**Using the Input-Output Model for Evaluating the Impact of Environmental Restrictions on the Economic Development of the Republic of Buryatia, Russia**[[1]](#footnote-1)

Zorikto Dondokov[[2]](#footnote-2)

Konstantin Dyrkheev[[3]](#footnote-3)

**Abstract**

Lake Baikal is a unique natural site listed on the UNESCO World Heritage List. There is a special regime for natural resources management throughout the Baikal Natural Territory (BNT), which covers Lake Baikal and the surrounding specially protected areas. The activity of timber and wood processing companies, agricultural enterprises, and fisheries is prohibited or strictly limited in this area. It negatively affects social and economic development of the BNT, which covers over 72% of the territory of the Republic of Buryatia, Russia.

The study presents calculations of direct and indirect economic losses of the region due to declining production and lost earnings in related sectors. These calculations are made based on the Input-Output Table of the Republic of Buryatia for 2011, which includes 50 types of economic activity.

The paper proposes an input-output model for analyzing social and economic development of the region using strict environmental restrictions as exogenous variables. The authors evaluate multiplier effects of the increment of gross output, tax revenues, and employment. The authors also make scenario calculations of direct and indirect economic losses of the Republic of Buryatia due to the impact of restrictions on economic activity in the Baikal Natural Territory.

***Keywords*:** environmental restrictions; Lake Baikal; economic losses; regional input-output tables; direct and indirect effects.

**JEL Classification:** C67; Q20; R15.

Lake Baikal is a unique natural site listed on the UNESCO World Heritage List. Russia has made a commitment to preserve the unique ecosystem of Lake Baikal to the international community.

Russian Federal Law “On Protection of Lake Baikal” introduced a special regime of nature management within the Baikal Natural Territory (BNT). The BNT includes Lake Baikal and the surrounding protected areas. In this territory, the following activities are prohibited or restricted:

* Chemical pollution of Lake Baikal, its parts, and catchment area by the discharges and emissions of hazardous substances, the use of pesticides, agricultural chemicals, and radioactive substances, transport operations, and the stockpiling of production and consumption waste;
* Physical transformation of the state of Lake Baikal or its parts (changing temperature regimes of the water, fluctuation of the water level indicators beyond the allowed values, changing drainage streams of the lake);
* Biological pollution of Lake Baikal by using, breeding, or acclimatizing aquatic biological objects alien to Baikal’s ecological system in the lake and water bodies that are permanently or temporarily connected to it.[[4]](#footnote-4)

These provisions impose restrictions on the scope and areas of development of the entire economic complex of the BNT. The work of timber processing companies, agricultural enterprises, and fisheries is prohibited or strictly limited in this area. It negatively affects social and economic development of the BNT, which covers over 72% of the territory of the Republic of Buryatia.[[5]](#footnote-5) The functioning of the economy of Buryatia under special business conditions in the BNT has a number of negative consequences for the population, businesses, and the budgetary system of the region. The consequences of environmental restrictions in Buryatia include the following:

1. The increase in the operating costs as compared to the Russian indicators due to higher fees for using natural resources, fines for environmental pollution, strict requirements for wastewater treatment, the allocation of a significant part of the fixed assets on the balance sheet of the companies for environmental protection, and the increase of the resource, material, capital, and labor intensity of production.
2. The increase of transportation costs of companies due to the changes in the traditional transportation patterns within the BNT and restrictions concerning the use of cheaper modes of transportation of timber from the harvesting to processing companies.
3. Direct losses in the production output due to strict restrictions imposed on nature management activities and the removal of production facilities from the coastal and water protection zones of Lake Baikal (in agriculture, logging, hunting, social and recreational activities).
4. The increase of non-production capital (investment) costs due to nature protection activities, the transformation and overhaul of the largest employers in small towns around the lake, and the closure, conservation, and relocation of existing production facilities.

Economic losses of Buryatia in 2011 were calculated by the Institute of Macroeconomic Research (IMR) of the Russian Ministry of Economic Development and Trade, which developed a relevant methodology. The amount of the lost gross value added (GVA) due to direct losses and underproduction was calculated as the sum of two indicators:

1. Lost revenues as a result of direct losses and/or underproduction;
2. Lost revenues in related sectors and production operations.

The first indicator includes lost revenues due to the decrease in production notably in such sectors as agriculture (plant production and livestock breeding) and timber industry. The second indicator represents indirect losses arising in related sectors and production operations due to the decrease in the consumption of raw materials, fuel, and other products that are used in agriculture, timber industry, and to a lesser degree in a number of other industries.

