CREATING FOREST CARBON LANDFILLS: FOREST CARBON

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Abstract

Currently, significant attention is paid to environmental issues at all levels of management. Over the long history of human civilization, significant environmental damage has been accumulated, because not only large-scale industrial production, but also ordinary human life leads to the formation of a significant amount of harmful products that pollute the atmosphere, soil, and water spaces. The huge scale of the accumulated damage makes it necessary to resolve environmental issues at the highest level - the level of international organizations and the leadership of individual states. At the same time, interest in the environmental agenda is connected both with the health of the population and with economic aspects, because in the near future in Europe, and then, possibly, in Russia, much more significant taxes and fines for non-environmentally friendly production and products will be introduced. Among a significant number of important environmental issues of our time, one of the most acute is the issue related to emissions of the so-called greenhouse gases (primarily carbon dioxide CO_2 and methane, but also other gases) and the environmental damage resulting from this phenomenon.

Keywords: gas emissions, forest carbon, climate change, carbon landfills, environmental protection, Forest Carbon.

I. Introduction

Carbon landfills play a key role in the study of greenhouse gas emissions (Fig.1) and their impact on climate change, as well as in the development of strategies to combat this phenomenon. To estimate annual changes in carbon stocks, it is necessary to have a sufficient number of carbon landfills to cover a significant part of the territory of Russia. To assess the annual changes in carbon stocks in the forests of Russia, it is necessary to have carbon polygons for all types of forests in various climatic zones. There are more than 70 types of forests and more than 10 climatic zones in Russia, so several thousand carbon polygons need to be created to cover the territory sufficiently. In addition to forests, it is also necessary to estimate carbon stocks in soils, water ecosystems and other natural objects. This also requires the creation of carbon landfills in the respective territories. There are currently 17 carbon landfills operating in Russia, many of which are collaborating with leading Russian universities dealing with climate change issues.

Forests, in turn, are the main natural sink of greenhouse gases in terrestrial ecosystems in the world. As the world's leading forest power, Russia has natural natural capital in the form of forests accumulating 625 million tons of greenhouse gases annually. This gives Russia a significant competitive advantage, since the absorption of greenhouse gas emissions by forests occurs without significant costs from the state, the cost of measures to reduce emissions - for example, to extinguish forest fires - is moderate (3 billion rubles per year) compared to other types of measures, for example, to increase energy efficiency in industry. In general, in Russia there is a

huge and still not used reserve for reducing the carbon footprint of products due to the existing protective and other categories of forests on agricultural lands. Forests located on agricultural land are of great importance for the absorption of greenhouse gases [1]. If 1 hectare of forests on the lands of the forest fund absorbs on average about 1 ton of greenhouse gases per year, then 1 ha of protective and anti-erosion forests on agricultural lands - about 7 tons per year, i.e. 7 times more. At the same time, according to various estimates, from 40 to 90 million hectares of agricultural land in Russia are overgrown with forests, which are not yet taken into account in the national statistics of greenhouse gas absorption due to the fact that they do not belong to managed forests.

