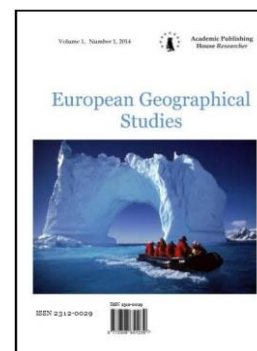


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Geocological Estimation of Water Resources and Ways to Optimization of Water Consumption

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Abstract

This article gives analysis of basic indicators of natural potential and usage of world and South Caucasus water resources, also discusses global problems of their condition. We should also note that ecologically sound, fresh water resources are one of the most important factors for sustainable development of the country economy. In the course of centuries up to recent decade, people assumed that water, air, forest and soil are elements of nature that can be utilized eternally and in any quantities. Though, due to population growth, industry and agriculture development, water demand has increased and resulted in sharp decrease of water resources.

Against the background of present global climate warming and increase of man-made actions, water resources get intensively contaminated that finds extremely negative impact on development of the country economy and finally becomes a reason for different conflicts. This contributed to raising the question of rational usage and protection of water resources. Future growth of water consumption shall be grounded on increased level of river flow monitoring via construction of regulating water reservoirs. In agriculture, it is required to expand the network of sprinklers and introduce dripping irrigation. Important is also problem of stimulation of atmospheric precipitations for expansion of incoming water balance. Necessary complex schemes for water resource utilization shall be developed and protected based on reservoir management principles. Besides, the given work recommends set of measures for improvement of water resource management level.

Keywords: water flows, rational usage, water management.

1. Introduction

«Water gives life», this ancient Georgian proverb says that there is no life without water. Water is the main component and defining element of biosphere existence on earth. Unlike other natural resources, water is diversely utilized in people's lives. Water exists in all biological processes and none of the economic sectors can develop and revive without water. Water plays significant and decisive role in agriculture, industry, energy, etc. There cannot be found even one sphere in biological, public or economic activity that has not touched water problem.

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In the course of centuries up to recent decade, people assumed that water, air, forest and soil are elements of nature that can be utilized eternally and in any quantities. Presently, against the background of global warming, natural resources of vital importance expect irretrievable loss. That's why, scientists are working on rational usage of natural resources, which will secure their preserve and improve environment. For that, in the first row, culture of better production and wise consumption shall be developed.

Water appears to be the crucial factor for ecological-economic development of the country. Until recent decade, the scientists assumed that water resources are inexhaustible and they can be used limitless. Water is prescribed to renewable natural resource, though in case of its incorrect usage it becomes useless. Water is used by the population and multiple agricultural sectors. The more developed the country is, the more contaminated its environment occurs. Development, especially of chemical industry contaminated water basins, seas, rivers, lakes and water reservoirs. Humans contaminate water while performing communal services, also they make water dirty with various waste, etc., while the contaminated water creates danger to health and nature. Water flows into rivers from sewage system, in their turn, rivers appear to be the life habitat for lots of live beings.

2. Study Area

In the 60s (20th century), contamination of environment was obvious. While human survival primarily depends on high quality water consumption. Under intensive man-made actions, the water not only becomes contaminated, but it can also dry out, e.g. in parallel to forest cutting, destruction of soil-grounds, intensive excavation of underground waters, which often causes soil depression and creates huge sinkholes. A lot of people already experience water deficit and are forced to use not quite clean water, which stirs up different diseases.

In the world, annually, about 500 billion m³ of used (contaminated) water flows into water basins, as a result, some water basins fail to renew water and it is expected for such water to become dead. Based on the World Health Organization data, 80 % of diseases fall at contaminated water. Presently, among various issues in ecological environment, humankind faces the problem of fresh water contamination, which creates danger for physical and reproductive health of live beings.

Contamination of seas and oceans mainly by oil products also is on the agenda. The Black sea is in a difficult state, where water productive layer earlier was about up to 200m in-depth, while nowadays, it is up to 150m in-depth, as hydrogen sulfide exists beneath and oxygen is absent. Sparseness of productive water could be associated with the fact that in comparison to earlier times, less fresh water flows into the Black Sea nowadays. During only one occasion, in July 1987, when a sewer exploded in Odessa, during three days, the sea became so contaminated that composition of pathogenic microbes in the sea exceeded 1000 times the admissible threshold (Newspaper "Komsomolskaya Pravda", 1988). The Black Sea salvation is a complex issue, which can be resolved in cooperation with all the coastal states.

