CARBON POLYGONS AS A TOOL FOR IDENTIFICATION, ANALYSIS AND ASSESSMENT OF VARIOUS TYPES OF NATURAL AND ANTHROPOGENIC HAZARDS

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Abstract

Environmental issues, including those related to the reduction of anthropogenic greenhouse gas emissions and climate conservation, occupy an important place on the agenda of most world powers, including the Russian Federation (RF), which was documented by the adoption of the Paris Agreement. The countries of the European Union (EU) have historically been the most active supporters of environmental initiatives and have long adapted various fiscal instruments (taxes and quotas) to stimulate enterprises to reduce carbon dioxide and other greenhouse gas emissions. One of the latest steps towards such a policy was the introduction of a proposal to introduce cross-border taxes on carbon dioxide in relation to a number of goods imported into the EU countries. And although this project is currently under development, and the legal and methodological details of its implementation are unknown, experts are confident that the new tax will be introduced and entail significant financial losses for the Russian Federation. Taking into account the fact that more than 40% of Russian exports go to the EU, of which more than 70% are "environmentally dirty": oil, coal, gas and metal, due to the new tax, the Russian economy will lose from three to five billion dollars annually already from 2022, and by 2030 these costs will amount to more than eight billion a year.

Keywords: Carbon polygons, greenhouse, gas emissions, environmental problems, environmental protection, carbon dioxide

I. Introduction

The main hypothesis is that the creation of a network of carbon polygons will make it possible to form a domestic method for calculating the ability of carbon dioxide absorption by the environment. Dedicated reference areas are used to calibrate satellite and drone data, and the results obtained can be extrapolated to the rest of the country to obtain accurate data on the absorption capacity of different types of landscapes without the use of laborious and time-consuming ground studies. The stated principles of analysis are: the use of satellite images of the surface from space, surveys from a drone and ground-based measurements [1]. Ground measurements are used as data markup (for training machine learning algorithms) received from the drone and satellite. In the future, this should make it possible to assess the absorbing capacity of territories using drone/satellite data, without using ground-based measurement data. For native spectral analysis, satellite and radar data are used. The selected area is analyzed using various unmanned systems for the layout of "hyperspectral cubes" (different spectral signatures make it possible to determine the type of the earth's surface). Thus, the polygon is used to calibrate satellite data and drone data, with the subsequent extrapolation of the results to the rest of the territory. To ensure the operation of this approach in different types of territory, it is necessary to collect data on the absorption capacity of different types of landscapes (news sources say about 80 polygons), including spectroscopy data (no information) [2].

The main goal of creating a wide network of carbon polygons throughout the country is to fully take into account climatic features in various parts of the Russian Federation, which is necessary to determine the territorial correction factors in the developed model for calculating the carbon balance. The global federal program (10-15 years) related to greenhouse gases and the economic consequences of their control can be divided into three major stages [3-4]: 1. Development and certification at the international level of a unified methodology for calculating and accounting for the absorption and emission of greenhouse gases; 2. Development of technologies for changing the carbon balance (reducing emissions and increasing sequestration); 3. Linking the carbon balance to economic systems (quotas). After all, this market, which may be formed after the entry into force of the Kyoto Protocol, provides for taking into account not only emissions, but also absorption (sequestration) and conservation of carbon, which allows Russia to enter it as a supplier of carbon units. At the same time, all the listed stages can be additionally divided into two more blocks: - related to natural phenomena; - associated with the results of technogenic activities. Today, there is no unequivocal confirmed method for calculating the carbon balance of natural systems specifically, in particular in terms of absorption (in contrast to emissions based on the results of technogenic activities, which, in accordance with some recognized methods, are calculated mathematically).

The carbon polygon is a geographically distributed research platform designed to solve three main tasks: - developing a model for calculating the carbon balance of the area, taking into account the absorption and emission of the local ecosystem; - development of a method for using aerospace data to track emitted and retained greenhouse gases within specific biogeocenoses; - training of highly qualified personnel in the field of the latest methods of environmental control, promising technologies for the low-carbon industry, agriculture and municipal economy.

