Water-resource substantiation of strategic planning in the regions of the Ob-Irtysh basin

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Abstract. The paper substantiates the need to conduct water assessment for the strategic planning documents of the regions, including the elaboration of strategies and the forecasts of long-term socio-economic development of the Russian Federation. In this regard, we present the theoretical and methodological approach and the algorithm of such assessments. The approach is based on the landscape-basin principle of territory organization. On the example of the Ob-Irtysh basin regions, the assessing has revealed water availability in the territories, anthropogenic load, water intensity, water consumption forecast, and prospects for water resources use. They indicate local water shortage in some landscape provinces of Omsk Oblast with a total population of more than 130 thousand people. Within the boundaries of river basins, we have estimated the anthropogenic load of low and medium intensity and calculated water intensity of territories (municipal districts), including for different types of economic activity and yearly dynamics. These results have been also a basis for forecasting the prospective use of water resources for drinking, industrial, irrigation and agricultural purposes. Using the forecasts, we have developed scenarios of the water supply of the regions, considering water content (minimum, maximum and average) of the period.

1. Introduction
The strategic planning documents set out the main directions or scenarios of regional economic development. According to Federal Law No. 172, the strategies of the Russian Federation (RF) subjects specify the priorities, goals and objectives of public administration, whereas the forecasts – the expected results of the socio-economic development. These documents often do not include issues related to water consumption and discharge. Therefore, it seems necessary and urgent to develop the approaches and methods for water-resource substantiation of strategic planning of the regions’ development.

2. Methodology and methods
Previously, the theoretical-methodological approach, which fully reflects the formation specifics of the water-resource potential of territories and can assess current and future water supply in line with the planned changes in economic activity of an RF subject, has been proposed [1]. The foundation for this approach is the landscape-basin principle of territory organization. The landscape approach is implemented through defining physical-geographical units of different hierarchical levels, i.e. from countries and zonal areas to the provincial and topological structure of major river basins [2]. The
basin approach takes into account the peculiarities of watercourses formation, especially the issues of water resources use and management in the river basins.

The concept of the river basin as a natural and economic system appeared [3-7] in the 1970s-1980s. The point is that within such a system, the unidirectional flow of matter, energy and information contributes to the structuring of natural and economic constituents, the establishment of strong links and the interaction between them.

Specialists from Institute for Water and Environmental Problems SB RAS (IWEP SB RAS) have performed the in-depth analysis of zonal and azonal factors of landscape differentiation and developed a generalized scheme of physical and geographical zoning of Siberia [8-9]. The authors emphasize that nature management systems are formed due to landscape features of the territory (i.e. the level of natural zones and landscape provinces). Being more sustainable than socio-economic systems, they play an important role in the regional economy. The landscape-basin approach is proposed for purposes of nature management [10-11].

We adapted this approach for assessing water availability of the studied regions. It is worth noting that the landscape structure of the Ob-Irtysh basin is represented by steppe, forest-steppe, taiga, forest-tundra and tundra zones of the West Siberian Lowland, the Altai-Sayan and the Ural mountain countries, within which 83 landscape provinces have been identified. Here, the Ob-Irtysh river basins and their major tributaries, i.e. rivers Tobol, Tom, Chulym, etc. were defined. According to the administrative-territorial division, the regions partially or completely located within the Ob-Irtysh river basin (15 RF subjects) were studied. Water zoning accounted for 81 water management sites.

Water availability was estimated using the method developed by the State Hydrological Institute (SHI) with regard to potential and real water resources [12].

3. Results and discussion

The basic results of the water-resource substantiation of strategic planning in the Ob-Irtysh regions were obtained due to Federal research works accomplished by IWEP SB RAS in 2007-2018. For instance, natural factors responsible for water-supply systems formation in the regions were identified, and the decisive role of anthropogenic factors in systems’ functioning was proved [13]. Based on the calculation results, we estimated water availability of territories using the average annual long-term data. The results indicated local water shortage in some landscape provinces, for example, in Omsk Oblast with a total population of more than 130 thousand people. Local water deficit occurred in other regions of the basin, thereupon, regions were ranked by the population living under conditions of water resources scarcity.

Assessments of anthropogenic loads on the catchments and some water bodies were implemented within the boundaries of water management zoning. In most cases, the evaluation showed a low and medium level of impact intensity. The areas with high anthropogenic load required extra calculations for different by water content periods. For instance, water availability for the Aley basin ranged from medium to high in years with 50% water content up to low and critical in periods with minimum water content (95%), including summer-autumn and winter low water seasons.

In addition, the calculations were performed to assess water intensity of the territories at the regional and municipal levels, including that for different types of economic activities and in yearly dynamics.

