Mobilization strategy to overcome global crisis of water consumption

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Abstract. Today, the global water consumption crisis is one of the main threats that can disrupt socio-economic and environmental conditions of life of the majority of the world’s population. The water consumption mobilization strategy is based on the idea of increasing the available water resources. The main direction for the implementation of this strategy is the construction of anti-rivers – the systems for inter-basin (interregional) water resources redistribution. Anti-rivers are intended for controlled redistribution of water resources from regions with their catastrophic excess to regions with their critical shortage. The creation of anti-rivers, taking into account the requirements of environmental safety, will form large-scale managed natural-engineering systems and implement the principle of sustainable development adopted by the United Nations. The aim of the article is to substantiate a new methodological approach to address the problem, where the implementation of this approach can prevent large-scale humanitarian and environmental disasters expected in the coming years.

1. Introduction

The “global water consumption crisis” problem revealed itself as a result of simultaneous analysis of two global tendencies. The first one is an increase in the total amount of water consumption caused by the growing world population and the expansion of the production sphere. The second one is a reduction in the global fresh water resources that are used to meet this need. In a generalized form, the phenomenon of the global water consumption crisis is graphically illustrated by the two trends reflecting the tendencies described above. Their crossing, which, according to various sources, will occur during the period from 2025 to 2045 [1, 2], is seen as the emergence of the “global water consumption crisis”. Such a simplified vision of the problem is purely speculative and does not reflect the existing situation. In reality, the global water consumption crisis is a long process involving several different phases. Its intensive development is already taking place. The aim of the article is to substantiate a new methodological approach to address the problem, where the implementation of this approach can prevent large-scale humanitarian and environmental disasters expected in the coming years.
2. General patterns of the crisis extension
Available fresh water resources are unevenly distributed. Their disastrous shortage has long been existing in several parts of the world, much before the predicted global crisis. The situation in such areas can be described as “regional water consumption crises” [3]. In some cases, they were caused by increased water consumption and water pollution [4]. In other cases, water scarcity was due to climate phenomena – disastrous droughts, the frequency of which is likely to increase in the near future because of the current global climate change.

Socio-economic and environmental consequences of the crises in the field of water consumption cannot be viewed in isolation from regional food shortage problems. Droughts and gradual depletion of water resources reduce the volume of agricultural food products and their accessibility to people, which affects political and geopolitical processes. The amount of necessary humanitarian assistance and the size of the crisis-affected territories that need it are increasing. Mass migration of people from disadvantaged regions is increasing too. In some cases, the scarcity of water resources causes interstate, interethnic and other armed conflicts [3].

The scarcity of water resources also causes degradation of natural ecosystems. Sometimes people, by increasing their own water consumption, deprive natural ecosystems of water and, subsequently, experience a negative impact of their degradation themselves. The most famous is the ecological catastrophe in the Aral Sea basin [2, 4] that was caused by the intensive development of irrigation systems without due regard for the environmental impact of such activity. There is also an ecological catastrophe at Lake Chad in North Africa connected with the water withdrawal for irrigation from the rivers feeding it. Over the past 40 years, the area of the lake has shrunk from 25,000 km² to 1,359 km², and its depth – from 10 m to 1-2 m. About 50% of the remaining water area of Lake Chad has grown over. Soil salinization began in its basin, which caused crop failure. Combined with the disappearance of fisheries, it has caused the impoverishment of the local population. So far, half of the wetlands of Europe and North America have disappeared, mainly due to the increased industrial water use. These areas used to be a habitat for many species of animals and plants, including protected ones. Thus, the extension of the global water consumption crisis requires a coordinated solution of the problems of humanitarian and environmental safety.

The analysis of available materials shows that the general patterns of the extension of the crisis in the field of water consumption are [3]:
- emergence and extension of the regional water consumption crises in various parts of the world, which increasingly affect global socio-economic, demographic and migratory processes;
- acute environmental problems that arise for these reasons;
- intensification of negative phenomena caused by the scarcity of water resources as a result of the global climate change.

What can change in the life of humanity upon coming of the “global water consumption crisis” predicted for 2025-2045? The nature of the negative phenomena listed above will remain the same. The water consumption crises themselves will continue to be regional – an acute water deficit will be observed only in certain parts of the world. Along with them, there will be regions that will have sufficient water resources and will be able to provide humanitarian assistance. However, at some point, it will not be enough for people to live and to ensure an acceptable state of the environment in water-stressed regions. This will be the beginning of the global water consumption crisis.

