“Improvement of the water resources management system at the territorial level”

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IMPROVEMENT OF THE WATER RESOURCES MANAGEMENT SYSTEM AT THE TERRITORIAL LEVEL

Abstract

The article is devoted to the improvement of the water resources management system at the territorial level. The article covers problems in different countries of the world, which are described in the water supply with an increase in the population of a harsh climate. Today, the existing trend shows that about two-thirds of forests and wetlands have been lost or degraded since the early 20th century, the soil was destroyed and deteriorated in quality. These trends predict floods and droughts, which in turn affects our ability to adapt to climate change. The analysis of the literature on the peculiarities of determining the main elements of influence on the use of water resources in the world is carried out. The article used a dialectical method, which is due to the need for analysis and generalization of certain aspects of scientific knowledge that analyze the availability of water resources in different parts of the world. Structural-functional analysis of the principle of systematic study of phenomena and processes is applied. With the help of the system-analytical method, the maintenance of the territories (areas) of Ukraine by local water resources is calculated, on average, per year, this m3 per person, based on the resource of surface water, as well as the exploration and catchment of groundwater. The decomposition of criteria for assessing the effectiveness of water resources management at the territorial level based on the integral territorial index is developed. According to the numerical value of the integrated territorial efficiency index, it is proposed to combine regions into homogeneous groups depending on the proximity or distance from the average value of this index.

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INTRODUCTION

In order to improve the water resources management system at the territorial level, we need to conduct a detailed analysis of available resources and potential, and to develop new solutions to address the problem of lack of drinking water, this applies both to Ukraine and the world as a whole. The problems associated with water supply increase every year due to population growth, as well as to climate change (Zeitoun, 2011).

An urgent need to reduce the burden on nature caused by an increased water demand, the task of countries to meet this requirement in such a way as not to exacerbate the negative impact on the ecosystems of the area, is actualizing. Today, the existing trend indicates that about two-thirds of the forests and wetlands have been lost or degraded since the early 20th century, the soil has been destroyed and deteriorated by its quality. Since the 1990s, water pollution has worsened in almost all the rivers of Africa, Asia and Latin America (UNESCO, 2015). These trends predict floods and droughts, which in turn affects our ability to adapt to climate change. It should be borne in mind that lack of water can lead to civil unrest, mass migration and even conflicts within and between countries. The United Nations, in its 2018 report, recognized one of the priority development tasks of 2030 – the importance of providing water resources in the world (UNEP, 2013). The realization of this goal can ensure food security in the area and reduce the risk of natural disasters.

Over the centuries, surface and groundwater have been the source of water supply for agriculture, urban and industrial consumers (UNESCO, The United Nations World Water Development Report 4, 2012). Besides the fact that the rivers are a source for hydropower, they are also involved in logistics as an inexpensive way of transporting goods. Water resources provide people with recreational opportunities and are a source of water for wildlife and their habitat (UNESCO-IHP, 2012a). In addition to the economic benefits that come from rivers and reservoirs, the aesthetic beauty of most natural rivers has made land adjacent to them attractive sites for recreational development.

The study of the provision of water resources in the territories provides a more holistic approach to the use of resources, and is also vital to the long-term peace and prosperity of any country. Achievements in agricultural production mean that farmers use more chemical fertilizers and pesticides, which contribute to increasing the level of water pollution. The consequences of biological and chemical pollution, changes in the hydrological regime of rivers and lakes and the decline of groundwater levels can be terrible. Rivers become supersaturated nutrients and overgrown with water weeds. This destruction or degradation of ecosystems poses serious risks to many communities that depend on natural resources. Biodiversity is lost, and fisheries are falling. In addition, more and more people are endangered by diseases transmitted through water. Even very optimistic forecasts suggest that in the near future, due to illnesses transmitted with water, people will die from 2 to 5 million people annually, and by 2030 mortality rates can reach 59-139 million people.

1. THEORETICAL BASIS

The most often used formulation is the lack of access to large quantities of water at national scale (EC, 2000). The algorithm for calculating this indicator is simple: if we know how much water is needed to meet human needs, the lack of human access to water can serve as a measure of deficit. The most widely used measure is the Falkenmark indicator or the water stress index (Falkenmark, Lundquist, & Widstrand, 1989). They suggested counting 1,700 m^3 of renewable water per capita per year as a threshold based on estimates of water needs in the sectors of the economy, agriculture, industry, energy, and the environment. Countries whose renewable sources of water cannot support this figure relate to those experiencing water stress. If the figure is reduced by 1,000 m^3, the country feels water shortage, below 500 m^3 says absolute shortage.

Ohlsson (1998, 1999) changed the Falkenmark indicator, referring to the "adaptive capacity" of the territories that provides the ability to adapt to the lack of water through economic, technological or other ways. The researcher used the UNDP Human Development Index to measure the Falkenmark index and called it "Social Water Stress Index". The main advantages that make this indicator almost unbeatable are the following:

a) data accessibility;

b) its value is comprehensible and easy to prove with the help of statistical data.

The disadvantages of this indicator are:

a) the ability of countries to influence the reflection of the real picture due to lack of water resources within their national data;

b) the indicator does not take into account the availability of infrastructure that affects the availability of water resources for users;

c) simple thresholds do not reflect changes in water demand, such as lifestyles, climate, and the like.

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Some authors focused on a more accurate assessment of water demand than on fixed demand, which is calculated in accordance with the requirements of a person's national scale, taking into account the annual rate of water renewal, as well as the annual demand for water. We distinguish researchers who have done a great job for several decades, namely the State Hydrological Institute in St. Petersburg (Russia), headed by Professor Igor Shiklomanov. Their research differs from most published global analyses of demand and availability of water resources over the last 15 years of the year (Shiklomanov, 1991). The global assessment of water resources (Raskin, Gleick, Kirshen, Pontius, & Strzepek, 1997) uses Shiklomanov's basic evidence of water availability in conjunction with the Water Resources Vulnerability Index of the United Nations Commission on Sustainable Development Nations. These data indicate that there is not enough water in the country if the annual water intake is 20-40% of the annual supply, data on water scarcity are indicated if this figure exceeds 40%.

Alcamo, Henrichs, and Rosch (2000), Alcamo, Doll, Kaspar, and Siebert (1997) suggest the use of a critical water supply coefficient as a relation of water dispensing for human use to common renewable water resources. The ratio is calculated using the global WaterGap model and used to analyze water scarcity (Cosgrove & Rijsberman, 2000a, 2000b). A similar definition is used (Vorosmarty, 2000) with colleagues who use climatic models to assess water scarcity (Montaigne, 2002), which uses Vorosmarty analysis.

