



Assessment of the carbon balance of industrial hemp cultivation in Ukraine and its impact on achieving carbon neutrality

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Abstract. The aim of the study was to determine the climatic potential of industrial hemp as a tool for carbon sequestration and to assess its contribution to achieving carbon neutrality in Ukraine's agricultural sector. The work employed a systematic analysis of contemporary scientific research, an analysis of official statistical data on areas under industrial hemp cultivation, as well as elements of a full life cycle assessment approach to identify emission sources within the cultivation process chain. For the quantitative evaluation of the climatic effect, a computational model of a "digital twin" of a one-hectare hemp field was developed for typical soil and climatic conditions of the Forest-Steppe zone of Ukraine. Based on the modelling of the "digital twin" of the hemp field and the calculated parameters, three carbon sequestration scenarios were established: low, medium and high, reflecting minimum, average and maximum biomass yield levels. It was determined that under the low, medium and high scenarios, the potential absorption amounts to approximately 15.5, 16.5 and 24.75 tonnes of CO₂ per hectare over a single growing season, respectively. At the same time, direct CO₂ emissions from the combustion of diesel fuel used for field operations in the baseline cultivation model were estimated at approximately 0.421 tonnes of CO₂ per hectare, indicating a substantial predominance of sequestration processes over agrotechnological emissions. Under the low scenario, the volume of absorption exceeds direct emissions by approximately 36.8 times; under the medium scenario, by approximately 38 times; and under the high scenario, by 58.8 times. Scenario modelling, developed on the basis of official statistical data on industrial hemp cultivation areas, demonstrated that even with relatively small sown areas, industrial hemp cultivation showed positive dynamics in achieving decarbonisation goals and enhancing the role of agriculture in the national carbon balance. The practical value of the study lies in the possibility of using the obtained results to substantiate carbon farming programmes, integrate industrial hemp into climate policy, and plan the development of processing infrastructure

Keywords: agricultural decarbonisation; sequestration; climate change; biomass; scenario modelling

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INTRODUCTION

Agriculture is increasingly being viewed not only as a source of greenhouse gas emissions, but also as a sector with significant potential for biological carbon sequestration. Industrial hemp, due to its intensive biomass accumulation over a short growing season, is a promising crop for carbon farming systems; however, a quantitative assessment of its net climate impact in the Ukrainian context remains under-researched, although Ukraine is characterised by favourable natural and climatic conditions for growing industrial hemp, particularly in the Polissya and Forest-Steppe zones, where a combination of moderate temperatures, sufficient moisture and fertile soils ensures high crop productivity.

In Ukrainian studies, O.M. Drozd *et al.* (2025) substantiated the feasibility of growing industrial hemp in the Forest-Steppe zone as the region with the most balanced soil and climatic conditions, adaptive crop rotations and suitable agronomic practices. Field experiments by M.V. Roik *et al.* (2024) also confirmed the feasibility of zone-oriented variety selection and optimisation of the mineral nutrition system to achieve stable biomass yields. The dominant direction of research into the environmental efficiency of industrial hemp is the application of a full life-cycle assessment approach and the analysis of the potential 'carbon negativity' of products based on hemp biomass. Such studies focus not only on the biological absorption of carbon dioxide during crop cultivation, but also on the entire value chain – from field to end product. A.T.M.F. Ahmed *et al.* (2022) considered industrial hemp as a promising renewable resource, including its potential use in paper, textiles, composites, biofuels and the food industry.

LCA studies of materials by J.H. Arehart *et al.* (2020) showed that the overall CO₂ balance depends significantly on the business processes accounted for, the method of carbon accounting, and the consideration of carbonisation processes in binding materials. Under certain long-term use scenarios, materials made from industrial hemp can demonstrate a neutral or even negative carbon balance (Nazari & Woods, 2025). The study by M. Michels *et al.* (2025) analysed three aspects that influence the cultivation of industrial hemp: economic, environmental and social. In particular, regarding environmental aspects, it is emphasised that industrial hemp's ability to absorb CO₂ classifies it as a critically important crop for mitigating the effects of climate change. Furthermore, CO₂ sequestration in biomass, as well as the use of industrial hemp in sectors such as construction, further cements this crop's status as "important" for mitigating the effects of climate change, highlighting the need to utilise these plants to create long-term sustainable agricultural systems.

