

The impact of human activity on the global warming

*Oksana Evseeva*¹, *Svetlana Evseeva*^{1*}, and *Tamara Dudarenko*¹

¹Peter the Great St. Petersburg Polytechnic University, 195251, St.Petersburg, Polytechnicheskaya, 29, Russia

Abstract. The global temperature of the planet is directly related to human activity. Landfills, vehicles, deforestation, production and, in particular, livestock, affect the temperature change on the planet and global warming. Greenhouse gas emissions, solid aerosol particles and soot, deforestation, methane, nitrous oxide and freons' concentration in the Earth's atmosphere are the key influencers on the changes in the global temperature. All of it is the result of human's activities and needs the human control. The problem of the impact of the human activity on the global warming in environmental economics should be scrutinized in order to avoid the negative effects from its distribution. Research methods used: system analysis, synthesis, comparison and generalization and econometrics' methodology. The main results include investigation into the impact of the human activity on the global warming (the level of global temperature as the main indicator) on the global world level. They showed that all of the chosen types of human activities influence on the global warming – rising temperature and industrial production and livestock have the greatest impact on global warming during the period.

1 Introduction

Modern climate warming is an anthropogenic-ecological reality. It is one of the global problems in environmental economics that affects all the humanity.

The scientific community had become to a consensus in assessing the causes of global warming. In the Fifth Report (2013), the Intergovernmental Panel on Climate Change (IPCC) stated:

"It was found the human activity's influence on the rise in atmospheric and ocean temperatures, a change in the global hydrological cycle, a decrease in snow and ice, a rise in global average sea level, and on some extreme climatic phenomena ... It is extremely likely that human influence was the main cause of the warming observed since the mid-twentieth century " [1].

The likely value of a possible temperature rise over the 21st century based on climate models will be 0.3–1.7 ° C for the minimum emission scenario; 2.6-4.8 ° C for the maximum emission scenario [2].

* Corresponding author: yevoksana@inbox.ru

Changes in temperature and subsequent climate changes can lead to various consequences in all regions of the world, such as: rising sea levels, changes in the amount and nature of precipitation, and desertification.

Warming is most pronounced in the Arctic, it leads to the retreat of glaciers, permafrost and sea ice. The temperature of the permafrost layer in the Arctic over 50 years has increased from -10 to -5 degrees. The surface area of the Arctic ice from 1970 to 2018 decreased by about 25%, and their thickness decreased by 1.3 m, about half [3].

Other effects of warming include: an increase in the frequency of extreme weather events, including heat waves, droughts and rainfall; ocean acidification; extinction of species due to changes in temperature.

In the future, global warming can trigger an irreversible mechanism for the release of carbon dioxide from the oceans (where it is 50-100 times more than in the Earth's atmosphere) and disturbed ecosystems and lead to a greenhouse effect like Venus [4].

There is a set of sources of distribution of the global warming problem in environmental economics. Greenhouse gas emissions, solid aerosol particles and soot, deforestation, methane, nitrous oxide and freons' concentration in the Earth's atmosphere are the key influencers on the changes in the global temperature. All of it is the result of human's activities and needs the human control [5].

The problem of the impact of the human activity on the global warming in environmental economics should be scrutinized in order to avoid the negative effects from its distribution.

Thereby the chosen research topic is relevant and needs more investigation in the field of the variety of factors in environmental economics that influence on global warming and its level of influence.

2 Materials and methods

Being vital field of research in environmental economics, global warming is one of the most disturbing the whole society and government problems. The key question is how to avoid the influence of human activities creating the environmental friendly policy. Stating new approaches, methods and mechanisms of protection the Earth from global warming is the subject for the global society with cooperation of all the national governments. It is usually discussed on annual IPCC meetings and then provided to the spread on the national level by the national institutions responsible for the environmental policy.

As it was mentioned above the global warming distribution depends on the spread of several sources.

The first one is greenhouse gas emissions (the greenhouse effect). There is a scientific consensus that current global warming is caused by an anthropogenic increase in carbon dioxide concentration in the Earth's atmosphere, and, consequently, an increase in the greenhouse effect. Just as the greenhouse retains heat, the Earth has a "natural greenhouse effect," in which part of the solar infrared radiation is delayed to warm the planet. There are certain gases in the atmosphere, such as carbon dioxide, methane, nitrogen oxides, ozone and water vapor, which help in this process by reflecting heat back to earth. This process allows the Earth to maintain a comfortable temperature. Otherwise, the average temperature on Earth would fall to -18 degrees Celsius [6, 7].

