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Study of Carbon Sequestration Processes in Forestry on Carbon Farms

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Abstract. The earth "plays a key role" in the climate system as an important carbon sink because land surfaces such as forests regulate the planet's temperature and help store carbon. In the last decade alone, terrestrial ecosystems have absorbed about 30% of carbon emissions from human activities such as the burning of fossil fuels.But our lands are under increasing pressure from deforestation, urbanization, industrial development, agricultural expansion, and unsustainable farming practices that undermine the ability to sustain food production, sustain freshwater and forest resources, and climate and air quality regulation. Conserving tropical forests has many benefits, from protecting biodiversity, sustaining indigenous and local communities, and safeguarding climate. To achieve the ambitious climate goals of the Paris Agreement, forest protection is essential. Yet deforestation continues to diminish the world's forests. Halting this trend is the objective of the international framework for Reducing Emissions from Deforestation and forest Degradation (REDD+). While previous studies have demonstrated the contribution of tropical forests to mitigate climate change, here we show that tropical forest protection can 'flatten the curve' of the costs of transition to climate stability, estimating tens of trillions of dollars in policy cost savings.

1 Introduction

Today, up to 40 percent of the land surface in the world is degraded, including 30 percent of arable land and 10 percent of pastures. Over the past five decades, the area of drylands has increased by an average of more than 1% per year, mainly affecting countries in Africa and Asia. If we continue to abuse the land, an area the size of South America will be degraded by 2050. Land degradation affects food security, water availability, and ecosystem health, directly impacts half of humanity, and results in the loss of approximately $40 trillion in ecosystem services each year, nearly equivalent to global GDP in 2021 ($93 trillion). Land degradation has also been identified as the "largest cause of loss of terrestrial biodiversity", leading to the destruction of many plant and animal habitats. Severe land degradation, such as drought and desertification, can also destroy

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communities and lead to social and economic instability. By 2050, up to 250 million people could be displaced due to desertification caused by climate change [1].

Sustainable forest management requires taking into account various factors of landscape resilience, including planning for multi-purpose forest management, changing the strategy of reforestation towards hardwoods, better biodiversity conservation, countering the entry of invasive species, land degradation, etc. Avoiding unsustainable practices of nature management is impossible without solving the socio-economic problems of the territories and active interaction of companies with local communities. Economic models of forestry and agro-climatic projects should focus not only on the tasks of investors represented by large companies to receive greenhouse gas absorption credits, but also on the contribution to employment and income of the population in the project implementation areas. Today, scientists have come to a new understanding of the climatic and ecological role of the progressive degradation of underwater permafrost and the destabilization of hydrates - the massive emission of methane into the water column-atmosphere in the context of the impact on human development [2]. The processes of uncontrolled natural release of greenhouse gases into the atmosphere, the source of which are shelf gas hydrates and other geological reservoirs (pools) of methane, require the development of a monitoring and control system. An interdisciplinary approach is needed, including hydrophysical, biogeochemical, geophysical and geological methods accepted in world practice, as well as new methods proposed by a team of scientists in the fourth section of this report and introduced into international maritime practice. An extended data bank on the state of underwater permafrost and identified areas of massive methane discharge due to destabilization of hydrates can be used to identify the mechanism for the formation of the maximum allowable volume of planetary atmospheric methane over the Arctic, which is one of the modern world challenges in the field of natural sciences.

2 Research Methodology

Today, in most countries, the level of CO2 emission or absorption is estimated by calculation. For example, it is taken as a basis that a twenty-year-old forest of mixed species absorbs on average from 1 to 5 tons of CO2 per year per hectare. But this is a huge “run-up”, which becomes very inconvenient if you are going to trade it. Accurate measurements are required [3-4]. Considering that it is necessary to measure over large areas, there is no other way than remote sensing of the earth. A picture is taken from the satellite, decoding is carried out through software tools, and reliable data is obtained on how much a certain piece of land has absorbed and how much has allocated at a particular point in time.

3 Results and Discussions

In the current international practice, carbon farms are in the foreground as a promising area of activity for natural absorption and removal (sequestration) of GHGs. For example, the EU defines a carbon farm as “a green business model that encourages owners and managers to improve land management, which translates into increased carbon sequestration in living biomass, dead organic matter and soil by increasing carbon sequestration and/or reducing carbon emissions.” into the atmosphere, in accordance with environmental principles that support biodiversity and natural capital in general [5].” Carbon farms are expected to contribute to the achievement of the EU climate targets, for which they are expected to be supported through the Common Agricultural Policy and programs such as LIFE6 and Horizon Europe, as well as private initiatives linked to carbon markets (climate projects).

