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# Urbanization and Greenhouse Gas Emissions from Industry

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**Abstract.** This article analyses the global environment. The article describes processes that characterize the global environment, specific indicators are suggested, that can be used to measure the change in the global environment. It is said that cities and all urbanized territories have a negative effect on the global environment. Originally, the authors wanted to call the article «City as a source of destruction of the global environment». But taking into account the fact that urbanization contributes to improving the economic efficiency of the state, cities are the centers of the economic, cultural and informational potential that provide a «breakthrough» into the development of the economy. The article assesses the impact of urbanization on the global environment. For the analysis of the impact of urbanization on the natural habitat, the autoregressive distributed lags (ADL-model) are chosen.

**Key words:** global environment; city; impact of urbanization; Greenhouse Gas Emissions from Industry; ADL-model.

## 1. Introduction

The global space surrounding modern man, includes the natural habitat, artificial habitat, created by a man and social habitat. City is an artificial environment created by a man.

Global space is currently characterized with a set of processes, capable of rendering direct or indirect, immediate or remote impact on human activity, its health and future generations. A person always has a need for space, clean air, water, and a presence of some wild forest plants.

In a large modern urbanized areas it is hard to talk about the presence of sufficient volume and quality of a space enough to satisfy a person's needs minimum human requirements. A lot of different products were created, and at the same time a pollution levels were also rapidly growth. As a industrialization and urbanization result, a global space surrounding a man gradually became very «aggressive» for mans senses, senses that were evolutionary adapted for the congenital space through a millions years.

A concentration of harmful substances in the air inside is becoming much greater than in the outdoors in many cases.

With its activity a man initiates many processes that affect a global space, for example: disasters associated with climate change, growth of CO<sub>2</sub> proportion in the air, increase in greenhouse gases in the atmosphere, increase global temperature, reduction of freshwater resources on the planet, reduction of the forest area as a result of cutting down. The main negative contribution to the characteristics of environmental processes is provided by the artificial habitat, created by a man – a cities.. All cities have a great influence on the growth and development of modern economy. More than half the world's population lives in cities since 2015. Six hundred of the world's largest cities will be producing sixty



percent of world GDP by 2025 according to the research organization Mc Kinsey Global Institute (MGI).

Mc Kinsey Global Institute recommends companies to switch their strategy from the largest cities and include 577 rapidly developing cities of the medium size. It is expected that their contribution will cap at 35 % of the worlds' GDP [1]. The modern vector of urbanization is the growth of the industries in the cities, transformation of the rural villages into urbanized areas, motorization and therefore pollution of the atmosphere [2]. The air pollution and indirectly the water pollution consists of greenhouse gases [3], that have a large contribution into the global warming, emission of the nitrogen gasses, dust and aerosols, carbon monoxide, volatile organic substances, that affect mans health in an extremely negative way [4–6].

A problem of global space pollution is that the quality of atmospheric air is continuously deteriorating, and this causes serious concern. To measure the level of the atmospheric pollution in urbanized areas, was created a network of observation posts service and control of atmospheric pollution as part of the global space [7, 8]. The network determines the content in the atmosphere of different harmful substances, coming from anthropogenic sources of emissions.

It is important in the conditions of constant pollution of the global environment to be able to predict the impact of the city as a source of pollution on variables that assess the state of the global environment.

The aim of this article is to demonstrate the basis for methods for predicting the pollution of the global environment, by sources of an artificial environment – a city.

## 2. Estimation of the natural conditions state

Characterizing a current state of the natural conditions as critical, we distinguish several following causes, which lead to the destruction of the natural conditions.

First, climate disasters (CD), estimated by economic damage from natural disasters caused by processes of long-lived / mesomacroscale processes (in the range from seasonal to multi-decadal climate variability).

Secondly, it is pollution, poisoning of the natural habitat of man, greenhouse gas emissions(GGE) including CO<sub>2</sub> emissions(COE), oxygen depletion, ozone holes, etc.

Thirdly, this is a change in the global temperature (CGT) on the planet because of the greenhouse effect and the resulting increase in temperature and climate change.

Fourthly, it is predatory use of available natural resources, traditional sources of energy and sources of raw materials, reduction of fresh water supplies (RFW), and reduction of forest area (RFA).

The fifth reason is a rapid, unregulated population growth. According to the forecast for 2040, the world population will reach 13 billion people.