In turn, Z. Shen *et al.* (2022) investigated the potential for carbon sequestration in soil using the example of 100 years of hemp cultivation in France. The study assessed two long-term scenarios for the production of

products such as insulation boards for buildings and automotive panels. The production of such products requires the use of hempcrete as a by-product. The study by Z. Shen *et al.* showed that, although additional long-term carbon sequestration in the soil could not be achieved, both scenarios provided long-term climate benefits even beyond 2100, mainly due to carbon sequestration in hemp-based products, as well as the avoidance of fossil fuel-based products.

In the scientific literature, the environmental aspects of industrial hemp cultivation are primarily considered in the context of sustainable agriculture, resource conservation and the reduction of the negative impact of agricultural production on the environment. Indeed, industrial hemp is classified as a crop with high environmental efficiency due to its intensive biomass growth, low requirement for plant protection products, and ability to produce significant amounts of plant biomass over a short growing season without substantially depleting soil resources (Mishchenko & Laiko, 2024). In addition, industrial hemp is considered a bioremediation crop suitable for cultivation on degraded and contaminated land, as it is one of the few plant species capable of reclaiming polluted and abandoned soils.

A study by the Intergovernmental Panel on Climate Change (2019) considered the use of degraded land for industrial hemp cultivation as an effective approach to avoiding competition with food agriculture and minimising the risks of indirect land-use change, which is an important factor in assessing the carbon balance of the agricultural sector. According to the recommendations of the Food and Agriculture Organization of the United Nations (2021), the use of marginal land for growing industrial crops with high biomass accumulation potential allows for a positive climate effect to be achieved even with moderate yields. In turn, there are studies analysing CO₂ emissions from industrial hemp. Thus, the largest contribution of industrial hemp to CO₂ emissions is associated with harvesting, the use of mineral fertilisers and diesel fuel, as well as with energy-intensive post-harvest processing (drying, grinding, pressing) and logistics (Akbarian-Saravi *et al.*, 2025).

Despite the growing number of scientific studies, the issue of quantitatively assessing the net climate effect of industrial hemp cultivation in Ukraine, taking into account both biological carbon sequestration and agronomic emissions, remains under-researched. This study aimed to establish the role of industrial hemp in shaping the carbon balance of agricultural systems and to provide a quantitative justification of its ability to facilitate carbon sequestration in the context of the climate transformation of Ukrainian agriculture.

MATERIALS AND METHODS

The study employed a comprehensive methodological approach combining the synthesis of contemporary

scientific research, the processing of official statistics on the scale of industrial hemp cultivation, and the use of elements of life cycle assessment methodology to identify the principal sources of emissions within the production process. Quantitative evaluation of the climatic effect was carried out on the basis of a developed “digital twin” model of a hemp agroecosystem covering 1 hectare, parameterised in accordance with the typical soil and climatic conditions of the Forest-Steppe zone of Ukraine, which accounts for CO₂ absorption during plant growth, carbon accumulation in biomass and soil, and related processes. The methodological foundation of the study also included a systematic analysis of scientific publications by Ukrainian and international authors, regulatory documents of the European Union

(EU) in the field of climate policy, and research findings devoted to the environmental characteristics of industrial hemp cultivation and the directions of utilisation of its biomass. The “digital twin” of the hemp field is a conceptual computational model of 1 hectare of industrial hemp crops. The modelling utilised data obtained from the analysis of scientific publications by Ukrainian and international researchers, the author’s own calculations, and assumption-based forecasting methods, as presented in Table 1.

The “digital twin” model of a hemp field has been applied to the national statistics on industrial hemp cultivation in Ukraine, shown in Figure 1, in order to determine potential volumes and model possible absorption scenarios in Ukraine.