The International Water Management Institute (IWMI) takes into account the share of renewable water available to human needs (taking into account the existing water infrastructure) (Seckler, Amarasinghe, Molden, de Silva, & Barker, 1998). The IWMI analysis is based on consumption (evapotranspiration) and the water balance, which takes into account the return flows, that is (Seckler et al., 1998), analyzes the potential of water resources nationally, which can be adapted primarily by assessing the potential development of infrastructure and improving the efficiency of irrigation by improving water management policies in the area. However, the disadvantage of the IWMI model is its complexity in estimating. Unlike per capita figures and even more simple models of supply and demand, this model is not available to the general public.

The Water Poverty Index (Sullivan et al., 2003) has developed a disaggregated approach that assesses the availability of water resources for households (physical accessibility) and territories (infrastructure for service). The Water Poverty Index developed reflects both the physical availability of water resources and the degree of infrastructure development in which people serve water resources and maintain environmental integrity. The poverty index in the field of water includes components of index clusters in five dimensions: access to water; quantity of water, quality and variability; use of water for household, food and grocery purposes; water resources management; environmental aspects. The disadvantage of this index is its complexity, and is applied correctly not in the whole country, but locally in a specific region.

Technical and technological aspects of water resources management in river basins, environmental protection and ecological and economic aspects of environmental management, and water use are defined in the work (The official web site of the Verkhovna Rada of Ukraine, 2012). Unfortunately, the issue of public water management is considered in the context of environmental and economic problems and in isolation from theoretical foundations of modern government.

Holian (2009) notes in his work that preservation and effective use of the natural potential of the water fund of Ukraine needs regulation of water management and rational allocation of available water resources in order to satisfy the interests of all stakeholders. State intervention in this area is urgent and inevitable at all levels of public administration – national, regional and local.

The functions of water in a modern society are multifaceted, the failure to consider their role at the national level can lead to threats at national level, which already takes place in Ukraine and manifests itself through aspects such as water shortages, especially drinking water, in selected regions; flooding territories and settlements; catastrophic floods in individual regions, constant progressive deterioration in surface and groundwater quality prevailing of the most river basins, water supply to the temporarily occupied territories of Crimea and Donbas (Ivanova, 2011).

Further disclosure of the methodological principles of water supply management at the territorial level, which provides an understanding of the system and mechanism of the state management, is urgent in solving this problem. It is clear that a specially designed mechanism of the water resources security system must be effective and efficient, aimed at achieving certain strategic goals and objectives in the field of public water management, taking into account world achievements.

2. RESULTS

According to the Food and Agriculture Organization of the United Nations (FAO), 9-14 thousand km^3 of water are available to mankind, that is, only 0.001% of all water resources, of which it takes about 3.6 thousand km^3. Almost 2.4 are needed for ecological balance in the system of river basins and lakes. Thus, in a circle you can enter a rather limited amount.

In addition, according to UNESCO, during the last century, the use of water resources on a planetary scale has increased significantly (Table 1), which adversely affects both the quantitative and qualitative characteristics of water bodies (World Water Assessment Programme (WWAP), 2012).

Table 1. The dynamics of water use in the world by years

Source: According to UNESCO (UNESCO-IHP, 2012a).

Sector	1900	1950	2000	2015	2025 (forecast)
Population, billions of people	1600	2,542	6,181	7,113	7,877
Irrigated area, billions of hectares	47.3	101	264	288	329
Agriculture, km³ per year	513	1,080	2,605	2,817	3,189
Industry, km³ per year	21.5	86.7	384	472	607
Communal and domestic needs, km³ per year	43.7	204	776	908	1170
Others, km³ per year	0.3	11.1	208	235	269
Total, km³ per year	579	1,382	3,973	4,431	5,235

As a result of this, and under the influence of a set of other factors, a significant part of the population of the Earth is experiencing a shortage of water resources. Statistics show that 1.7 billion people live in areas where the water availability is 1,000 m^3 or less. According to the World Commission on Water for the 21st century, 31 countries, most of which are still developing, suffer from a lack of water, and by 2050 they could become 55 (Ministerial Declaration of The Hague on Water Security in the 21st century, 2010). Thus, the area of water deficit areas is increasing.

Using UN data (UNW-DPC, UNESCO-IHP and BM, 2009) on the availability of water per capita in the context of public entities, we divided the countries were divided into three groups: 1 – with high availability – more than 3,000 m^3; 2 – with limited – 3,000-1,000 m^3; 3 – with "water hunger" – less than 1,000 m^3.

To study the water scarcity, research was conducted by the International Water Management Institute, which developed the Water Stress Indicator (WSI) (see Appendix A, Table A1).

This indicator characterizes the level of consumption of fresh water from the point of view of environmental norms. It is assumed that approximately 20-50% of the annual runoff of rivers in different basins should be kept in freshwater ecosystems in order to maintain them in a stable condition. This is hardly possible in many countries of Asia and North Africa, in parts of Australia, North America and Europe. More than 1.4 billion people are currently living in river basins with high ecological stresses on water resources. This indicator will increase as water intake due to population growth.

The data show that in many regions the demand for water consumption is already substantially higher than the possibility of its recovery and, accordingly, supply, which is a direct threat to water security. In a large number of countries, water has already become a deterrent to economic growth. For example, according to a report by the United Nations Public Information Department, the low rainfall intensity in Ethiopia affects the reduction of the country's economic rise by more than 30% (United Nations Department of Public Information, 2011).

The InVenture Company tried to combine water issues with financial research to evaluate investment-attractive regional markets for investing in the production and supply of fresh water in terms

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Source: Compiled by the authors.

