plans of use of water resources of the Pyanj River Basin in Afghanistan

2.1.1. The irrigation and Hydroelectric power station (HPS) building in downstream of Kokcha River. Realization of the first phase of this project has begun before 1980, but because of war works have been stopped. The equipment design, and also technical and economic the project substantiation has been executed with support of experts of the former USSR. For the period 2004 -2009 the Feasibility Report it has been finished by the well-known international consulting firm taking into account new social and economic and ecological requirements. Now preparation for tender carrying out is spent on detailed studying of the project which includes following services and works:

• Maintenance of a necessary quantity of water for an irrigation of the existing of 96 Th.ha lands;
• Maintenance of a necessary quantity of water for an irrigation of 37000 ha new mastered agriculture lands;
• Building of HPS by capacity in 42 MWt and maintenance with the electric power of the machine irrigation and the next settlements;
• The contribution to maintenance of national food safety by means of production more a crop;
• Creation of possibility of employment for increase in incomes of the local the population.

Project performance is broken into phases: restoration of 96 Th. ha roughly should be finished by 2016 and the irrigation of the new lands of 37 Th.ha by 2020.

2.1.2. *The Kelagaysk project- irrigation and hydroelectric power station building*

This project is carried out on the river Kunduz, one of inflows of Amu Darya in a province Baghlan. Researches and design works also were carried out at technical and the financial help of experts of the former USSR in 70 and 80th years. Recently was the new feasibility report well-known is executed the international consulting firm taking into account all new requirements.

The basic characteristics of the project:

• Reliable water supply for an irrigation of the existing of 43250 ha of agriculture lands;
• Reliable water supply for an irrigation of 25365 ha new mastered of agriculture lands;
• Production of electric power by building of hydroelectric power with capacity of 60 MWt.

The project is at present on design stages and its finish it is expected by 2020.

2.1.3. Irrigation and Hydroelectric power station building in upstream of Amu Darya or downstream Pyanj Rivers

This project is carried out on the river Kunduz, one of inflows of Amu Darya in a province Baghlan. Researches and design works also were carried out at technical and the financial help of experts of the former USSR in 70 and 80th years. Recently was the new feasibility report well-known is executed the international consulting firm taking into account all new requirements.

At present the project is at an initial stage of planning. By estimations, nevertheless, potentially suitable area for an irrigation exceeds 500 000 ha already mastered and the new lands. The capacity of under construction hydroelectric power station can reach 1000 MWt. It is expected that in the following of 10 years 215 Th. ha of the lands will be irrigated.

Rational use of water resources of Afghanistan is impossible today without maintenance with the qualitative hydrological information. At the heart of reception of the authentic and universal information regular long-term supervision over various hydrological characteristics and a condition of water objects of republic lie.All are more loudly distributed appeals to apply methods of complex water resources management (CWRM), recognized as a key component of successful water resources management at the UN conference on water resources in Mar del Plata, Argentina, in 1977 and at the UN conference on inhabitancy of the person in Stockholm in 1972. They are widely used now in the developed countries as the most suitable way of the decision of problems of water resources management. In a reality to apply CWRM it is difficult, as they demand much more the information, than simple water resources management.

3. Modern state of Hydrometeorological network in Pyanj River Basin.

As it is known, efficient control any real process probably only in the event that is known the future condition of system, and the last is established in advance, due to mathematical modeling. Thus, efficient control depends on level justify techniques of forecasting of dynamics of considered process. Forecasting watersheds of the rivers should be considered as the activity normalizing functioning of manufacture. Efficiency of wildlife management is reached by means of Hydrometeorological maintenance. It assumes not only rational, but also optimum use of knowledge of forthcoming changes of the rivers discharge for the economic organization of hydrotechnic points .Productivity of industrial operations and other actions depending from watershed of the rivers will be that above, than more optimum system of Hydrometeorological maintenance. Decisions made by the consumer in this case will be decisions water-economic which are based on the information arriving from prognostic divisions and should provide the maximum benefit or the minimum losses at performance of the set industrial operations. In the