In the end of the 20th century, fresh water problem gradually shifted from local crisis to global ecological problem. It turned out that all states on earth are economically bounded. It became obvious that all states shall put their lands and families straight, otherwise it is extremely difficult to resolve ecological problem on our planet.

Since the 70s (20th century), African states were the ones that experienced water deficit most of all: Mali, Ghana, Mauritius, Zambia, Chad, Niger, Senegal, etc. Though, progressive desertification is under way not only in Africa, but it also relates to other parts of the planet. Annually, on earth, 21 mln. ha of fertile lands become useless for agricultural production, while 6 mln. ha is added to deserts (Gigineishvili, 1988). This problem is mainly attributed to water due to man-induced actions and global climate warming.

In the 90s (20th century), about 80 states where 40 % of world population resides, already have experienced water deficit. Presently, 1/3 population lives in those countries, where water consumption is 10 % higher than water resources. In future, water demand will expand more and world population will face fresh water deficit. World Economic Forum report in Davos (2008) underlined majority states water demand has become more important than oil demand (Global Ecological Perspective 4).

Thus, fresh water deficit is one of the significant problems of present day. Based on the UN forecast, by 2025, water demand will have been increased by 40% and two third of mankind will live in severe drinking water deficit conditions ([Access to Water in Developing Countries, 2002](#)). In present ecological situation – global climate warming and progressive desertification – this problem will worsen more.

Based on UN data, 0,263 m³ fresh water resources fall at 1 square meter of land territory, while 7056 m³ of water - per capita. These indicators for Europe compound 0,318 and 3934 m³ correspondingly ([Babunashvili, Khutashvili, 2003](#)).

Presently, the world consumes 4,2 mln. km³ fresh water. Though, due to population growth, industry and agriculture development, water demand has increased and resulted in sharp decrease of water resources. The world suddenly found out that water is in deficit and this might become the main limiter of economic development, as well as reason for conflicts. In most countries, due to dry climate, it is impossible to develop agricultural crops without irrigation.

Volume of water resources in South Caucasus with three states: Azerbaijan, Armenia and Georgia is 141 km³ in whole. From this amount, annually, renewable water resources, that equal to the cumulative water flow from all rivers, consists of 91 km³, the rest 37 % of water resources is century-long storage of water (glaciers, water reservoir, lakes and bogs). Cumulative flow of all rivers incorporate 12 %-11,1 km³ water inflow from outside (from Turkey and Iran).

The icy waters at the mouths of the rivers feeding with beautiful mountain glaciers flow into the Black Sea warm waters at high speeds; the glaciers in nival zones are natural water accumulators and a certain type of water reservoirs with the water accumulated in them as ice. The glaciers give out this water in hot summer months when the demand for water is high. This water is useful in all respects as high-quality fresh drinking water and the feeding source for rivers.

The overall outflow of water from the given territory sums with the water outflow beyond region: via West Georgia into Black Sea in volume of 48,0 km³, via East Georgia into Russia (Caspian Sea) along river basins of Terek and Sulak in volume of 1,85 km³, via Azerbaijan into Caspian Sea – 19,77 km³. In total, the outflow volume of water totals to 69,62 km³.

Water resources are inconsistent. Recently, their expansion by 13,5 % has been observed in South Caucasus due to creation of water reservoir series with about 20 km³ water accumulated within.

Water availability per 1 km² area of the discussed territory is 484 thousand m³/km². Georgia is most provided with water with average 949 thousand m³ water falling on over 1 km² area. While in Armenia and Azerbaijan, water availability is 316 thousand m³ and 337 thousand m³ correspondingly.

The same regards to water availability per capita. In Georgia, 11,3 thousand m³ of water falls at per capita per year, Armenia and Azerbaijan is less provided with water resources, with 2,6 thousand m³ and 1,9 thousand m³ of water falling per capita per year correspondingly ([Babunashvili, Khutashvili, 2003](#); [Water Resources in Transcaucasus, 1988](#)).

Water resources are widely used in all sectors of agriculture of the given states. For population, needs, also energy, industry, irrigation, cattle-breeding and other purposes, water withdrawals are made from water basins and spilled into other places. Water objects are used also for water transport, fishing, sport, recreation, etc.

