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THE STRUCTURE AND ESTIMATION OF THE RESOURCES POTENTIAL OF WATER BODIES

Water is one of the requisites of the existence of life on the earth. All spheres of human activity are directly or indirectly connected with water and water bodies. The knowledge of the preconditions and limits offered by water resources for human activities is a premise of the evolution of the society. It supposes the measuring and estimating of the resources potential of a territory.

The term *natural resources potential* (sometimes also natural potential) is rather widely used in scientific literature published nowadays in the Soviet Union. At the same time there is no unanimity among the scientists with regard to the definition, structure, measuring and estimating criteria of natural resources potential.

The first to use the term natural resources potential (NRP) to characterise the natural resources of a territory was a well-known geographer Y. Dmitriyevski, who referred to the whole complex of the natural resources of a territory by this term [1, 2]. In his monograph dealing with estimating the natural resources A. Mints gives the NRP an analogous interpretation [3, p. 270]. According to him the NRP represents the absolute summary value (in monetary expression) of all resources found on a certain territory. E. Silayev and V. Shimov also define the NRP as a sum of the natural resources of a region [4].

By the dictionary of N. Reimers and A. Yablokov the NRP is the ability of the natural systems (geosystems, ecosystems, etc.) to produce a product or perform work that can be used in the economic activities of humans [5, p. 93]. Several authors have also defined the NRP of a territory by means of productivity [6, p. 12; 7, p. 8]. They determine the essence of the NRP through the total productivity of the natural resources as the objects of production and consumption.

All the interpretations of the NRP presented above are rather indefinite and similar in their basic meaning. So we can state that the majority of scholars are on close positions upon the general meaning of the term NRP. Most authors usually confine themselves to such vague definitions of the essence of the NRP.

However, when studying and estimating the natural resources of a certain territory in a greater detail, we cannot be satisfied with such a general definition. First of all there arises the question which are these resources we have to sum up to get the total value of the NRP of a territory. To answer that question we must know the structure of the NRP. The second problem is in which units the NRP should be measured and estimated.

The present paper is an attempt to answer these questions. The different structures of the NRP offered by several authors are observed and analysed and the scheme of the structure of the resources potential of water bodies is presented. The paper also deals with the problems of measuring and estimating the NRP of water bodies.

The structure of the natural resources potential of a territory

Different authors use the term natural resources in different meanings. The natural factors affecting human activity are often divided into natural resources and natural conditions. The criteria of differentiation are their direct participation in the production sphere (resources participate, conditions do not) [3, p. 26—27] and the changing of their natural state as a result of human activity (resources do) [8, p. 11; 9]. This is a strict interpretation of the notion of natural resources. But natural conditions also exert significant effect upon human activities. So the strict interpretation of the notion natural resources cannot be considered suitable in estimating the NRP of a territory. Frequently it is very difficult to determine whether the natural factor belongs to resources or conditions. The point of view of Y. Dmitriyevski, the author of the term NRP who interprets natural resources in a broad meaning of the word including also natural conditions, is more logical.

Only a few scientists have dealt with the questions of the structure of the NRP in greater detail. Estimating the NRPs of eight administrative districts of the Georgian SSR, E. Silayev and V. Shimov distinguish the potential of three groups of resources (land, forest and mineral resources) [4]. The important role of water resources is also mentioned, but as they are difficult to estimate and their use is variegated, they are not dealt with closely.

The Ukrainian geographers N. Ignatenko and V. Rudenko distinguish six basic structural units in the composition of the NRP: the potential of mineral resources, land, forest, fauna, water and recreation resources. These potentials, in their turn, are divided into subpotentials. For example, within the potential of forest resources the potential of timber, berries, medicinal plants and environmental protection are distinguished. Their monograph is up to now the only thorough investigation devoted to the study of the NRP [6].

The most detailed grouping of the NRP has been presented by Y. Dmitriyevski, who divides the natural resources of a territory into eight potentials: geographical position, relief, mineral resources, climate, water resources, land, botanical and zoological potentials, which in their turn are divided into several subpotentials [10].

In spite of the different number of resources distinguished by the authors mentioned above, the basic scheme of their NRP structures is of the same kind: subpotential of a certain resource — the total potential of that resource — total NRP of the whole territory. Therefore the central link of the system is the total potential of a single resource. Summing up these potentials of resources we get the total NRP of a territory. A graphical interpretation of such a strucure of the NRP is given in Fig. 1A.

