Assessing the sustainable development of an enterprise from the water use standpoint

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Abstract. The role of industrial enterprises in ensuring a sustainable development project are analysed. It shows that when planning their work, the companies should take into account not only their economic performance, but also the state of the environment. It is the negative consequences of production that have a destructive effect on the environment, including water resources. To assess the state of water resources, which is shaped by the work of enterprises, it is proposed to use indicators and indices. The study gives an overview of the existing assessment methods, as well as proposes custom ones.

1. Introduction

Today an unstable and rapidly changing external environment forces enterprise leaders to reconsider their views on management and often make decisions in uncertainty. Previously the basic economic performance of a company was the main focus, whereas now a large enterprise cannot fail to take into account the state of the environment, the footprint of the company activity [1]. Only this way the leadership of large enterprises will be able to ensure the ability to meet the needs of the next generations – the sustainable development. Sustainable development is a balanced development of economic, social and ecological subsystems in order to meet the needs of present and future generations [2].

The problem of analysis and management becomes especially relevant in the context of globalization, the growing interdependence of financial markets and the increasing role of corporations in the sustainability of the national economy. A modern enterprise is a complex corporate entity that uses not only financial, but also natural resources to achieve its goals. Therefore, it is very important to keep the enterprise development sustainable, and hold the enterprise leadership accountable for it. Even if the enterprise is resistant to the impact of various factors apart from its development, at some point it will inevitably face a crisis or downfall. However, the sustainable development (SD) process, the relationship between development and sustainability and the mechanisms underlying them are insufficiently studied and are of great interest for research. This fact only increases the urgency of the problem. According to a survey of CEOs of companies participating in the UN Global Compact, 93% of them believe that sustainable development is the key factor in a successful business [1]. The very same SD concept was adopted at the UN Conference on Development and Environment in Rio de Janeiro in 1992. Today it is the most widespread concept and is often referred to as the "global model of the future of civilization" [3].

Every year Russian and foreign researchers pay more and more attention to the field of sustainable development of an enterprise. A considerable number of works has been devoted to the management of socio-economic systems, including the works by: V.G. Afanasiev, J. Elkington, R. Akoff, S.Bir, J. Casti, A.A. Bogdanov, M.A. Kreymina, B.Z. Milner, G.B. Kleiner, D.V. Sokolov and others. Certain aspects
of the use of tools in determining the sustainable development of enterprises are analysed in the works of L.A. Belousova, N.V. Pakhomova, I. D. Afanasenko, S.N. Bobylev, S.V. Trubetskov and E.B. Borodul, etc.

2. Materials and methods
The theoretical and methodological basis of the study originates from the scientific work of Russian and foreign authors on sustainable development, economics, theory of socio-economic systems effectiveness, as well as world and domestic practice. The scientific novelty of the work lies in the development of theoretical and practical provisions for the formation and calculation of sustainable development indicators of an enterprise from the standpoint of water use.

3. Results and discussion
The environmental sphere is of huge importance in the sustainable development of an industrial enterprise. It is the negative consequences of production that have a significant destructive effect on the environment, including water resources. In December 2016 the UN General Assembly adopted the Resolution 71/222 declaring the period 2018–2028 an international decade for action called "Water for Sustainable Development" (WSD). It started on the World Water Day, March 22, 2018 and will end on March 22, 2028. The resolution stresses the importance of promoting efficient use of water at all levels, taking into account the relationship between water resources, food, energy and the environment, including in the implementation of national programs. The growing understanding of the overarching nature of water and its great importance for the natural environment and human activities has highlighted the need for a rational use of water resources. The main unit in this case is an industrial enterprise. Its use of water resources can have a harmful effect on the environment due to the discharge of wastewater and on the water consumption due to the impact on the water reserves. In this regard, the assessment of the role an individual enterprise plays in the state of surface waters is very significant [3, 4].

In foreign literature, the problem of sustainable development of the enterprise goes hand in hand with economic and financial development (J. S. Mill, J. Schumpeter, R.F. Harrod, P. Kotler, etc.). Russian scientists (M.I. Bakanov, A.A. Kolobov, E.N. Kucherova, G.V. Savitskaya, etc.) adhere to practically the same research path. The question is: what indicators (characteristics) should be used when assessing the sustainable development of a particular enterprise?