Table 1. Key parameters of the “digital twin” model

| | |
|---|---------------------------------------|
| Area of modelling | 1 ha |
| Crop used | <i>Cannabis sativa</i> L. |
| Duration of the growing season | 120-150 days |
| Average yield of dry biomass per hectare | 8-15 tonnes |
| Carbon content in dry biomass | 45-50% |
| Average CO ₂ absorption per hectare per season | 13-25 tonnes |
| Energy inputs | Diesel fuel for mechanised operations |

Source: created by the author

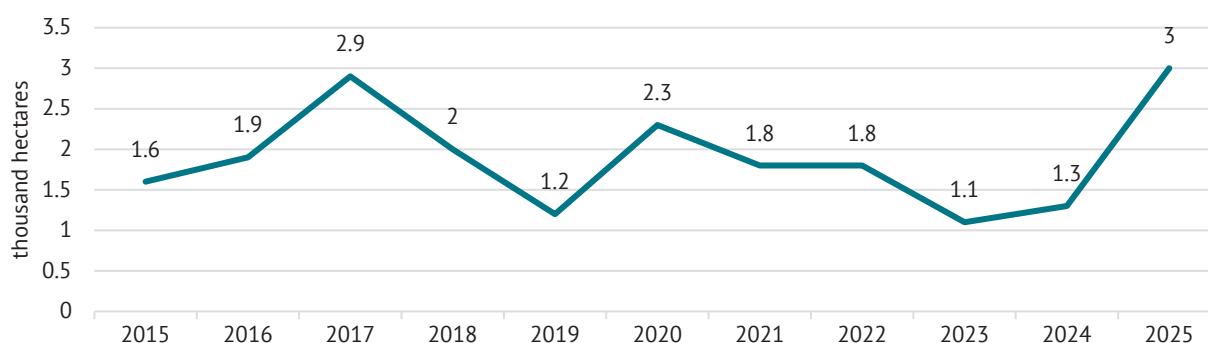


Figure 1. Trends in the area under industrial hemp cultivation, 2015-2025, in thousands of hectares

Source: compiled by the author based on data from the State Statistics Service of Ukraine (n.d.)

The empirical basis for the scenario modelling consisted of official statistical data on the areas sown with industrial hemp in Ukraine. In particular, data from the State Statistics Service of Ukraine (n.d.) were used to calculate the potential volumes of carbon sequestration by industrial hemp at the national level for the period 2020-2025, on the basis of which the dynamics of changes in industrial hemp cultivation areas from 2015 to 2025 were constructed. To estimate the volume of emissions absorption, the results of the study by S.M. Madden *et al.* (2022) on CO₂ absorption by industrial hemp under temperate climate conditions were utilised. According to this study, the level of CO₂ absorption in temperate climates is determined by the duration of the growing season, agronomic practices,

and the volume of biomass per hectare, which were taken into account in the parameterisation of the digital twin model. For an accurate assessment of CO₂ absorption, data on dry biomass yield (stems/straw) and the carbon content in the plant mass of *Cannabis sativa* L. were used. In Ukraine, according to the research of H. Laiko (2023), the dry biomass of stems at a minimum level amounts to 8.55-9.81 tonnes per hectare; at a medium level (under average agronomic conditions) – 8-12 tonnes per hectare; and at a high level (in trials with high nutrient supply and optimal conditions) – up to 15 tonnes per hectare. CO₂ absorption is determined on the basis of the stoichiometric relationship between the carbon content in dry biomass and the molar masses of carbon (12) and CO₂ (44). It is assumed that all

carbon accumulated in plant biomass originates from atmospheric CO₂. The calculation of absorption was carried out taking into account the carbon fraction in dry biomass using the following formula:

$$\begin{aligned} \text{absorption indicator (tonnes CO}_2\text{/ha)} &= \\ &= Y(\text{dry}) \times 0.45 \times \frac{44}{12}, \end{aligned} \quad (1)$$

where $Y(\text{dry})$ – the yield of dry stem biomass; the coefficient 0.45 represents the carbon content in the dry

biomass of industrial hemp stems (45%); and the multiplier $\frac{44}{12}$ – the stoichiometric conversion factor from carbon mass to CO₂ equivalent.