Thus, these greenhouse gases are very important and play a central role in the survival of living organisms on Earth. The greenhouse effect is what makes the Earth unique among other planets.

Nevertheless, an excess of greenhouse gases in our atmosphere is harmful to life and the environment. With the advent of a large amount of these gases emitted into the atmosphere by human innovation, the greenhouse effect is increasing, and this causes a rise in temperature that we have experienced over the past two centuries. Since 1750 (the beginning

of the industrial revolution), only carbon dioxide production has increased by about 36%, and since 1880, which marks the end of the industrial revolution, the temperature of the Earth has risen by 0.85 degrees Celsius [8]. Although it may not seem like a huge increase, the impact it leaves on the environment and the organisms that live in it is devastating and deadly. Many plants and animals can not quickly adapt to temperature changes in the environment, and this leads to the fact that they are endangered and sometimes die [9].

The greenhouse effect was discovered by Joseph Fourier in 1824 and was first quantitatively investigated by Svante Arrhenius in 1896 [10].

The second one, solid aerosol particles and soot (named also as black carbon) stimulates climate warming in two ways. First, black soot particles in the air absorb sunlight and directly heat the surrounding air. Secondly, the ingress of soot on snow or ice turns the reflective surfaces into absorbing, that is, soot reduces the albedo. Therefore, soot deposits increase the rate of melting of snow and ice, including glaciers and arctic ice.

Black carbon is a “short-term” climate factor. In the short term, this is an important contribution to warming: reducing soot will have immediate advantages in slowing warming over the next 40 years, by 0.1–0.2 °C worldwide [11]. Reducing black carbon in the Arctic can also slow down the increased feedback from melting Arctic snow and ice.

Diesel emissions and agricultural waste fires are the main sources of black carbon in developed countries, while in the developing world soot comes from such sources as biomass burning for cooking and heat.

Trees play a huge role in the carbon cycle. In the process of photosynthesis, they convert CO₂ in air into oxygen, and thus they can be considered as a natural regulator of carbon dioxide. The more trees, the less carbon dioxide in the atmosphere and more oxygen. Unfortunately, deforestation hinders the implementation of this work completely. The more carbon dioxide in the atmosphere, the more solar radiation is reflected back to Earth, and not to space, and this causes an increase in our average temperature. Thus, deforestation is one of the major problems when it comes to global warming [12].

Methane (CH₄) is a greenhouse gas that is much stronger than carbon dioxide (CO₂), 34 times stronger than in a 100-year period [13]. Although the concentration of methane in the atmosphere is about 200 times lower than that of carbon dioxide, methane caused 60% of the equivalent radiation exposure caused by carbon dioxide from the beginning of the industrial revolution. The presence of methane in the atmosphere can also affect the content of other greenhouse gases, such as ozone (O₃), water vapor (H₂O) and carbon dioxide [14].

The lifetime of methane in the atmosphere is about 10 years. The relatively short lifetime combined with a large greenhouse potential makes it a candidate for mitigating the effects of global warming in the near future.

Livestock is a major source of anthropogenic methane emissions (CH₄). Livestock accounts for about 14.5% of global greenhouse gas emissions [15].

Nitrous oxide is released during agricultural and industrial activities, as well as the combustion of fossil fuels and solid waste.

The greenhouse activity of nitrous oxide is 298 times higher than that of carbon dioxide. In addition, nitrogen oxides can affect the ozone layer as a whole.

Nitrous oxide does not have a local environmental impact. However, on a global scale, it contributes to global warming, it is the third most important greenhouse gas. Although relatively small amounts are released, it has a high global warming potential. Nitrous oxide also damages the ozone layer, thereby reducing protection from harmful UV rays from the sun.

The effect of freon as greenhouse gases is 1300-8500 times higher than that of carbon dioxide. The main source of freon is refrigeration and aerosols.

Refrigeration plays an important role in modern life: from refrigerators to air conditioning systems and industrial processes. However, accelerated technical development and economic

growth throughout the world over the past century have led to the emergence of separate environmental problems, which leads us to recognize that, although these technological advances can contribute to human comfort, they can also threaten the environment due to depletion of the ozone layer and global warming [16].

It is believed that one of the reasons for the decrease in ozone in the stratosphere and the formation of ozone holes is the production and use of chlorine and bromine-containing freons. Getting into the atmosphere after use, they decompose under the influence of ultraviolet radiation from the sun. The released components actively interact with ozone in the halogen cycle of the decay of atmospheric ozone.

