CARBON CREDIT GENERATION POTENTIAL OF AFFORESTATION ON AGRICULTURAL LAND IN LITHUANIA

Deividas STRUMILA, Vytautas Magnus University, Agriculture Academy, Faculty of Forestry and Ecology, e-mail: deividas.strumila@vdu.lt

Abstract

Afforestation and forest restoration have become central components of climate and biodiversity policy with voluntary carbon trading emerging as a potential tool. The aim of this study is to assess the carbon credit generation potential of afforestation on agricultural land in Lithuania. Eleven agricultural land plots located in the Utena, Vilnius, and Siauliai regions were analysed using data from the Arbonics assessment platform. Of these, eight plots were found suitable for afforestation, with a total eligible area of approximately 72 ha (59.6% of the total area). Plots were classified by forest site type: Ld (temporarily waterlogged fertile sites – birch), Nc (normal moisture fertile sites – Norway spruce), and Sd (wet fertile sites – birch). Over a 50-year period, the eight plots are projected to generate approximately 11,633 carbon credits with a total economic value of EUR 814,310 (at EUR 70 per credit). Birch (Ld) and Norway spruce (Nc) scenarios showed similar revenue efficiency (~EUR 11,250/ha), while wet fertile (Sd) habitat plots demonstrated the highest potential at EUR 19,122/ha. Revenue begins to accumulate significantly from years 6–9 and increases throughout the project period. This study thus shows that afforestation of agricultural land for carbon credits has the potential to be a valid business model. However, this is dependent on the economic markets of carbon trading.

Keywords: afforestation; carbon credits; agricultural land; forest site type; silver birch; Norway spruce; economic assessment; Lithuania.

Introduction

Across Europe, afforestation and forest restoration have become central components of climate and biodiversity policy. The European Union's Forest Strategy for 2030 and the broader European Green Deal emphasise expanding and sustainably managing forests as key nature-based solutions for climate mitigation, biodiversity conservation, and rural development (European Commission, 2021; European Commission, 2019). Forest ecosystems currently absorb a substantial share of the EU's greenhouse-gas emissions, highlighting their importance within the Land Use, Land Use Change and Forestry (LULUCF) sector and long-term climate neutrality targets (Grassi et al., 2017; European Environment Agency, 2022). Consequently, several EU Member States are exploring mechanisms that combine public policy incentives with market-based instruments to accelerate forest establishment, particularly on marginal or abandoned agricultural land (Nabuurs et al., 2017; Griscom et al., 2017). In this context, voluntary carbon markets and emerging carbon-removal certification systems are increasingly viewed as complementary tools capable of mobilising private investment in afforestation while supporting national climate objectives (European Commission, 2022; Favero et al., 2020). However, the effectiveness of these mechanisms depends on reliable assessments of site suitability, tree species selection, and long-term carbon sequestration potential at the local scale (Nabuurs et al., 2017). Evaluating the carbon credit generation potential of afforestation projects under specific environmental and management conditions is therefore essential for aligning national afforestation strategies with broader European climate policy goals.

Lithuania's strategic planning documents stipulate that the country's forest cover should reach 35%, which requires the establishment of approximately 85,500 ha of new forests (Mozgeris et al., 2021). Afforestation of agricultural land is one of the primary measures to achieve this goal; however, in practice the process has been slow and fragmented. Traditional subsidies provided under the Common Agricultural Policy (CAP) are often insufficient and do not ensure long-term economic attractiveness, especially on lower-fertility lands (EU Commission, 2021). Due to complex administrative procedures and limited financial incentives, many private landowners are reluctant to invest in afforestation (Mozgeris et al., 2021).

In recent years, carbon credits have become an increasingly important economic instrument capable of supplementing traditional subsidies and enhancing the financial attractiveness of afforestation projects. Carbon credits are generated by quantifying additional, verifiable, and long-term carbon sequestration relative to a baseline scenario (Griscom et al., 2017). The EU Carbon Removal Certification Framework aims to standardise the monitoring and verification of carbon removals, which should reduce transaction costs and increase trust in forest carbon credits (European Commission, 2022). Platforms such as Arbonics already provide the ability to automatically assess plot suitability for afforestation and forecast carbon credit potential and economic value (Arbonics, 2025).

Despite growing interest in carbon credits, there is a lack of research on how carbon credit value depends on forest site type, tree species, and plot characteristics under specific Lithuanian conditions. This information is particularly important for private landowners making afforestation decisions and for forestry specialists planning regional forest expansion.

