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METHODICAL SUPPORT OF INTEGRATED MANAGEMENT OF WATER RESOURCES OF THE BASIN OF TRANSBOUNDARY RIVERS

Abstract. Based on the principles of reasonable, equitable and rightful use of water resources in accordance with the concept, adopted at the «Agenda of the 21st Century» at the UN in Rio de Janeiro and developed by the European Environmental Agency – «DPSIR-analysis», as a method of systematizing the information and identifying the cause-effect connections in order to solve the problems of integrated water resources management in transboundary rivers, the system of integral criteria of geo-ecological restriction is justified, ensuring the restriction and prevention of the negative influence of transboundary impacts.

As an integral criterion for geo-ecological restriction, an indicator of the water availability curve taking into account climate change is developed, that is, the arithmetic average of the statistical series of the annual river flow, geomorphological schematization of the catchment area of the transboundary river basin, taking into account the heat and water availability of their landscape system, the maximum pollution of the river flow, territorial planning water use based on integrated parameters using climatic, geological and geo-morphological, hydrological and landscape factors, the ecological situation of the hydro-agrarian landscapes of the river basin catchment in "soil-plant-human" systems, the maximum permissible level of use of river basin water resources and ecological runoff, the available land resources of the river basin catchment and the ecological services of the river basin catchment, possible area of hydro-landscape systems in the catchment areas of river basins, a comprehensive assessment of environmental, economic and social damage caused by human activities.

Methodological substantiation of the criteria of geo-ecological restriction when using the water resources of the transboundary river basin, as a method of systematizing information and highlighting cause-effect relationships in order to solve the problems of integrated water resources management of transboundary rivers, covering all levels of the water use process from the formation and shopping of water resources and their watershed dispersal zones transboundary river basins can be used in the planning and implementation of integrated Water Management (IWRM).

Key words: water resources, transboundary rivers, concept, strategy, use, management, implementation, planning, integrated water resources management.

Relevance. To accelerate the transition to more sustainable methods of developing and managing water resources, based on the principles of reasonable, equitable and rightful use of water resources in accordance with the concept adopted on the «Agenda of the 21stCentury» at the UN in Rio de Janeiro, which is the fundamental norm of the legal regime of transboundary waters, according to which every state of the basin has the right within its territory to a reasonable and rightful share of the benefits from the use of the water of this basin. At the same time, the degree of equal use of transboundary waters which is reasonable and fair should be determined by taking into account the comprehensive consideration of all factors, including hydrographic, hydrological, hydrogeochemical and climatic conditions, as well as the use of water resources in the past and present to solve the economic and social problems of each state, located in catchment of river basins. One of the factors in determining the reasonableness, equality, and justice is the degree in which the needs of each state can be met without causing significant damage to other States within the catchment areas of transboundary river basins. To solve this problem, it is necessary to form an integrated water resources management (IWRM) system for transboundary river basins, including mechanisms for organizing and jointly carrying out comprehensive measures aimed at reducing, limiting and preventing the negative influence of transboundary impacts, which requires the development and justification of criteria for geoecological restrictions that ensure the principles of reasonable, equitable and rightful use of water resources in accordance with the concept adopted on the «Agenda of the 21stCentury» [1,2,3].

The goal of the research is to develop the methodological support for planning and implementing the integrated water resources management in the transboundary river basins based on qualitative and quantitative integral criteria of geoecological restrictions, allowing the implementation of the principles of reasonable, equitable and rightful use of water resources in accordance with the concept adopted on the «Agenda of the 21stcentury».

Materials and research methods. The geoecological restrictions in the integrated water resources management of transboundary rivers are understood as the requirements and criteria for the environmentally acceptable use of the natural-resource potential of the catchments of river basins, confirming the preservation of the sustainability and sustainability of the natural system, their environmental and resource-generating functions.

To substantiate the integral criteria of geoecological restrictions in the integrated water resources management of transboundary rivers and their systematization, were used a concept developed by the European Environmental Agency «Driving force-Pressure-State-Impact-Responsibility»-DPSIR-analysis, as a method of systematization of information and the allocation of cause-effect relationships in order to solve environmental problems [European Environment Agency,1999] [4].