65 % of overall water loss is connected to its usage in agriculture, e.g. based on the water cadaster materials in 1985, water withdrawal for agricultural needs summed 25,2 km³, out of which 21,6 km³ from surface fountains, and 3,6 km³ from underground fountains; out of them, 4,6 km³ - in Georgia (including 3,9 km³ from surface and 0,7 km³ from underground fountains). Water withdrawal in Azerbaijan totaled 15,7 km³ (14,1 km³ from surface and 1,6 km³ from underground fountains). Water withdrawal in Armenia 4,9 km³ (3,6 km³ from surface and 1,3 km³ from underground fountains) ([Water Resources in Transcaucasus, 1988](#)).

Significant part of the region's water resources (about 70%) is used in agriculture. Large quantity of water in the region is consumed by industry, partially by power sector. For example, 8 heat and 60 hydraulic electric stations operate in Georgia presently. They produce about 15 billion kw hour electric power that uses about 35 km³ water. Similar condition appears in Azerbaijan, where total production in 1980 reached 17 billion kw hour with the usage of about 40 km³ water. Irrigation and drainage areas expanded as well.

3. Discussion

It should be noted that the dynamics of the Alpine and Caucasian glaciers have similar descending trend having started at the end of the XIX century. In the 1960-70s, the glaciers were shifted forward on them when the air temperature fell to 0,4°C. At present, on the background of modern global warming, when the natural zones of Georgia have been elevated by 100-150 m, the population has started to cultivate subalpine and alpine zones meaning a stronger anthropogenic load of glaciers. In the XXI century, as per the existing prognosis, by 2040 and 2050, the area of glaciers will decrease by 20 % and 40 % and result in the reduction of the water reserves in the glaciers by 10 % and 30 %, respectively. The present movement of mountain glaciers is closely linked to the fresh water deficit problem (Mumladze et al., 2008).

In relation to economy growth and population expansion, water resource consumption in future will sharply increase, which will bring us to water loss. It means that systematic decrease of water content of the region is mainly induced by human activity. That's why, implementation of various measures for solving the problem of rational usage and protection of water resources is on the agenda.

In order to eradicate disparities in water supply, most countries are working on development project re territorial re-distribution of river outflow. But, artificial re-distribution of water resources will break the natural balance. Along with material and physical expenses, it is also impossible to determine what changes water withdrawal from one basin and its spillage into another basin will bring. Water shall not be withdrawn from Black Sea Basin Rivers, as it will result in reduction of fresh water inflow into the sea and water productive layer correspondingly, also will break the essential mechanism of sediment runoff supply to coastal zone. In the basin, where water re-discharge takes place, coastal zone will wash-off and get destructed and ground water logging will occur.

At present, the field of consumption of water resources of Georgia faces many problems, including inadequate registration of water consumption, severe deficit of water treatment works, problems with realizing the water protection measures, great water losses with waterworks facilities, etc. (Basilashvili, Begalishvili, 2012).

The optimal use of water resources in Georgia needs the registration of water consumption and waste waters, their control and management with modern techniques.

The basic problem for water management specialists is data receipt on rivers' water regime, connection between the runoff and loss. That's why, hydrological observations shall be improved in zones of runoff formation, taking into account water withdrawal and water-spill; also automated network of monitoring shall be provided.

Future growth of water consumption shall be grounded on increased level of river flow monitoring via construction of regulating water reservoirs.

Standards shall be introduced for rational utilization of water resources; these standards shall be recorded and controlled. In relation to this, it is required to increase funding of scientific-research and design works in the sphere of water consumption.

At the same time, water shall be saved everywhere and its losses monitored with all possible measures. The following measures are necessary to liquidate the water losses: technical perfection of the irrigation systems, including the restructuring of the old systems and building new faultless systems; introduction of modern progressive irrigation methods (overhead, drip, underground irrigation, etc.); use of the waste waters from industrial enterprises and animal farms for irrigation; changing the irrigation standards in connection to the introduction of new irrigation methods. Advocacy shall be run regularly with the aim to reduce water contamination. For decreasing water losses in water management systems, tapping network shall be rehabilitated and irrigation channels reconstructed. Best measure to protect and save water resources is rational usage of this resource. For that, in industry and other enterprises, it is needed to practice recycling water supply, raise coefficient of utilization of technical facilities for multiple recycling of water and widely introduce progressive methods of multiple utilization of water in enterprises.