The **aim** of this study was to assess the carbon credit generation potential of afforestation on agricultural land in Lithuania. Specifically, the study evaluated i) the land characteristics of the 11 potential afforestation areas, ii) quantified and compared the carbon credit generation of these areas over a 50-year period, iii) projected the potential economic value of the generated carbon credits and iv) identified the most favourable conditions for potential carbon sequestration and trading.

Research Object and Methods

Study area

Focussing on Lithuania, the research object consisted of 11 agricultural land plots located in the Utena, Vilnius, and Siauliai regions of Lithuania. The plots are managed by UAB Forest Management. The total area of the studied plots is approximately 132 ha, with an area suitable for afforestation of approximately 72 ha (Figure 1).

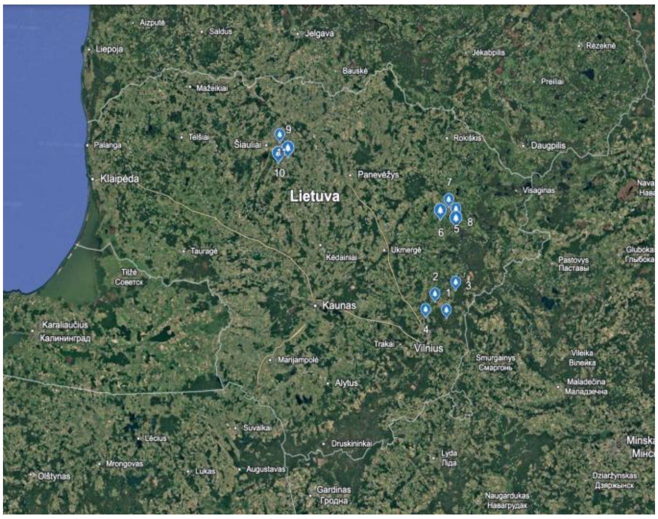

Figure 1. Location of the study areas in Lithuania.

Data analysis

Plot eligibility

The study areas were analysed for the carbon trading restrictions. This included Natura 2000 territories, recently cleared forest, drained territories (amelioration), organic soils, high-quality agricultural land, and forested areas. These constraints were considered because afforestation-based carbon credit projects must comply with environmental regulations, land-use policies, and carbon market eligibility criteria (Verra, 2025). Protected areas such as Natura 2000 restrict land-use change due to conservation requirements. Recently cleared or already forested areas are generally excluded to ensure the additionality of carbon removals. Drained lands with amelioration infrastructure may impose technical limitations on afforestation, while organic soils are regulated due to their high carbon stocks and potential emissions if disturbed. High-quality agricultural land may also be restricted to maintain agricultural productivity. Considering these constraints ensures that afforestation projects for carbon credit generation remain environmentally appropriate and legally compliant.

This was achieved by using a Geographical Information System and two data sets: 1. Natura 2000 territories (biomon.lt), 2. Lithuanian National Forest Database (geoportal.lt).

Estimated carbon trading potential

To assess carbon credit generation potential by habitat type and tree species, parcel-level data from the Arbonics platform were aggregated and analysed. Each of the 8 suitable plots was divided by the Arbonics assessment tool into one or more parcels according to forest site type (habitat type) and recommended tree species. In total, 15 parcels were identified across the 8 plots.

Each parcel was assigned a forest site type following the Lithuanian forest site type classification system (Vaičys, 2006): Ld (temporarily waterlogged fertile sites), Nc (normal moisture fertile sites), or Šd (wet fertile sites). The Arbonics platform automatically determines the forest site type for each parcel based on soil, hydrological, and land-use data, and assigns the recommended tree species and planting parameters accordingly. For Ld sites, silver birch (*Betula pendula*) was recommended at a planting density of 4,000 trees/ha with a rotation age of 61 years. For Nc sites, Norway spruce (*Picea abies*) was recommended at 3,000 trees/ha with a rotation age of 71 years. For Šd sites, silver birch was recommended at 4,000 trees/ha.

For each parcel, the Arbonics platform provided the following data: eligible area (ha), projected carbon credits over the project period, and projected revenue (EUR). To construct Table 2, parcels were grouped by forest site type (Ld, Nc, Šd), and the following values were calculated for each group: total eligible area (sum of all parcel areas within the group, ha), planting density (as assigned by the platform), and average revenue per hectare (EUR/ha), calculated by dividing total projected revenue of each group by its total eligible area. Specifically, 9 parcels were classified as birch parcels (8 in Ld sites, total area 33.01 ha, and 1 in Šd site, 0.41 ha), while 6 parcels were classified as Norway spruce parcels in Nc sites (total area 38.69 ha).