The amount of the lost GVA due to the direct losses and underproduction ($D$) was calculated as the sum of the lost revenues due to the direct losses and/or underproduction $(D\_{1})$ and the lost revenues in related sectors and production operations $(D\_{2})$:

$D=D\_{1}+D\_{2}$; (1)

$D\_{1}=Pd$; (2)

$D\_{2}=P(1-d)δ$, (3)

where $P$ – is the total value of losses and underproduction due to the introduction of a special regime of economic activity in the BNT; $d$ – the share of GVA in the gross output of a sector; $δ$ – the share of GVA in the cost of material, technical, and other resources that are used for production.

The results of the calculations of the losses in the main sectors of the Republic of Buryatia in 2011 are shown in Table 1.

**Table 1**

**Lost GVA due to the losses and underproduction in Buryatia in 2011**

**(million rubles)[[6]](#footnote-6)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Sectors | $P$  | $d$  | $D\_{1}$  | $D\_{2}$  | $$D $$ |
| 1 | Agriculture (plant production and livestock breeding) | 10,848.4 | 0.62 | 6,726.0 | 2,019.9 | 8,745.9 |
| 2 | Timber industry  | 8,884.7 | 0.58 | 5,153.1 | 2,394.5 | 7,547.6 |
| 3 | Social and recreational activities  | 196.1 | 0.68 | 133.3 | 31.7 | 165.0 |
| 4 | Other sectors  | 49.0 | 0.52 | 25.5 | 11.7 | 37.2 |
| 5 | Economy of Buryatia, total  | 19,978.2 | - | 12,037.9 | 4,457.8 | 16,495.7 |

Based on the results of calculations using the IMR methodology, in Buryatia in 2011, the amount of economic losses ($D$) due to the impact of the Baikal Factor was 16,495.7 million rubles. The loss of GVA in Buryatia is almost entirely composed of the losses in revenues in agriculture and timber industry (53.0% and 45.8% accordingly).

However, this methodology determines economic losses in an aggregate form with no regard to the industry-specific production, which significantly reduces the accuracy of such calculations. For more accuracy, it is necessary to disaggregate the indicators. In this case, the economy must be viewed as a collection of several industries (economic activities). This problem can be addressed based on the studies using the regional input-output tables.

In Russia, after a long break, input-output tables are being developed at the national and regional levels in accordance with the Russian Classification of Economic Activities (OKVED). In Buryatia, by the initiative of the local government and with the participation of the region’s researchers and experts, the input-output table was developed in 2011. The goal of that work was to create a data base for the analysis and forecasting of the social and economic development of Buryatia. The tables were developed in the context of 50 economic activities for all large and medium-sized enterprises, as well as on the basis of sampling for small businesses.

A structural analysis of Buryatia’s economy using the main regional macroeconomic indicators was conducted based on the input-output table aggregated by 16 types of economic activity. A regional static input-output model for making scenario calculations of the economic development of Buryatia taking into account the impact of various factors including environmental ones was created based on the data of these tables. Taking into consideration the Baikal Factor in the assessment of social and economic development is especially important for Buryatia. The production process of the consumption of natural resources should be a link in the common environmental and economic balance in the region.

Essentially, input-output models allow to study different scenarios of regional development and make variant calculations including the environmental aspect into the regional economic activity. Creating a regional environmental and economic input-output model, first of all, it is necessary to identify the options for disaggregating basic input-output tables in order to perform deeper analysis and make quality decisions concerning specific types of economic activity taking into account environmental restrictions.

In order to address this task, we developed a methodology, which allows to evaluate input-output effects of air, water, and soil pollution in the BNT and assess direct and indirect economic losses of Buryatia in connection with the impact of the Baikal Factor.

This methodology is based on the input-output balance, which allows to comprehensively evaluate the impact of various factors on the social and economic development of the region taking into account direct and indirect effects. Direct effects include changes in the end consumption of a specific type of products. Indirect effects include the effects that arise in sectors and related production operations that are linked to the production of the specified type of products with production and cooperation ties and stipulated by the changes of the volume of its end consumption. In sum, direct and indirect effects make multiplier effects.

In order to create a regional input-output model, we developed an information base consisting of two blocs — endogenous and exogenous. The parameters of the exogenous bloc are the input information for this model. They reflect the indicators of the regional end product for specific components. The endogenous bloc of the regional input-output model includes the changes in the gross output and GVA, tax revenues, employment, and the amount of production losses due to the special nature management regime in the BNT.

Based on technology matrix $A$ and identity matrix $E$, we calculated the matrix of full regional economic costs $(E-A)^{-1}$, where each coefficient represents the sum of direct and indirect costs on all stages of production stipulated by the production of a unit of the specific type of product or service. With the help of the matrix of full costs, it is possible to calculate the changes in gross output$ ∆X$, the volume of tax revenues$ ∆V$, and employment $∆L$ by the types of economic activity depending on the changes of the elements of the regional end products $∆Y$ using these formulas:

$∆X=(E-A)^{-1}∆Y$;

$∆V=T(E-A)^{-1}∆Y$;

$∆L=M(E-A)^{-1}∆Y$,

where $T=(T\_{j})$ — is the diagonal matrix of the share of net taxes for the production in gross output; $M=(M\_{j})$ — the diagonal matrix of labor intensity of production.