A. Ignatyev and others have solved the problem of the structure of the NRP in a different way [11]. They have proceeded from a proposition by which the central link of the structure of the NRP is not single resources (land, water, climate, etc.), but subpotentials with a clearly sectoral character (agrarian, hydro-electric, mining industrial, etc.). The value of a subpotential is not usually determined by a single resource, but by a complex of resources characteristic of a concrete territory. All together, seven groups of subpotentials are distinguished: the potential of bioproduction, water management, mining industry, building, recreational, selfpurification and the potential of biotical regulation. This model of the structure of the NRP is schematically presented in Fig. 1B.

Analysing these two structural models of the NRP presented above we see that as compared to model A, two lower levels are reversed in

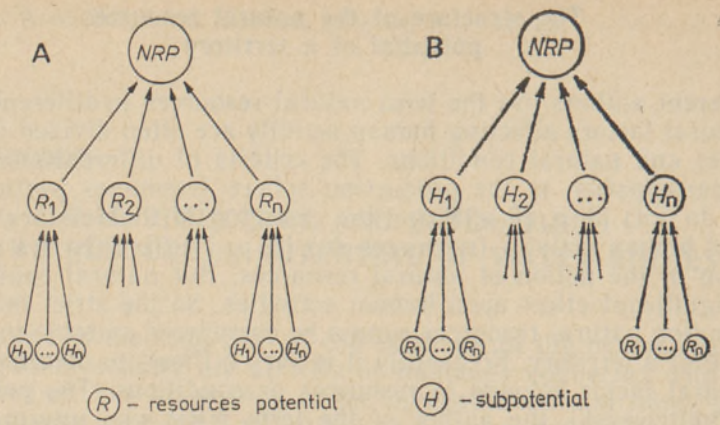

Fig. 1. The different graphical interpretations of the NRP of a territory.

model B. In model A the sectoral subpotential is distributed between several resource potentials. In model B the situation is the opposite. The resource is distributed there between the sectoral potentials and is reflected in the total NRP by them. For example, the potential of water resources is reflected in the NRP of a territory by the potential of fishery, water management, recreation, water transport, etc. In mathematics it is known that the sum does not depend on the order of the addends. Therefore, at the first glance we might get an impression that both models yield the same result. In ideal cases it is so. But in reality it is practically impossible to achieve this, especially in cases of diverse natural resources and regions with a developed economy. To answer the question which of the models should be preferred, let us see what the practical estimation of the NRP of a territory proceeding from these models looks like.

Model A requires the knowledge on the distribution of the sectoral potential between various resources. In practice it means that we must determine which part of the agrarian potential is given by soil, how much by water, solar radiation (climate), etc. Or more figuratively: we should know how to determine what part of the one thousand roubles obtained from selling 20 tons of potatoes is given by soil, by water or the sun. Of course, it is impossible to answer such a question, because here we have to deal with the synergetic effect when using those three resources together. The value of the effect does not equal the sum of the values of single components. But if we cannot distribute the sectoral potentials between the resources with necessary exactness, we cannot speak about the exactness of determing the total NRP. It may easily happen that something is accounted repeatedly while something else is omitted altogether.

In case of using model B there is no need to distribute sectoral potentials between the resources. Instead, the resources must be divided between sectoral potentials. Evidently, it is much simpler to divide land between agriculture and industry than to distribute the profit received from wheat yield between soil and water. Therefore model B must be considered more adequate for social practice than model A.

The structure of the resources potential of water bodies

In composing the structural scheme of the NRP of water bodies the author proceeded from model B (Fig. 1) and the conception presented by A. Ignatyev and others [11]. Taking into account the peculiarities of

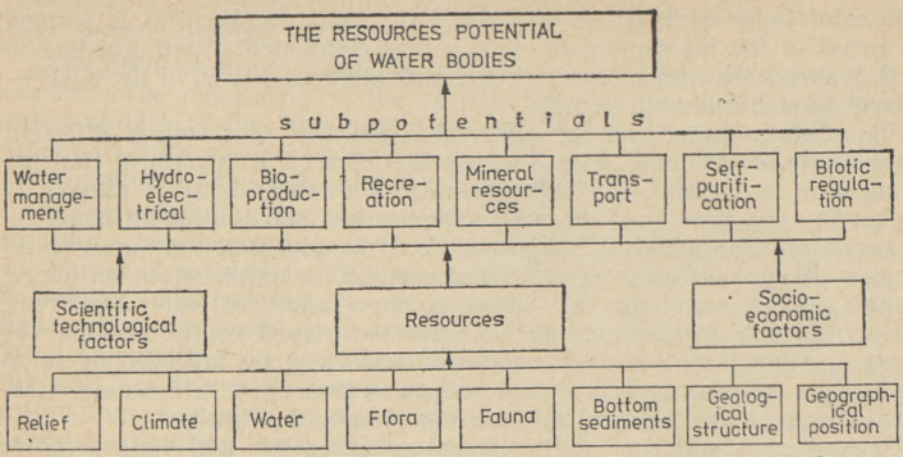

Fig. 2. The structural scheme of the resources potential water bodies.

water bodies as specific geosystems, the schematic solution for the structure of the NRP of water bodies is presented (Fig. 2).