With the existing ways to address the problem, further deterioration of the situation is inevitable, leading to a geopolitical and global ecological collapse. In order to avoid this scenario, the world community must fundamentally change its vision of ways to resolve the problem of the growing deficit right now.

3. Basic water consumption strategies and their role in the extension of the crisis
Throughout the period of the human civilization existence, including the present-day stage, the so-called “extensive water consumption” dominated. This development strategy involved meeting the growing human water needs by increasing the amount of its withdrawal from accessible sources (rivers, lakes,
underground aquifers). In all cases, the development of the extensive water consumption, due to the limited available water resources, eventually creates conditions for the water deficit and the need to ration the water consumption, i.e. to control the release of a certain amount of water for the needs of individuals or their associations (communities, etc.). At the current stage, it is this water consumption strategy that increases the frequency of the regional crises and their deepening, creating a threat of a similar global phenomenon. Therefore, prevention of the global water consumption crisis is impossible without a refusal or at least limitation of the traditional extensive water consumption. However, the growing water needs of humanity require immediate satisfaction. For this reason, the only possible way to solve the problem is to develop other strategies.

Some experts believe that the development of the “intensive water consumption” can be the only alternative to the extensive water consumption. This strategy involves a wide introduction of water-saving technologies that allow to use water resources sparingly and to protect water bodies from pollution [2]. Ideally, the strategy of intensive water consumption should be based on rational water consumption, economy and regeneration, creation of a sustainable balance between water demand and available reserves. The “concept of virtual water trade” has particular importance among this group of methods [6]. Its goal is to minimize water consumption in regions that experience water shortages, by importing “water-intensive products” (products manufactured with the use of a significant amount of water) from countries that do not experience the deficit. It is noteworthy that the idea of replacing sales of water with supplies of water-intensive products has adherents in countries that consider themselves as potential producers and suppliers of virtual water. In many cases, countries experiencing acute water shortages have underdeveloped economies. They do not have adequate funding to import water-intensive products in the amount that can cover the deficit in the field of water consumption. Thus, the virtual water trade or the water-intensive products supplies in the form of humanitarian aid, given the continuing human population growth, can only slow down the development of crises and moderate their most negative consequences.

There can be a third scenario for the development of the water consumption sector, based on increasing the accessibility of water resources that currently cannot be used for various reasons. It should be recalled that fresh water resources available for people now account for no more than 0.3% of the Earth’s water supplies. This approach to address the global water consumption crisis can be described as the “mobilization strategy”. First of all, the implementation of this strategy implies the construction of engineering and technical systems for inter-basin (inter-regional) redistribution of water resources. When it is impossible to solve the problem of water scarcity by inter-basin redistribution of the river flow, the water consumption mobilization strategy can be based on establishment of systems for the industrial desalination of seawater. There are other possible solutions, for example, towing of Antarctic icebergs [7]. All these actions will require significant financial costs and time. Therefore, mobilization strategy projects should be worked out and implemented now, without waiting for the global water consumption crisis to come. Some countries are already making active efforts in this area. However, the stereotypes of “ecological thinking” [8, 9] impede the systemic organization of the mobilization strategy. Many experts in this field are ready to deplore the death of ecosystems because of the water scarcity, but strongly oppose displacement of a part of the river flow. This position remains unchanged even with the regular increase in the water content of some rivers caused by global climate change [10, 11]. Floods that cause not only huge economic, but also environmental damage are considered as inevitable natural phenomena. At the same time, the construction of hydraulic systems that drain excess water is seen as an “environmental crime”. According to such views, it is better to make heroic efforts to transfer the excess water after floods into the world oceans than to use these water resources to save natural objects that need them. Attention should be drawn to the fundamental difference between the strategies of extensive and mobilization water consumption. In the first case, it is a continuous increase in the consumption of available water resources, in the second one it is a controlled expansion of the available water resources. It should also be noted that the authors of the article do not consider any of the strategies for the development of the sphere of water consumption described above as the only one acceptable, rejecting the others. It is difficult to imagine that in the near future humanity will universally reject the
strategy of extensive water consumption. Despite the increasing environmental risks, the development of the infrastructure of many regions of the world goes exactly in this direction. The role of the intensive water consumption strategy also significantly increases. In particular, this applies to economically developed countries that have the resources to introduce water-saving technologies and to import water-intensive products.