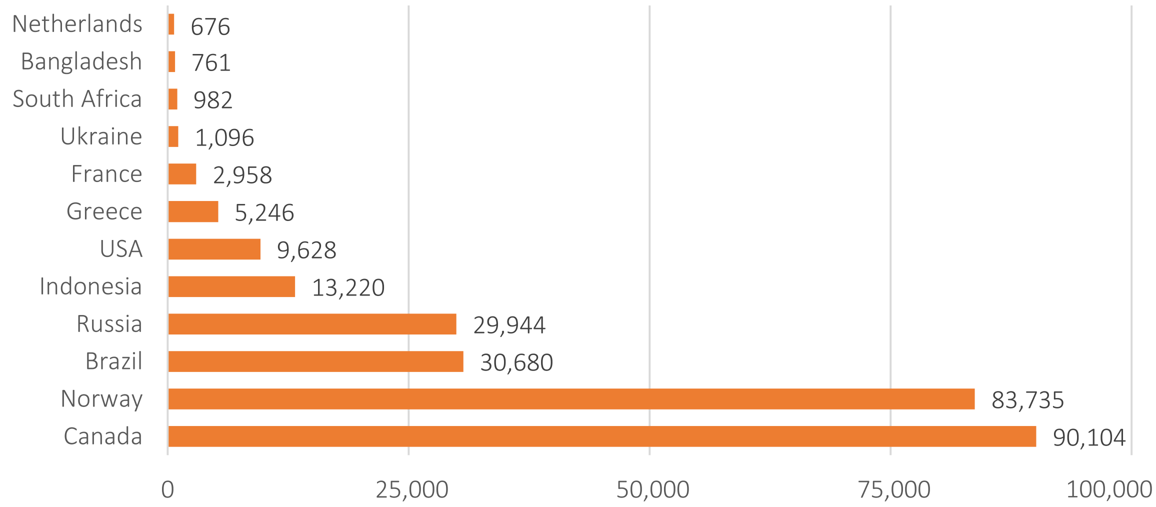

Figure 1. Resources of fresh water in different countries on average per person, м^3

of water availability and solvency. The InVenture Water Index combines four indicators that characterize the region's appeal for the development of water supply systems: renewable inland fresh water per capita, the dynamics of change in renewable inland fresh water resources, the ratio of consumed and renewable water resources, as well as GDP per capita. It should be noted that these indicators are not an investment call, because they do not take into account many factors, ranging from regional features of access to natural resources, and ending with individual elements of the investment climate of countries. United Arab Emirates, Qatar, Bahrain and others are among the most promising countries worth attention of investors (see Appendix A, Table A2).

Today, the annual turnover of the global fresh water market is estimated at around USD 450 billion. According to the World Water Council, the total cost of extraction and storage of water is about USD 80 billion. The United States and the next 20 years should increase by 2 times (Global Environment Facility (GEF), 2004).

As for fresh water resources per person on average, Canada is one of the most well-off countries. High positions are occupied by Norway, Brazil, Russia (Figure 1). However, it is possible to identify a significant number of states with a significant water deficit. According to the UN Millennium Development Goals, 2015, it is planned to cut the proportion of people without permanent access to good drinking water by half (UNESCO, GRGTA (Groundwater Resources Governance in Transboundary Aquifers), 2015). But this is unlikely in conditions of increasing anthropogenic pressure on ecosystems, directly related to water resources.

UN and World Bank specialists have tried this issue in the "World Resources, 2000–2001" collection. First of all, they noted that rivers, lakes, wetlands contain only 0.01% of the world's volume of drinking water and occupy only 1% of the surface of the planet, so the cost of supplying fresh water reaches a trillion dollars. At the same time, one and a half billion people depend on underground water, so excessive exploitation or pollution of the latter threatens their reduction (Andriushchenko, Lavruk, et al., 2019). The prospect of water supply per capita is very pessimistic.

According to the forecast, by 2025 the global water catchment will be 5,000 km^3, of which more than 3,000 km^3 (more than 60%) will consume agriculture, over 1,000 – industry, about 500 – the municipal sector, about 200 km^3 – other industries. At the same time, on the Arabian Peninsula, the population, industry, agrosphere use more than 40% of water resources. India, Mongolia, Caucasus, USA, Mexico, Spain, other countries will absorb 20-40%; China, part of the states of Africa and South Asia – 10-20%; Canada, Russia, Australia, a number of Sub-Saharan Africa, the countries of South and Central America and the Caribbean – less than 10%.

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Increasing water resources to meet demand in many parts of the planet from an economic point of view is unrealistic, as the costs of developing new hydropower, according to the forecast, will increase by 2-3 times (Khvesyk, 2013). In this regard, key elements of the increase in water reserves are deemed to be effective, comprehensive operation, technical innovations, pricing reform for efficient use, and water demand adjustment.

In addition, the water resources of the planet are responsive to climate change, as indicated in the report of the Intergovernmental Panel on Climate Change (IPCC). The IPCC document focuses on fresh water and includes an analysis of the effects (both current and projected) of climate change for water resources. IPCC experts led by the head of this international organization Dr. R. Pachauri estimated how precipitation, snow and ice cover (on the mainland), sea level, groundwater, runoff and water flow in the rivers will change, and how these changes will affect human health, its economic activity and biodiversity of the Earth.

In particular, according to these projections, in Europe by 2020, an increase in the risk of violent floods is expected, and most likely flooding caused by melting snow will be shifted from spring to winter. Such emergencies will be mostly natural (Andriushchenko et al., 2018).

This risk will also increase for Northern Europe. At the same time, the annual drain in Southern Europe is expected to decrease by 23% and increase by 15% in Northern Europe. By the 70s of the XXI century, the number of droughts in Western and Southern Europe will increase, and large floods in Northern Europe. It is projected that those droughts, which are possible once every 100 years, will be repeated on average every 10 years, and even more often in certain parts of Spain and Portugal, Western France, in the Wisla basin in Poland and Western Turkey. The same applies to floods: today's floods, which are possible every 100 years, will become more frequent in the North and North-Eastern Europe (Sweden, Finland, north of Russia), Ireland, Central and Eastern Europe (Poland, Alpine rivers), individual countries of the Atlantic coast of Southern Europe (Spain, Portugal).

Changing the status of water resources will also affect biodiversity. Many systems, such as permafrost areas in the Arctic and short-lived aquatic ecosystems in the Mediterranean, will disappear. The disappearance of permafrost in the Arctic is likely to result in the reduction of certain wetlands. The risk of water blooms in lakes will increase as a result of the proliferation of algae and the increased growth of toxic cyanobacteria. Higher temperatures can increase the species diversity in freshwater ecosystems in Northern Europe and reduce it – in some regions of South-Western Europe.

Water is one of the most important factors that determines the location of productive forces and means of production. It should be noted that the potential of water supply and its characteristics also determine the level of safety and determine its features. Given acceptable water availability indicators for the state, it will be determined by all necessary levers to maintain an adequate level of safety.