By the end of 2022, legislative proposals are expected in the EU for the certification of "carbon withdrawals", based on reliable and transparent accounting, monitoring and verification. Another example is Australia's Carbon Farms Roadmap8, which aims to increase state revenues and create new jobs by 2030. At the same time, there are still quite a lot of questions regarding the stability and reliability of the results obtained for carbon farms. (Fig.1).

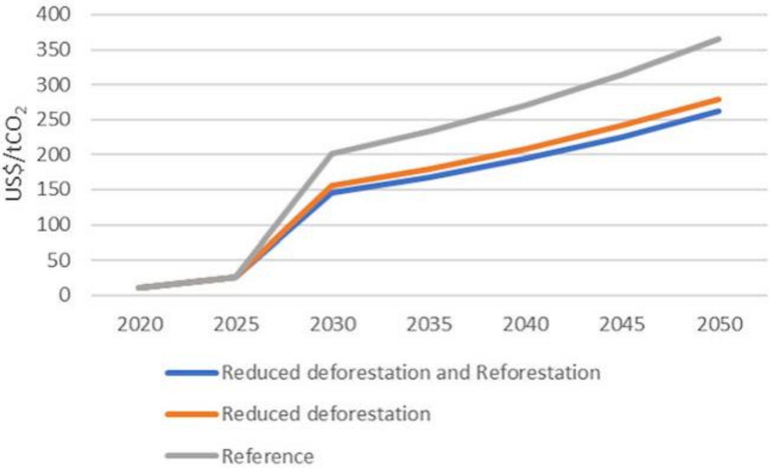

Fig. 1. CO2 price for 1.8 °C-consistent (970 Gt emissions) budget with policy delay until 2030 (1.8C, PD2030 scenario) with and without REDD+.

The application of areal accounting principles by soil types and the use of GIS technologies with the current level of cartographic provision in Russia in the future can be applied only at the regional level. Of the indicators of forest cover available in statistical reporting, the following data are used to assess phytomass [6]: - Areas and stocks of stands of various forest-forming species; Distribution of areas and reserves by age groups of forest-forming species; Average stocks of timber per 1 ha for the same species or their groups (calculated as a ratio of stocks to planting area in age groups) [7]. At the next stage, state statistics materials are used to calculate phytomass (carbon) reserves using predictors obtained from specialized databases. Phytomass is calculated by the ratio of the mass of different fractions (trunks, branches, roots, stumps, leaves or needles) to the stock of stem wood (Ph/SC-ratios). Carbon stocks in tree layer phytomass are determined in terms of stemwood stocks using conversion factors. Conversion of wood reserves was carried out according to the age groups of forest-forming species. The amount of carbon sequestration by forest vegetation is calculated from the change in the average carbon stock for plantations of different age groups [8]. The methodological basis of information processing processes in GIS is digital terrain modeling, which combines the processes of collecting primary information, its modeling and updating, processing and generating documents. Due to the use of modern technical means, automation of field and cameral work is carried out. Aerial and satellite images provide excellent substrates for digitizing GIS data: they contain coordinates along with the image (Fig. 2).

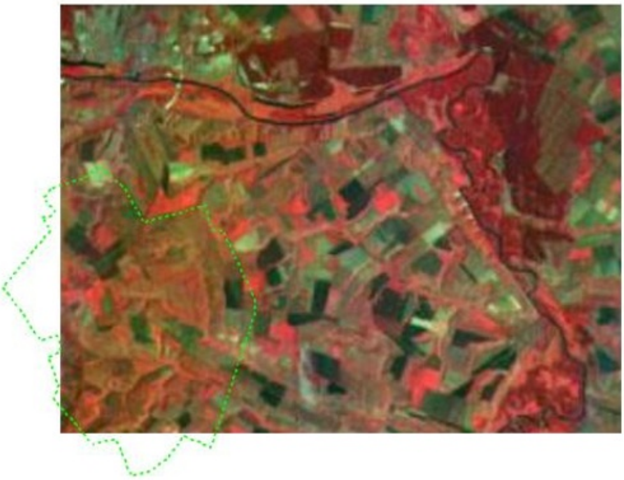

Fig. 2. GIS technology for studying forestry

The widespread recognition of the problem of climate change is forcing scientific teams and corporations to look for ways to reduce the carbon footprint of the economy, including the extraction of greenhouse gases already in the atmosphere. Modern research highlights a whole range of sequestration strategies [9]:

- physico-chemical;
- biological;
- geological.