Pyanj river basin on the territory of Tajikistan there are 43 Hydroposts in 41 from which water level measurement is spent. According to the working plan in 40 Hydroposts should it is spent gauging of the water discharge of the rivers. Hydroposts of Gunt-Alichur, Bartang-Pshart are completely destroyed. Four Hydroposts of the Pyanj River (Ishkoshim, Shidz, Khirmanjo and Nijni Pyanj) concern border stations which with 1992 on 2004 didn't work. Since 2004 measurements only a water level has been renewed. Hydroposts in the rivers Kizilsu, Toirsu and Jaksu (Bobokhonshaid, Kurbonshaid, Somonchi, Shahbur and Vose) have failed as a result of flooding 1992 and 1998. The insufficiency and reliability of meteorological data now is main problems of Pyanj River Basin. At the analysis of the meteorological a database on four meteorological stations (Bulunkul, Darvaz, Ishkoshim and Khorog) of the Pyanj River Basin from 1960 on 2010 we weren't possible manage a continuous line of the data on change of temperature, precipitation except for the data on temperature for period 2000-2006 years(Fig.1).

The similar situation is observed also in the Afghani part of the Pyanj River basin. About this are testify Table 1 and Table 2 where the data about availability of the meteorological data on the basic inflows of the Pyanj River the river Kunduz and Kokcha basins is presented.

The government of the Republic of Tajikistan taking into account importance of protection of the population from flooding the investment project “Management of risk of flooding in Khatlon area” which is financed by the Asian Bank of Development has supported. According to the working project plan a recovery work at these stations and building of water gauging is provided.

Conclusion

Thus, results of the spent analyses shows that the Pyanj River Basin possesses a unique stock of hydropower resources. The present stage of development of hydropower resources is characterized by working out of feasibility reports on objects and negotiations between the next states Tajikistan and Afghanistan on their effective development. Building of hydraulic engineering constructions on inflows and the Pyanj River opens wide prospect on development of new farmlands in territory of Afghanistan and by that to provide food safety of the country. Efforts of two states of Afghanistan and Tajikistan with support of financial institutions and the international organizations conduct work on restoration old and building of new and modern Hydrometeorological stations

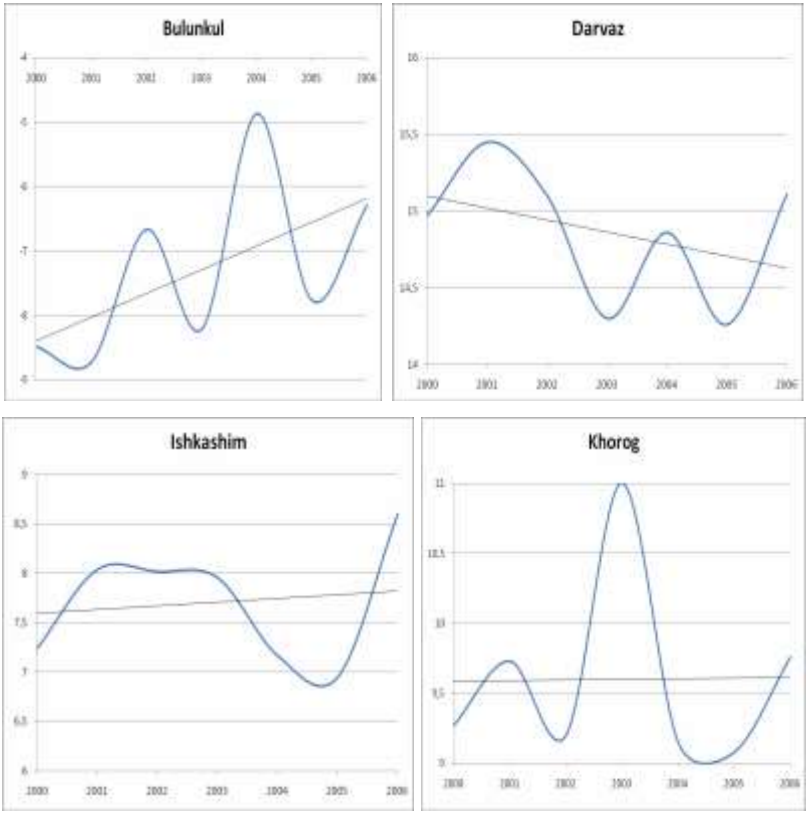


Fig. 1. Trends of temperature change in Pyanj River Basin according to data of four stations for 2000-2006 periods