Water resource management is implemented through public policy and also envisages the creation of an effective mechanism(s) of public administration as a complex system-forming structure, which contains certain elements that in interaction ensure the effectiveness of management decisions (Mumladze et al., 2010). It is obvious that in such a generalized scheme of water resources management there is necessarily a state management mechanism as its full component.

The conceptual understanding of the mechanism of public administration should be considered as a system of elements that, in their combined action, lead to the expected result. First, let's define the definition of "water management mechanism" (Bil, Tretiak, & Krainyk, 2009).

Ukraine, like other countries of the world, feels, in its own development, the whole complex of advantages and issues that are localized in the field of water resources. Comparing the availability of fresh water resources (m^3 per 1 person) of our state with other countries of the world, there is every reason to consider it one of the least secured in Europe. If, for example, this indicator in Norway is 83,735 m^3 per person, Greece – 5,246, France – 2,956, then in Ukraine – 1,096 m^3 per person. In the regional sec-

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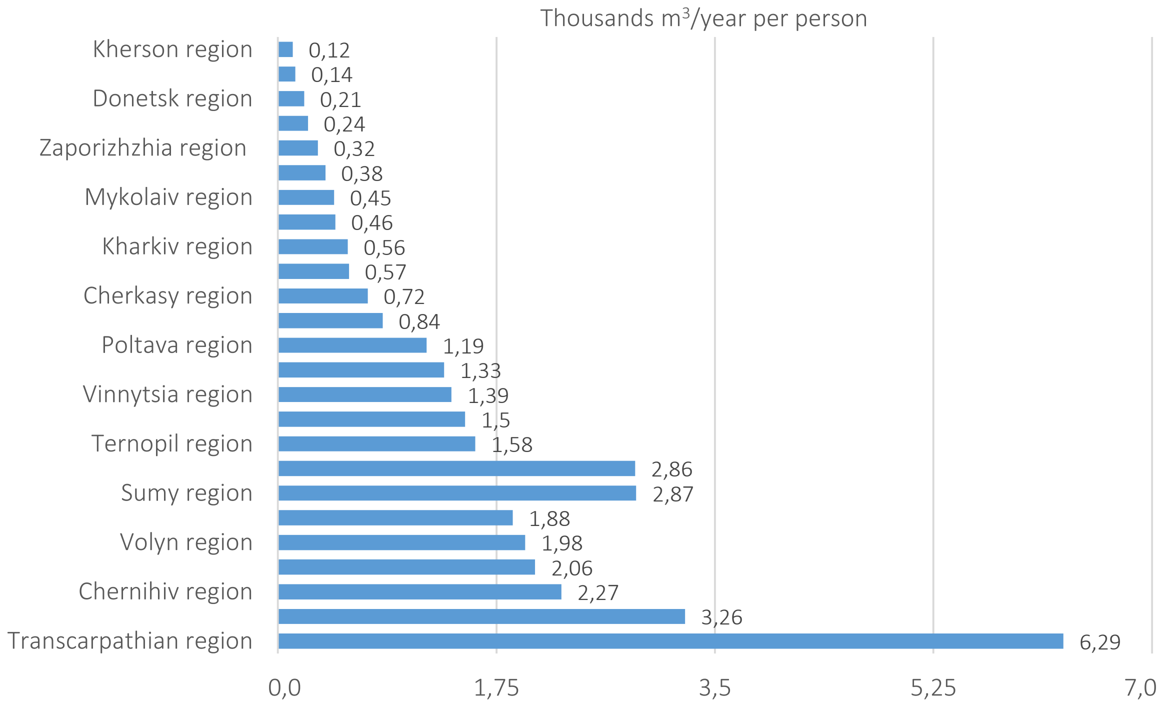

Figure 2. Provision of the population of Ukraine regions with local water resources in the average water year, thousands, m^3 per person

tion, in almost half of the regions, this indicator is lower than the average in the state (Figure 2).

Surface water resources of Ukraine are formed at the expense of inflow from foreign countries along the rivers Danube (122.7 km^3), Dnipro (34.4), Dniester (0.8), Seversky Donets (1.8 km^3), and its own runoff (52.4 km^3). The share of the latter, which falls on international rivers, is 84%.

From Ukraine, river flows are exported to Moldova (Prut, Dniester), Romania (Prut, Siret), Hungary (Tisza), Slovakia (Latoritsa, Uzh), Poland (Vyshnya, Shklo, West Bug), Belarus (Western Bug, Prypiat with tributaries), Russia (Seversky Donets, small rivers of the Azov Sea).

Of the total inflow of river water from foreign countries, 77% falls on the Danube river, the lower part of which is located in the extreme southwest of Ukraine at a distance of 170 km from the mouth. The river crosses the state border with Romania. Therefore, the Danube river runoff has a relatively limited use in the Odesa region.

The internal regional differences are characterized by the fact that, according to the international classification, only the Transcarpathian region belongs to the middle-income local drainage (6.3 thousand m^3 per person).

According to the State Water Resources Committee, Ukraine's water resources include transit and local river runoff, total river runoff resources (Table 4) and predicted groundwater resources. The balance of local water runoff in Ukraine is 52.4 per year on average, 29.7 km^3 in shallow years. The use of river runoff complicates its variability in time: the spring runoff accounts for 60-70% in the north and north-east and 80-90% in the south.

The process of assessing the effectiveness of water resources management at the territorial level involves a number of calculation and analytical procedures according to the conceptual scheme (see Appendix A, Figure A1).

In the first stage, after the formation of data tables for each group of indicators within the limits of a separate criterion, standardized values are calculated – individual territorial indices of efficiency for each year. For standardization, it is necessary to use the average data of the corresponding indicators of water use in terms of regions.

At the next stage, in order to carry out a comparative assessment of the effectiveness of water resources management at the territorial level, for each formed group within the framework of a separate criterion, a group of indicators is proposed to calculate the integral territorial indices of efficiency according to the methodology:

$$I_i^k(t) = \sqrt[n]{\prod_{j=1}^{n}\left(1 + I_{ij}^k(t)\right)} - 1, \qquad (1)$$

where $I_{ij}^k(t)$ – integral territorial index of efficiency of the i region for the k criterion in the period t.

According to the numerical value of the integrated territorial efficiency index, it is proposed to combine regions into homogeneous groups depending on the proximity or distance from the average value of this index. Such a grouping will characterize the economic environment profile by a certain set of indicators within a criterion or for a specific period.