In analyzing the structure of the NRP of water bodies three hierarchical levels can be distinguished. The components of the geosystem of the water bodies or single resources form the lowest level.

In addition to the traditional resources the geographical position is separately brought out on the scheme to stress the close connection between the territory and the NRP. The NRPs belonging to a certain territory give it both general and individual characteristics and turn it into a systematic notion. Besides the intraterritorial relations the geographical position of the water body with regard to a probable consumer of its NRP must be taken into account. For example, a favourable geographical position can successfully compensate for the lower quality of a resource.

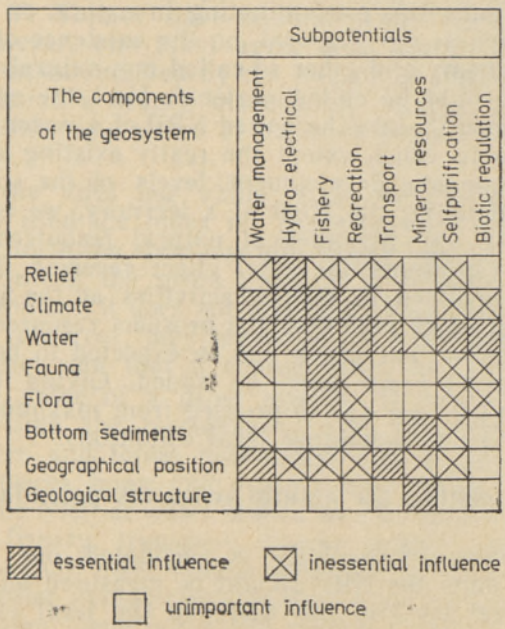

Fig. 3. The influence of the components of the geosystems on the formation of the subpotentials of the NRP.

A water body with all its characteristics and peculiarities is formed as a result of the interaction of eight initial components distinguished in Fig. 2. It forms the natural basis to the next hierarchic level of the NRP — the level of sectoral subpotentials.

The relative importance of different resources in forming different subpotentials is not equal. Fig. 3 shows this clearly. It is natural that the leading role in forming the subpotentials of a water body is played by the quantity and quality of the water which exert substantial influence on all (except mining industry) subpotentials. If we give 2 points for essential influence, 1 point for inessential influence and 0 for unimportant influence, we shall get 15 points for the "index of importance" of water resources. An essential role in forming the NRP is also played by the climate (11 points) and geographical position (9 points). They are followed by relief with 7, flora and fauna with 6 and bottom sediments with 5 points. Geological structure has the most modest importance (2 points).

An analogous operation with sectoral subpotentials will yield a figure that might be called "complexity index". Calculations show that the fishery potential (10 points) is the most complex one, i. e. it depends on the greatest number of factors. The next are water management and recreational potentials with 9, hydro-electric and self-purification potentials with 7, transport and mining industry with 6 and the potential of biotical regulation with 5 points. All these calculations presented are conventional, but still they give an idea about the relative importance of different resources and the complexity of subpotentials.

On the level of resources we have to deal with pure natural categories (relief, water, etc.), but on the next level sectoral subpotentials represent natural-socio-economic categories. In the formation of these subpotentials social and economic factors have an important role in addition to the natural ones. Therefore in the scheme of the NRP scientific-technological and socio-economic factors are distinguished separately. Without taking these factors into account it is impossible to get adequate estimations of the subpotentials corresponding to reality and having a practical value.

The estimation of the NRP also depends on our knowledge about the connections and regularities predominating in nature, on the level of the technologies we have at our disposal, on the existence of labour, on the requirements of economy and other so-called non-natural factors.

The third level could be called regional. Here the second level subpotentials are summed up into the united NRP of a water body.