In a similar way, it is possible to calculate multiplier effects of full economic losses in the region including direct and indirect losses due to the impact of environmental restrictions on the economic activity in the BNT.

In order to implement this methodology, we developed an algorithm for calculating the losses in the output of goods and services by the types of economic activity based on the input-output tables and taking into account the impact of direct environmental losses in specific types of economic activity:

$∆R=(E-A)^{-1}∆Q$,

where $∆R$ — is the vector of the lost gross outputs by the types of economic activity as a result of environmental losses; $∆Q$ — the vector of underproduction of the end product in each type of economic activity as a result of environmental losses.

This way, by identifying the value of underproduction of the end products in each type of economic activity as a result of environmental losses, it is possible to calculate multiplier volumes of the lost gross outputs as a result of environmental restrictions by the types of economic activity and in the region in general.

Based on the expert calculations (Table 1), we found that basically the whole volume of direct losses and underproduction due to the introduction of the special regime of economic activity was observed in agriculture (53.0%) and timber industry (45.8%).

In Table 2, we provide multiplier calculations of the volumes of the lost gross outputs in all types of economic activity and in Buryatia’s economy in general in 2011 that resulted from the losses and underproduction in agriculture, where the value of the lost GVA ($D$) in 2011 was 8,745.9 million rubles.

**Table 2**

**Multiplier effects in the economy of Buryatia as a result of the losses and underproduction in agriculture (**$D$ **= 8,745.9 million rubles)**

|  |  |  |
| --- | --- | --- |
| No. | Types of economic activity | Volumes of underproduction of gross outputs,  mln. rub. |
| 1 | Agriculture, hunting, and forestry | 9,177.4 |
| 2 | Fishing and fish breeding | 0.01 |
| 3 | Extraction of minerals | 1,735.4 |
| 4 | Manufacturing | 2,699.6 |
| 5 | Timber industry | 267.0 |
| 6 | Production and distribution of electricity, gas, and water | 260.7 |
| 7 | Construction | 351.3 |
| 8 | Wholesale and retail; repair of cars, motorcycles, home and personal appliances | 470.9 |
| 9 | Hotels and restaurants | 7.7 |
| 10 | Transportation and communication | 845.6 |
| 11 | Finances | 6.2 |
| 12 | Real estate operations | 256.9 |
| 13 | Governance and defense; social security | 11.9 |
| 14 | Education | 0.9 |
| 15 | Healthcare and social services | 7.0 |
| 16 | Other utility, social, and personal services | 16.8 |
|  Total in the region’s economy | 16,115.1 |

As we see in this table, the multiplier volume of underproduction in agriculture as a result of the losses in GVA in this sector is 9,177.4 million rubles. In general, in the economy of Buryatia, the volume of underproduction is 16,115.1 million rubles. Significant volumes of underproduction are in manufacturing (2,699.6 mln. rub.), extraction of minerals (1,735.4), and transportation and communication (845.6 mln. rub.). To a lesser degree, underproduction is also observed in the wholesale and retail sector (470.9 mln. rub.), construction (351.3 mln. rub.), timber industry, power production, and real estate operations (257-267 mln. rub.). Input-output connections of other sectors with agriculture are insignificant.

So, the input-output tables developed for the Republic of Buryatia are an effective tool for analytical and forecasting calculations of the social and economic development of the region and the evaluation of direct and indirect economic losses due to the environmental limitations in the Baikal Natural Territory.

1. This research is funded by the Russian Foundation of Fundamental Research under Research Project No. 15-46-04321: “The study of the impact of the Baikal Factor on the social and economic development of the Republic of Buryatia based on the input-output model with an expanded composition of endogenous parameters”. [↑](#footnote-ref-1)
2. Department of Regional Economic Studies, Buryat Scientific Center, Siberian Branch of the Russian Academy of Sciences, Russian Federation

E-mail: dzorikto@mail.ru [↑](#footnote-ref-2)
3. Department of Regional Economic Studies, Buryat Scientific Center, Siberian Branch of the Russian Academy of Sciences, Russian Federation

E-mail: konst0506@rambler.ru [↑](#footnote-ref-3)
4. Federal Law of the Russian Federation No. 94-FZ “On Protection of Lake Baikal”, dated May 1, 1999, Art. 5-6. [↑](#footnote-ref-4)
5. Dondokov Z. (2012). Economic Losses of the Republic of Buryatia Due to Baikal Factor. Journal of BSC SB RAS, 1, 26-30. [↑](#footnote-ref-5)
6. Calculated based on the data of the Territorial Body of the Federal State Statistics Service in the Republic of Buryatia. [↑](#footnote-ref-6)