Depending on the value of the integral territorial index, it is proposed to allocate four groups of regions:

with a relatively high level of efficiency:

$$I_{ij}^k(t) \ge I_c^k(t) + \sigma_k(t),$$

with a higher than average level:

$$I_c^k(t) \le I_i^k(t) < I_c^k + \sigma_k(t),$$

with a lower than average level:

$$I_c^k(t) - \sigma_k(t) \le I_i^k(t) < I_c^k(t),$$

with a relatively low level of efficiency:

$$I_i^k(t) < I_c^k - y_k(t),$$

where $I_c^k(t)$ – the average value of the integral territorial performance index for the k criterion in the period t $\left(I_c^k(t) = 1\right)$, $\sigma_k(t)$ – the standard deviation of the value of the group index from its average level for the k criterion in the period t, which is determined by the formula:

$$\sigma_k(t) = \frac{\sqrt{m \cdot \sum_{i=1}^{m}\left(I_i^k(t)\right)^2 - \left(\sum_{i=1}^{m} I_i^k(t)\right)^2}}{m}. \qquad (2)$$

At the next stage, integral group indices of the efficiency of the water resources management system at the territorial level for each year are calculated based on the values of the integral territorial indices of the individual evaluation criteria by a similar formula:

$$I_i^{gr}(t) = \sqrt[k]{\prod_{k=1}^{k}\left(1 + I_i^k(t)\right)} - 1, \qquad (3)$$

where $I_i^{gr}(t)$ – the integral group index of the effectiveness of the i region by the group of criteria in the period t.

Classification of regions of Ukraine, depending on the value of the integral group index, should also be carried out according to the same criteria as for territorial indices.

In the process of research, it is also important to evaluate the change in effectiveness in general and in terms of each criterion over the entire period for each region (Andriushchenko et al., 2019). It is proposed to conduct it by calculating the integral criterion index of the dynamics of the efficiency of the water resources management system at the territorial level by the formula of the arithmetic mean integral group efficiency indices for each period (year) for each criterion:

$$I_i^k = \frac{\sum_{t=1}^{T} I_i^k(t)}{T}, \qquad (4)$$

where I_i^k – integral criterion index of the dynamics of the efficiency of the water resources management system at the territorial level of the i region for the period T for the k criterion.

In addition to analyzing the efficiency of water use for certain periods, it is also important to evaluate the dynamics of the efficiency of the water resources management system at the territorial level for the entire period. To this end, it is recommended for each region to calculate the integral indices of the dynamics of the efficiency of the water re-

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sources management system at the territorial level as the average arithmetic mean of the integrated groups of water use efficiency indices for each period (year):

$$I_i = \frac{\sum_{t=1}^{T} I_i(t)}{T}, \quad (5)$$

where I_i – integral index of the dynamics of water use efficiency of the i region for the period T.

The grouping of regions by the integral criterion index and the integral index of the efficiency of the water resources management system at the territorial level is performed on the basis of the same criteria.

After calculations of the relevant indices, the grouping of the regions is carried out according to the level of efficiency of the water resources management system at the territorial level in separate years, by the groups of indicators within each criterion, as well as for the whole period and in the context of separate evaluation criteria (Table 2).

Table 2. Criteria for determining the trend of changing the efficiency of the water resources management system at the territorial level

Source: Compiled by the authors.

Characteristics of the tendencies	Criteria
Stable growth tendencies	Continuous increase of the index and transition to higher group
Unstable growth tendencies	Continuous increase of the index, but without a constant transition to a higher group or a gradual transition to it without index growth
Absence of stable tendencies	Alternating in the direction of trends: increase and decrease of the index, transition to the higher and lower group
Unstable tendency to recession	Invariance or constant decrease of the index, but without a constant transition to lower group or with such a transition without decreasing the index
Stable downward tendency	Constant decrease of index and transition to lower group

But in order to make decisions on the prospects of developing a water management complex in a particular region and its individual spheres and directions of activity, the results of the analysis of the level of efficiency of the water resources management system at the territorial level in certain periods or in general for the whole period is insufficient. In this case, it is important to identify the general trend of change in water use efficiency in order to have an idea of the trends in the development of the water management complex in the region and its individual areas of activity in general.

As a basis for obtaining a characteristic of the trend of changes in the efficiency of the water resources management system at the territorial level, it is proposed to use the values of the calculated preliminary indices (territorial, group, integral), and the identification of the trend – to conduct the following criteria.

On the basis of the obtained results, an extended grouping of regions is carried out according to the tendency of changing the efficiency of the water resources management system at the territorial level throughout the period in terms of groups of indicators corresponding to a certain evaluation criterion.

In the process of generalizing this indicator, the general tendency of changes in the efficiency of the water resources management system at the territorial level and in the context of individual evaluation criteria is taken into account.

At the final stage, the regions are positioned in the matrix of choosing the baseline guidelines for the water resources management system at the territorial level (Table 3), depending on the level of water use efficiency of the region over the entire period, and an assessment of the general trend of this indicator change.

In the case of assigning a matrix of several regions to one cell, the same policy model is chosen for them, with further details of the individual provisions depending on the change in the efficiency of water use at the level of individual criteria 3. In order to specify the basic provisions for improving the institutional environment of the state policy of water sector development, an expanded matrix is developed in the context of separate evaluation criteria (see Appendix A, Table A3).

Table 3. The matrix of the choice of the basic guidelines for the water resources management system at the territorial level

Source: Compiled by the authors.

Level of competitive advantage	The tendency of the level of competitive advantage change				
	Stable growth tendency	Unstable growth tendency	Absence of stable tendencies	Unstable tendency to recession	Stable tendency to recession
Relatively high					
Higher than average					
Below the average					
Relatively low					

3. DISCUSSION

Most efforts in the management of water resources are aimed at optimizing the use of water and minimizing the environmental impact of water. Analysis of the use of water resources in the territory as an integral part of the ecosystem of a specific territory is based on integrated water resources management, where the quantity and quality of ecosystems help to determine the basis of natural resources.

DESAFIO (abbreviation "Democratization of Water Resources Management and Sanitation through Socio-Technical Innovations") deals with the problem of restrictions on access to water resources. The project has been developed for 30 months and funded by the EU's Seventh Framework Program. This project faces a difficult challenge for developing countries: the elimination of structural social inequalities in access to water and health. Successful management of any resources requires accurate knowledge about availability to this resource, its use, resource requirements. For water as a resource, this is particularly difficult as water sources can cross many national boundaries. It is sometimes difficult to assess the financial value of the water resources used, and may also be difficult to manage under normal conditions, for example, rare species of ecosystems, ancient groundwater reserves.