Research results. For balanced use of water resources of transboundary rivers, when planning and implementing IWRM, it is necessary to ensure the principles of reasonable, equitable and rightful use of water resources in accordance with the concepts adopted at the «Agenda of the 21stCentury» at the UN in Rio de Janeiro, which requires solutions:

2. Geomorphological schematization of the catchment area of a transboundary river basin taking into account the heat and water supply of their landscape system [5], possibly using the energy or work performed by the groundwater flow in the following form:

$$\Delta E = A_i = m_i \cdot g \cdot \Delta H = m_i \cdot g \cdot \Delta_i \,.$$

where ΔE – change in energy at the site ΔH ; ΔH , Δ_i - excess of the surface of the earth above the shore, m; m_i – average mass of underground water; g- acceleration of gravitational force.

2. Based on the long-term data of the hydrogeochemical regime and nutrient in the water resources of the transboundary river basin, an assessment of the quality and water pollution index of the environmental requirements of the fisheries and drinking water use [6], that is, methods based on the use of complex indicators, that is, determining the limits of permissible changes (ПДИ), are widely used to assess the quality of water resources and the ecological state of aquatic ecosystems in water management practice [7], threshold of critical action (ПДВВ) [8], maximum permissible concentration (ПДК) [8], hydrochemical pollution index (ГЗВ) [8], as well as methodological support N.G. Bulgakov [9], V.P. Yemelyanova [10], T.N. Moiseenko [11], V.V. Shabanov [12] and M.ZH. Burlibaev[13].

At the same time, to assess the quality of water and the ecological status of water bodies in the river basin, it is estimated using the method of V.V. Shabanov, using the coefficient of maximum pollution ($K_{пз}$) [12]:

$$K_{пз} = \frac{1}{N} \cdot \sum_{i=1}^{N} \frac{C_i}{ПДК_i} - 1,$$

where i – water pollutant number; N - amount of substances taken into account; $ПДК_i$ - maximum allowable concentration of substances taken into account; C_i - actual concentration of substances taken into account; $K_{пз}$ - coefficient of maximum pollution, characterizing the quality of water, the state of the water body of rivers and its water economic value, which are assessed according to the classification of water quality.

As structural characteristics of ecosystems, indicators of the species, size, trophic structure, flow structure can be used. For the quantitative characteristics of the structure most often used different indices, among which the most often - the Shannon index (H) [14]:

$$H = \sum (N_i / N) \cdot \lg 2 (N_i / N),$$

where: N_i - number i - i-th species; N - number of all species.

3. Territorial water use planning based on integral parameters using climatic, geological, geomorphological, hydrological and landscape factors determining the ecologically acceptable limits for using the natural resource potential of the catchment area of a transboundary river basin are determined taking into account the geoecological restrictions proposed by Zh.S. Mustafayev and with co-authors [15,16]: lower threshold of maximum permissible level of water demand ($O_p^{нижс}$) – transpiration of plants, ensuring the formation of biological masses *(T)* and the upper maximum permissible level of the norm of water demand ($O_p^{верх}$) – ecological norms of water needs of agricultural land ($O_p^{э}$),providing targeted regulation and management of soil-forming processes on irrigated lands [22], and the biological irrigation rate (O_p) are determined on the basis of the bioclimatic method proposed by N.V.Danilchenko [17]: $E_v = E_o \cdot K_o \cdot K_б$ (where K_o - microclimatic coefficient; $K_б$ - biological coefficient), that is $O_p = E_v - (O_c \pm g + \Delta W)$, where ΔW - productive moisture in soil, mm.

4. On the basis of indicators of anthropogenic impacts, that is, demographic, industrial and agricultural, characterizing economic activities, the assessment of anthropogenic load on the catchment area of the river basin [18,19,20], can be used the generalized indicator ($K_{тн}$), which is determined by the formula [19]:

$$K_{кт} = \sqrt[i]{\prod_{i=1}^{n} K_i^i},$$

where $K_i^i = \exp(-K_i)$- relative values of the level of anthropogenic load on the catchment areas of river basins or the coefficient of anthropogenic activity [19].