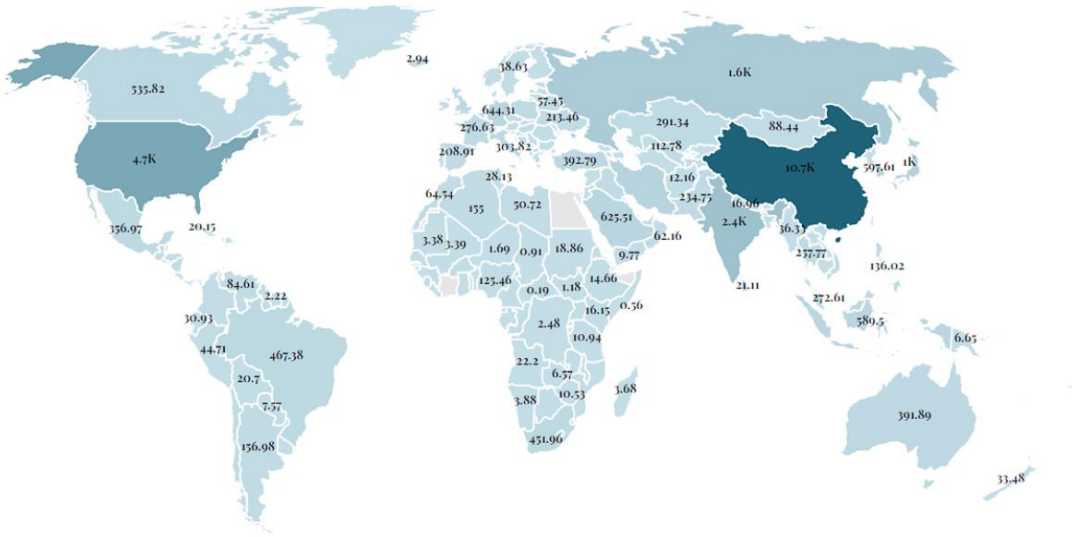

Fig. 1: *CO_2 Emissions by Country 2023*

Forest breeding should be aimed at obtaining varieties and species with high growth rates and high potential for carbon sequestration in the climatic conditions of Russia [7]. In recent years, along with the active spread of state regulation systems for greenhouse gas emissions, as well as various sectoral emission regulation systems, voluntary carbon offsetting schemes have been rapidly developing based on the implementation of investment projects. Voluntary carbon markets are platforms for the implementation of transactions for the sale and purchase of greenhouse gas emission reduction units.

II. Methods

Carbon farming by creating carbon farms is an innovative way of agriculture/forestry to sequester carbon in the soil (Fig.2). A carbon farm can be located on forest fund lands and on lands of other categories, for example, agricultural purposes (old arable land). In the first case, the carbon farm will be forest plantations - forest plantations, in the second case, the farm will be represented by both forest plantations and agricultural land. When creating forest plantations used as carbon farms, it is important to take into account the period of their operation, the main tree species, and the technology of creation. In the present study, we limited ourselves to a carbon farm, represented by a forest plantation with monocultures of poplar and pine.

