Application of sustainable development indicators in the context of the region's transition to a «green» economy

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Abstract. Compliance with environmental priorities in the economic activities of the regions should be an important direction in solving socio-economic problems in order to transition to “green” economic growth and sustainable development. For the regions of the Baikal natural territory (BNT) the paramount importance is to assess the intensity of the main types of environmental pollution in order to determine the ratio of the results of economic activity to the level of its negative impact on the environment. The paper presents a comparative analysis of indicators of environmental capacity, such as eco-intensity and per capita emissions on the example of the regions that are part of the BNT, which include the Republic of Buryatia, Irkutsk region and Zabaykalsky Krai. Also, it was necessary to determine whether there is a mismatch in economic activity between the rate of economic growth and the consumption of resources and the environmental impact on the environment, that is, the achievement of a decoupling effect. The obtained results of modeling to assess the current economic situation on the example of the Republic of Buryatia, taking into account environmental parameters, allowed identifying the main factors that have the greatest impact on per capita emissions. A positive aspect of the economic activity of the Republic of Buryatia is the observed decrease in per capita emissions, with an increase in the growth rate of the main economic indicators, which indicates the presence of the decoupling effect.

1. Introduction

The economic activity of the regions and the assessment of its impact on the environment require the use of economic indicators to take into account the environmental component of the socio-economic development of the territories. Strengthening environmental restrictions in the development of the regional economy actualizes research directions to determine the main parameters for assessing the quality of the socio-economic development of the regions and the transition to "green" economic growth. The use of quantitative parameters will provide information support for monitoring the development of regions in terms of assessing resource, environmental and social factors.

In the current practice of determining the sustainable development of territories, a number of indicators of environmental capacity are widely used [1-5], which in some cases are defined as eco-intensity or intensity of pollution, per capita emissions and resource intensity. As noted Bobylev S.N. “Along with macroeconomic indicators adjusted for the environmental factor, environmental capacity is an important indicator for assessing the environmental and economic efficiency of macroeconomic
policies, and among environmental and economic criteria, a decrease in the environmental capacity of an economy in dynamics is one of the effective criteria for sustainable development and transition to a green economy” [2].

In international organizations and individual states, different approaches to the construction of this indicator have been developed. From our point of view, the indicator of environmental capacity is an indicator of the quality of socio-economic development of territories, reflecting the level and degree of anthropogenic impact on the environment as a whole [6]. At the same time, “indicators of environmental capacity themselves say little. Their main advantages are manifested when they are measured in dynamics or when compared with other countries, economic structures, technologies, etc.”[2].

A comparative dynamic assessment of indicators at the regional level has its own characteristics, due to the natural-geographical and socio-economic conditions of the territories. For example, the Republic of Buryatia, a region with environmental regulation, occupies ¾ of the Baikal nature protection territory. In recent years, the achievement of the “decoupling effect” has played an important role in the formation of the green economy [7, 8]. Decoupling is “the strategic basis for moving towards an environmentally sustainable economy, which allows mismatching the growth rate of human well-being, on the one hand, and resource consumption and environmental impact, on the other” [7] and can be expressed in terms of environmental capacity. Therefore, the assessment of the intensity of the main types of environmental pollution to determine the ratio of the results of economic activity with the level of its negative impact on the environment is of paramount importance for the republic.

For the first time decoupling was mentioned in OECD environmental strategy: “Decoupling environmental pressures from economic growth, with a view to ensuring that continued economic growth is accompanied by enhanced environmental quality, is needed”. UNEP divides 2 types of decoupling - Resource decoupling, which essentially means using less natural resources to generate the same income and Impact decoupling, which is an increase in economic well-being while reducing negative environmental impacts [8].

2. Models and methods
In connection with the foregoing, let us consider the indicators eco-intensity and per capita emissions of the Republic of Buryatia against the background of the average russian and regional average indicators of BNT for pollution of water resources and atmospheric air. The calculation of these indicators characterizes the effectiveness of the functioning of any economic system and reflects the pressure of the economy on the environment and the person himself.

The eco-intensity indicator is the specific value of the negative environmental impact (for example, pollution) per unit of final result (final product or contribution to GRP). Various pollutants, gases, production and consumption wastes can be considered as pollution [6].

The eco-intensity $E_i$ of the industry, taking into account the environmental load $P$, is defined as the environmental load per unit of the final result:

$$E_i = \frac{q_i^P}{v_i},$$

(1)

where $v_i$ - GRP produced by industry ($i$), $q_i^P$ - environmental load $P$ by industry ($i$).

This indicator essentially shows “pollution intensity” establishes the correlation between the efficiency of the economy and the negative impact of economic activity on the environment. A decrease in this indicator is possible due to the introduction of environmentally more advanced, in particular “green technologies”, as well as an increase in the economic result (for example, the region’s contribution to the GRP).

The next parameter for assessing the level of sustainable development is the indicator per capita emissions. Per capita emissions show the specific load of the negative impact of produced pollution on humans and the environment.
Per capita emissions $E_h$ is defined as the environmental load (emissions, discharges of pollutants and waste disposal) per person:

$$E_h = \frac{q_i^P}{H}, \quad (2)$$

where $H$ – number of people exposed to polluted environment, $q_i^P$ – environmental burden ($P$) by industry ($i$).