To assess the level of anthropogenic load on the drainage basin of transboundary rivers, was used the indicator of A.G. Isachenko, putting them in the form of a coefficient (K_i),characterizing the ratio of the individual actual technogenic load to their optimal value, which is taken as the level of the average load, that is, [20]:

- coefficient ($K_i^{пл}$), characterizing population density: $K_i^{пл} = П_{опт} / П_{фак}$, where $П_{фак}$ - actual population density, person/sq.km; $П_{опт}$- optimal population density, which corresponds to the level of average load, person/sq.km;

- coefficient ($K_i^{пр}$), characterizing the density of industrial production: $K_i^{пр} = ПР_{опт} / ПР_{фак}$, where $ПР_{фак}$ – actual density of industrial production, thousand dollar/sq.km; $ПР_{опт}$- optimal density of industrial production, which corresponds to the level of average load, thousand dollar/sq.km;

- coefficient ($K_i^{ра}$), characterizing the plowing of natural landscapes: $K_i^{ра} = F_{рас}^{опт} / F_{рас}^{фак}$, where $F_{рас}^{фак}$ – actual plowing of natural landscapes, % ; $F_{рас}^{опт}$- optimal plowing of natural landscapes, which corresponds to the level of average load, % ;

- coefficient ($K_i^{жив}$), characterizing the density of livestock loading: $K_i^{жив} = N_{опт}^{жив} / N_{фак}^{жив}$,

where $N_{фак}^{жив}$ – actual density of livestock loading, conventional heads /sq.km; $N_{опт}^{жив}$ - optimal density of livestock load, which corresponds to the level of average load, conventional heads /sq.km.

At the same time, the total techno-genic load on the catchment areas of river basins was determined as the square root of the product of the relative values of the level of certain types of anthropogenic loads, as a result of which a generalized integral indicator can be obtained($K_{тн}$)characterizing the result of human activity[20].

5. Based on the indicators of anthropogenic activity, the assessment of the ecological situation of the hydro-landscapes of the catchment area of river basins in the systems «soil-plant-man» [22,23] can be done as follows, first consider the natural environment at the regional or local level, zoning by activity, not changing significantly on a spatial-temporal scale using the above negative reaction factors for humans - $\overline{NR} = NR_i / NR_{\max}$ and its habitation environment - $\overline{nr} = nr_i / nr_{\max}$ [22,23]:

- for human $\overline{NR} = \left(\sum_1^i \overline{D}_i \cdot q_x \right) \sum_1^i \varepsilon_i(k)$;

- for its habitat $\overline{nr} = \left(\frac{\overline{D}_{вв}}{\overline{D}_{рв}} + q_x \right) \sum_1^i \beta \cdot \varepsilon_i(k)$,

where $\overline{D}_i$ - the degree of contamination with chemicals of potable water for the supply of the population; $\overline{D}_{вв}$ - level of river water use for irrigation; $\overline{D}_{рв}$ - the level of use of return water for irrigation; ε_i - private parameters of the deterioration of the properties of the components of the natural system (for humans, this is the dynamics of diseases associated with the consumption of polluted water and air pollution-$\varepsilon_i(r)$, for soil, plants, and crops - the content of toxic salts in the soil, for groundwater - an increase in their mineralization and level - $\varepsilon_i(k)$); β - correction factor (for soil and groundwater $\beta = 1$, for agricultural crops $\beta > 1$); q_x - the intensity of the entry of toxic chemicals and nitrates into the soil and groundwater.

The intensity of the entry of toxic chemicals and nitrates into the groundwater ($q_x^{гв}$) and into the soil (q_x^n) estimated by empirical dependencies [22,23]:

$$q_x^{гв} = 1 - q_x^n; \; q_x^n = \exp\left[-(\alpha \cdot q_w + 1 - R_ф\right],$$

where α – constant, depending on the type of toxic chemicals; q_w - intensity of infiltration nutrition (in shares from the norm); $R_ф$ - infiltration resistance, which is determined by the formula: $R_ф = 1/f_m$, here f_m – relative area occupied by soils with low soil thickness.

6. Assessment of the maximum allowable level of water resources use of the river basins and environmental flow, that is, disposable water resources for use in sectors of the economy [30].