All of these sources influence on the global warming effect on the different level that depends on the human activities that is the field of research.

Data for the research are collected on the basis of official sources in the public domain: IPCC reports, Earth Observatory (part of the EOS Project Science Office located at NASA), Framework Programme in the European Commission (EC) funded One Planet Economy, The European Commission's in-house Emissions Database for Global Atmospheric Research (EDGAR), World Bank data, the Euromonitor database [17].

The object of research is the impact of the human activity on the global warming (the level of global temperature as the main indicator) on the global world level.

The article is a quantitative and qualitative study - an empirical study in which data are also presented in the form of numbers. Research methods used: system analysis, synthesis, comparison and generalization and econometrics' methodology.

3 Results

The influence of the human activity on the global warming is reflected via the level of global temperature. It could be considered on two levels (Figure 1): the main elements of human activity and influencing factors.

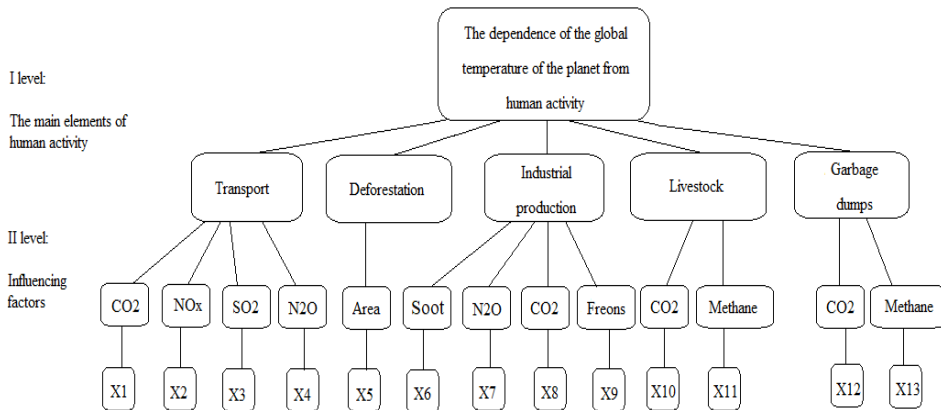


Fig. 1. Structuring the problem of global temperature dependence on human activity.

Covering the main elements of human activity' reflection on the global warming it should be included:

1. Transport. According to the calculations of Bernsten and Fuglestvedt, cars played and will play the greatest role in raising the temperature of the Earth. Due to the huge scale of carbon dioxide emissions, their share in warming is 6–7 times the contribution of all other types of transport combined. Airplanes were in second place after cars, but their contribution

will decline in the future. The transport sector, as the main consumer of energy and source of greenhouse gases (GHG), is a problem for sustainable development [18]. In 2015, the transport sector accounted for approximately 24% of global CO₂ emissions from fuel combustion. The rapid technological development of alternative transmissions has generated great interest, and many countries have begun to introduce rules or subsidy mechanisms to protect vehicles with alternative fuels [19, 20].

2. Deforestation. The greatest scale deforestation has reached in the XX century. By the beginning of the XXI century, 75% of the reduction in forest area was in the 20th century, which is primarily due to the need to meet the needs of the rapidly growing population of the Earth. By 2000, 50% of the former forest area on the planet has already been completely reduced by man, only 22% of the remaining forests are in a relatively intact state. Deforestation leads to an increase in the greenhouse effect due to the release of carbon into the atmosphere in the form of CO₂, which was found in forest biomass [21].

3. Industrial production. The main waste from production is CO₂. After go freons, N₂O and soot.

4. Livestock. It is the main source of methane. Until recently, it was believed that the greenhouse effect of methane is 25 times stronger than that of carbon dioxide. But now the United Nations Intergovernmental Panel on Climate Change (IPCC) claims that the greenhouse potential of methane is even more dangerous than previously estimated. As follows from the recent IPCC report, which Die Welt cites, per 100 years the greenhouse activity of methane is 28 times stronger than that of carbon dioxide, and in the 20-year term, 84 times. Moreover, 51% of CO₂ emissions also come from livestock [22, 23].

5. Garbage dumps. The most toxic of the main components of emissions are hydrogen sulphide and methane - they are in high concentrations can cause poisoning [24].

The set of the influencing factors is based on the sources of distribution of the global warming problem in environmental economics.