To assess the factors affecting per capita emissions of the discharge of polluted wastewater from the Republic of Buryatia, a model of the multiple regression equation, described by a function [9]:

$$\tilde{Y}_{1,2,\ldots,k} = f(x_1, x_2, \ldots, x_k), \quad (3)$$

where $\tilde{Y}_{1,2,\ldots,k}$ – regressand, $x$ – repressor, $f(X)$ – some function, according to the interaction of variables $Y$ and $x$ goes.

To build a multivariate relationship model, we used a linear multiple regression model:

$$\tilde{Y}_x = a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3, \quad (4)$$

### 3. Results and discussion

To establish the ratio of the effectiveness of economic activity with the level of its impact on the environment, we determine how high the intensity of the main pollution of the BNT regions is.

The intensity of emissions into the atmosphere or the eco-intensity of air pollution. On the graph (figure 1) there is a positive trend, which indicates a tendency for a decrease in the eco-intensity of the economy as a whole for the main types of pollution. According to the results of 2016, the economy of Zabaykalsky Krai had the lowest impact on air pollution (0.000464 t/thousand rubles); indicators of the Republic of Buryatia (0.000471 t/thousand rubles), which is almost two times higher than the average Russian level. Irkutsk oblast has the highest eco-intensity indicator (0.000600 t/thousand rubles), which exceeds, for example, the level of the Republic of Buryatia by 1.27 times.

The current situation in terms of the impact of the economy on water pollution also demonstrates the dynamics of a decrease in eco-intensity (figure 2). Zabaykalsky Krai has the lowest indicator, the value of which is 0.13 m$^3$/thousand rub. The Republic of Buryatia has a slightly larger value – 0.19 m$^3$/thousand rub. The average value of this indicator in the Russian Federation is 0.21 m$^3$/thousand rub. The eco-intensity indicator of the Irkutsk oblast (0.48 m$^3$/thousand rubles) is more than twice the average Russian level. In Zabaykalsky Krai, the value of the eco-intensity indicator decreased by 8.47 times for the period 2005-2015, this is the best dynamics among the subjects of BNT.

**Figure 1.** Eco-intensity of air pollution, t/thousand rub.  
**Figure 2.** Eco-intensity discharge of polluted wastewater, m$^3$/thousand rub.
The analysis for the period 2005-2016 in the BNT regions showed that the per capita air emissions changed in different ways (figure 3). So, for example, in the Republic of Buryatia this indicator increased by 6% on average, in Zabaykalsky Krai, on the contrary, decreased by 10%, as well as the average for Russia this indicator decreased by 20%. Irkutsk oblast was especially distinguished, for which this indicator increased by 32%.

Analysis of the dynamics of the indicator of the per capita water emissions over the same period showed that there was a positive decrease in this indicator. In the Republic of Buryatia with 63.08 m³/person up to 38.62 m³/person (figure 4), which is 1.63 times less. In Zabaykalsky Krai this indicator decreased 2.34 times (from 73.84 m³ per person to 31.54 m³ per person). And in the Irkutsk oblast, this indicator decreased by 1.53 times (from 326.64 m³ per person to 213.36 m³ per person). However, the indicator values remain quite high, compared with the Republic of Buryatia and Zabaykalsky Krai, as well as the average Russian indicator.

Using the example of the Republic of Buryatia, in order to assess the influence of the main factors on the indicator of the per capita water emissions (y), a model of the multiple regression equation was constructed. The following factors were identified as exogenous variables of the model: \(x_1\) – production per capita, mln. rub/person; \(x_2\) – share of investments in environmental protection, %; \(x_3\) – fixed assets per capita, rub./person. The study period was 2000-2016.

The equation of multiple regression of per capita water emissions is:

\[
y = 138.6 - 1.587x_1 - 3.571x_2 - 0.062x_3 \tag{5}
\]

The actual value of the F-test is \(F = 9.539\). Since \(F_p > F_t\), the statistical significance of the regression equation, its parameters and the indicator of closeness of connection \(R\) are recognized. As a result of modelling this indicator, it follows that the main factor that has had the greatest positive impact is the share of investments in environmental protection. At the same time, the observed decrease in per capita water emissions, with an increase in the growth rate of the main economic indicators, shows the presence of a “decoupling” effect.

4. Conclusion
In this paper, we examined the relationship between the regions of Russia that are part of the Baikal natural territory in terms of environmental capacity: eco-intensity and per capita emissions.

Analysis of the relationship between the components of the economy and the environment of the Baikal region in the period 2005-2016 showed the following.

1) A gradual decrease in the eco-intensity indicator indicates a tendency to reduce the environmental load with a relative increase in GRP, characterized as a positive process. At the same time, in comparison with the all-Russian level, this indicator remains very high and this applies to both...

Figure 3. Per capita air emissions, kg/person.

Figure 4. Per capita water emissions, m³/person.
air pollution and water pollution. First of all, this indicates a low level of technical equipment for enterprises in the Baikal region.

2) The indicator of per capita emissions also shows a relatively positive trend. In principle, we can say that in general there is a trend in the reduction of pollution, but along with this we also observe a decrease in the population, both in the regions and in Russia as a whole, which also affects the values of this indicator.

It is also important to note that in order to manage and coordinate further economic development, it is necessary to take into account the characteristics of each region separately; this will increase the effectiveness of the measures taken and help prevent financial losses.

As a result of the study, we determined that for the BNT regions, the obtained quantitative estimates of the environmental capacity indicators can be applied in assessing the socio-economic development towards the transition to a green economy. Also, to predict the development of environmental consequences of anthropogenic pollution of the regions and the adoption of preventive management measures to prevent them.

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