The Swiss Agency for Development and Cooperation (SDC) and its partners are committed to addressing global water management challenges through a variety of projects and activities, the Global Water Program (DGPM). At the beginning of the 21st century, these efforts are aimed at increasing the security of water supply on a global scale within the framework of the Sustainable Development Agenda for the period up to 2030. In particular, they are aimed at supporting the achievement of the Sustainable Development Goal 6, relating to water, and solving related tasks, as well as water related issues such as climate change, health, hunger, energy, etc.

On the basis of the performed analysis, it is suggested to determine the theoretical basis of mobilization water use that does not contradict the concept of sustainable development and will take into account the factors of external and internal influence on the socio-economic system of the state in general and the redistribution of water resource rent, in particular, through the use of appropriate institutional tools. The peculiarity of this mechanism is the self-organizing aspect of the subjects of management based on the mobilization capacity of individuals in the conditions of external and internal pressure on the socio-economic system of water resources management at the territorial level (Figure 3).

Block 1. Analysis of the current state of water use at a water facility. It enables to realize the analytical function of self-assessment of the state of rationalization of water use by the subject of management within the limits of a water management object. Its task is to analyze the indicators of the quantitative and qualitative state of a water facility; construction of analytical models of mobilization water use; a synchronous analysis of streamlining water use and its fluctuations.

Block 2. Determination and withdrawal of water resource rent, received by economic entities, which is its purpose. Since the economic entity

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Source: Compiled by the authors.

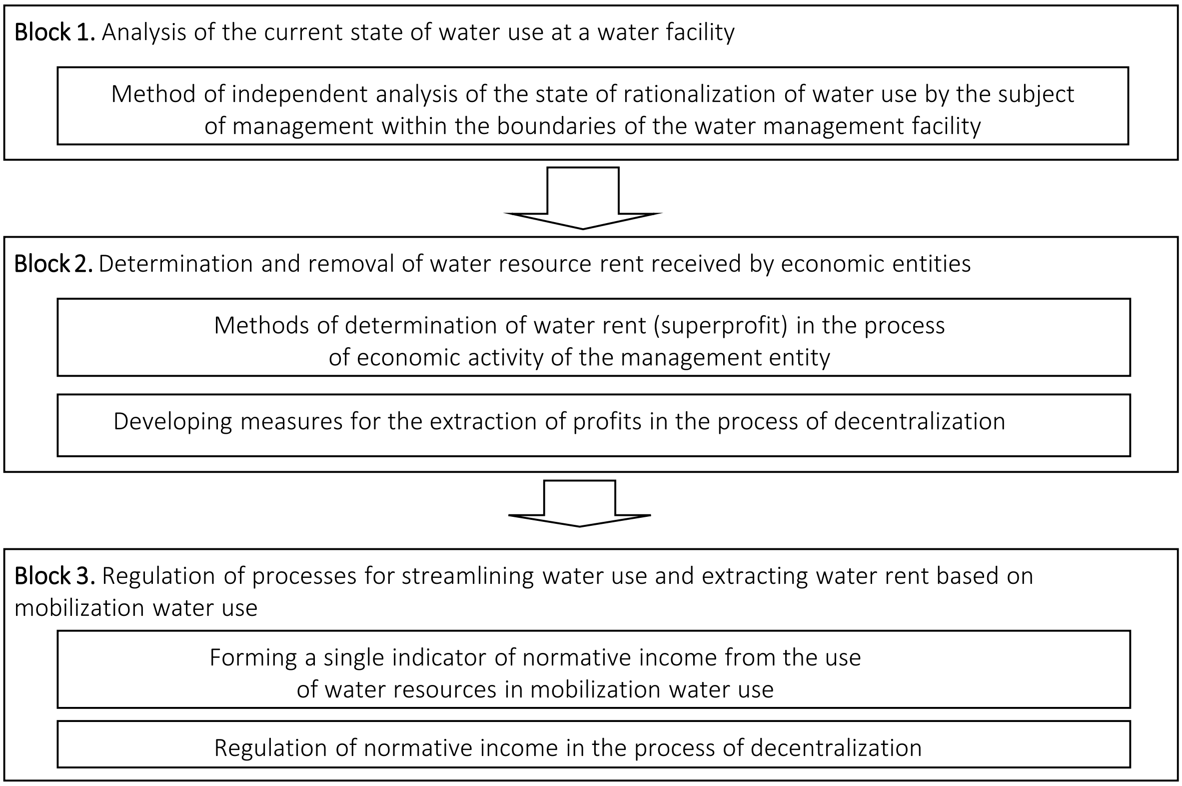

Figure 3. Conceptual scheme of the mechanism of the state policy of water sector development based on the concept of mobilization water use in the process of decentralization

can be a structural element in providing water resources at the territorial level at which management and redistribution of capital is carried out and taking into account the possible negative social effect that could lead to catastrophic consequences for the whole economic system, it is important to provide the legal basis for the seizure super profits. Self-organization is a public support for the adoption and implementation of relevant decisions.

Block 3. Regulation of mobilization water use through internal processes. Its purpose is to determine the possibility of reducing the volume of discharges, costs and losses of water and the formation of regulatory measures directly on the subjects of water use to control the deviations from mobilization water use, except for emergencies.

Within the framework of this block, the following tasks are solved: the formation of a single indicator of normative income from the use of water resources during mobilization water use. Such a general indicator should reflect the results of the calculation of indicators in different modes of water use and take into account the need for obtaining the consent of the central and local authorities and the public on the extraction of excess profits from the use of water resources of the water supply facility.

The scheme of the mechanism of water resources management at the territorial level based on the mobilization of water use is particularly relevant in the context of the rapid development of modern forms of financial and economic relations and the tools that they operate. Similar processes also apply to water resources that are unique in their characteristics and fulfill a number of important functions for the environment, individual individuals and the state. The situation is developing now, when in the context of the development of finance and the economy, there is the attraction of water resource potential to these processes.