The ADL (autoregression and distributed lag) model is used for the evaluating the influence of human activities. Currently, the ADL – model is widely used in various fields of human activity. This function can be used to determine the causes of the greenhouse effect, and to assess the impact of various factors on global warming. In this paper, we studied the influence of human activity on the global temperature of the planet.

The main findings and generalizations allow to select endogenous and exogenous variables.

Endogenous (dependent) are the values of variables that are determined within the model, or interdependent (y).

Exogenous (independent) - these are the values of variables that are set "from the outside," autonomously, to a certain extent, they are controlled (planned) (x).

It is necessary to establish the dependence of endogenous (dependent) variables on exogenous (independent), using the above information obtained. To do this, certain endogenous variables are selected and an assumption is made about their dependence on certain exogenous variables.

In our analysis, the following endogenous variables are selected:

1. Y^0_t – the change of the temperature on the planet from human activity.
2. Y^1_t - the share of total emissions from transport in t year (million tons).
3. Y^2_t - the share of the total area of deforested forests in t year (million square kilometers).

4. Y^3_t - the share of total emissions from industrial production in t year (million tons).

5. Y^4_t - the share of total emissions from livestock in t year (million tons).

6. Y^5_t - the share of total emissions from garbage dumps in t year (million tons).

Thus, after analyzing and formulating the prerequisites, we can present the following table of endogenous and exogenous variables (Table 1).

Table 1. Endogenous and exogenous variables.

Endogenous variables	Exogenous variables				
Y_t^1	Y_{t-1}^1	X_{t-1}^1	X_{t-1}^2	X_{t-1}^3	X_{t-1}^4
Y_t^2	Y_{t-1}^2				X_{t-1}^5
Y_t^3	Y_{t-1}^3	X_{t-1}^6	X_{t-1}^7	X_{t-1}^8	X_{t-1}^9
Y_t^4	Y_{t-1}^4			X_{t-1}^{10}	X_{t-1}^{11}
Y_t^5	Y_{t-1}^5			X_{t-1}^{12}	X_{t-1}^{13}

Selected and reasonable endogenous and exogenous variables allow to build a system of equations:

$$\left\{ \begin{array}{l} Y_t^1 = a_0 + a_1 Y_{t-1}^1 + a_2 X_t^1 + a_3 X_{t-1}^1 + a_4 X_t^2 + a_5 X_{t-1}^2 + a_6 X_t^3 + a_7 X_{t-1}^3 + a_8 X_t^4 + a_9 X_{t-1}^4 \\ Y_t^2 = b_0 + b_1 Y_{t-1}^2 + b_2 X_t^5 + b_3 X_{t-1}^5 \\ Y_t^3 = c_0 + c_1 Y_{t-1}^3 + c_2 X_t^6 + c_3 X_{t-1}^6 + c_4 X_t^7 + c_5 X_{t-1}^7 + c_6 X_t^8 + c_7 X_{t-1}^8 + c_8 X_t^9 + c_9 X_{t-1}^9 \\ Y_t^4 = d_0 + d_1 Y_{t-1}^4 + d_2 X_t^{10} + d_3 X_{t-1}^{10} + d_4 X_t^{11} + d_5 X_{t-1}^{11} \\ Y_t^5 = e_0 + e_1 Y_{t-1}^5 + e_2 X_t^{12} + e_3 X_{t-1}^{12} + e_4 X_t^{13} + e_5 X_{t-1}^{13} \end{array} \right. \quad (1)$$

where, $a_0, a_1 \dots a_n, b_0 \dots b_n, e_0 \dots e_n \dots$ are the coefficients of the structural form of the model.

Table 2. Emissions from various types of human activity each year.

Year	Y_t^1	Y_t^2	Y_t^3	Y_t^4	Y_t^5
2020	7637	37,963	38477	13207	5.764
2019	7599	38,975	38210	12859	5.585
2018	7553	39,095	37461	12570	5.475
2017	7495	39,875	36908	12244	5.332
2016	7374	39,958	36581	11930	5.174
2015	7288	40,024	36266	11829	5.113
2014	7220	40,057	35854	11801	5.011
2013	7156	40,091	35468	11794	4.954
2012	6979	40,124	34870	11588	4.876
2011	6898	40,157	33509	11482	4.81
2010	6579	40,191	31691	11247	4.756
2009	6617	40,225	32045	11467	4.687

The following notation is used in the structural and reduced forms of the model (all indicators are selected for the world as a whole):

t - 1 - prehistory of indicators.

X_t^1 - Automobile CO₂ emissions, billion tons per year.

X_t^2 - NO_x emissions from motor vehicles, thousand tons per year.