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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

1. 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 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, is an increase in consumption of the foodstuffs in developing countries with another is an economic and financial crisis which has caused slump in production and population incomes.

Among calls which the whole world has 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 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 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.

2. Ecological & Irrigation and Energetic Criteria of Reservoirs

The hydropower with agriculture is one of 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 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 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 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^{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) [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).

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 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

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

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)

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.

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 an plains. For large reservoirs is 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 considered at creation of new reservoirs in the Tajikistan and also 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. 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 [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 ^{o}C) is observed in November-December. In process of removal from a dam, this difference decreases up to 1.2 ^{o}C. The influence small channels reservoirs on change of temperature of water on length of the river are traced on in significant distance (Table 5).

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 (Fig. 1).

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

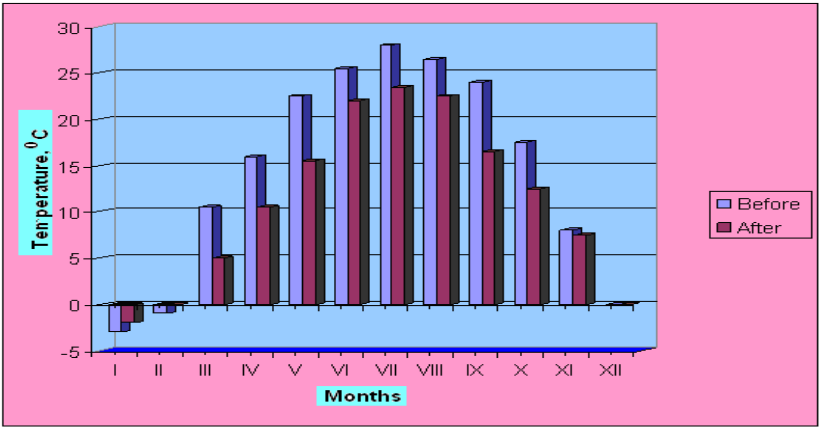

Fig. 1. Average monthly temperature before and after building of the Nurek reservoir

3. Impact of Reservoirs on Irrigation Regime of Agriculture

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 were used. The evaporation and humidity coefficient were defined by calculation (Table 6).

The data presented on the Table 6 demonstrated that for 32 years (1968-2000) the average annual temperature has raised on 1.0-1.5°C 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 and 7.2 % and relative humidity and factor of humidifying raise on 7.2 % and 10 % accordingly.

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

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 considered parameters of meteocondition for all period of supervision. But 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 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 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 are made more 60 mln.m^3.

4. Sedimentation of Reservoirs

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 is 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 mln. t.

Thereby the sediment flow Vakhsh River at the input in Nurek reservoir in condition average on waterless of year can be evaluated 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 will 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 was accepted that the process of sedimentation will conditionally begin 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 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 is 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 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 are reduced to an estimation of passage by them of phenological phases.

5. 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 not independent "units" which could be kept in zoos and botanical gardens, and the equilibrium community which 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 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 a water level in lakes of reserve and to 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 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 which 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 is 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 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 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 got is almost liquidated. Water on the cleaned channels and drains has directed in drying up lakes — and it was filled with water, as in former years when 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 by more safe – earlier they often fell outside the limits protected territory.