It is clear that with such a rapid increase of the population of the Earth, the negative consequences of anthropogenic activity will sharply increase. The negative results are not only the growth of the population itself, which increases the burden on nature beyond the permissible limits, but also the need to further accelerate the extraction of the raw materials of nature, with the consequent increase in their processing, the accumulation of industrial waste and the detrimental impact on the biosphere.

The authors suggest the status of the environment to be assessed by the following seven indicators (Endogenous indicators):

- 1) Climatological Disasters (CD), USD million; Climatological Disasters: refers to the value of economic damage from climatological disasters, i.e. events caused by long-lived/meso to macro scale processes (in the spectrum from intraseasonal to multidecadal climate variability).
- 2) CO<sub>2</sub> Emissions per Unit of Output(COE), gr./USD (grams per USD in constant prices);
- 3) Greenhouse Gas Emissions from Industry(GGEI), tonnes of CO<sub>2</sub> equivalent;
- 4) Greenhouse Gas Emissions from Agriculture(GGEA), tonnes of CO<sub>2</sub> equivalent;
- 5) Mean Temperature, Year, Growth (%), global temperature change (GTC), %C;

6) Fresh Surface Water Withdrawal (FWW), million cu m, reduction of the fresh water resources, mil.m<sup>3</sup>;

7) Forest Land, reduction in the area of the forests and forest vegetation in the process of urbanization (RFA), sq km.

Using this indicator as an example – Greenhouse Gas Emissions from Industry (GGEI) the article shows the creation of the basis for methods predicting the pollution of the global environment by sources of an artificial environment – urbanized areas.

### 3. Peculiarities of the process of negative impact of human activities on the ecology

To show the impact of the human activity on the ecology, we use the example of the change of GGEI in the life environment. The process of the change of GGEI is characterized by the following peculiarities:

- a) Different dynamic factors of human activity influence the current assessment of the process of the change of GGEI in the life environment;
- b) other processes occurring in the environment have an impact on the current assessment of the process of the change of GGEI in the life environment;
- c) the pre-history of the process of the change of GGEI in the life environment affects the current assessment of the process of the change of GGEI in the life environment;

The influence of the factors of human activity on the process of the change in GGEI in the environment. Factors of human influence on the environment are characterized by dual nature, although the consequences are the same and have a negative impact on the environment. On the one hand, humankind needs more and more sources for nutrition, and because of that, they consume more and more lands of the nature. On the other hand, humanity has a constant need to increase energy.

The influence of the humankind on the environment always leads to the planned or forecasted consequences. And one of the most dangerous of them is the global warming of the climate. Forest destruction during the economic activity and GGEI during the fuel combustion lead to a decrease of oxygen in the atmosphere, and the invention of aerosols cause ozone depletion. This way the Earth's shell began to accumulate more heat. As a result, it can lead to the accelerated melting of glaciers, an increase in the ocean level and the sinking of land. Man's productive activity constantly exerts an increasing negative influence on the quality of the environment. All the growing scales of the man's productive activity typical for the period of the scientific and technological revolution, has violated the natural cycle of substances and energy in nature.

The evaluation of the factors of the human activity impact on the environment was fulfilled by a number of quantitative and qualitative economic indicators, which are:

GDP, World, US\$ Per Capita; Employed Population, World, Unit; Economically Active Population, World, Unit; Exports (fob) by Commodity + Imports (cif) by Commodity, World, USD million; Energy, Utilities and Recycling: Production (turnover) MSP, USD million, USD million; Primary Materials Forestry- Production (turnover) MSP, USD million; and others.

By using of the qualitative and statistical methods of analysis it was found that there are six indicators that have an impact on the current assessment of the process of the change of GGEI in the environment:

$X_{1r}^3$  – Energy, Utilities and Recycling: Production (turnover) MSP, USD million, USD million;

$X_{2r}^3$  – Exports (fob) by Commodity + Imports (cif) by Commodity, World, USD million;

$X_{3r}^3$  – Road Freight Traffic (volume of transported goods). World, Million net tonne-kilometres;

$X_{4r}^3$  – Transport and Communications: Production (turnover) MSP, USD million, USD million;

$X_{5r}^3$  – Economically Active Population, World, Unit;

$X_{6r}^3$  – Material Resource Productivity, USD per kg in constant prices.