Sustainable development indicators are being designed by the United Nations Department of Political Coordination and Sustainable Development, the United Nations Commission on Sustainable Development (CSD), and the Scientific Committee of Problems of the Environment (SCOPE). The problem of creating a system of indicators of sustainable development is still far from being solved. Still, there are projects of indicators that propose systems of different scales: global, regional, national, local, sectoral, even for individual settlements and enterprises.

As of today, a large number of environmental indices have been developed in Russia and abroad, for example:

- hydrochemical water pollution index (WPI) (1986), which is the average proportion of exceeding the maximum permissible concentrations for a strictly limited number of individual ingredients [5];
- general sanitary water quality index (WQI) (1987), representing a generalized numerical assessment of water quality in terms of a set of basic indicators and types of water use [5];
- combinatorial pollution index, a slightly modified, in comparison with WPI, method of integral assessment of water quality, based on the totality of pollutants in it and the frequency of their detection [5];
- the integral index of the ecological state (IIES) (2000), that’s calculated based on the widely known hydrochemical (mineral forms of nitrogen, phosphates, volatile phenols, etc.) and hydrobiological (abundance and biomass of macrozoobenthos, species diversity, biotic and oligochaete indices and etc.) indicators [6].
- water quality index (WQI) is an index based on eight water quality parameters [7];
• Canadian Water Quality Index (CWQI) has been approved as a suitable model for assessing the quality of drinking waters globally by the United Nations Environmental Program [7].

Despite the large number of different systems of environmental indices and indicators developed and adopted at the global level [8] and in the Russian Federation [3-5], there is currently no single definition of an indicator. For example, the Free Encyclopedia says that "Index of sustainable development is an indicator (it is derived from primary data, which usually cannot be used to interpret changes), makes it possible to evaluate the state or change of economic, social or environmental variables" [9]. According to V.V. Dmitriev, an indicator is a vector of the ecosystem state, it is a set (a list) of ordered ecosystem variables that reflects its most important properties [10].

Here we define an indicator as an index that makes it possible to assess the state or changes in the characteristics of the ecological component of the enterprise's SD (e.g. the quantity and quality of water resources).

The analysis of publications shows that during the implementation of projects for sustainable development of enterprises, no one has dealt with a separate assessment of the environmental component of SD, a part of this component (namely, water resources). We believe that indicators used for water resources assessment should also meet a number of requirements, such as:
• relevance, i.e. compliance with the tasks that a certain indicator is designed to solve;
• apprehensibility – the indicator should be clear;
• validity and ease of interpretation;
• spatio-temporal variability – indicators should have a sufficient range of measurement of parameters characterizing water resources and their trends over time;
• reliability – indicators should be based on real facts.

However, to have individual indicators is not enough in order to control the state of the entire system. We need to assess the mutual relationships between the individual factors of the system’s state. This challenge can be solved by the integral indicators that contain generalizing characteristics of the entire system’s state. These indicators are called indices. They are calculated on the basis of particular markers, i.e. indicators.

The main purpose of introducing indices is to assess a situation or event to predict the development of the current situation and come up with the solutions to the existing problems [2, 11]. The indices can be used when causal relationships are well understood.

To characterize the amount of water taken by an enterprise, we suggest using two groups of indicators:

a. annual withdrawal of surface water - the percentage of the taken water compared with the total available water reserves;
b. the volume of circulating water as a percentage of its intake from water sources.

To characterize the water quality, we also recommend applying two groups of indicators:

a. discharge of contaminated wastewater into surface water bodies;
b. discharge of pollutants into surface water bodies.

According to the international scale, the indicators of response are also added: wastewater treatment (% of the total population served and the type of treatment).

It is generally accepted that a river catchment area is a natural unit in terms of water resources management. Unfortunately, the boundaries of the political and administrative division usually do not coincide with the boundaries of catchments, while water resources are formed within these catchments. How can this be taken into account if an industrial enterprise does not fit into the framework of one catchment? Hence there’s a challenge of calculating the water consumption in such a way that the administrative territories of the studied catchment area are not left water-deficient. Apparently, it is necessary to proceed from the worst conditions for the formation of surface runoff (e.g. a dry year with 95% of the water supply) and rely on the total water management balance of all enterprises located within the catchment area.

A simplified water balance equation for the accepted time interval can be written as follows:
\[ W - R = \Delta W, \]  

(1)

Here \( W \) and \( R \) are total income and expense parts of the balance; \( \Delta W \) is the resulting balance.