This grouping allowed for a direct comparison of carbon credit generation efficiency between the two main tree species and across different forest site types under Lithuanian conditions.

Economic value and revenue efficiency of the plots

To construct Table 3, plot-level data were extracted from the Arbonics platform assessment reports for each of the 8 suitable plots. The primary parameters obtained directly from the platform were: eligible area (ha), total projected carbon credits over the 50-year project period, and total projected revenue (EUR), calculated at a fixed carbon credit price of EUR 70 per credit.

Three derived indicators were then calculated in Microsoft Excel to enable standardised comparison of economic efficiency across plots of varying sizes. Revenue per hectare (EUR/ha) was obtained by dividing total projected revenue by the eligible area of each respective plot. Carbon credit density (Credits/ha) was obtained by dividing the total number of projected carbon credits by the eligible area. Annualised revenue per hectare (EUR/ha/yr) was obtained by dividing the revenue per hectare value by the 50-year project duration, representing the average expected annual income per hectare for the landowner.

The summary row was calculated by summing eligible area, total credits, and total revenue across all 8 plots. The efficiency indicators in the summary row were recalculated as weighted averages – total revenue divided by total eligible area for EUR/ha, total credits divided by total eligible area for Credits/ha, and EUR/ha divided by 50 for EUR/ha/yr.

Results

Plot characteristics and afforestation suitability

Of the 11 plots studied, 8 were recognised as suitable for afforestation and their carbon credit potential was calculated. Three plots (440018281638 – 0.61 ha, 440020546032 – 1.29 ha, and 545800020196 – 8.94 ha) were rejected as unsuitable due to insufficient eligible area and a large proportion of the areas were deemed unsuitable due to restriction. For example, in plot 545800020196, out of the total area of 8.94 ha, as much as 8.81 ha was unsuitable for afforestation due to drained territories and organic soils. Data on the characteristics of the 8 suitable plots are presented in Table 1.

The data presented in the table show that the largest plot studied is 440024154841 (46.56 ha), located in the Utena region, with an eligible area of 35.26 ha – the largest eligible area among all studied plots (Figure 2). The smallest eligible area (1.41 ha) was found in plot 440018281695. The total area of the 8 suitable plots is approximately 121 ha, while the eligible area is 72.09 ha, representing 59.6% of the total area.

The main restrictions reducing the area eligible for afforestation were forested areas (all 8 plots), organic soil territories (6 plots), amelioration ditches (4 plots), registered forest land (5 plots), and wetlands (4 plots). These restrictions reflect the specificity of Lithuanian agricultural land, where a significant proportion of territories have complex hydrological conditions and fragmented land-use structures (Manton et al., 2025). This confirms that not all agricultural land is suitable for afforestation and carbon credit projects, preliminary plot assessment is necessary, considering legal, natural, and hydrological restrictions (Mozgeris et al., 2021).

Table 1. Characteristics and afforestation suitability of the studied plot

Cadastral ID	Region	Total area, ha	Eligible area, ha
348400030142	Utena	17.00	9.90
440018281695	Utena	5.71	1.41
440020546098	Utena	2.70	2.42
440024154841	Utena	46.56	35.26
440059895055	Utena	8.73	3.44
440060739474	Utena	14.92	4.18
545800020197	Siauliai	13.27	8.34
893200030016	Vilnius	12.21	7.14

Figure 2. An example of the afforestation for carbon opportunity for site 440024154841. Red areas represent zones where planting is not permitted, orange areas indicate zones where planting is allowed but subject to certain restrictions, and green areas are the sites that can be planted.

Carbon credit potential by tree species

When analysing carbon credit generation potential by tree species, parcels were divided into two main groups: silver birch (*Betula pendula*) parcels in Ld and Sd habitats, and Norway spruce parcels in Nc habitats. A total of 15 parcels were identified: 9 silver birch (total area – 33.42 ha) and 6 Norway spruce (total area – 38.69 ha). The data are presented in Table 2.