The influence of other processes occurring in the environment on the change in GGEI. The change of GGEI in the environment is influenced by other processes occurring there, which are:

a) Climatological Disasters(CD); b) CO<sub>2</sub> Emissions per Unit of Output (COE), g / USD (grams per USD in constant prices); c) Greenhouse Gas Emissions from Agriculture(GGEA); d) Mean Temperature, Year(GTC), Growth (%); e) Fresh Surface Water Withdrawal(FWW), million cu m; f) Forest Land(RFA), sq km.

Using qualitative and statistical methods of analysis, it is indicated that the current assessment of the process of change of GGEI is affected by three processes estimated by the indicators:

$y_t^2$  –COE, grams / USD (grams per USD in constant prices);

$y_t^4$  – GGEA , tonnes of CO<sub>2</sub> equivalent;

$y_t^7$  – RFA, sq km.

The influence of pre-history of the course of GGEI in the environment change process on the change of GGEI.

The main greenhouse gases, placed in order of the estimated impact on the heat balance of the Earth, are water vapor, carbon dioxide, methane and ozone. The planet is heating up. Scientists have practically the same view on this: the cause of warming is the industrial activity of man. The result of this activity is an increased allocation of the so-called greenhouse gases. Concentration of one of them, CO<sub>2</sub>, is not only growing, it is increasing exponentially.

Exponential growth is an increase of the value when the growth speed is proportional to the value itself. This fact is reflected in the influence of previous values of GGEI on the current value of GGEI.

#### 4. The empirical models

As a theoretical model for analyzing the impact of urbanization on the environment a autoregressive distributed lags (ADL-model) is chosen, in which the current values of the time series depend on both on the past values of this series, and on the current and past values of other time series [9]. The model is generalized in the case of having several exogenous variables. In general we can assume that all exogenous variables are included in the model with the same number of lags, it is possible to exclude some lag of some variables

Additive form of the ADL model:

$$y_t = a_0 + \sum_{i=1}^n a_i y_{t-i} + \sum_{j=0}^{q^1} b_j x_{t-i}^1 + \dots + \sum_{j=0}^{q^k} b_j x_{t-i}^k + E_t \quad (1)$$

where  $k$  – number of exogenous variables;

$q_i$  – number of lags in exogenous variable ( $i = 1, 2, \dots, k$ );

$n$  – the depth of delays in the endogenous variable;

$E_t$  –remnants forming the process of white noise.

This model suggests that if at some time  $t$  the independent variable  $X$  changes, then this change will affect the values of the variable  $y_t$  during the future moments of time.

#### 5. Date and analysis of the primary data

Working with the input data consisted of two steps: a) data collection for the selected variables; b) the primary processing of endogenous and exogenous variables that correspond to the analyzed process and reflect the essence of the problem.

Primary data collection. The primary data was taken from the following sources: Euromonitor Passport Database (<http://www.euromonitor.com/>), World Bank Open Data (<http://data.worldbank.org/>).

The primary statistical information on endogenous and exogenous variables is collected for the countries of the world for the period from 1998 to 2015. Endogenous and exogenous

parameters for use in the model were determined on the basis of the primary country statistical information as the mean geometric indicators of the countries of the world in the year  $t$ .

## 6. The procedure for finding of the model coefficients

A methodology for empirical verification of the model is developed [10]. The methodology includes the following main steps: checking time series of variables for stationarity, using Dickey-Fuller test; checking exogenous variables for multicollinearity; selection of endogenous variable lags that have a strong correlation with the value of the variable in the last period and verification of the significance of the autocorrelation coefficients using Ljung-Box Q-test; compilation of the structural form of the model; determining the coefficients of the model using regression analysis; checking the significance of the regression equation and finding the coefficients of the regression equation.

Dickey-Fuller test is a finding of the coefficient in an autoregressive equation of following form:

$$y_t = a y_{t-1} + \varepsilon_t \quad (2)$$

where  $y_t$  – time series, and  $\varepsilon_t$  – error.

If  $|a| < 1$ , then the time series is stationary. If  $|a| = 1$ , then the process has a single root, in this case the time series is not stationary, it is an integrated time series of the first order.

The coefficient  $a$  for all time series is in the range  $0.47480575 \leq a \leq 0.718665$ , which according to the Dickey-Fuller test indicates that all time series are stationary.