In our case, the equation will look like this:

\[ W - (R_1 + R_2) = \Delta W \]  

(2)

Here, the input part \( W \) is the volume of water resources formed during one dry year, with 95% of the supply within the studied catchment area; the expenditure part includes two components: \( R_1 \) – the volume of water resources consumed by the settlement company, \( R_2 \) – the volume of water resources consumed by the rest of the enterprises within the catchment area. The value of \( \Delta W \) should be greater than the value of \( V \cdot N \), where \( N \) is the number of inhabitants consuming water from the rivers of the studied catchment area and \( V \) is the required water supply, established per person in the region.

With the equality \( V \cdot N = \Delta W \) – the water consumption is in a critical state and the consumption part should be reduced. Comparing the values of \( R_1 \) and \( R_2 \) one can assess the contribution of the enterprise to the formation of the water deficit of the territory. In this case, the location of the water intakes does not play a significant role, and the indicator of water use \( (I_{\text{water}}) \) is calculated as follows:

\[ I_{\text{water}} = \frac{R_1}{W - \Delta W - R_2} \]  

(3)

The lower the indicator value, the better. When \( I_{\text{water}} = 1 \) it is a state of crisis, it means scarcity of water resources due to the activities of the enterprise in question.

The state of water resources depends not only on the amount of water taken by the enterprise, but also on wastewater discharges into surface water bodies. Every year statistical reports show the volume of discharged wastewater with a subdivision into polluted, normatively clean and normatively purified water. This division is often very arbitrary. For example, until 1999, collector-drainage waters from irrigated lands were classified as “normatively clean”, while being polluted with pesticides, nitrogen and phosphorus compounds. With all the conventionality of dividing wastewater into categories, polluted wastewater has the greatest negative impact on water bodies. Therefore it makes more sense to use the “discharge of polluted wastewater into surface water bodies” as an indicator.

To calculate the indicator of wastewater discharges by an enterprise into water bodies \( (I_{\text{dis}}) \) we propose to use the following equation:

\[ I_{\text{dis}} = \frac{C_f}{C_n} \]  

(4)

Where \( C_f \) is the actual amount (fact) of pollutants discharged by the enterprise into water bodies. These data can be found in the protocols of the enterprise laboratory for each polluting (standardized) substance selected in accordance with its environmental monitoring program. Most often, such a selection is made for each "official" source of discharge in accordance with the "Permit for the discharge of substances (except for radioactive substances) and microorganisms into water bodies". The amount is measured in mg/L or t/year; \( C_n \) is the normative amount of discharges of pollutants into water bodies. This is the value of the allowable discharge standards (ADS). This value is determined for each standardized substance and for each source of discharge separately, in accordance with [12]. The amount is measured in mg/L or t/year. For \( C_f = C_n \) the value of \( I_{\text{dis}} = 1 \) is the permissible limit of the indicator value.

This approach can be used if there is no need to take into account the chemical composition of the discharged wastewater. If it is necessary to take into account the chemical composition, then it should be calculated as follows:

\[ I_{\text{disi}} = \frac{C_{fi}}{C_{ni}} \]  

(5)

where \( i \) is an element of the chemical composition of wastewater.
Then

\[ I_{\text{dis}} = \sum f_i c_{ni} \]  

(6)

The integral indicator (or index – I) is the geometric mean of the indicators of the quantity and quality of water resources:

\[ I = \sqrt{I_{\text{dis}} I_{\text{water}}} \]  

(7)

4. Conclusion

The method of assessing the environmental sustainability of an enterprise's development makes it possible to determine its place in the development, and, consequently, to prevent water shortages within the catchment area where it is located. The indicators of the state of water resources are indicators and indices calculated on their basis. They can serve as an assessment indicator for the initial stage of planning the development of an enterprise to be more effective in terms of environmental policy, including the calculation of investment in the modernization of production. Thus, the company can follow the implementation of the global trend of transition to sustainable development. For modern scientists, a comparison of the state of the surrounding aquatic environment on the basis of an integral indicator will make it possible to quantify the features of dynamics in space and time, the degree of anthropogenic transformation, as well as the degree of permissible impact on water bodies, the tendencies of their changes. To visualize such changes, both digital mapping and 3D modelling can be used.

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