For the analysis of energy inputs in the baseline cultivation model, in particular diesel fuel consumption, it was established on the basis of the author's own calculations and developed technological maps that over the growing season 1 hectare of industrial hemp crops requires approximately 159.9 litres of diesel fuel (Table 2).

Table 2. Diesel fuel consumption in the baseline model of industrial hemp cultivation technology, litres per hectare

| Type of work | Quantity, l/ha |
|------------------------------------|----------------|
| Fuel consumption for direct work | 117.9 |
| Fuel consumption for indirect work | 42.0 |
| Total | 159.9 |

Note: direct work – ploughing, sowing, harvesting and other types of land cultivation; indirect work – transporting seeds, workers and other items

Source: created by the author

Using the method of carbon mass balance under complete combustion, it should be noted that diesel fuel has a density of approximately 0.838 kg per litre and a composition of carbon and hydrogen such that, upon complete oxidation, all carbon is converted into CO₂. The database of the Intergovernmental Panel on Climate Change (2019), which contains emission factors for all types of fuel, including diesel, is based on the assumption that all carbon in the fuel is oxidised to CO₂, and the emission factor for diesel fuel is determined by its calorific value and carbon content, amounting to 2.63 kg CO₂ per litre. The CO₂ formation factor is determined on the basis of combustion stoichiometry:

$$0.838 \text{ kg/L} \times \frac{44}{14} \approx 2.63 \text{ kg CO}_2\text{/L}, \quad (2)$$

where 44 and 14 – the molar masses of CO₂ and the carbon equivalent of diesel fuel, respectively.

This approach is widely used in scientific research and national reporting, as the amount of CO₂ produced is directly proportional to the amount of fuel burned and its physicochemical characteristics.

RESULTS AND DISCUSSION

Achieving climate neutrality is one of the key challenges facing contemporary global environmental policy. The European Green Deal sets the target of reducing greenhouse gas emissions by at least 55% by 2030 and establishing a climate-neutral economy by 2050, as enshrined in the relevant EU strategic and regulatory acts (Regulation (EU) 2021/1119, 2021; European Commission, n.d.b). In this context, agriculture is increasingly viewed not only as a source of emissions, but as a sector with significant potential for biological carbon sequestration and the implementation

of nature-based climate solutions. One of the promising crops in this regard is industrial hemp (*Cannabis sativa* L.), the cultivation of which is showing a steady upward trend globally due to the liberalisation of legislation and growing demand for environmentally friendly raw materials. As of 2025, over 70 countries permit the cultivation of industrial hemp, with China, France, Canada and the USA being the largest producers. Furthermore, Australia, New Zealand, Germany, the Netherlands and other countries have active industrial hemp markets that continue to grow (Fig. 2). The cultivation of industrial hemp is gaining momentum in the EU as well, as evidenced by data from the European Commission (n.d.a.), which showed that the area under industrial hemp has increased significantly. The overall trend in the development of this segment of agricultural production between 2004 and 2023 is shown in Figure 3. Thus, cultivation areas are gradually increasing across the EU, with France being the largest producer of industrial hemp in the EU, accounting for around 60% of total production, followed by Germany (17%) and the Netherlands (5%), whilst the remaining market share is accounted for by other Member States (European Commission, n.d.a). A study by J.G. Cortés *et al.* (2024) noted that the rise in demand for industrial hemp in the EU has contributed to a significant increase in the area under cultivation of this plant, rising by 46.5% between 2016 and 2022. This demand is driven not only by the wide range of economic applications for industrial hemp, but also by its environmental benefits, particularly the goal of achieving climate neutrality by 2050. The authors also highlight the industrial use of hemp fibre in the context of the future potential of hemp by-products as alternative agricultural commodities in EU countries. According to estimates by the European

characteristics of the crop indicate its significant potential as a tool for carbon sequestration in agricultural systems. Furthermore, a study by E. Campiglia *et al.* (2020) notes that the cultivation of industrial hemp is characterised by a relatively low need for capital

investment and can be carried out using simplified technologies. Based on data on sown areas (Fig. 1), the potential carbon sequestration volumes of industrial hemp in Ukraine for the period 2020-2025 were calculated under three scenarios (Table 3).