These studies formed the basis for a comparative analysis of the regions of the Ob-Irtysh basin and other regions of Siberia and Europe in terms of specific (per capita) water consumption and GDP-related water intensity. The analysis suggests that the highest level of water consumption indicates the RF subjects focused on raw materials and industrial development (Kemerovo, Tyumen and Tomsk oblasts). In 1995-2017, the share of re-circulated and re-sequential water supply decreased. Kemerovo oblast was leading in GDP-related water intensity. At the same time, in the regions with high water consumption (Tyumen and Kemerovo oblasts), the water share of transportation loss was significantly lower than in oblasts distinguished by little water consumption (Republic of Altai). A comparison of GDP-related water intensity between the regions of West
Siberia, Russia and Europe (on the example of Germany) implies a crucial impact of industrial specialization on the efficiency of water resources use. In the resource provinces and the regions with the developed industrial infrastructure (e.g., energy), GDP was much higher than that in Russia and the average one for the economically developed countries. The obtained results on water intensity and water consumption in the regions became the basis for forecasting the prospects for water resources use (table 1). Taking into account the Rosstat demographic forecast, the periods of water content and the basic variant of the socioeconomic development of the RF subjects, we elaborated the scenarios of water supply to the regions (table 2).

Table 1. Forecast of target use of water resources in the regions of the Upper Ob (basic version).

| Freshwater use                                           | 2020   | 2025   | 2030   | 2035   |
|----------------------------------------------------------|--------|--------|--------|--------|
| for drinking and household purposes, total, million m³   | 463.79 | 461.09 | 458.62 | 457.43 |
| Novosibirsk oblast                                       | 153.83 | 157.99 | 162.19 | 166.81 |
| Altai Krai                                               | 73.92  | 71.65  | 69.12  | 66.64  |
| Republic of Altai                                        | 2.94   | 2.97   | 2.98   | 2.99   |
| Kemerovo oblast                                           | 180.95 | 175.64 | 170.73 | 166.65 |
| Tomsk oblast                                              | 52.16  | 52.85  | 53.59  | 54.33  |
| for production needs, total, million m³                  | 2399.68| 2768.41| 3223.39| 3746.94|
| Novosibirsk oblast                                       | 393.47 | 471.85 | 565.84 | 678.56 |
| Altai Krai                                               | 234.98 | 269.77 | 309.71 | 355.57 |
| Republic of Altai                                        | 1.96   | 2.38   | 2.94   | 3.44   |
| Kemerovo oblast                                           | 1520.18| 1731.70| 2005.57| 2315.99|
| Tomsk oblast                                              | 249.09 | 292.71 | 339.33 | 393.38 |
| for agriculture and irrigation, total, million m³         | 63.66  | 67.41  | 71.57  | 76.11  |
| Novosibirsk oblast                                       | 20.73  | 23.11  | 25.77  | 28.73  |
| Altai Krai                                               | 35.12  | 35.74  | 36.37  | 37.01  |
| Republic of Altai                                        | 1.40   | 1.54   | 1.72   | 1.90   |
| Kemerovo oblast                                           | 3.06   | 3.38   | 3.73   | 4.12   |
| Tomsk oblast                                              | 3.34   | 3.63   | 3.97   | 4.34   |

To substantiate the need for water resource assessments in the documents of strategic planning of territories, we generalized the obtained results.

Table 2. Water supply scenarios of the Upper Ob regions for different periods of water content at the basic variant of the socioeconomic development, thousand m³/capita per year.

| Region / water content | 2017  | 2020  | 2025  | 2030  | 2035  |
|------------------------|-------|-------|-------|-------|-------|
| Novosibirsk oblast     |       |       |       |       |       |
| average                | 23.06 | 22.76 | 22.16 | 21.58 | 20.97 |
| maximum                | 31.57 | 31.17 | 30.34 | 29.55 | 28.72 |
| minimum                | 15.37 | 15.17 | 14.77 | 14.38 | 13.97 |
| Altai Krai             |       |       |       |       |       |
| average                | 23.53 | 23.82 | 24.57 | 25.46 | 26.40 |
| maximum                | 35.15 | 35.58 | 36.70 | 38.04 | 39.45 |
| minimum                | 16.36 | 16.56 | 17.08 | 17.70 | 18.35 |
| Republic of Altai      |       |       |       |       |       |
| average                | 156.29| 154.28| 152.52| 151.96| 151.35|
| maximum                | 232.60| 229.61| 226.99| 226.16| 225.25|
| minimum                | 97.44 | 96.19 | 95.10 | 94.75 | 94.37 |
Kemerovo oblast

|           | Average | Maximum | Minimum |
|-----------|---------|---------|---------|
| average   | 15.88   | 23.17   | 9.81    |
| maximum   | 16.11   | 23.50   | 9.95    |
| minimum   | 16.58   | 24.20   | 10.23   |

Tomsk oblast

|           | Average | Maximum | Minimum |
|-----------|---------|---------|---------|
| average   | 168.95  | 220.89  | 117.67  |
| maximum   | 168.27  | 219.98  | 117.19  |
| minimum   | 166.06  | 217.10  | 115.65  |

4. Conclusion

We propose to use water resource assessments of territories in the documents of strategic planning of the regions.

For this purpose, we have developed the theoretical and methodological approach as well as the algorithm for assessing water supply to the population and economy of the RF subjects, which we present in this paper.

The results of assessing the potential and actual water resources, the anthropogenic load on water bodies and their catchments, the water use efficiency in the regions, and the dynamics of water management indicators for 1990-2017 have become the basis for estimating current and future water availability. In calculations, we have also considered the demographic forecast, the periods of water content and the basic scenario of the socio-economic development of the regions.

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