In the cities the water pipelines and sewerage systems are to be modernized and extended, the population should use water sparingly; the city waste waters should be treated and used by industries. The main thing is the improvement of the technical and sanitary state of the water pipe headworks and protection of the zones of springs (Jabnidze et al., 2010).

At present, as the number of population and economic objects increases, the rivers are polluted with industrial and waste waters, as well as pesticides and fertilizers used in agriculture and there is a severe deficit of water treatment works. Such objects are necessary to construct. In agriculture, it is required to expand the network of sprinklers and introduce dripping irrigation. For irrigation, water outflow from cattle-breeding farms shall be used.

Important is also problem of stimulation of atmospheric precipitations for expansion of incoming water balance. Results of earlier conducted work in river basins of Georgia and Lake Sevan in Armenia on precipitation expansion (1970–1990) by Caucasus Hydro-Meteorological Institute (present Hydro-Meteorological Institute of Georgian Technical Institute) gave positive results. Based on artificial impact, precipitations increased by 10–15 % on convective clouds; this is a good basis for restoring the mentioned works and especially needed in present climate warming conditions, when evaporation increases, soil becomes dry and desertification occurs (Begalishvili et al., 2002).

4. Recommendations and Conclusions

In order to protect water resources and avoid their contamination:

- Sanitary zones of protection of water sources, springs and ponds shall be picked out;
- Effective cleansing equipment shall be constructed;
- Irrigation channels, water supply systems and sewage networks shall be modernized.

Often, in different states, data on water resources are based on previous century materials and don't reflect those changes re river flow volume and other hydrological parameters of basins that could easily have arisen in recent decade due to climate change on earth. Thus, statistics on water resources appear improper and sometimes methodical instructions on water consumption are lacking (Sharashidze et al., 2010).

Growing demand for water and upcoming problems of water deficit linked to growth of city population, development of agriculture sectors, also climate change requires following actions to be undertaken:

- Water strategy shall be developed;
- State water fond, water cadaster and water-management balances shall be created;
- Complex schemes for water resource utilization shall be developed and protected based on reservoir management principles;
- Rational standards for water consumption shall be developed and precise accounting made, also control exerted on water utilization in all sectors of economy.

For implementation of all these measures, complex monitoring is needed. State organizations have to introduce economic tools for stimulating of water resource economy and decrease the level of contamination of water medium. Besides, it is quite important to make commercial and do the promotional work for increasing the ecological knowledge of population regarding the issues on water resource as basic mean of living.

People have to change their conception and attitude towards water, soil, forest and air. All have to understand that nothing is inexhaustible and inconsistent in this world. Everything needs special care and expedient utilization.

In the end, it should be noted that in South Caucasus, Georgia possesses significant resources of ecologically sound water and gives opportunity for stable water supply of population and agriculture inside the country, also has the potential of export of high quality drinking water.

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Геоэкологическая оценка водных ресурсов и пути оптимального водопользования

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Аннотация. Приводится анализ основных показателей природного потенциала и использования водных ресурсов Мира и на Южном Кавказе, рассматриваются глобальные проблемы их состояния. Отмечается, что ресурсы экологически чистой пресной воды – один из важнейших факторов устойчивого развития экономики страны. В течение многовековой истории, до последних десятилетий, люди считали, что вода, воздух, лес и почва элементы природы, которых можно использовать в любом количестве. Но, из-за увеличения населения, развития промышленности и сельского хозяйства увеличилась водопотребность, что вызвало значительное уменьшение водных ресурсов.

На фоне современного глобального потепления климата и увеличения антропогенного воздействия происходит интенсивное загрязнение водных ресурсов, что очень отрицательно сказывается на развитии экономики страны и здоровья людей. Дефицит воды может стать и причиной конфликтов. Поэтому на данном этапе остро стоит вопрос для решения проблемы рационального использования и охраны водных ресурсов. Дальнейший рост водопотребления должен основываться на повышении степени регулирования речного стока путём строительства регулирующих водохранилищ, что позволит резко повысить коэффициент использования стока. В сельском хозяйстве необходимо расширить сеть дождевальных установок и внедрить в практику капельное орошение. Немаловажным является проблема стимулирования атмосферных осадков для увеличения приходной части водного баланса. Кроме этого, в работе рекомендован комплекс разных мероприятий по улучшению уровня управления водными ресурсами.

Ключевые слова: сток воды, рациональное использование, управление водными ресурсами.

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