X_t^3 - SO₂ emissions from motor transport, thousand tons per year.

X_t^4 - Emissions of N₂O vehicles, thousands tons in a year.

X_t^5 - Forest area (million sq. km.).

X_t^6 - Emissions of soot, thousands tons per year

X_t^7 - N₂O emissions by enterprises, mln. tons per year.

X_t^8 - CO2 emissions from enterprises, billion tons per year.

X_t^9 - Freon emissions (refrigerants) thousands tons per year.

X_t^{10} - CO2 emissions from livestock, billion tons per year.

X_t^{11} - Methane emissions from livestock, billion tons per year.

X_t^{12} - CO2 emissions, landfill gas. million tons per year.

X_t^{13} - Concentration of methane in the air due to landfills, million tons per year.

Based on these statistics, the volumes of emissions from various types of human activity were calculated annually (Y^1_t , Y^2_t , Y^3_t , Y^4_t , Y^5_t) from 2009 to 2020. Table 2 shows the statistics for the last 10 years.

4 Discussion and conclusions

As it could be seen from the results all of the chosen types of human activities influence on the global warming – rising temperature.

Industrial production and livestock have the greatest impact on global warming every year since 2009 till 2020. In 2020, emissions from industrial production amounted to 38.5 billion tons, from livestock - 13.2 billion tons.

The global temperature is also affected by the emissions from the transport a lot in the last year as well as in previous years. It is also concluded that emissions have a cumulative effect: the more emissions accumulate from human activity the more temperature is raising.

Certainly it should be studied the deeper influence in each activities in order to prevent speedy growth of the global temperature. Based on the results of the current research there could be several directions to search for the instruments of preventing global warming in each element of human activity.

Concerning transport it could be continuous improvement of engine models and reduction of car bodies in order to minimize their fuel consumption, the use of environmentally friendly fuels (natural gas, liquid hydrogen, ethyl alcohol), creating a zone of greenery along the roads, automated traffic control systems in order to reduce the running time of automobile engines in idle mode and set speed (creating high-speed highways, organizing the intersection of streets at different levels), development the legislative base, for example, to use mandatory carbon dioxide emissions standards for trucks and buses. The new law obliges automakers to significantly reduce the harmful emissions of these types of cars. In addition, automobile concerns will be obliged to ensure that by 2030 at least 20 percent of the total number of trucks produced should be cars with reduced emissions (at least 50%) of exhaust gases [25, 26].

As for the deforestation, forest protection policies are the key directions for the research because it varies significantly from country to country. Someone imposes a restriction on the use, and someone just increases the volume of remediation landings. But a completely new approach to this problem was developed by Norway. This country has officially announced that the so-called “zero deforestation” policy will be implemented on its territory. In 2015, Norway allocated Brazil with 1 billion rubles to preserve the Amazon rain forest. Investments from Norway and a number of other countries have helped cut down logging by 75%. This example of human activities reflects how some simple actions may influence in a positive way on the global warming problem [27].

Open approaches to dealing with emissions information [28] could also be the direction to search for the instruments of preventing global warming in the element of industrial production. It could be presented in the form providing an open access to environmental quality indicators from different industries.

In the livestock there is the direction of animal diets reduces methane emissions. Also vaccinating against conventional viruses reduces their mortality, allowing farmers to focus on increasing the number of healthier individuals that will release less methane. One of the

latest innovative directions is genome modification in order to prevent methane emissions from the livestock.

As for the landfills there could be such fields of research as recycling for reuse, separate garbage collection, incineration plants, the policy of non-disposable goods.

The results of the study undoubtedly confirm the importance of the problem being investigated - global warming. This problem does not affect a single country, but the whole world. In this regard, the authors seem appropriate to carry out research in each country, including Russia (special importance of the Arctic zone).