4. Basic principles of organization of inter-basin (inter-regional) redistribution of water resources

We suggest using the term “anti-river” to refer to any hydraulic engineering system that performs this function and the term “water logistics facilities” to refer to facilities for water transportation [12, 13]. The organization of anti-rivers can cause large-scale environmental changes. Maximum environmental safety in implementing the water consumption mobilization strategy based on the construction of anti-rivers requires compliance with the following principles:

1. An environmentally oriented assessment of the possibility of exporting water resources that should be based on the determination of their surplus stocks, the withdrawal of which will not have negative environmental consequences, but rather will preserve the favorable situation in the environment. First of all, it is the diversion of flood waters, the runoff of which can cause serious economic damage and worsen the ecological situation. This amount of water resources displacement of which to another region has positive consequences is referred to as “mobile water resources” [14]. It should be determined on the basis of special hydrological studies, taking into account the long-term trends in the river flow.

A necessary condition for organizing the export of mobile water resources is the possibility of their temporary deposit in the amount necessary to ensure uninterrupted supplies that are sufficient to meet the needs of the importing regions. It is reasonable to use already existing reservoirs as such primary depositories, because one of the functions of these reservoirs is the regulation of a river flow, including prevention of harmful effects of excess water during floods.

To assess the feasibility of organizing the export/import of water, it is necessary to take into account all potential deposits of mobile water resources in the donor region, determine the trends of their capacity changes, and work out “sketch maps of water resources logistics” [13] that reflect possible ways of laying routes of water resources logistics and the composition of their facilities.

2. Feasibility of the need for interregional water transportation. The organization of anti-rivers is justified only if the prospect of their long-term operation is beyond doubt. This issue must be considered from several perspectives simultaneously. For example, the expediency of construction of hydraulic engineering systems for inter-regional transportation of mobile water resources may not only be meant to obtain economic benefits from their sale, but also to prevent damage caused by periodic catastrophic floods. In addition, geopolitical factors can play a significant role. A country exporting mobile water resources significantly strengthens its position in the region to which it supplies the resources.

At the same time, it is necessary to have reasonable confidence that the regional crisis of water consumption, for the addressing of which this interregional water transportation is planned, cannot be resolved in any other, more economical way (for example, by construction of sea water desalting units). It should be borne in mind that water is indispensable for the existence of human, therefore, the rationale for the reasonability of water resources must be based not only on short-term economic benefits and winning solution of current geopolitical issues, but on consideration of the possibility of preventing humanitarian and environmental disasters in the future.

3. Integrated approach to the development of anti-river projects. The implementation of this principle is twofold. Firstly, it is necessary to use all existing hydraulic engineering systems when seeking water transportation routes. Secondly, laying of water communications for water transportation can be simultaneously used for hydro-energetic purposes. An example is the All-American Canal, a large-scale multifunctional irrigation and hydropower system created in 1928-1942 [15]. It is responsible for 90% of the Colorado (California) river flow, used to meet the needs of water consumers in other regions of the United States. Simultaneously, the flow of the transported water passes through a hydroelectric power chain with a total capacity of 58 MW. Compliance with the principle of the integrated approach
can significantly improve the profitability and relevance of the organization of interregional water transportation.

4. Ensuring sustainable water supply. This principle can be put into practice only if facilities of water resource logistics ensure a sufficient level of water transportation independence from fluctuations in the hydrological regime of rivers that are donors of mobile water resources. To do this, the simplest route of water resource logistics must include the following set of functionally related facilities [13]:

- hydraulic engineering structures that function as primary depositories of mobile water resources and perform the function of their controlled release into transporting hydraulic engineering structures;
- transporting hydraulic engineering structures (canals, water conduits, etc.), providing the transportation of water between depositories of mobile water resources;
- intermediate depositories of mobile water resources (their creation, as well as creation of primary depositories, increases the stability of the mobile water resources export/import systems);
- terminal depositories of mobile water resources in the importing country, from which water resources are distributed between their end users (domestic water supply systems, irrigation systems, etc.);
- hydraulic engineering equipment of water transport infrastructure (floodgates, etc.) and hydroelectric power facilities connected to the route of water resource logistics.