Depending upon to which extent the really existing scientific-technological and socio-economic development levels of the society are taken into account in estimating the NRP of a territory, we can speak of the realized, perspective and hypothetical natural resources potential. The realized potential represents the total effect received from the use of natural resources involved in human activities at the present time. In estimating the perspective potential, the prospect resources that have not been taken into use yet, but which can be expected to be taken into use in the nearest 10—20 years must be added. Giving the hypothetical estimation of the NRP, one has to proceed from maximum values of the resources that could be used under ideal conditions.

Estimating the natural resources potential

When the structure of the NRP is elucidated, one is faced by the question in which units the NRP should be measured and estimated. On the lowest structural level of the NRP, on the level of resources, this problem does not cause particular difficulties because of the lack of the necessity to sum up different resources. On this level we are fully satisfied with the results of the measurements and investigations that describe

resources and laws of nature and are expressed in natural units (tons, cubic meters, degrees, etc.).

The problem arises when the next level, the level of subpotentials, is reached. The measuring of the "production" or the useful output of the subpotentials is the first step here too. But to compare different subpotentials with each other and to sum them up, the subpotentials should be estimated in the same units of measurement.

When estimating the natural resources the term "estimation" is used in quite a broad meaning. By L. Mukhina the estimation is understood as 1) the act of estimating, determining the price, ascertaining the value of something or somebody; 2) an opinion or decision about the quality or importance of something or somebody [12]. Thus one term signifies both the act of getting an estimation and the result of this act. According to the way how the estimation is understood, different authors suggest that estimations expressed in monetary terms or scores and words should be used in estimating the NRP of a territory. The estimation of the NRP in absolute power units is in principle also considered possible and interesting [10; 13], but because of the lack of the criteria and methods, no practical results in this field have been achieved yet.

In estimating the natural resources, monetary or the so-called economic estimations are widely used. Many economists in the Soviet Union and also in some other countries of Eastern Europe nowadays stand for the estimation of the natural resources by the method of differential rent. According to this method, the estimation of the natural resource is equal to the difference between the maximum socially necessary and expedient costs and actual costs of the production received from this resource. Here the branch of economy acts as the subject of estimation, estimating the object (resource) proceeding from the profit received from its exploitation. It is a comparative estimation where the estimated resource is compared with the worst resource still necessary for satisfying social needs. Therefore the estimation received does not reflect the total value of the resource, but the economy of work or money, obtained from exploiting the relatively better part of the resource. Using this method, E. Silayev and V. Shimov have estimated the NRP of the Georgian districts [4]. However, one must agree with the researchers in whose opinion the estimation received by the method of differential rent can be used primarily inside a branch of economy while it is not suitable for comparing the utility and value of different resources used in different fields of economy.

To estimate the total use value of a resource N. Ignatenko and V. Rudenko have used the index of "gross product value" [6]. Although the authors bring forth the shortcomings of this method (it does not show the cocts in producing the gross product, it depends on a number of purely economic indices, it does not take into consideration the geographical position of a resource), they regard as its main advantage compared with the differential rent that it characterises the resource as a whole.

The monetary value of a gross product is surely one of the main indices characterising the resources in such branches of economy as mining, agriculture and forest husbandry, because for their production there exist fixed prices, home and world market prices. In estimating the subpotentials of the NRP of water bodies we can speak of prices or tariffs only in case of fishery, transport, mining industry and hydro-electric potentials. But we shall meet serious difficulties when we try to estimate the potential of water management. Water is not an article of commerce and there are neither home nor world market prices of water. There are also no unitary tariffs for water consuming both in Estonia and in the Soviet Union. Naturally the water conveyed to a consumer has a cost

price, but if we try to find out the water managemental value of a water body by using the cost price we shall get the result where a farther and more polluted water body gets a higher estimation because of bigger expenses on purification and transport of water.

It is even more difficult to find the monetary value of the gross product for the potentials of recreation, self-purification and biotic regulation that have mainly social and ecological importance. It is clear that a holiday spent at a water body has a positive influence on man's health and thus has an economic effect (the decrease in the days of sick-leave will rise labour productivity), but it characterises only one side of the recreational potential apparent in economy, not the total potential of recreation. The human health and life have no price.* In case of the predominantly social values we can express in money terms only their coaction apparent in economy, but not their total value.

The fact that the monetary estimation of some subpotentials of the NRP of a territory is connected with serious methodological difficulties or it is impossible at all, has made it necessary to use expert estimations. These estimations may be expressed differently: verbally (the conditions on exploitation are very difficult, difficult, satisfactory, favourable, highly favourable), or numerically — in scores, categories, etc., where a numerical value is assigned to every verbal estimate mentioned above. It must be stressed that an estimate is always relative, because it shows only the suitability of the resource for a certain purpose. Therefore, the estimates expressed in scores or categories must be also regarded as one of the means of expressing the verbal estimates [15]. The advantage of scores over verbal estimates is their laconism, they can be easily processed and compared, and if necessary, united into integral estimates.