References

1. D.F. Skripnuk, E.A. Samylovskaya, IOP Conf. Series: Earth and Environmental Science **180**, 012021 (2018) doi :10.1088/1755-1315/180/1/012021
2. S.K. Jalota, B.B. Vashisht, S. Sharma, S. Kaur, Understanding Climate Change Impacts on Crop Productivity and Water Balance (Academic Press, 2018) DOI: 10.1016/B978-0-12-809520-1.00002-1
3. Y. Shi, F. Niu, Zh. Lin, J. Luo, Science of the Total Environment. Elsevier BV **660**, 1294-1305 (2019) DOI:10.1016/j.scitotenv.2019.01.121
4. A. Alexiadis, Ecol. Model. **203**, 243–256 (2007) DOI: 10.1016/j.ecolmodel.2006.11.020
5. S.T. Hassan, E. Xia, Ch-Ch. Lee, Energy & Environment, **32**, 2, 338-363 (2020) DOI:10.1177/0958305X20932550
6. D. Archer, V. Brovkin, Climatic Change, **90** (3), 283-297 (2008) doi: 10.1007/s10584-008-9413-1
7. N.A. Timofeev, Physical Oceanography, **16**, 322–336 (2006) DOI: 10.1007/s11110-006-0036-7
8. S. Ermakov, L. Volkova, I. Kapustina, Transportation Research Procedia **54**, 47 – 57 (2021) DOI: 10.1016/j.trpro.2021.02.046
9. M. Mario, Z. Durwood, K. Madhava, S.O. Andersen, R. Veerabhadran, K. Donald K. PNAS, **106** (49), 20616-20621 (2009) doi: 10.1073/pnas.0902568106
10. T.R. Anderson, E. Hawkins, P.D. Jones. Endeavour **40**, 3 (2016) doi: 10.1016/j.endeavour.2016.07.002
11. A. Ahmad, QI-J. Liu, S.M. Nizami, A. Mannan, S. Saeed, Land Use Policy, **78**, 1-818 (2018) DOI: 10.1016/j.landusepol.2018.07.009
12. Y. Peng, I.K. Schmidt, H. Zheng, P. Heděnc, et al, Forest Ecology and Management, **478**, 118510 (2020) doi: 10.1016/j.foreco.2020.118510
13. Climate Change 2013 – The Physical Science Basis, Cambridge University Press, 1447-1466 (2014) doi:10.1017/CBO9781107415324.031
14. N.Y. Titova, Universidad y Sociedad, **12**(5), 203-208 (2020)
15. B. Zhu, J. Kros, J.P. Lesschen, I.G. Staritsky, W. de Vries, Regional Environmental Change, **16** (6), 1571-1582 (2016) doi: 10.1007/s10113-015-0896-9
16. F.F. Adedoyin, M.I. Gumede, F.V. Bekun, M.U. Etokakpan, D. Balsalobre-Lorente, The Science of the Total Environment **710**, 136284 (2019), DOI: 10.1016/j.scitotenv.2019.136284
17. M. Fortin, Mitigation and Adaptation Strategies for Global Change, **26** (2), 1-20 (2021) DOI: 10.1007/s11027-021-09947-4

18. O.A. Kalchenko, S.A. Evseeva, O.A. Evseeva, K.S. Plis, E3S Web Conf. **110** (2019) DOI: 10.1051/e3sconf/201911002030
19. J.R. Moreira, S.A. Pacca, Transportation Research Part D: Transport and Environment, **86**, 102454 (2020) DOI: 10.1016/j.trd.2020.102454
20. I. Dincer, Comprehensive Energy Systems, **2**, 435-474 (2018) doi: 10.1016/B978-0-12-809597-3.00232-7
21. A. Golub, T. Hertel, H.-L. Lee, S. Rose, B. Sohngen, Resource and Energy Economics, **31** (4), 299-319 (2009) doi: 10.1016/j.reseneeco.2009.04.007
22. K. Sakadevan, M.-L. Nguyen, Advances in Agronomy, **141**, 147-184 (2017) doi: 10.1016/bs.agron.2016.10.002
23. K. Sakadevan, M-L. Nguyen, Chapter Four – Livestock Production and Its Impact on Nutrient Pollution and Greenhouse Gas Emissions. In: Sparks DL (ed) Advances in Agronomy (Academic Press, 2017)
24. D. Caro, Encyclopedia of Food Security and Sustainability, **1**, 228-232 (2019) doi: 10.1016/B978-0-08-100596-5.22012-X
25. T.M. Letcher, Managing Global Warming. An Interface of Technology and Human Issues (Academic Press, 2019) DOI: 10.1016/B978-0-12-814104-5.00001-6
26. H.-X. Zhao, R.-C. He, N. Yin, (2021) European Transport Research Review, **13** (1), 5 (2021) doi: 10.1186/s12544-020-00466-y
27. R.W. Gorte, P.A. Sheikh, Deforestation and climate change, Nova Science Publishers (Inc. Deforestation and Climate Change, 2010)
28. A. Zaytsev, E. Konnikov, Y. Asaturova, S. Didenko, E3S Web of Conf. **211** (2020) doi:10.1051/e3sconf/202021102007