In many cases, there may be several options for such a scheme, and it is necessary to choose a more economical and environmentally safe option. It should be noted that some publications dealing with the problems of interregional water resources transportation, without any evidence, state that such projects have no prospects, since the alleged crossing of watersheds makes them economically unjustified. In this regard, it should also be noted that in the modern world, there are no large watersheds (except for Antarctica and Greenland) without already laid transport or conveying communications. As the history of the network of oil and gas pipelines shows, if there is a demand for a product that can be transported by special engineering systems, their creation is only a matter of time. They can be laid not only through mountain ranges, but also through marine areas. For example, the water supply of Hong Kong and Singapore is carried out in this way [14].

5. Consideration of long-term prospects for the development of water resource logistics.

The configuration of interregional water transportation routes may be more complicated than the system of consecutive water supply logistics facilities discussed above. For example, intermediate storage depositories of mobile water resources can simultaneously receive water from several donors or supply it to several recipients. It is also possible that one recipient is fuelled by several depositories. Finally, several intermediate depositories can be interconnected for greater sustainability of the water supply. This expands the possibilities for redistribution of excess water or compensation for its shortage during transportation by one of the routes connecting the donor of water resources and the recipient. For the convenience of describing the routes of water resource logistics, it is expedient to distinguish their following types:

- water resource logistics chain is a way of phased transportation of water, including one of each type of water resource logistics facilities;
- water resource logistics complex is a set of water resource logistics facilities that allows several options for water transportation from a specific donor of mobile water resources to a specific recipient;
- interregional water resource logistic network is a set of functionally interconnected water resource logistic chains through which the redistribution of water resources between different regions is carried out;
- continental water resource logistics network is a set of functionally interconnected water resource logistic chains that provide controlled redistribution of water within one continent.

The material basis for the formation of water resource logistics complexes and networks can arise only from a long and multi-stage process referred to as the “bottom-up approach” [3]. It consists in creating separate facilities that are originally intended for the subsequent integration into a single system. In the case under consideration, this implies creating routes of water supply logistics that are optimal
both for immediate benefits and for a long-term development through the inclusion in more extensive systems.

6. Assessment of the possibility of concluding international agreements and developing terms thereof.
This problem is not limited to the obvious need to reach agreement between an exporter and importer of mobile water resources, as well as with transit countries.

The issue of the ownership of mobile water resources is a separate problem. Unlike oil, in many cases freshwater resources cannot be unequivocally considered as the property of a particular public entity, likening them to a kind of “water deposits”. That is why the solution of the problem mentioned above is not only (and not even primarily) an issue of diplomacy, but an issue of water resource logistics. There are several reasons for this.

Firstly, large river systems are often formed on the territory of several state entities. An extensive set of international instruments regulating the transboundary use of river basins has already been developed [16, 17]. However, it is impossible to use it in the sphere of interregional transportation of water resources. Relations concerning the use of rivers flowing through the territories of various states have evolved over many centuries. An anti-river paved across state borders is an artificially created natural and man-made object establishing new relationships [18].

Secondly, any accumulations of water are fragments of the global hydrological cycle (water cycle). And, to some extent, like the atmosphere, they can be considered as the property of humanity as a whole. For this reason, activities that can have a significant impact on the global processes must be timely adjusted at the international level.

7. The water resource logistics structure should be designed and operated as a unified managed natural-engineering system.
The natural-engineering system is any set of functionally interconnected natural, natural-anthropogenic and anthropogenic water bodies [3]. Management of the state of the natural-engineering system is achieved by assigning to one of its elements the function of an "environmental regulator". For example, some hydroelectric power stations are playing this role now [19]. Depositories of mobile water resources and water communications with a regulated flow of water can also be used as regional environmental regulators. The functioning of chains, complexes and networks of water resource logistics can serve as an environmental regulator of interregional (continental) scale.

Thus, the long-term development of water resource logistics must be regarded as the formation of hierarchies of managed natural-engineering systems that ensure the practical implementation of the UN sustainable development principle. [3, 20].

8. Conclusion
The only feasible way to prevent the “global water consumption crisis” is the prioritized development of the mobilization strategy in this area. In order to do that, it is necessary:

1. To develop possible sketch maps of water resource logistics.
2. To assess the possibilities of existing hydraulic engineering systems and facilities as potential components of anti-rivers, and, if appropriate, develop design-layout solutions necessary to give them these functions.
3. To create interstate and national legal norms for the creation and operation of anti-rivers.
4. To develop water resource logistics structures as regulators of managed natural-engineering systems ensuring the stability of the socio-economic situation and environmental safety.
5. To organize work on the formation of a positive ecological image of anti-rivers in the minds of the community, professionals and public.

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