Table 3. Potential carbon sequestration volumes by industrial hemp in Ukraine for the period 2020-2025 under three scenarios

| | Biomass accumulation rate | Annual sequestration volume per 1 ha | Sequestration volume for the period 2020-2025 |
|-----------------|---------------------------|--|---|
| Low scenario | 8.55-9.81 tonnes/ha | 15.5 tonnes of CO ₂ per hectare per year | 1.05 million tonnes CO ₂ |
| Medium scenario | 8-12 tonnes/ha | 16.5 tonnes of CO ₂ per hectare per year | 1.12 million tonnes CO ₂ |
| High scenario | 15 tonnes/ha | 24.75 tonnes of CO ₂ per hectare per year | 1.68 million tonnes CO ₂ |

Source: compiled by the author

For a total cultivated area of 11.3 thousand hectares, it was determined that under the low scenario for the period from 2020 to 2025, industrial hemp, under conditions of minimal biomass accumulation, absorbed approximately 15.5 tonnes of CO₂ per hectare per year. This corresponds to a cumulative sequestration volume of about 1.05 million tonnes of CO₂ over six years. The medium scenario indicates that under average agro-climatic conditions and typical yield levels, the average absorption amounts to 16.5 tonnes of CO₂ per hectare per year. Over the period 2020-2025 and with an area of 11.3 thousand hectares, the total sequestration is estimated at approximately 1.12 million tonnes of CO₂, which significantly exceeds direct emissions associated with diesel fuel use in the baseline cultivation model. The high scenario assumes that, taking into account optimal biomass growth, an extended growing season, and intensive agricultural technologies, the sequestration level may reach 24.75 tonnes of CO₂ per hectare per year. Under these conditions, the total CO₂ absorption by industrial hemp across 11.3 thousand hectares amounts to approximately 1.68 million tonnes of CO₂.

It should be noted separately that the obtained volumes of CO₂ absorption by industrial hemp did not initially account for greenhouse gas emissions associated with cultivation operations. Thus, for an accurate assessment of the net carbon balance of the agroecosystem, it is appropriate to compare the CO₂ absorption potential of plant biomass with emissions arising from, in particular, the use of fuel and lubricants for field operations, application of plant protection products, harvesting, and related activities. The assessment of energy inputs in the baseline cultivation model indicates that approximately 159.9 litres of diesel fuel are required per hectare of industrial hemp crops. Using the emission factor of 2.63 kg CO₂ per litre, confirmed by combustion stoichiometry, the emissions amount to:

$$159.9 \text{ L} \times 2.63 \text{ kg CO}_2/\text{L} = 420.54 \text{ kg CO}_2. \quad (3)$$

Following the calculation of potential carbon sequestration volumes by industrial hemp in Ukraine for the period 2020-2025 under three scenarios (Table 3), it was established that under the low scenario the estimated absorption amounts to 15.5 tonnes of CO₂ per hectare per year. Considering that the baseline cultivation model for 1 hectare requires 159.9 litres of diesel fuel, direct emissions from complete combustion, using the adopted factor of 2.63 kg CO₂ per litre, are equal to 0.421 tonnes of CO₂ per hectare (3). The comparison shows that absorption under the low scenario exceeds direct CO₂ emissions from diesel use by approximately 36.8 times, with a difference of about 15.1 tonnes of CO₂ per hectare. Under the calculated medium scenario, the estimated absorption for industrial hemp is 16.5 tonnes of CO₂ per hectare per year, exceeding direct CO₂ emissions from diesel by approximately 38 times, with a difference of about 16.1 tonnes of CO₂ per hectare. Under the high scenario, absorption exceeds direct CO₂ emissions from diesel use by approximately 58.8 times, with a difference of about 24.3 tonnes of CO₂ per hectare. Taking the above into account, it can be concluded that direct CO₂ emissions from diesel use per hectare are relatively small compared to the magnitude of the potential carbon sequestration by industrial hemp biomass.