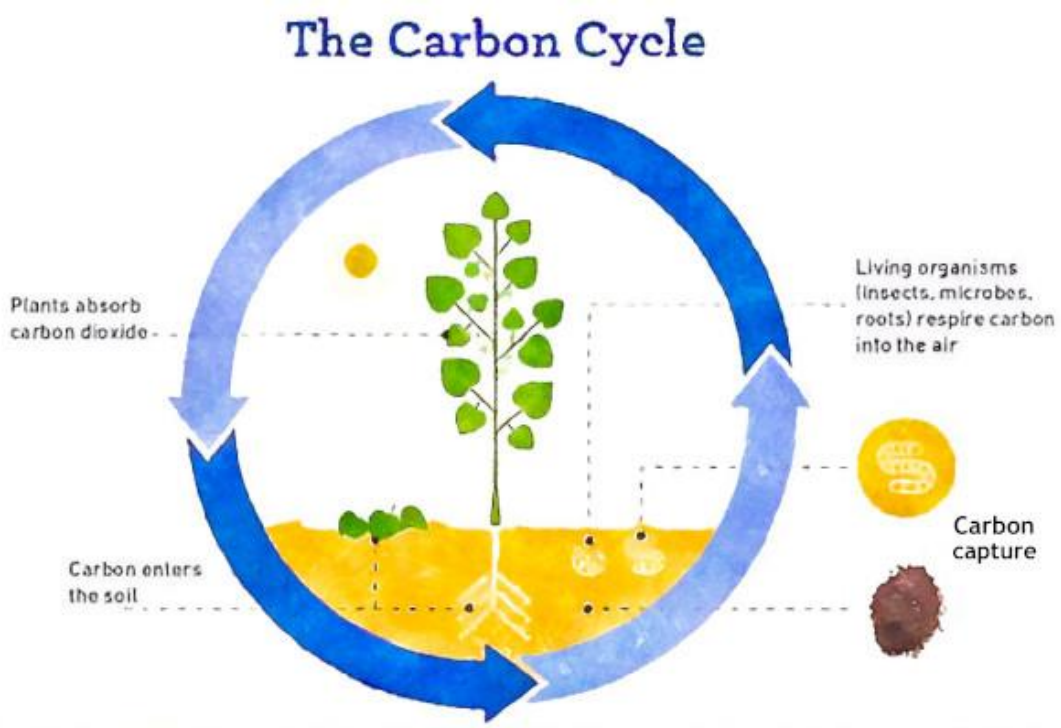

Fig. 2: *Carbon farming*

Seedlings with a closed root system were used to create forest plantations. At the first stage, the organization of the carbon farm included the preparation of a forestry area for the creation of a plantation (clearing the territory), the second stage included plowing, disking and cultivating the soil, fertilizing [3]. The third stage, the actual planting of seedlings with a closed root system, was characterized by the greatest labor and material intensity of work. The cost of creating one hectare of a carbon plantation is presented in Table 1 and amounts to 239.89 thousand rubles. In subsequent years, it is necessary to spend 64.0 thousand rubles on the organization of care work and maintenance of the plantation. Thus, the cost of creating and maintaining 1 hectare of poplar plantations, with a density of 2.5 thousand per piece. ha, felling age of 50 years is 303.9 thousand rubles.

The creation of carbon polygons is possible on the basis of public-private partnership, with the combined efforts of science, business and government. The reason for this lies in the presence of significant risks, determined by the long-term nature of the project to create carbon farms, the presence of uncontrollable climatic factors, as well as the possibility of forest fires and diseases of forest plantations. The risks of creating carbon farms can also lie in the economic plane and be associated with technological and market changes, which requires a balanced approach when launching carbon projects. In order to minimize the consequences of risky events, we consider it necessary at the first stage to organize a network of carbon test sites. To implement this actual practice-oriented task, there are the following prerequisites [2]:

- The Chechen Republic, geographically located on the border of the forest and steppe zones, is the most vulnerable to climate change and, therefore, needs measures to adapt ecosystems, including through the conservation and cultivation of forests;

- the key measure to reduce the greenhouse effect is the creation of artificial green spaces in non-forest areas and on forest lands, where, due to a number of circumstances, natural reforestation does not occur;

- a high concentration of specialized scientific organizations with a scientific background and competent personnel in the field of monitoring forest ecosystems and assessing ecosystem services;

- university researchers have already obtained promising tree species for the purposes of afforestation and the creation of carbon landfills, which are distinguished by stress resistance, high growth rate and productivity;

Table 1: *Cost of creation, maintenance (standard costs) of 1 hectare of poplar forest plantations, density 2.5 thousand pieces/ha, felling turnover 50 years, rub.*

Enlarged types of work included in the technology	Required number of people o-days	Costs for the maintenance and operation of equipment	General payroll	Payroll accruals 30.9%	Cost of basic materials	Total production cost
Preparatory work	7,02	617,99	5997,13	1853,1	27812,18	36280,40
Site arrangement	3,44	296,48	2963,98	915,86	17311,79	21488,11
Establishing a plantation by planting seedlings	4,77	426,2	4354,0	1345,38	176003,3	182128,76
Care and maintenance of plantations	32,64	5182,74	26498,94	8188,17	24131,50	64001,35
Total cost						303898,62

III. Results

As of January 1, 1991, the forested area within the Chechen-Ingush Republic was 285 thousand hectares, of which 7.8 thousand hectares were coniferous. The total stock of forest plantations at that time was estimated at 41.5 million cubic meters, and the stock of mature and over nature timber at 8.6 million cubic meters. The estimated cutting area for the main use was 88 thousand cubic meters. Occupying one fifth of the territory of the republic, forests consist of high-quality species, where valuable hard species predominate - beech, hornbeam, ash. In orchards and forests there are significant reserves of the most valuable furniture and ornamental wood - apple, pear, cherry and other fruit trees. All this can serve as a basis for the development of the furniture industry in the republic, capable of producing high-quality furniture from solid wood and fine veneer. The role of forest resources in the national economy of Chechnya did not remain constant. In the pre-revolutionary past, wood served as the main building material, and firewood made up the vast majority of the fuel balance. During the formative years of the logging industry, woodworking served as the basis for its industrial development. As the economic complex of the republic developed on the basis of the accelerated growth of the fuel and energy, petrochemical and machine-building groups of production, the share of the forest industry in the industry of the republic gradually decreased [3]. By the beginning of the crisis, the timber and woodworking industry was a complex of industries that ensured the cultivation and exploitation of timber, its processing into lumber and the production of furniture.