CONCLUSION

The paper proposes solving a scientific problem, which is manifested in deepening of the theoretical positions, methodical principles and development of applied recommendations regarding the management of water resources supply at the territorial level in the long-term period, based on a comprehensive study of modern trends in water resources management at the territorial level. For this purpose, it is recommended to calculate the integral indices of the dynamics of water use efficiency for each region as the average arithmetic values of integrated group indices of water use efficiency for each period (year). After the calculations of the relevant indices, the grouping of regions according to the level of water use efficiency in separate years is carried out in the context of the groups of indicators within each criterion, both for the entire period and in the context of individual evaluation criteria. Thus, the theoretical basis for the mobilization of water use is determined that does not contradict the concept of sustainable development and will take into account the factors of external and internal influence on the socio-economic system of the state in general. The peculiarity of this mechanism is the self-organizing aspect of the subjects of management based on the mobilization capacity of individuals in the conditions of external and internal pressure on the socio-economic system of water resources management at the territorial level.

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APPENDIX A

Table A1. Top 20 countries with the highest level of water resources exploitation

Source: According to World Water Assessment Programme (WWAP) (2012).

No.	Country	Level
1	Bahrain	Critical
2	Qatar	Critical
3	Kuwait	Critical
4	Saudi Arabia	Critical
5	Libya	Critical
6	Western Sahara	Critical
7	Yemen	Critical
8	Israel	Critical
9	Egypt	Critical
10	Djibouti	Critical
11	Jordan	Critical
12	Morocco	Critical
13	Algeria	Critical
14	Oman	Critical
15	Tunisia	Critical
16	Aruba	Critical
17	Malta	Critical
18	Syria	High
19	Mauritania	High
20	United Arab Emirates	High

Table A2. Rating of investment-attractive countries in the context of the relevance of water production/water supply

Source: United Nations (2012).

Ranking	High potential	InVenture Water Index	Ranking	Average potential	InVenture Water Index	Ranking	Low potential	InVenture Water Index
1	UAE	2.8	56	Puerto Rico	75.0	111	Slovenia	97.3
2	Qatar	3.5	57	Eritrea	75.5	112	Venezuela	97.5
3	Bahrain	9.0	58	Japan	75.5	113	Estonia	98.0
4	Saudi Arabia	17.0	59	Poland	75.8	114	Belize	98.5
5	Israel	21.5	60	Swaziland	75.8	115	Sweden	98.5
6	Jordan	29.3	61	USA	76.0	116	Canada	99.3
7	Oman	31.5	62	Senegal	76.8	117	Belarus	99.8
8	Yemen	37.3	63	Czech Republic	77.0	118	Indonesia	100.0
9	Libya	38.8	64	Chad	77.8	119	Uruguay	100.0
10	Mauritania	42.0	65	UK	77.8	120	Nepal	100.3
11	Syria	43.0	66	Ghana	78.3	121	Madagascar	101.0
12	Irag	43.5	67	Switzerland	78.8	122	Finland	101.8
13	Cyprus	44.5	68	China	79.3	123	Gabon	102.0
14	Egypt	46.0	69	Zimbabwe	79.3	124	Ecuador	102.3
15	Malta	46.0	70	Portugal	79.5	125	New Zealand	102.3
16	The Netherlands	47.0	71	Greece	80.0	126	Ireland	103.3
17	Maldives	49.5	72	Nigeria	80.5	127	Brazil	104.0
18	Algeria	50.0	73	Thailand	80.5	128	Honduras	104.5
19	Sudan	50.8	74	Timor-Leste	81.3	129	Chile	105.0
20	Niger	51.3	75	Tanzania	81.5	130	Cambodia	105.3
21	Pakistan	51.5	76	Ukraine	82.0	131	Kirghizia	105.3
22	Turkmenistan	52.3	77	Benin	82.5	132	Ethiopia	105.5

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Table A2 (cont.). Rating of investment-attractive countries in the context of the relevance of water production/water supply

Ranking	High potential	InVenture Water Index	Ranking	Average potential	InVenture Water Index	Ranking	Low potential	InVenture Water Index
23	South Africa	54.0	78	Malawi	82.5	133	Norway	106.5
24	Singapore	54.3	79	The Philippines	82.8	134	Croatia	106.8
25	Barbados	55.3	80	Austria	83.5	135	Lesotho	106.8
26	Belgium	55.3	81	Kazakhstan	84.0	136	Paraguay	107.8
27	Lebanon	56.8	82	Argentina	84.8	137	Albania	108.3
28	Tunisia	57.0	83	Gambia	84.8	138	Mozambique	108.3
29	Azerbaijan	59.0	84	Australia	85.0	139	Tajikistan	108.5
30	Iran	59.0	85	Mali	85.8	140	Latvia	108.8
31	Antigua and Barbuda	60.0	86	Trinidad and Tobago	85.8	141	Panama	109.3
32	Korea	61.0	87	Sri Lanka	86.5	142	Congo (Republic)	110.5
33	Djibouti	61.5	88	Uganda	87.3	143	Iceland	111.0
34	Botswana	62.5	89	Haiti	88.0	144	Peru	111.5
35	Hungary	62.5	90	Romania	88.0	145	Cameroon	111.8
36	Germany	63.5	91	Bulgaria	88.5	146	Columbia	111.8
37	Kenya	63.5	92	Malaysia	88.5	147	Lao Republic	111.8
38	Uzbekistan	64.0	93	Vietnam	89.0	148	Guinea	112.8
39	Afghanistan	65.0	94	Angola	89.3	149	Mongolia	114.0
40	Spain	65.0	95	Slovakia	89.5	150	Bolivia	115.3
41	Denmark	65.3	96	Cuba	89.8	151	Congo	115.8
42	Luxembourg	65.3	97	Equator. Guinea	89.8	152	Guinea-Bissau	117.3
43	Morocco	66.8	98	Macedonia	90.5	153	Russia	117.5
44	India	68.8	99	Costa Rica	91.5	154	Surinam	117.5
45	Namibia	70.5	100	Comoros	92.0	155	Butane	117.8
46	Bangladesh	70.8	101	Guatemala	92.0	156	Papua New Guinea	119.0
47	Burkina Faso	71.0	102	Rwanda	92.8	157	Myanmar	121.5
48	Cape Verde	72.0	103	Armenia	93.5	158	Georgia	123.8
49	Turkey	72.5	104	Zambia	93.5	159	Bosnia and Herzegovina	124.0
50	Mauritius	73.0	105	Lithuania	93.8	160	Nicaragua	124.0
51	Italy	73.3	106	El Salvador	94.5	161	Liberia	128.0
52	Mexico	73.3	107	Togo	94.8	162	Fiji	129.3
53	Dominican Republic	73.5	108	Burundi	95.0	163	Sierra Leone	130.0
54	France	74.3	109	Jamaica	96.0	164	Central African Republic	131.8
55	Moldova	74.3	110	Côte d'Ivoire	97.0	165	Guyana	139.5

Table A3. The dynamics of the integrated territorial index of the efficiency of the water resources management system at the territorial level by the investment criterion, 2015–2017

Source: Excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and parts of the area of the anti-terrorist operation.