Physical-chemical approaches are mainly used in industry, energy and transport to reduce new emissions and include the use of adsorbents and separation membranes to capture, compress and transport greenhouse gases. Biological and geological methods make it possible to reduce the volume of gases accumulated in the atmosphere. Geological methods involve the injection of greenhouse gases into underground storage facilities (eg depleted deposits) [10]. This solution is very reliable from a safety point of view (most storage facilities will not be disturbed by tectonic processes for the next millions of years), but from an economic point of view, sustainable economic models have not yet been found to build a stable sequestration industry using geological methods. Biological methods involve using the potential of natural living systems to sequester carbon. Plants, algae, bacteria in the soil in the bottom silt are natural "devices" for absorbing greenhouse gases.

Management practices that capture carbon from the atmosphere are known as carbon (or carbon) in increasing soil carbon by increasing the amount of carbon put into the soil and reducing the rate of carbon loss through respiration and soil erosion. The reduction of greenhouse gas emissions associated with agriculture is achieved, among other things, by minimizing the use of agrochemicals (fertilizers, plant protection products). In many ways synonymous with carbon farming is the concept of regenerative (i.e. restorative) agriculture (regenerative agriculture) - a set of non-destructive farming methods that ensure soil restoration in the process of managing. In a broad sense, forest technologies for carbon sequestration can probably also be attributed to carbon farming.

Forest farms are focused on growing special forest and non-wood forest products, including such valuable ones as mushrooms, ginseng, nuts, herbs and dyes [11]. The activities of such a farm change the forest ecosystem, but do not violate such important functions as soil erosion control, microclimate regulation and the creation of wildlife habitats. Windbreaks are strips of trees and/or shrubs that are maintained to change the wind flow and affect the microclimate. Such strips can protect sensitive crop species, improve water use efficiency, better control wind erosion, and increase bee and pesticide pollination efficiency. These ecosystem services can improve soil health by increasing soil diversity, reducing soil disturbance, and providing year-round soil cover. Coastal (tugai) forest buffers consist of strips of grass, shrubs, and trees between the shore, just below the water's edge, and arable land [12]. Trees and shrubs stabilize the coast, improve and protect the aquatic environment, and protect arable land from water erosion and weeding. Grass slows and disperses runoff from arable fields, promoting sedimentation and infiltration of nutrients and pesticides. Finally, silvopasture agriculture is the intentional use of a forest area as a pasture. Typically, this system includes seeding with native pasture grasses, fertilization and nitrogen-fixing legumes, and rotational grazing. Potential benefits of this system include a cooler environment for livestock, shorter logging cycles due to higher levels of nitrogen fertilizers and control of competition, and more efficient uptake of nutrients by plants. The costs and challenges associated with setting up a silvopastoral irrigation system include the high capital costs associated with planting trees, the need for fencing and monitoring of livestock, and ensuring correlation between livestock and plant species. In practice, it is noted that agroforestry management systems have different effects on carbon sequestration potential. Sequestration potential is determined by plant characteristics (tree species, crops, tree density), system characteristics (structure, stability) and management factors (tillage, harvesting practices, fertilization and crop residues).

4 Conclusions

Considering that the problem of CO2 emissions associated with global warming is now becoming more and more obvious. The search for possible directions for solving this problem remains relevant. One of the solutions was the development of carbon landfills and farms, which is an important step in achieving the goals of the new climate policy. The author carried out a bibliometric analysis of domestic and foreign sources of scientific literature. It is shown that the development of carbon farms in the regions to a greater extent positively affects their economic and social development, and also brings a number of environmental benefits. Russia’s obligations to participate in the climate agenda necessitate the development of tools to reduce greenhouse gas emissions and the development of climate projects, including those aimed at increasing the sequestration (absorbing) capacity of forest cover.

The Earth’s forests cover an area of almost 4 billion hectares, which is about 30% of the planet’s surface. They provide the livelihood for about 25% of the world's population and are home to about 80% of all terrestrial flora4 and fauna. The UN Strategic Plan for Forests (2016) recognizes the essential ecosystem services that forests provide, including food, fodder, fuel, timber, non-timber products and shelter, as well as the conservation of soil and water resources and clean air. In addition, the report highlights the role of forests in preventing land degradation and desertification and in reducing the risk of floods, landslides, droughts, storms and other natural disasters. When discussing the potential for carbon sequestration in forestry, it is important to define some relevant terminology. FAO defines afforestation as the creation of forest through the planting and/or deliberate seeding of land that was not previously classified as forest; deforestation is the conversion of forest land to other land uses; reforestation is the restoration of a forest by planting and/or deliberate seeding on land that was previously classified as forest. Typically, afforestation and reforestation projects capture atmospheric carbon, while preventing deforestation maintains the amount of carbon held in forests. In the context of carbon sequestration techniques, afforestation, reforestation and avoidance of deforestation are seen as low-cost and economically attractive activities.

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