Agroforestry combines trees with other agricultural land uses such as field crops and livestock. In addition to saving production, agroforestry can remove carbon dioxide (CO2) from the atmosphere because trees themselves capture and store carbon and increase carbon in the soil around them. Agroforestry comes in many varieties (Fig.3). Examples include forest pastures where animals graze under trees; inter-row and alley crops, in which other crops are planted

under trees or between trees; hedgerows and windbreaks in which rows of trees or woody shrubs separate areas of agricultural land; as well as pasture gardens in which animals graze under fruit trees.

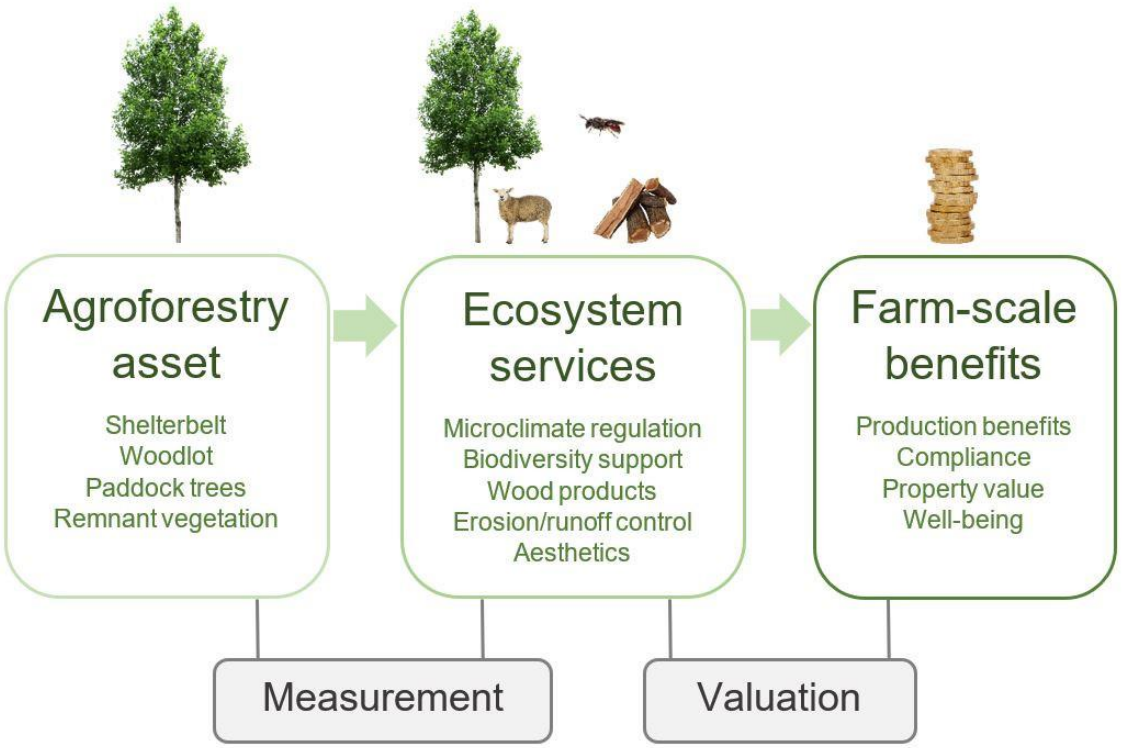

Fig. 3: *Agroforestry Decision-Making at the Farm Scale*

Co-benefits and challenges: - Food security: instead of competing with arable land, agroforestry coexists with food production; diversifies crop production and, in some cases, increases yields (for example, by improving soil quality or crop shading). - Commercial products: Agroforestry can diversify income sources by providing commercial products such as timber and non-commercial inputs such as firewood. - Ecological benefits: Trees and shrubs can contribute to the conservation of biodiversity by providing habitat; reduce erosion and improve air, water and soil quality. - Possibility of reduced yields: In some cases, agroforestry systems will produce less yield per hectare than field crops, potentially reducing farm income, especially in the short term. - Saturation: Trees can only hold a finite amount of carbon; they will eventually stop removing additional CO2. - Reversible [4]: Carbon captured by trees can be released if trees burn, die, or are destroyed by land-use change. - Difficult to measure: Monitoring and verifying carbon removal through agroforestry is difficult and expensive. Possible scale and cost. Different approaches to agroforestry can be applied at different scales and sequester CO2 at different rates. For example, installing windbreaks can capture 20 tons of CO2 per square kilometer per year, while growing alley crops can capture 120 tons of CO2 per square kilometer per year. Carbon sequestration rates also vary by region, ranging from 954 tons of CO2 per square kilometer per year in semi-arid areas to 3,670 tons of CO2 per square kilometer per year in humid regions. Costs also vary by practice and region. Many approaches offer very high ROI but may include high upfront costs [5]. Technological readiness. Agroforestry is an ancient, established practice that is ready for further development. As of 2010, agroforestry occupied approximately 43% of the world's agricultural land, including any agricultural land with at least 10% tree cover. This is about one billion hectares of land, which is equivalent to the land area of Canada. Current barriers to agroforestry expansion tend to be social, financial and infrastructural rather than technical: Governance and development

issues. Robust incentives, agricultural extension services, financing, input subsidies and other policies can help overcome barriers. In addition, processes, standards and technologies need to be developed to reliably measure carbon sequestration in biomass and soil under forests.

To overcome the negative consequences and ensure the rational use of the forest fund, the following is required:

1. Carrying out forest management.
2. Construction (rehabilitation) of administrative buildings (offices of forestries and forestries).
3. Restoration of the nursery.
4. Restoration of the production base.