Table 2. Carbon credit potential by habitat type and tree species

Forest site type	Tree species	Total area, ha	Planting density	Avg. revenue, EUR/ha
Ld	Silver Birch	33.01	4,000 trees/ha	~11,253
Nc	Norway Spruce	38.69	3,000 trees/ha	~11,223
Šd	Silver Birch	0.41	4,000 trees/ha	19,122

The results show that silver birch (Ld) and Norway spruce (Nc) scenarios generate very similar revenue – approximately 11,253 and 11,223 EUR/ha over a 50-year period, respectively, suggesting that tree species selection between these two forest site types should be guided not only by economic returns but also by ecological criteria such as site moisture, soil properties, and stand resilience to climate change (Larsen et al., 2022; EU Commission, 2021). In contrast, the wet fertile (Šd) forest site type parcel demonstrated a significantly higher potential of 19,122 EUR/ha, nearly double that of Ld and Nc sites. This finding suggests that wetter sites were generally less suitable for agriculture, but may offer the greatest efficiency for carbon accumulation through afforestation (Larsen et al., 2022; Favero et al., 2020).

Norway spruce parcels account for a larger total area (38.69 ha); however, this is driven by the dominance of one plot (440024154841), where the Nc Norway spruce parcel occupies 27.15 ha. Silver birch parcels are more evenly distributed across different plots, indicating greater versatility of birch as an afforestation species under Lithuanian conditions.

Economic value and revenue dynamics

The total economic value of carbon credits for the 8 suitable plots over a 50-year period amounts to EUR 814,310, applying a price of EUR 70 per credit. The highest total value was found in plot 440024154841 – EUR 400,050 (35.26 ha eligible area), while the lowest was in plot 440018281695 – EUR 15,680 (1.41 ha). The average revenue per eligible hectare is approximately EUR 11,300 over the entire project period, or approximately EUR 226/ha per year. Data on the economic value of each plot are presented in Table 3.

Table 3. Economic value and revenue efficiency of the plots

Cadastral ID	Eligible area, ha	Credits	Revenue, EUR	EUR/ha	Credits/ha	EUR/ha/yr
348400030142	9.90	1,591	111,370	11,250	161	225
440018281695	1.41	224	15,680	11,121	159	222
440020546098	2.42	388	27,160	11,223	160	224
440024154841	35.26	5,715	400,050	11,346	162	227
440059895055	3.44	553	38,710	11,253	161	225
440060739474	4.18	671	46,970	11,237	161	225
545800020197	8.34	1,342	93,940	11,264	161	225
893200030016	7.14	1,149	80,430	11,264	161	225
Total	**72.09**	**11,633**	**814,310**	**11,295**	**161**	**226**

The data presented in the table show that revenue efficiency per hectare is very similar across all plots – ranging from 11,121 to 11,346 EUR/ha, or 159–162 credits/ha over 50 years. This indicates that the Arbonics platform applies standardised carbon accumulation models in which the main variable is the eligible area rather than individual plot specifics.

Based on the revenue timeline graphs presented in the Arbonics assessment reports, the carbon credit financial flow is not uniform. Revenue is projected to begin growing rapidly from years 6–9, when the stand accumulates sufficient biomass. The most intensive credit generation occurs during the 15–35 year period, with the highest annual revenues reached in the second half of the project (Arbonics, 2025). This dynamic is consistent with forest growth patterns, where the most intensive carbon accumulation occurs during the young stand and middle-aged stand phases (European Commission, 2023; Nabuurs et al., 2021).

Conclusions

1.Of the 11 agricultural land plots studied (total area ~132 ha), 8 were found suitable for afforestation. The eligible area for afforestation is approximately 72 ha (59.6% of the total area). The main restrictions reducing the eligible area are forested areas, organic soil territories, amelioration ditches, and wetlands.

2.Over a 50-year period, the 8 plots would generate approximately 11,633 carbon credits. Silver birch (Ld) and Norway spruce (Nc) scenarios generate similar revenue (~EUR 11,250/ha), while wet fertile (Sd) habitat type plots demonstrate the highest potential at EUR 19,122/ha.

3.The total projected carbon credit value is EUR 814,310 over 50 years (at EUR 70 per credit). Revenue begins to grow rapidly from years 6–9 and accumulates most intensively during the 15–35 year period, consistent with forest growth patterns.

4.The most favourable afforestation conditions were identified in plots with the fewest restrictions, the largest eligible area, and wet fertile (Sd) or normal moisture fertile (Nc) habitat types. Integrating carbon credits into afforestation planning can significantly increase the economic attractiveness of these projects for private landowners.

5.This study shows that afforestation for carbon trading has the potential to be a viable business model.

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