Region	2015	2016	2017	Index
Vinnytsia	0.280	0.065	0.137	0.157
Volyn	0.139	0.064	0.082	0.094
Dnipro	5.011	4.957	5.527	5.160
Zhytomyr	0.216	0.102	0.091	0.135
Zakarpattia	0.105	0.140	0.210	0.151
Zaporizhzhia	1.730	2.045	1.748	1.838

Table A3 (cont.). The dynamics of the integrated territorial index of the efficiency of the water resources management system at the territorial level by the investment criterion, 2015–2017

Region	2015	2016	2017	Index
Ivano-Frankivsk	0.741	0.571	0.847	0.716
Kyiv	1.506	2.344	2.472	2.076
Kirovohrad	0.129	0.113	0.108	0.116
Lviv	0.505	0.771	0.736	0.666
Mykolaiv	0.401	0.295	0.096	0.257
Odesa	0.550	0.312	0.504	0.451
Poltava	0.578	0.808	0.894	0.755
Rivne	0.265	0.255	0.335	0.284
Sumy	0.308	0.177	0.205	0.229
Ternopil	0.121	0.056	0.072	0.083
Kharkiv	0.971	2.148	1.063	1.339
Kherson	0.277	0.223	0.286	0.262
Khmelnitskyi	0.088	0.102	0.167	0.118
Cherkasy	0.322	0.232	0.296	0.283
Chernivtsi	0.244	0.081	0.080	0.132
Chernihiv	0.551	0.317	0.451	0.437
The standard deviation of the indexes from the average (σ) = 1.191 Efficiency level:				
1-st interval: I < 0.191 – relatively low				
2-nd interval: 0.191 ≤ I < 1 – below the average				
3-rd interval: 1 ≤ I < 1.9 – higher than the average				
4-th interval: 1.9 ≥ ∞ – relatively high				

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Source: Compiled by the authors.

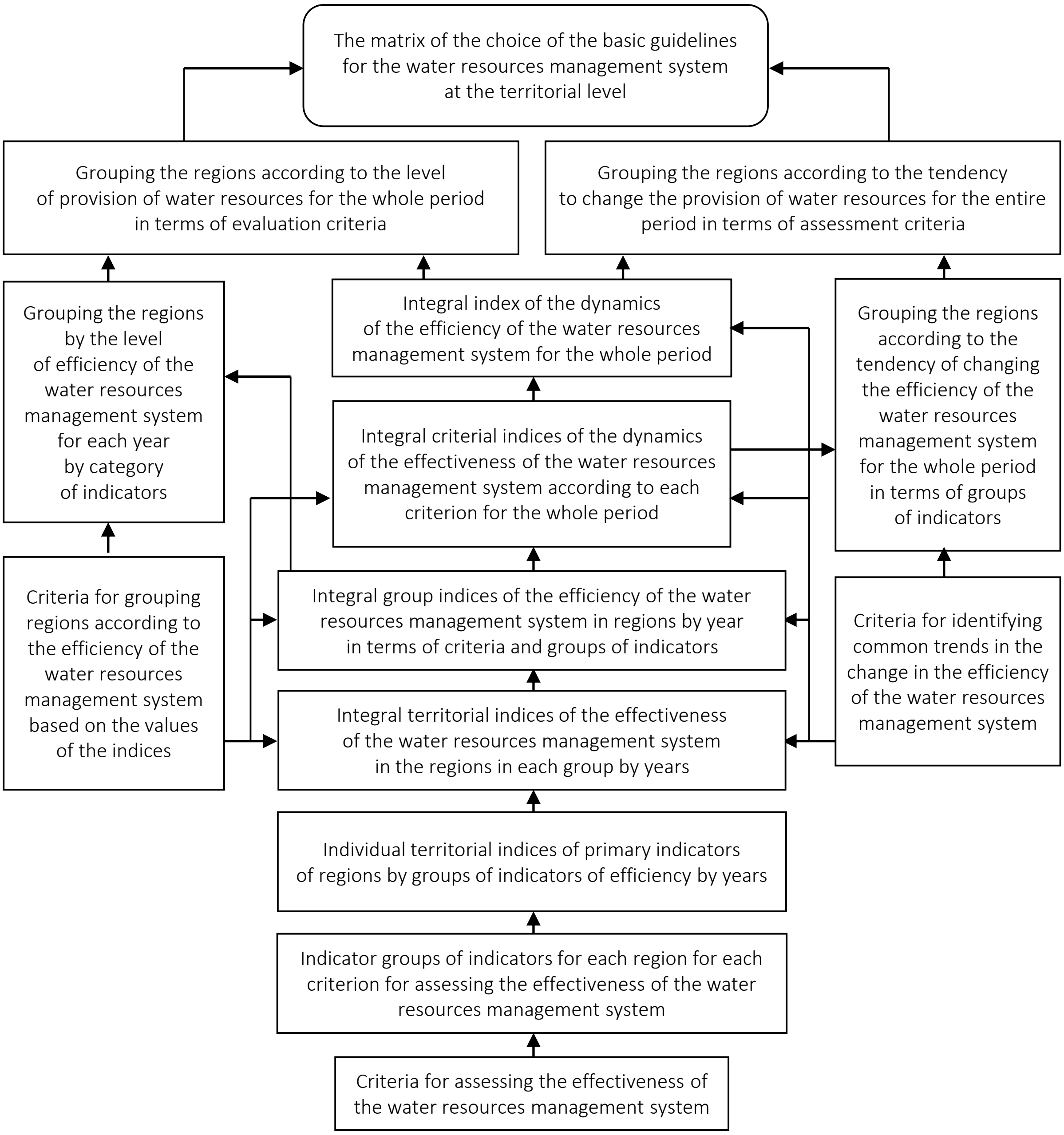

Figure A1. Algorithm for assessing the effectiveness of the water resources management system at the territorial level