For the environmental and economic justification of the maximum permissible level of use of natural resources in the context of anthropogenic activity, a retrospective analysis of the state of the components of the natural system and a long-term forecast of the expected consequences from the impact of various measures on them are necessary. As an integral indicator of assessing the environmental and economic efficiency of the complex use of natural resources, the total effect ($Z(x)$) can be used, which can be determined by the following formula [24]:

$$Z(x) = Z_n(x) - Z_э(x) - Z_{эк}(x) - Z_c(x) - ЗТ \cdot B_t,$$

where $Z_n(\overline{P}_n)$ – total profit of the natural-technical complex; $Z_n(x) = Z_n(\overline{P}_n - P_n(x))$; $Z_n(P_n(x))$ – natural complex profits in natural conditions; $Z_э(x) = Z_э(\overline{P}_э - P_э(x))$; $Z_э(\overline{P}_э)$ – economic damage from the deterioration of the quality parameters of the natural-technical system; $Z_э(P_э(x))$ – costs required for qualitative improvement of environmental parameters; $Z_{эк}(\overline{P}_{эк})$ – environmental damage from the deterioration of the quality parameters of the natural-technical system; $Z_{эк}(x) = Z_{эк}(\overline{P}_{эк} - P_{эк}(x))$; $Z_{эк}(P_{эк}(x))$ - costs necessary to improve the ecological conditions of the environment; $Z_c(x) = Z_c(\overline{P}_c - P_c(x))$; $Z_c(\overline{P}_c)$ – social damage from the deterioration of the quality parameters of the natural environment; $Z_c(P_c(x))$ – costs of improving the social conditions of the natural environment; $B_t = (1+e)^t$ – the coefficient of reduction in time of multi-time costs or discounting; t – calculation step number; e – efficiency coefficient; $ЗТ$ – society's costs for the implementation of environmental management systems.

On the basis of the Hurwitz criterion, it is possible to present a model of the design value of the coefficient of the ecological and economic activity of society when using natural resources.: $K_э^{np} = \lambda \cdot K_э^{max} + (1-\lambda) \cdot K_э^{\min}$, где $K_э^{max}$ – the maximum possible value of the coefficient of economic sustainability of the natural system of the river basin; $K_э^{min}$ – the minimum value of the coefficient of economic sustainability of the natural system of the river basin; λ - empirical coefficient; $\lambda = 1 - \Delta Э$, here $\Delta Э$ – ecological state of the natural system of river basins [24].

7. Based on the principles of reasonable, equitable and rightful use of water resources of transboundary rivers, distribution of available water resources for use in economic sectors in the interstate level, in the administrative regions and districts [25] can be used the coefficient of available land resources($K_{зpi}$) of the catchment area of the river basin in the section of facies, which is determined by the formula [25]:

$$W_{бкi} = K_{зpi} \cdot (W_{oi} - \Delta W_{сэi}),$$

where W_{oi} – the volume of water resources of river basins, cubickm; $W_{сэi}$ - the volume of guaranteed sanitary-ecological water resources of river basins, ensuring the environmental sustainability of the natural system in the lower reaches.

8. Using the climate index of productivity of landscapes D.I.Shashko [26], determine the natural and potential bioclimatic potential of geomorphological facies of the catchment area of transboundary river basins using the system of «export-import» environmental services of water resources within the framework of interstate water distribution [21], i.e. the coefficient of ecological services of the catchment area of river basins, ensuring the balancing of the biological productivity of hydroagrolandscapes in the context of anthropogenic activities value, which is determined by the formula: $K_{бкi} = 1 - (Б_{кфi} / Б_{кфi}^{cp})$ и $\sum_{i=1}^{n} K_{бкi} = 0 \rightarrow const$ [19,25].

At the same time, the volume of water resources(W_i) for the provision of environmental services in order to increase «natural capital» ($ЕПК$) to potential natural capital ($ППК$) from the standpoint of the biological productivity of the plant and soil cover of certain landscape classes or catchment areas of river basins is determined by the formula [19,27]: $W_{бк(э-и)i} = K_{бкi} \cdot W_{бкi}$.

9. Based on the biological and ecological water requirements of vegetation and soil cover of landscape systems and disposable water resources in the context of geomorphological facies of the catchment area of transboundary rivers, determine the maximum possible area of hydro-landscape systems [28] taking into account the lack of regulation and over-regulation of the river flow, because of the level of rational use of river flows also depends on them, taking into account the intra-annual natural rhythm of their formation:

- in the unregulated zone, on the one hand, as indicators allowing to determine the maximum allowable($F_{n\partial o}$)and optimum(F_{oo}) area of irrigated land is the discharge of the river's available flow (Q_{rai}, cubic m/sec), i.e. the difference of natural discharge (Q_{oi}, cubic m/sec.) and ecological flow of the river ($Q_{эi}$,cubic m/sec.), and on the other hand, the norms of specific water requirements of the plant (q_{pi}, cubic m/sec. or l/sec. per 1 ha) and soil(q_{ni}, cubic m/sec. or l/sec. per 1 ha) covers formed in as a result of hydro-landscape systems in the watersheds of transboundary basins;
- in the zone of flow regulation, on the one hand, as indicators allowing to determine the maximum allowable ($F_{n\partial o}$) and optimal (F_{oo}) area of irrigated land is the volume of the river's disposable flow (W_{rai}, cubicm), that is, the difference of natural (W_{oi},cubic m) and ecological ($W_{эi}$,cubic m) volumes of the river basin, and on the other hand, the norms of water requirements of the plant (O_{pi}, cubic m/sec.or l/sec.per 1 ha) and soil covers (O_{ni},cubic m/sec. or l/sec. per 1 ha) of agricultural lands, formed as a result of hydro-landscape systems in the catchment areas of transboundary basins.

In the zone of unregulated flow of river basins, the maximum allowable area of irrigated land ($F_{n\partial o}$) is determined by the following formula:

$$F_{n\partial o} = \frac{(Q_{oi}^{\max} - Q_{эi}^{\max}) \cdot K_{ac}}{q_{pi}^{\max}} \cdot \eta_{кп\partial},$$

And the optimal area of irrigated land(F_{oo}) is determined by the following dependence:

$$F_{oo} = \frac{(Q_{oi}^{\max} - Q_{эi}^{\max}) \cdot K_{ac}}{q_{ni}^{\max}} \cdot \eta_{кп\partial}$$

where $F_{n\partial o}$- maximum allowable area of irrigated land, ha; F_{oo}- optimal area of irrigated land, ha; - the natural flow discharge of the river, cubic m/ha; - ecological flow discharge of the river, cubic m/ha; q_{pi}- the norm of specific water requirements of agricultural land cover, cubic m/s or l/s; q_{ni}- the norm of specific water requirements of the soil cover of agricultural land, cubic m/s or l/s;$\eta_{кп\partial}$- the efficiency of the water system; K_{ac}- coefficient of synchronization of river discharge and the norm of specific water demand for agricultural land, which is determined by the following expression:

$$K_{ac} = \frac{\sum\limits_{i=1}^{n} K_{aci}}{n},$$

where n – the number of months in the vegetative (considered) period; K_{aci}- coefficient of synchronization of river flow and the rate of specific water requirements of agricultural land and the i–th month of the growing season (considered) period, which is determined by the following dependencies:

$$K_{aci} = [(Q_{rai} / Q_{rai}^{\max})/(q_{pi} / q_{pi}^{\max}]; \; K_{aci} = [(Q_{rai} / Q_{rai}^{\max})/(q_{ni} / q_{ni}^{\max}],$$

where $Q_{rai}^{\max}$ – the maximum value of the natural flow of the river in the vegetative (considered) period, cubic m/sec.; $q_{pi}^{\max}$- the maximum norm of specific water demand for vegetation cover of agricultural land within the growing season, cubic m/sec.; $q_{ni}^{\max}$ - maximum norm of specific water demand for soil cover of agricultural land within the growing season, cubic m/sec.

In the zone of regulated flow of river basins, the maximum allowable area of irrigated land($F_{n\partial o}$) is determined by the following formula:

$$F_{пдо} = \frac{(W_{oi}^{\max} - W_{эi}^{\max}) \cdot K_{ac}}{O_{pi}^{\max}} \cdot \eta_{кпд},$$

and, the optimal area of irrigated land (F_{oo}) is determined by the following dependence:

$$F_{oo} = \frac{(Q_{oi}^{\max} - Q_{эi}^{\max}) \cdot K_{ac}}{O_{ni}^{\max}} \cdot \eta_{кпд}$$

where $F_{пдо}$- maximum allowable area of irrigated land, ha; F_{oo}- optimal area of irrigated land, ha; Q_{oi}- natural flow discharge of the river, cub.m/s; $Q_{эi}$ - ecological flow of the river, cub.m/ha; $O_{pi}^{\max}$- water requirement of vegetation cover of agricultural land, cub.m; $O_{ni}^{\max}$- water demand of soil cover of agricultural land, cub.m/s or l/s.