Y. Dmitriyevski also recommends scores as one of the possibilities to express the estimation of the NRP and presents the following formula:

$$P = K_1 \cdot P_1 + K_2 \cdot P_2 + \ldots + K_n \cdot P_n,$$

where P_{1-n} denotes the estimation of the subpotentials expressed in scores and K_{1-n} is the relative importance (weight) of the subpotentials in forming the total NRP.

Therefore, the estimation of the NRP obtained by this method represents the weighted average of the subpotentials. The weakest side of the formula, acknowledged also by Y. Dmitriyevski himself, is the growth of estimation subjectivity, accompanying the determination of the importance of the subpotentials.

To estimate the subpotentials of the NRP of a water body and to compare them with each other one more possibility can be suggested. Here it is proceeded from the thesis that the final purpose of an economy is to satisfy human needs. Consequently, the estimation result depends on the extent to which the use value of the subpotential is able to satisfy the needs of the population. Here, in estimating and comparing the subpotentials the notion *a human year* might be successfully used [16], where one human year is equalized with one person's need for the annual production of the estimated subpotential. For example, the fishery potential of a water body (P_F) can be found by the following formula:

$$P_F = F / C,$$

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* V. Babkov has calculated the monetary losses caused by traffic accidents on Soviet economy and society [14. p. 12—17]. Proceeding from the fact that the average age of traffic accident victims in the Soviet Union is 32.5 years, a hard injury costs the society 665 roubles because of unreceived production, disablement 15 190 roubles and the death of the victim 24 800 roubles. It may be true, but the last figure can never be regarded as the estimation given to human life.

where F denotes the annual fish productivity of the water body and C is the average annual consumption of fish by one person (in Estonia it is about 23 kg per person).

While the monetary estimation can rightly be called an economic one, then the estimation expressed in human years is rather a social estimation. In human years it is possible to express also the values that can be measured in monetary terms only partially or cannot be measured at all. Therefore, to characterize the NRP of water bodies, it is expedient to use both economic (monetary) and social (in human years) estimations, because they contain to a certain extent different information and complement each other.

Conclusions

1. One of the preconditions of the rational usage and protection of water resources is the measuring and estimating of the resources potential of water bodies.
2. In analyzing the structure of the notion "resources potential" of water bodies three hierarchic levels can be distinguished: 1) the level of the components (resources) of the geosystem of water bodies; 2) the level of the subpotentials with a sectoral character; 3) the regional level, where the subpotentials are summed up into the united resources potential of a water body.
3. Depending on the object and the subject of the estimation and also on the information available, the estimates can be expressed in monetary terms (economic estimations), human years (social estimations) or in scores (expert estimations) in estimating the resources potential of water bodies.

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VEEKOGUDE RESSURSIPOTENTSIAALI STRUKTUUR JA HINDAMINE

Veekogudele sotsiaal-majandusliku hinnangu andmise ja nende ratsionaalse kasutamise ning kaitse üks eeldusi on veekogude ressursipotentsiaali hindamine. Ressursipotentsiaali kui kompleksse näitaja mõõtmise ja hindamise esimene etapp on tema enda struktuuri kindlaksmääramine.

Veekogu ressursipotentsiaali struktuuri analüüsil on eristatavad kolm hierarhilist taset. Kõige madalama taseme moodustavad veekogu geosüsteemi komponendid e. üksikud ressursid: reljeef, kliima, põhjasetted, vesi, taimestik, loomastik ja geoloogiline ehitus. Lisaks traditsioonilistele ressurssidele on ressursipotentsiaali ja territooriumi seose rõhutamiseks otstarbekas iseseisva komponendina eristada ka veekogu geograafilist asendit.