In the autumn of 2008 to reserve "Tigrovaya balka" was executed 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 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 level of ground waters. So, 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 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 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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Climate as a Factor of Sustainable Development of Continental Asia

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In the last decade, the increased interest to the problems of global climate change is primarily related to climate impact on human life and functioning of various sectors of the economy. Global climate change is the scope of regional changes at different temporal and spatial scales. Often, regional changes are of extreme nature (droughts, floods, severe and mild winters).They had and still have the most significant effect on economic and social life. The events associated with the latest global warming have urged scientists, practitioners and policy makers to consider the climate as a major natural resource, which redistribution among countries may have serious socio-economic and political consequences.

Particular emphasis has been made on climate change impact on the standard of living and life quality in the mountain areas, i.e. Inner Asia. Chapter 27 of the UN Resolution "Millennium Ecosystem Assessment" (2005) says that mountain dwellers face such challenges as severe weather conditions, the vulnerability of mountain ecosystems to natural and anthropogenic impacts and low agricultural productivity. Interestingly, the mentioned changes are all climate-induced themselves (Aidaraliev, 2009). Along with other objective factors, climatic conditions seem to be more important than, for example, inaccessibility and isolation of territories.

The Agenda of XXI Century adopted by the UN conference in Rio- de-Janeiro (1992) clearly shows that "the mountains are very susceptible to disturbance of ecological balance caused by human activity or natural processes." The increase in the surface temperature leads to reduction in the mountain glacier area. In addition to risks associated with the decrease in strategic reserves of fresh water, the glacier melting results in seasonal increase of flow, which, in turn, causes a dramatic increase in the frequency of landslides, avalanches and landslides, flooding, soil salinization and soil erosion. Soil erosion and decline in pasture productivity because of intensive use and climate change in the mountains of Central Asia have become critical. Many areas of the intermountain basins have a strong tendency to climatic desertification, particularly in Mongolia, China and Kazakhstan that substantially aggravates the ecological and economic situation. Natural conditions, hard for living in the inland mountain areas, lag living standards, intensify migration and the development of other negative social and economic processes.

Currently, the mountain ecosystems have become a haven for nearly half of the world's biodiversity. The presence of many species of plants and especially animals determines and forms the basis for the traditional way of life, including cultural and spiritual development of the local population. Among the main threats to the biodiversity of mountain ecosystems, climate change also plays a significant role.

Thus, we can identify the direct and indirect impacts of climate change on natural systems, living conditions and socio-economic development of the plains and mountain areas of continental Asia.

A brief overview of potential effects and risks of climate change is evidence of urgent study of this topical problem.

According to the Fourth Assessment Report of the IPCC, rise in the air temperature in Russia for the past 100 years (1907-2006) made up 1,29 ° C (Evaluation Report ..., 2008) at an average global warming of 0,74 ° C (2007).. Meanwhile, it is known that often a global averaging eliminates various trends in regional and local change. Hence, "despite the fact that the global average temperature, rainfall, etc. are suitable for tracking changes in the global climate, many sectors of the society need for more practical information applicable to small scales" (Bassalachi, Asrar, 2009). The demand for climate change data on regional and local scales are one of the main issues of global change to be discussed.

Note that according to the data from Barnaul weather station, the annual temperature increased by 1,8 ° C for 100 years (1901-2000). Warming is most typical for winter and spring seasons. Long-term trends are accompanied by a small-scale positive and negative deviations of cyclic (rhythmic) character. Still, late spring and early autumn frosts with increased extreme variability are probable. In recent years, a growing frequency of a very low absolute minimum of air temperature indicative of strengthening winter severity has been observed. Inter-annual variability (contrast) of seasons intensifies (Kharlamova, 2013).

In order to identify climate change trends, the series of meteorological data from weather stations in the Russian part of the Altai-Sayan mountain country (ASMC) are compared to those (most complete) from Barnaul station (BWS) situated in the south-east of West Siberia. Good correlation of changes in the air temperature and annual precipitation from ASMC stations and BWS makes it possible to use long-term trends identified by BWS as background ones for the study area.