The findings of S.M. Madden *et al.* (2022) have demonstrated the potential environmental benefits of growing industrial hemp. This is also evident in the present study, as a synthesis of the findings suggests that industrial hemp possesses high climate potential as a crop with intensive biomass accumulation and significant CO₂ sequestration capacity. Even under a low-carbon absorption scenario, the carbon absorbed by industrial hemp significantly exceeds the direct emissions associated with the use of diesel fuel during cultivation, indicating a positive net carbon balance at the

agroecosystem level. At the same time, the estimates obtained reflect only the initial stage of the climate effect and do not take into account the impact of the use of plant protection products, nor the subsequent accumulation or release of CO₂ during the processing, use and disposal of hemp products. This is confirmed by the study by A. Pawar *et al.* (2026), particularly regarding the need to account for the carbon content accumulated in above-ground and below-ground biomass.

As noted in the study by C. Schluttenhofer & L. Yuan (2017), the cultivation of industrial hemp requires further research, as the global production market has growth potential. This statement is consistent with the authors' research; to assess the effectiveness of industrial hemp's actual contribution to achieving carbon neutrality in the agricultural sector, an in-depth analysis of the product's full life cycle is advisable – from cultivation and primary processing of biomass to its end uses. A similar view regarding the need to investigate all aspects related to factors that potentially influence carbon sequestration by industrial hemp, such as soil type, climate and agricultural practices, in order to define industrial hemp as an environmentally friendly crop, is shared by the authors A. Suardi *et al.* (2024).

In contrast to the authors' study, there is debate in the scientific literature regarding the environmental viability of growing even organic hemp, as its impact on the environment is not unequivocally positive and depends on production technology and the subsequent use of biomass. As demonstrated by Z. Shen *et al.* (2022), the climate impact of hemp cultivation involves trade-offs: leaving plant residues in the soil contributes to an increase in organic carbon stocks, but does not provide effective climate change mitigation, whereas the use of biomass for the production of durable biomaterials yields a more pronounced long-term climate effect.

In particular, a study by M. Meffo Kemda *et al.* (2024) showed that, alongside the positive effects (the ability to absorb and store carbon), it is necessary to take into account the emissions arising at various stages of production, as some hemp processing products are climate-neutral: for example, the production of oil and flour is accompanied by significant emissions that are not fully offset by carbon sequestration; furthermore, the environmental impacts of processing and packaging play an important role, as they also contribute to the overall carbon footprint of production. This is also confirmed by a study by I. Bošković & A. Radivojević (2023), which demonstrates a pessimistic scenario regarding the impact of industrial hemp on the carbon balance throughout its life cycle, due to the possibility that greenhouse gas emissions may exceed absorption over the product's full life cycle.

Summarising the results obtained in the context of existing scientific research, it can be stated that industrial hemp demonstrates high climate potential as a crop with intensive biomass accumulation and

significant CO₂ sequestration capacity. At the same time, as the literature review indicates, the assessment of the actual climate effect is ambiguous and depends significantly on cultivation technology, the uses of biomass, and the accounting of emissions at all stages of the production chain. Thus, the results of this study are consistent with the broader scientific debate regarding the potential of industrial hemp as a tool for decarbonisation, whilst emphasising the need for a comprehensive approach to assessing its carbon balance.

CONCLUSIONS

The study confirmed the high climatic potential of industrial hemp (*Cannabis sativa* L.) as a tool for atmospheric carbon sequestration in Ukraine's agricultural sector. During its short growing season, the crop is capable of accumulating significant amounts of carbon, making it a promising tool for carbon farming and climate-oriented agricultural practices. A "digital twin" model of a 1-hectare hemp field, developed for the typical soil and climatic conditions of the Ukrainian Forest-Steppe, enabled a quantitative assessment of the ratio between biological CO₂ absorption during biomass formation and direct emissions associated with the use of diesel fuel in agricultural operations. It was found that the potential CO₂ absorption from 1 ha over a single growing season ranges from 15.5 tonnes under a low dry biomass yield scenario to 24.75 tonnes under a high scenario. At the same time, direct CO₂ emissions associated with the combustion of diesel fuel in the baseline cultivation model are estimated at around 0.421 tonnes CO₂/ha, demonstrating the significant dominance of sequestration processes over agricultural emissions. Under the medium scenario, absorption exceeds direct emissions by approximately 38 times, confirming the formation of a positive net carbon balance within the agroecosystem.