5. Acquisition of means of communication.
6. Acquisition of a motor and tractor fleet.
7. Construction of roads for forestry purposes.
8. Construction (restoration) of cordons.

Restoration of the timber industry complex of the republic is possible if the industrial processing of wood is put under strict control and the balanced consumption of renewable resources. The development of forest areas should be entrusted to a limited circle of specialized enterprises. Which, in turn, should, along with the harvesting and processing of wood, be engaged in the systematic planting of young animals. Enterprises that have received licenses to conduct logging activities must also have targeted funding. In terms of commercial timber harvesting - targeted lending, in terms of planting young trees - budget financing with a fixed amount of work. Targeted loans allocated to operating specialized enterprises should be used to purchase new technological equipment, which should increase the level of integrated use of wood raw materials. The new equipment should include machines and units that make it possible to produce medicines, food and feed additives, sorbents, biologically active substances and other products from wood waste that meet the needs of the region. However, in the short term, the republic needs to restore and develop the timber and woodworking industries. It is economically efficient to single out three woodworking enterprises to be restored, which will have to organize a network of raw material logging organizations [6]:

• State Unitary Enterprise "Alkhan-Kalinsky woodworking plant". The company previously specialized in the production of chipboard, sliced veneer, synthetic resin, wood harvesting and processing. The restoration program provides for the development of additional nomenclature (parquet, CMP, furniture and joinery production) with an annual output of marketable products worth 30.0 million rubles, the number of employees is up to 220 people.

• State Unitary Enterprise "Grozny Experimental Furniture Factory". Specialized in the production of office and upholstered furniture. The restoration program provides for the development of additional nomenclature (office furniture, kitchen furniture, for medical and medical institutions, carpentry) with an annual volume of up to 40 million rubles, the number of employees is up to 180 people.

• State Unitary Enterprise Grozny Furniture and Woodworking Plant. Specialized in the production of upholstered furniture. The restoration program provides for the development of additional nomenclature (the production of chairs, the production of highly artistic furniture from hardwood, the production of armchairs and kitchen furniture. At present, investments are already being made to restore the Grozny furniture and woodworking plant, the Alkhan-Kalinsky DOK, the Fagus State Unitary Enterprise and the Druzhba cardboard factory. The cardboard factory is able to meet local demand for the simplest products - stationery, school supplies, writing materials, cardboard packaging and containers, labels, advertising booklets [5]. In the opinion of experts, it is advisable to consider the construction of a small enterprise for processing waste paper into sanitary and hygienic products. In view of the fact that the modern furniture market in Russia is highly monopolized, and equipment for furniture production is expensive and scarce, an external investor is needed who will bear the costs of purchasing equipment, training personnel and the risks of selling finished products in exchange for production facilities and tax benefits