Checking exogenous variables for multicollinearity consisted in finding the coefficients of pair correlation between exogenous variables and with the value of the coefficient of pair correlation greater than  $|0.7|$  it was necessary to exclude one variable from the pair from the further analysis. As a result of this check, the variables  $X_{1t}^3$  and  $X_{3t}^3$  were removed and as having high closeness with variables  $X_{2t}^3, X_{4t}^3, X_{5t}^3, X_{6t}^3$ , at the significance level  $\alpha = 0,05$ , the number of degrees of freedom  $n - 2 = 17$  of the Student's t-criterion is greater than  $t_{table} = 2,11$ .

The choice of the endogenous variable lags, which have a strong correlation with the value of the variable in the last period, is realized using the autocorrelation coefficients. The verification of the significance of the autocorrelation coefficients was confirmed by the Ljung-Box test. The analysis showed that the endogenous variable  $y_t^3$  depends on a given level only on the value of one past period  $y_{t-j}^3$ . The coefficient of autocorrelation of the endogenous variable  $y_t^3$  to  $y_{t-1}^3$  is 0.8055. The Q-statistics of Ljung-Box is 11,182 at  $p = 0.000827$ .

Taking into account the results of previous analyzes, the ADL-model takes the following structural form:

$$y_t^3 = a_0 + a_1 y_{t-1}^3 + a_2 y_t^2 + a_3 y_t^4 + a_4 y_t^7 + a_5 y_{t-1}^7 + a_6 x_{2t}^3 + a_7 x_{4t}^3 + a_8 x_{5t}^3 + a_9 x_{6t}^3 \quad (3)$$

The coefficients of the model were found using the regression analysis module from SPSS 17.0.

According to the results of the coefficients found, the equation is written in the following form:

$$y_t^3 = 32515.056 + 0.705 y_{t-1}^3 + 3.806 y_t^2 + 1.081 y_t^4 - 0.206 y_t^7 - 0.905 y_{t-1}^7 - 0.041 x_{2t}^3 + 0.002 x_{4t}^3 - 0.001 x_{5t}^3 + 3947.703 x_{6t}^3$$

The accuracy of the regression equation is estimated using the coefficient of determination, which equals 0.97765481 for  $F_{calculate} = 62,50337804 \geq F_{table} = 2,51$ .

The statistical significance of the coefficients of the regression equation was verified on the basis of  $t$  statistics. The calculated value of  $t_p$  with a confidence probability  $p=0.9$  for all coefficients

of the higher level than the table value with the exception of  $y_t^7$  and  $y_{t-1}^7$ . The statistical significance of the coefficients of the regression equation for  $y_t^7$  and  $y_{t-1}^7$  is visible with a confidence probability of  $p = 0.6$ . In such cases, the calculation should be repeated, deleting the variables  $y_t^7$  and  $y_{t-1}^7$ . But we did not do this at this stage of the analysis, planning at the next stage, to introduce other additional exogenous variables estimating the urbanization.

## 7. Consideration

The article shows the influence of human activity on the environment by the example of the change of GGEI in the environment. The calculated model of the influence of exogenous variables on the endogenous variable (GGEI) shows the dependence of the endogenous variable of the current period on the variable of the past period with a lag of one year. We revealed the dependence of the endogenous variable (GGEI) on the following processes. Firstly, it is a dependence on other processes occurring in the environment that are: CO2 Emissions per Unit of Output and a reduction in the area of forests and forests in the process of urbanization.

Secondly, it is the dependence on macroeconomic indicators: an indicator of foreign economic activity, calculated as a foreign trade turnover between countries; Indicator of economic activity, calculated as an indicator of the productivity of material resources, as an indicator of the number of the employed in the sectors of the economy, capable of participating in the production of material values and the provision of services; And also as an indicator of the quantity of production in the industry of transport and communications.

We revealed the increase of the processes of pollution of the global environment by sources of an artificial environment, urbanized areas. The emerging markets, most affected by climate change and deforestation, including China, Indonesia and Brazil, represent the greatest concern about environmental damage.

The authors believe that the term of "environmentalism", as an isolated concept in the context of growing foreign trade processes between countries, under conditions of intensive economic development, is not relevant anymore.

In case when a modern urbanized areas becomes a source of destruction of the global ecology, and at the same time, the urbanization processes contribute to increasing efficiency of the economy, it is necessary to realize that the "green economy" should become a part of our life. In the life of companies, in the lives of individuals, "green economy" should maintain in different spheres of life – both culture and in production.

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