II. Methods

Let's take a look at different methods of implementing landfills around the world. Restoring and rewetting peatlands As the world's largest natural carbon store on land, peatlands play a key role in combating climate change. Intact peatlands play an important role in the carbon cycle, climate change mitigation and the provision of ecosystem services due to their role as a permanent water-locked carbon store and permanent sink. However, years of unsustainable land management practices have degraded peatlands, limiting their ability to provide effective climate management services. Currently, degraded peatlands emit 2 Gt CO_2 per year and account for almost 5% of global anthropogenic CO_2 emissions [7]. Only due to the drainage of peatlands, about 220 million tons of CO_2eq. are emitted into the EU per year. Therefore, restoration, rewetting and conservation of peatlands is an urgent priority in climate change mitigation, as well as in providing other ecosystem services. Impact on climate: mainly avoidance of emissions from drainage, in addition, peatlands actively sequester a large amount of carbon, but this is a slow process with low annual carbon growth. Monitoring, Reporting and Verification (MRV): It is not possible to continuously monitor primary data in situ. Therefore, mechanisms should rely on performance monitoring (eg GEST method). Project-level internal reporting and third-party verification by experts approved by the mechanism. Verification data is transmitted for verification. Overall conclusion: avoiding emissions from peatland drainage is an important mitigation option with significant co-benefits for the provision of ecosystem services. The development and operation of a carbon-based peatland mechanism is a promising and feasible way to incentivize government, authorities and farmers to take effective and efficient climate action in the EU. The study and use of already existing sub-national and national mechanisms and programs of peat payments based on results in the EU can contribute to the development of mechanisms and their scaling up in the EU. Agroforestry 11 Agroforestry is the practice of deliberately combining woody vegetation (trees or shrubs) with crop and/or livestock systems on the same piece of land. Traditional agroforestry systems are very diverse and adapted to local soils, climatic conditions and farming systems. Examples include the large deesa and montadón drylands in Spain and Portugal, perennial crop and pasture systems in southeastern Europe, and woodland pastures and bocage (hedge) landscapes in northern Member States. More recently, new agroforestry systems have been established on both arable and pastoral farms, but it is clear that the potential of agroforestry is not being tapped and existing long-established systems are under threat. Compared to traditional production systems, agroforestry contributes significantly to carbon sequestration, increasing. a range of regulating ecosystem services and enhances biodiversity.

Recent studies estimate that the introduction of agroforestry in croplands and rangelands where multiple environmental pressures already exist could lead to sequestration between 2.1 and 63.9 Mt C a − 1 (7.78 and 234.85 Mt CO2eqa - 1). The type of agroforestry adopted will affect both the sequestration potential and the contribution of agroforestry to creating other environmental pressures (Kay et al, 2019). However, as IPCC (2019) notes, agroforestry may take longer to realize greenhouse gas emissions benefits than other measures and cannot continue to capture carbon indefinitely. Agroforestry systems are also at risk of re-emissions associated with poor management and natural disasters. Climate impact: any action that maintains/improves or introduces wood components integrated into agricultural production to increase long-term carbon stocks and sequestration potential in biomass and soils without increasing emissions in the short term. Monitoring, Reporting and Verification (MRV): Only indirect methods to determine home garden carbon savings associated with aboveground biomass and actual values will depend on the agroforestry system, end-of-life wood use and local definitions of the baseline for the assessment. SOC methodologies are not yet considered fully tested or validated for results-based agroforestry mechanisms. Overall conclusion: Existing extensively managed agroforestry systems are under threat and their agricultural intensification risks increasing greenhouse gas emissions, so ongoing supportive management is a priority. The introduction of new agroforestry within traditional farming systems offers the potential for additional climate benefits (both mitigation and adaptation) as well as a range of other ecosystem and biodiversity services. However, achieving these cost-effectiveness requires careful selection of locally appropriate systems and the provision of other environmental public goods, not just reductions in greenhouse gas emissions. Significant advisory, technical and upfront investment support will be needed to overcome farmers' resistance in many parts of the EU. Results-based mechanisms have not yet been developed and tested for agroforestry and should take into account the time frame required to realize the full benefits of the woody element.

Preservation and increase of organic carbon content in mineral soils. Soil organic carbon (SOC) has proven beneficial to soil quality, agricultural productivity, and climate change mitigation and adaptation. The potential for SOC sequestration in the EU is estimated at 9 Mt to 58 Mt CO2-eq per year. In addition, maintaining existing SOC levels is critical given that many mineral soils continue to lose SOC, i.e. Estimated annual EU emissions from mineral soils under arable land are 27 MtCO2eq and from grasslands 41 MtCO2eq (2016 report; EC 2019). Research and existing SOC initiatives show that farmers can apply a range of management practices to improve SOC levels, including growing cover crops, improving crop rotations, agroforestry, avoiding conversion to arable land, and converting to pasture. Many of these methods are cost effective. However, soil heterogeneity, climatic conditions, existing SOC levels, and management practices mean that the likelihood of uptake can vary significantly at the farm and plot level. Climate impact: any action that maintains and increases SOC levels and benefits soil health [6].