At the same time, the coefficient of synchronization of river flow and the norm of specific water demand for agricultural land of the i-th month of a growing season (considered) period is determined by the following dependencies:

$$K_{aci} = [(Q_{rai} / Q_{rai}^{\max}) / (O_{pi} / O_{pi}^{\max}]; \; K_{aci} = [(Q_{rai} / Q_{rai}^{\max}) / (O_{ni} / O_{ni}^{\max}],$$

where $Q_{rai}^{\max}$ – the maximum value of the natural flow of the river in the vegetative (considered) period, cub.m/s; $O_{pi}^{\max}$- the maximum water requirement of vegetation cover of agricultural land within the growing season, cub.m/s; $O_{ni}^{\max}$- the maximum water requirement of soil cover of agricultural land within the growing season, cub.m/s.

10. Comprehensive assessment of environmental, economic and social damage from anthropogenic or economic activities associated with the use of natural resources for the sustainable development of economic sectors is determined by the method of Zh.S. Mustafayev [29], where economic (Э), socio-economic (ЭС) and social (С) damages are distinguished:

$$У_{ц} = Э + ЭС + С = (Э_с + Э_п + Э_л + Э_в) + (ЭС_з + ЭС_п + ЭС_о) + (С_з + С_п + С_{жс}),$$

where $Э_с$ - losses due to shortfall in production; $Э_п$ - losses from the reduction of the quality of products; $Э_л$ - costs of eliminating pollution; $Э_в$- the cost of restoring or maintaining the normal state of the environment; $ЭС_з$- losses in health care and social security due to increased incidence; $ЭС_п$ - losses due to migration caused by environmental degradation; $ЭС_о$- the cost of additional rest required due to the unsatisfactory state of the natural environment; $С_з$- - aesthetic losses due to the destruction of the natural environment; $С_п$- psychological losses caused by unsatisfactory state of rest; $С_{жс}$ - losses caused by deterioration of the ecological conditions of life of society members.

Thus, it should be noted that before planning integrated water resources management (IWRM) in the catchment area of the transboundary rivers basin, it is necessary to answer a number of important questions about the necessity and feasibility of using them for sustainable development and ensuring the country's food security located in the catchment area of the transboundary rivers based on the principles of reasonable, equitable and rightful use of water resources in accordance with the concept adopted by the «Agenda of the 21st century»at the UN in Rio de Janeiro, which require solving complex problems of the rational and balanced use of natural resources within the framework of the applied methodological support.

Discussion of results. Thus, the developed and proposed system of methodological support, formed on the basis of the principles of reasonable, equitable and rightful use of water resources in accordance with the concept adopted on the «Agenda of the 21st Century» at the UN in Rio de Janeiro and developed by the European Environmental Agency «DPSIR-analysis», as a method of systematizing information and

highlighting cause-effect relationships to solve the problems of integrated water resources management of transboundary rivers, covering all levels of the water use process from the formation and storage of water resources and their watershed areas of transboundary basins can be used in the planning and implementation of integrated water resources management (IWRM).

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ТРАНСШЕКАРАЛЫҚ ӨЗЕН АЛАБЫНЫҢ СУ РЕСУРСТАРЫН ИНТЕГРАЦИЯЛЫҚ БАСҚАРУДЫ ӘДІСТЕМЕЛІК НҰСҚАМЕН ҚАМТАМАСЫЗ ЕТУ

Аннотация. БҰҰ-ның Рио-де-Жанейрода қабылдаған «XXI ғасырдың Күн тәртібі» тұжырымдамасына сәйкес ақылға қонымды, тең құқылы және әділ пайдалану қағидасы мен Еуропалық экологиялық агенттігі әзірлеген «DPSIR-талдау» құжаты негізінде ақпаратты жүйелеу әдістемесі ретінде қарастыру арқылы трансшекаралық өзеннің су ресурстарын бірлесіп басқару мәселелерін шешу жолдары қарастырылған. Олардың арасындағы себеп-салдар байланысын ашып көрсету арқылы трансшекаралық әсердің зиянын шектеу және алдын алу мақсатында геоэкологиялық шектеудің интегралдық сынақ көрсеткіштер жүйесіне негізделген.