Linear trends of annual air temperature for all weather stations are positive, except for some deceleration in the last decade due to strengthening of winter severity. Meanwhile, the cold snap is still observed on the ascending branch of the long-term trend of global warming.

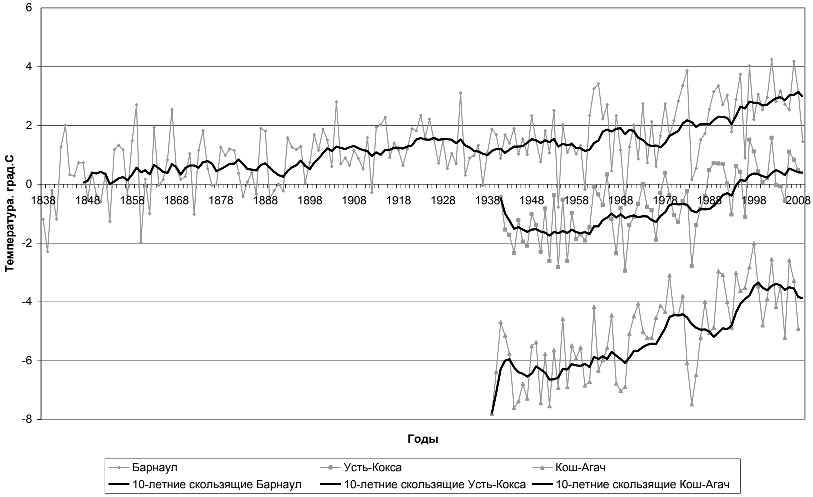

Fig. 1. Annual air temperature: values and 10-year moving average for Barnaul (1838-2010), Ust-Koksa, Kosh-Agach (1944-2010).

Linear trends demonstrate maximum increase in the annual air temperature for the 50 years for the intermountain basins (Kyzyl +3,5 ° C; Erzin +3,4 ° C; Kosh-Agach +2,7 ° C, Ust- Koksa +2,1 ° C) and minimum - for highlands (Kara-Turek +1,2 ° C; Akkem +1,5 ° C). In all high-altitude zones, the change in the average annual temperature is synchronous and cyclic.

The data on atmospheric precipitation is distinguished by considerable heterogeneity. The correlation analysis of the series on annual precipitation shows their asynchronous character (especially noticeable when comparing the stations in the intermountain basins and on the slopes of the mountain ranges). This is due to transformation of precipitation fields and different structure of annual precipitation. In the intermountain basins, most precipitation falls on the warm season: here, the sources are front cloud fields and local convective processes influenced by the topography and depression position relative to air masses transport. However, it is possible to establish good correlation in the change of precipitation recorded by BWS and many other weather stations located on the mountain slopes. For distribution of precipitation, we used the secular cycle of 1850-1976 with its maximum in 1907-1912. From 1977-1978 a new secular cycle with its probable maximum in 2038 has started. The increase in annual precipitation may reach 15-20% as compared to the year 2000. At present, after a humid period of 1986-2002, the growing inter- secular cycle of decreased humidity is observed. Important initial phases of vegetation period are accompanied with scarce moisture supply in spring and the first half of summer.

The ratio of heat and moisture is indicative of probable occurrence of further aridization (progressively developing xerothermic trend). This is supported by the increase in number of days with dry winds, dry weather and dust storms. Another characteristic of warming is increased inter-annual variability (contrast) of seasons and probability of adverse, severe weather events (hail, squalls, floods, etc.). These processes are cyclic, characterized by own territorial and regional specific manifestation.

Therefore, the implementation of the concept of sustainable development requires the consideration of climatic factors for functioning of the natural and socio-economic communities. The analysis of current climate in continental Asia, the identification of regional characteristics of potential climate change and the development of strategies for economy adaptation to the changing climate are urgent and of great importance for ensuring sustainable communities.

The solution of these extremely challenging problems related with defining trends of climate change to provide biodiversity conservation should be based on research coordination, joint efforts of scientists from different organizations and the use of different methods.

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