III. Results

The carbon polygon is a geographically distributed research platform designed to solve two main tasks: developing a model for calculating the carbon balance of the area, taking into account the absorption and emission of the local ecosystem, and developing a method for using aerospace data to track greenhouse gases emitted and retained within specific biogeocenoses. This is a somewhat narrower definition as it does not include a number of experimental aspects of the landfill operation, such as studies of the absorptive capacity of specific plant species or the study of the effectiveness of various carbon farming methods. However, a full-scale polygon requires significant financial and time resources, and carrying out additional experimental work is characterized by diminishing returns on the potential value of the information obtained as the number of polygons increases. In other words, if paulownia is planted in the conditional region N on the polygon (taking into account the long-term forecast - for a period of 7+ years - depending on the productive age of the plant) and it turns out that this tree is the optimal carbon sequester, then it seems inappropriate to plant the same paulownia on polygon of another region, for example, KO. Climate, soil, and other components of the environment are different, but not so much that the results obtained have a fundamental difference. A different approach seems to be more correct: large polygons are created, where all planting and farming are studied, then the obtained data are extrapolated to CR, or not used, depending on the climatic conditions of the productivity of certain plants. But since the main purpose of the landfill is accounting (taxes on exports, etc.), we will focus on “compact landfills”. The exact parameters of the model plots where research is planned will be specified based on the results of consultations with bioecological specialists. First, these should be territories that are characteristic representatives of the main types of ecosystems: meadow, swamp, forest. And if the definition of the list of terrain types studied is a flexible variable and may vary depending on expert advice and/or availability. appropriate territories for scientific work, then the condition of “modeling” is strict - if the site does not have the necessary representativeness (for example, in terms of species or age composition of trees), then it will not be possible to create a reliable statistical model based on it. Second, the study areas should be spaced apart to take into account the heterogeneity of climatic conditions and differences in soil composition, which can potentially manifest themselves at the scale of the CR. Thirdly, the size of each site should be, on the one hand, large enough to be considered a full-fledged ecosystem, and on the other hand, relatively compact in order to reduce the dispersion of measurements for identical objects within the site and reduce the cost of experimental work. The corresponding review article [7] was used as a reference material on modern methods for calculating the carbon balance. From which it follows that the reference in terms of measurement accuracy are field, subdivided into destructive and without interference in the natural biocycle. Based on the specifics of the polygon, the last type of measurements performed using allometric equations is of interest. In fact, this is the same statistical model that makes it possible to estimate the level of carbon sequestration by trees using indirect measurements: height, trunk diameter, crown size, etc. To determine the coefficients of allometric equations, it is necessary to first examine several samples of tree species using destructive methods: cut down, divide into separate parts and study them in the laboratory. Soil allometric equations are derived in a similar way: the coefficients derived from the detailed biochemical analysis are used to estimate measurements for more general parameters in the future. For the polygon being created, it is proposed to use internationally recognized calculation methods from the recommendations of the Intergovernmental Panel on Climate Change (IPCC) [10]. This not only simplifies the subsequent certification of the obtained allometric equations, but also reduces the range of possible errors in the course of experiments to measurement errors.

Conducting ground-based measurements is a resource-intensive process and has low scalability, and for some hard-to-reach areas it is not possible at all. The main modern trend in solving this problem is the use of air and space sounding systems. In such systems, various types of sensors are used (optical, thermal, radio frequency, etc.), and they themselves have different spatial (from a few to hundreds of meters) and temporal (from several hours to a couple of weeks) resolution, they differ in the area covered territory (from units to thousands of kilometers). The variety of available options and the advantages and disadvantages inherent in each of them make the choice of a specific method (or combination of them) of aerospace sounding one of the most important in the research protocol of the carbon test site being created. Given the combination of qualitative characteristics and parameters (given in the reference article), it is proposed to use a combination of hyperspectral sensors (for example, one of the following: AISA Eagle, HYDICE, ALOS) placed on an unmanned aerial vehicle (drone) and lidar sensors (for example, as in the Carbon project). 3D [4]) on board the satellite. Such a solution is distinguished by the maximum completeness of the collected information, is relatively resistant to weather fluctuations, and makes it possible to achieve an accuracy of about 0.9 from reference ground-based measurements (0.83 for hyperspectral sensors and 0.89 for lidar - combining data improves accuracy). The disadvantage of this approach is the high cost and technical complexity of the survey methods used, however, within the framework of the research site, this seems to be a rational compromise.