from the government of the republic. Currently, the leading furniture manufacturer in the North Caucasus is the Kavkaz company, it is possible to attract its investments, another option is to look for a foreign investor. This, for example, can be the German company Schieder Mobel Holding, which has begun to actively intervene in the Russian upholstered furniture market and is looking for a territory for building a factory in the North Caucasus, as well as the Swedish trading company IKEA [6]. Among the range of finished products possible for the production, we can especially recommend the manufacture of medical furniture. This production in Russia is poorly developed, and the demand for these products is huge. It is possible to organize the production of school furniture, cabinet furniture and wardrobes in the republic on the basis of the restoration of production teams and production facilities of the Terek furniture association and the Grozny furniture factory.

IV. Discussion

The forests of the region are under the strongest pressure, which is presented in the reviews of national forests and the forest sector. At the same time, the types of negative impact on forests in the region are quite similar and are given below. Demand for fuel wood by local residents leading to illegal/over-logging. Rural poverty is widespread in the region, and modern fuels are expensive since the collapse of the Soviet internal trade system. In many cases, there are few alternative sources to wood for cooking and heating in rural communities, especially during harsh winters. As a result, legal and illegal timber exports are at a high level [7]. This pressure is exacerbated by the use of inefficient stoves, as more wood is needed for the same level of heat supply. It should be noted that in countries where the government has been able to provide modern fuels such as gas at an affordable price, illegal firewood harvesting has been significantly reduced - this applies to countries that now have access to modern fuels. Depending on the institutional environment, the villagers either harvest the wood themselves or supply it from local forestry enterprises and intermediaries. Saxaul forests are particularly vulnerable due to the small stock of timber (more wood harvesting area is required to meet demand), and successful natural reforestation does not occur after felling due to harsh climatic conditions, dry and saline soils.

In the Caucasus, half of the population lives in rural areas and is highly dependent on agricultural activities, despite the lack of quality arable land. As a result, the well-being of the local population depends on the grazing of livestock - goats, sheep and horses. Land tenure systems vary between countries, but animals often graze on public lands to which all residents have access, including lands with and without forest cover and lands of the state forest fund. In fact, a significant part of the lands of the state forest fund is officially allocated for livestock grazing. Grazing management on public lands is often one of the main activities of local forest enterprises. Many sources report that overgrazing is putting pressure on forests that are being degraded by too many grazing animals, hindering forest restoration and contributing to the loss of forest cover.
• Irrigation projects have been implemented along the rivers, mainly for cotton and wheat, and hydropower facilities have been built [8]. As a result, floodplain forests (tugai) were destroyed in some areas. In addition to the anthropogenic pressures mentioned above, the region's forests are vulnerable to a wide range of natural disasters, including erosion and soil loss, landslides in mountainous areas as well as along watercourses, desertification, increased soil salinity and sandstorms. They are vulnerable to these non-anthropogenic impacts and, at the same time, play an important role in combating them.

The forests of the Caucasus protect the ecosystems and population of the region from a wide range of natural disasters, including erosion, reduced soil fertility and the threat of landslides in mountainous areas, reduced evaporation and desertification, soil salinity, and sandstorms. As a rule, in such cases, the very presence of a healthy forest ensures the fulfillment of protective

functions. These services are seen in the region as a common good, provided free of charge by national governments. This situation was recognized by the Soviet authorities in the 1950s and 1960s, when practically all forests in the region were assigned to the first group2. Although classification and administrative systems vary from country to country, the paramount importance of the forest protection function is recognized formally and at the highest political level throughout the region. In most of the region's forests, logging for the purpose of timber harvesting is prohibited or strictly limited. The proportion of forests formally "dedicated to protection" varies from 50 to 100%, but in practice the protection function takes precedence, at least in theory, over all other forest functions in all parts of the region. According to data collected for the Forest and Forest Sector Reviews, mainly through the FRA process but with little cross-country comparability, over 15 million ha have "defined management objective to maintain and enhance their protective functions", representing almost 90% of the region's forests. It is not possible to quantify the protective effects of actual or potential loss or degradation of forests in terms of erosion, loss of soil fertility, increased salinity, accelerated desertification, increased sandstorms, etc. Such a quantification, both physically and economically, will provide a powerful argument in political discussions about the resources needed to protect forests. It is very likely that the benefits to the ecosystems and economy of sustainably managed protective forests outweigh the economic costs of managing and protecting these forests. However, currently there is no system of payment for forest ecosystem services in the region, although the importance of these services is officially recognized [9].