Геоэкологиялық шектеудің интегралды өлшемі ретінде климат өзгерісін ескере отырып, сумен қамтамасыз ету қисығының көрсеткіші әзірленді, яғни өзеннің жылдық ағыны статистикалық қатарының орташа арифметикалық мәнін, ландшафттық жүйенің жылу және ылғалмен қамтамасыз етілу дәрежесін, шекаралас өзеннің су жинау алабының геоморфологиялық желісін, өзен ағынының шектелген ластануын, климаттық, геологиялық-геоморфологиялық, гидрологиялық және ландшафттық дәлелдеме негізінде құрылған суды пайдаланудың аймақтық бағдарламасының интеграл өлшемдерін, өзеннің су жинау алабы гидроагроландшафттарының «топырақ-өсімдік-адам» жүйесіндегі экологиялық жағдайын, өзен алабының су ресурстарын пайдаланудың шектелген-мүмкіндік деңгейін және экологиялық ағынды өзеннің су жинау алабындағы қолжетімді жер қорын және экологиялық қызметін, өзеннің су жинау алабындағы гидроагроландшафттардың шектелген-мүмкіндік ауданын, антропогендік қызметтің экологиялық, экономикалық, әлеуметтік шығынын кешенді бағалауға арналған көрсеткіштеріне негізделген.

Шекаралас өзендердің су ресурстарын пайдалануда геоэкологиялық шектеудің сынақ көрсеткіштері бағалау әдістемесін, ақпаратты талдау және себеп-салдарлық байланыстарды анықтаудың әдісі ретінде қарастыру арқылы шекаралас өзендердің су ресурстарын мақсатты басқару мәселесін шешу жолдары қарастырылған. Шекаралас өзеннің су жинау алабының барлық деңгейінде, яғни оның су ағынының қалыптасуынан бастап, таралу алабындағы қорлану аймағын қамтуға арналған су ресурстарын интеграциялық басқаруды жоспарлау және іске асыруда интегралдық көрсеткіштерді пайдалану жолдары қарастырылған.

Түйін сөздер: су ресурстары, трансшекаралық өзен, тұжырымдама, стратегия, пайдалану, басқару, іске асыру, жоспарлау, су қорларын интеграциялық басқару.

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МЕТОДИЧЕСКОЕ ОБЕСПЕЧЕНИЕ ИНТЕГРИРОВАННОГО УПРАВЛЕНИЯ ВОДНЫХ РЕСУРСОВ БАССЕЙНА ТРАНСГРАНИЧНЫХ РЕК

Аннотация. На основе принципов разумного, равноправного и справедливого использования водных ресурсов в соответствии с концепцией, принятой на «Повестке дня XXI века» в ООН в Рио-де-Жанейро и разработанного Европейским экологическим агентством – «DPSIR-анализ», как метода систематизации информации и выделения причинно-следственных связей с целью решения проблем интегрированного управления водными ресурсами трансграничных рек, обоснована система интегральных критериев геоэкологического ограничения, обеспечивающая ограничение и предотвращение негативного влияния трансграничного воздействия.

В качестве интегрального критерия геоэкологического ограничения разработан показатель кривой водообеспеченности с учетом изменения климата, то есть средняя арифметическая величина статистического ряда годового стока реки, геоморфологическая схематизация водосборной территории бассейна трансграничных рек с учетом тепло- и водообеспеченности их ландшафтной системы, предельной загрязненности речного стока, территориальное планирование водопользования на основе интегральных параметров с использованием климатических, геолого-геоморфологических, гидрологических и ландшафтных факторов, экологической ситуации гидроагроландшафтов водосбора речных бассейнов в системах «почва-растения-человек», предельно-допустимого уровня использования водных ресурсов речных бассейнов и экологического стока, располагаемых земельных ресурсов водособора бассейна рек и экологических услуг водосбора речных бассейнов, предельно-возможную площадь гидроагроландшафтных систем в водосборных территориях речных бассейнов, комплексная оценка экологического, экономического и социального ущерба при антропогенной деятельности.

Методологическое обоснование критериев геоэкологического ограничения при использования водных ресурсов бассейна трансграничных рек, метод систематизации информации и выделения причинно-следственных связей с целью решения проблем интегрированного управления водными ресурсами трансграничных рек, охватывающие все уровни процесса водопользования от формирования и магазинирования водных ресурсов и их зоны рассеивания водосборов бассейнов трансграничных рек могут быть использованы при планировании и реализации интегрированного управления водными ресурсами (ИУВР).

Ключевые слова: водные ресурсы, трансграничные реки, концепция, стратегия, использование, управление, реализация, планирование, интегрированное управление водными ресурсами.

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