IV. Discussion

In contrast to field work, there are no ready-made methodologies for organizing research for aerospace sensing, therefore, when moving from the concept (this document) to the implementation of a carbon test site in KO, it will be necessary to develop an appropriate protocol. It is recommended to include the following points in it: all sounding data will have to be compared with field measurements, the temporal resolution of the survey should compensate for weather fluctuations, the spatial resolution should correspond to the size of the minimum measurable unit (this is not necessarily a separate tree, it may be more rational to take into account the carbon balance for a small group of plants, which will reduce the error of discrete measurements), the satellite acquisition band should completely cover the model area, aerial photography over selected areas should be available, etc. If the relevant protocol is properly implemented and all surveys are carried out according to its letter, aerospace sounding data and the results of field studies can be used to develop algorithms for estimating carbon balance without ground-based measurements. Turning again to the experience should be said that the creation of software solutions responsible for mathematical modeling and processing of aerospace sounding images is the most difficult part of the entire carbon test site project [5]. However, in the absence of real data, it is not possible to give any recommendations regarding promising areas in the field of machine learning, which would be more suitable for solving the tasks set.

Tasks to be solved using the landfill [8-9]: 1. Development and evaluation of the effectiveness of methods for monitoring current levels (as well as emissions) of greenhouse gases. 2. Studies of the carbon balance of ecosystems characteristic. 3. Research on the carbon sequestration potential of various plant species at different stages of their life cycle. 4. Studies to evaluate the effectiveness of possible measures and practices aimed at reducing greenhouse gas emissions by ecosystems.

Drawing on world experience, the most relevant approaches in this area are:

● Restoring and rewetting peatlands to limit greenhouse gas emissions Peatlands, the world's largest natural carbon store on land, play a key role in combating climate change. In addition, peatlands sequester carbon, but the rate of this process is low. Unsustainable land use leads to the degradation of peatlands, which limits their ability to positively influence the climate. Currently, degraded peatlands emit 2 Gt CO_2 per year and account for almost 5% of global anthropogenic CO_2 emissions. Restoration, rewetting and conservation of peatlands is an effective approach in climate change mitigation.

• Agroforestry technologies for carbon sequestration Agroforestry refers to the practice of deliberately combining woody vegetation (trees or shrubs) with crop and livestock systems on the same piece of land. Specific technologies within this area are diverse, due to the need to adapt to specific soils, climatic conditions and agricultural systems. The introduction of agroforestry within traditional farming systems contributes to carbon sequestration in the long term without increasing emissions in the short term, and also has a positive effect on biodiversity.

● Maintaining and increasing soil organic carbon levels Maintaining and increasing soil organic carbon levels can be done by growing cover crops, improving crop rotations, introducing agroforestry, preventing plowing, organizing pastures. At the same time, the effectiveness of specific measures can vary significantly depending on climatic conditions, soil structure, and the current level of soil organic carbon. High monitoring costs, and such uncertainty in efficiency even at the site level, creates an obstacle to the actual implementation of sequestration projects of this type.

● Process optimization in agriculture and livestock production On the one hand, grasslands and pastures occupy a large area of agricultural land, which allows them to naturally sequester a significant amount of carbon. On the other hand, ongoing agricultural activities (for example, in the case of conversion of land to arable land) can lead to significant emissions. At the same time, in addition to the impact on the climate, it is necessary to take into account the problems of preserving biodiversity and increasing soil productivity and pasture productivity. Livestock such as meat, dairy, sheep and pig farms make a significant contribution to the total greenhouse gas emissions into the atmosphere. The introduction of technologies to combat climate change on farms (for example, the selection of special feeds, the treatment and processing of waste, etc.) can reduce greenhouse gas emissions. Thus, the polygon should contain on its territory the main types of ecosystems - meadow, swamp and forest - on which the research will be directly carried out. At the same time, it is possible to organize a polygon on the basis of several sites spaced apart in space, if such a need arises. The area of each such area should not be large enough to obtain reliable results. According to world and Russian experience, the landfill area can vary from tenths to units of square kilometers.

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