Scenario modelling, based on official statistics regarding the areas under industrial hemp cultivation in Ukraine in 2020-2025, showed that under the medium scenario, the total sequestration potential could exceed 1.1 million tonnes of CO₂ over the specified period. Even with relatively small cultivation areas, this highlights the crop's significant contribution to achieving decarbonisation goals and strengthening the role of agriculture as a compensatory sector in the national carbon balance. The results obtained confirmed the feasibility of integrating industrial hemp into carbon farming programmes, climate policies and sustainable land use strategies. The high rate of biomass accumulation over a short growing season allows industrial hemp to be considered an effective tool for rapidly offsetting a portion of anthropogenic CO₂ emissions. However, the assessment conducted covered mainly the cultivation and harvesting stages and did not account for the likely use of fertilisers, post-harvest processing, biomass processing, long-term storage, or the re-release of carbon in

end products. Thus, industrial hemp should be viewed not merely as an agricultural crop, but as an element of an integrated climate strategy, the effectiveness of which is determined by a combination of agricultural technologies, the spatial distribution of crops and the development of processing infrastructure, as well as its potential to contribute to sustainable agricultural development in Ukraine.

Prospects for further research involve extending the “digital twin” model to cover the full product life cycle, accounting for changes in soil organic carbon stocks, regional variations in growing conditions, and scenarios for the use of hemp biomass with varying durations of biogenic carbon sequestration. The further development of such models may provide a foundation

for establishing a system of quantitative accounting of the climatic effects of industrial hemp within national decarbonisation policy and carbon farming frameworks.

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CONFLICT OF INTEREST

No conflict of interest exists in relation to this study, including financial, personal, authorship or any other conflict that could influence the conduct of the study and the results presented in this article.

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Оцінка вуглецевого балансу вирощування промислових конопель в Україні та їх вплив на досягнення вуглецевої нейтральності

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Анотація. Метою дослідження було визначення кліматичного потенціалу промислових конопель як інструменту секвестрації вуглецю та оцінка їх внеску у досягнення вуглецевої нейтральності аграрного сектору України. У роботі застосовано системний аналіз сучасних наукових досліджень, аналіз офіційних статистичних даних щодо площ вирощування промислових конопель, а також елементи підходу оцінювання повного життєвого циклу для ідентифікації джерел викидів у технологічному ланцюгу вирощування. Для кількісної оцінки кліматичного ефекту розроблено розрахункову модель «цифрового двійника» конопляного поля площею один гектар для типових ґрунтово-кліматичних умов Лісостепу України. На основі моделювання «цифрового двійника» конопляного поля та розрахункових параметрів сформовано три сценарії секвестрації вуглецю: низький, середній та високий, що відображають мінімальні, середні та максимальні показники урожайності біомаси. Встановлено, що за низького, середнього та високого сценаріїв потенційні обсяги поглинання становлять відповідно близько 15,5, 16,5 та 24,75 тонн CO₂ з 1 га за один вегетаційний період. Водночас прямі викиди CO₂ від спалювання дизельного пального для обробітку поля у базовій моделі вирощування оцінено на рівні близько 0,421 тонн CO₂/га, що свідчить про суттєве переважання процесів секвестрації над агротехнологічними викидами. За низького сценарію обсяг поглинання перевищує прямі викиди приблизно у 36,8 рази, за середнього – приблизно у 38 разів, а за високим – у 58,8 раз. Сценарне моделювання, яке розроблено на основі офіційних статистичних даних щодо площ вирощування промислових конопель, засвідчило, що навіть за невеликих посівних площ вирощування промислових конопель показало позитивну динаміку у досягненні цілі декарбонізації та підвищення ролі сільського господарства у національному вуглецевому балансі. Практична цінність дослідження полягає у можливості використання отриманих результатів для обґрунтування програм вуглецевого фермерства, інтеграції промислових конопель у кліматичну політику та планування розвитку переробної інфраструктури

Ключові слова: декарбонізація сільського господарства; секвестрація; зміна клімату; біомаса; сценарне моделювання