Loetletud kaheksa lähtekomponendi koosmõjul formeerub veekogu kõigi oma omaduste ja eripäraga. See moodustab aluse järgmisele hierarhilisele tasemele — harukondliku iseloomuga osapotentsiaalide tasemele, kus võib eristada vee-, kala- ja puhkemajanduslikku, maavarade, transpordi, isepuhastuslikku ja biootilise regulatsiooni potentsiaali. Kui ressursside tasemel on tegemist puhtalt looduslike kategooriatega, siis teisel tasemel kujutavad osapotentsiaalid endast juba looduslik-sotsiaal-majanduslikke kategooriaid, millede formeerumisel on lisaks looduslikele oluline koht ka ühiskondlikel teguritel. Seetõttu on ressursipotentsiaali struktuuris eraldi välja toodud teaduslik-tehnilised ja sotsiaal-majanduslikud faktorid. Neid arvestamata ei ole võimalik saada reaalseid, tegelikkusele vastavaid ja praktilist väärtust omavaid osapotentsiaalide hinnanguid. Ressursipotentsiaali struktuuri kolmandat tasandit võib nimetada regionaalseks. Siin toimub teise taseme harukondlike osapotentsiaalide summeerimine ühtseks veekogu ressursipotentsiaaliks.

Loodusressursside hindamisel kasutatakse laialdaselt mitmesuguseid rahalisi hinnanguid. Rahaliselt on siiski võimalik tervikuna väljendada vaid majanduslikke väärtusi. Sotsiaalsetest väärtustest on rahaliselt hinnatav nende realiseerumisega kaasnev majanduslik efekt, mitte aga sotsiaalne väärtus tervikuna. Veekogu ressursipotentsiaali sotsiaalse väärtuse hindamiseks võib kasutada *inimaasta* mõistet, kus üks inimaasta võrdub ühe inimese aastase vajadusega hinnatava osapotentsiaali toodangu järele.

Kui rahalist hinnangut võib õigusega nimetada majanduslikuks hinnanguks, siis inimaastates väljendatud hinnang pretendeerib enam sotsiaalse hinnangu nimetusele. Majanduslik ja sotsiaalne hinnang täiendavad teineteist, sest nendes sisalduv info hinnatava objekti kohta on sõltuvalt osapotentsiaalist kas suuremal või vähemal määral erinev. Seetõttu on veekogude ressursipotentsiaali hindamisel ja looduse kasutust ning kaitset puudutavate otsuste tegemisel otstarbekas kasutada nii majanduslikke kui ka sotsiaalseid hinnanguid.

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СТРУКТУРА И ОЦЕНКА ПРИРОДНО-РЕСУРСНОГО ПОТЕНЦИАЛА ВОДОЕМОВ

Одной из предпосылок для социально-экономического оценивания и рационального использования водоемов является оценка их природно-ресурсного потенциала (ПРП). Первым этапом измерения и оценки ПРП является определение структуры ПРП. Анализируя структуру ПРП водоема, можно различить три иерархических уровня. Самый низкий уровень — это компоненты (ресурсы) геосистемы водоема: рельеф, климат, донные отложения, вода, растительность, животный мир и геологическая структура. Чтобы подчеркнуть связи между территорией и ПРП, целесообразно выделить в качестве самостоятельного компонента географическое положение водоема и дополнить им традиционные ресурсы.

Взаимодействие перечисленных восьми компонентов характеризует водоем со всеми его качественными признаками и особенностями. Тем самым закладывается основа для следующего уровня — уровня частных потенциалов отраслевого характера, среди которых различаются водохозяйственный, рыбохозяйственный, гидроэнергетический, рекреационный, минерально-ресурсный и транспортный потенциалы, а также и потенциалы самоочищения и биотического регулирования. Если на уровне ресурсов мы имеем дело с природными категориями, то на уровне частных потенциалов — с природно-социально-экономическими категориями, на формирование которых оказывают влияние не столько природные, сколько социально-экономические условия. Поэтому в структуру ПРП отдельно выделены научно-технические и социально-экономические факторы. Без учета этих факторов невозможно получить реальные и практически значимые оценки частных потенциалов. Третий уровень структуры ПРП можно назвать региональным. Здесь отраслевые частные потенциалы суммируются в единый ПРП водоема.

При оценивании природных ресурсов широко используются разные денежные или т. н. экономические оценки. В денежном выражении можно оценить только тот эффект от использования природных ресурсов, который проявляется в сфере экономики. Социальные ценности полностью выразить в рублях невозможно. Для социальной оценки ПРП водоемов можно предложить термин «человеко-год». Один человеко-год соответствует годичной потребности одного человека в продукции оцениваемого частного потенциала. В человеко-годах в принципе поддаются описанию и ценности, которые в рублях могут быть выражены только частично. Поэтому для характеристики ПРП водоема целесообразно использовать и экономические (денежные), и социальные (в человеко-годах) оценки, так как они содержат в известной степени разную информацию, чем и дополняют друг друга.

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