In many cases, non-timber forest products and services play a more important role in rural livelihoods than timber supplies. These types of products may take different forms depending on local conditions. Some of these are briefly listed below:

• Livestock grazing is often a key service that uses both the surrounding forests and forest land as grazing land. In some cases, forest managers use areas for grazing personal livestock, especially if local forest enterprises are responsible for pastures and forest land. In other cases, livestock owners use forest/pasture land, either through a system of public rights or through forest use fees. In many cases, it appears that overgrazing is permitted or cannot be prohibited, even if it causes forest degradation or destruction. Depending on existing arrangements (which vary widely), most participants do not have long-term tenure rights, so they have no incentive to manage forests and use pasture resources in a sustainable manner. In the 2015 FRA, many countries listed hay as a non-wood product supplied by forests, which is clearly related to livestock grazing.

• Honey and medicinal herbs are also collected and then sold or consumed by the locals.

• Some forest enterprises sell seedlings that they grow in their seed nurseries. This can be a very profitable undertaking.

• Georgia exports flower bulbs (Galanthus woronowii and Cyclamen coum) and tree seeds (Abies Nordmanniana).

• A tourist destination is developing in some forest areas.

• Hunting is also of great importance, both for obtaining fur and meat and trophies, mainly for foreign tourists who are willing to pay big money for pleasure. Income from the sale of non-timber products and services can play an important role in the livelihoods of people dependent on the forest, although neither this aspect nor the quantity or value of the products harvested appear to be known or investigated with certainty.

All countries in the region reported to the UNFCCC on their greenhouse gas (GHG) balances, including net GHG sinks to forest ecosystems, or emissions. This used the IPCC reporting guidelines for available forest data in their countries. Reports show that the net annual GHG sink to the forest ecosystems of the Caucasus and Central Asia – carbon sequestration – is about 25 Mt CO_2 equivalent (t CO_2 eq).

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References

[1] Ostapenko B.F., Classification of forest types and forest typological zoning of the Northern slope of the Greater Caucasus. // Tr. Kharkov Agricultural Institute. Kharkiv, 2019.

[2] Gakaev R.A., I.A. Bayrakov, M.I. Bagasheva, Ecological foundations of the optimal structure of forest landscapes in the Chechen Republic. In the collection: Environmental problems. A look into the future. Proceedings of the III scientific-practical conference. Executive editor Yu.A. Fedorov. 2006.pp. 50-52.

[3] Gakaev R.A., Comprehensive assessment of the current state of the mountain-forest landscapes of the Chechen Republic and measures for their optimization. In the collection: Modern problems of the geoecology of mountain areas, 2008.pp. 189-194.

[4] Silva L.C.R., G. Sun, X. Zhu-Barker, Q. Liang, N. Wu, W. R. Horwath, Tree growth acceleration and expansion of alpine forests: The synergistic effect of atmospheric and edaphic change. Sci. Adv. 2, e1501302 (2021).

[5] Earles J. M., O. Sperling, L. C. R. Silva, A. J. McElrone, C. R. Brodersen, M. P. North, M. A. Zwieniecki, Bark water uptake promotes localized hydraulic recovery in coastal redwood crown. Plant. Cell Environ. 39, 320–8 (2020).

[6] Salamova A.S., Socio-economic factors in the fight poverty and hunger in the modern world: the scientific approach of Amartia Kumar Sen, 2023, 17(1), pp. 237-245.

[7] Salamova A.S., Global networked economy as a factor for sustainable development, 2020, p. 03053.

[8] Dixon R.K., S. Brown, R. A. Houghton, A. M. Solomon, Global Forest Ecosystems. Science, 263:185–190 (2019).

[9] Novara A., T. La Mantia, J. Rühl, L. Badalucco, Dynamics of soil organic carbon pools after agricultural abandonment. Geoderma, 235-236: 191-198 (2019).