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# REDUCING THE CARBON FOOTPRINT IN SUSTAINABLE TOURISM AS A STRATEGIC OBJECTIVE OF THE ECOLOGICAL ECONOMY

# ЗМЕНШЕННЯ ВУГЛЕЦЕВОГО СЛІДУ У СТАЛОМУ ТУРИЗМІ ЯК СТРАТЕГІЧНЕ ЗАВДАННЯ ЕКОЛОГІЧНОЇ ЕКОНОМІКИ

*The article examines the economic and environmental aspects of reducing the carbon footprint of the tourism sector in the context of the transition to a green economy. Particular attention is paid to the transport component as the main source of greenhouse gas emissions. The factors contributing to the growth of the environmental burden, in particular, mass air travel, are analysed. A systematic list of mechanisms for decarbonising tourism is proposed, grouped by areas: strategic, infrastructural, behavioural, regulatory and digital. It is proved that the decarbonisation of tourism is an integral part of climate policy, which can ensure not only emission reductions but also the economic sustainability of the industry in the long term. A model for implementing these mechanisms in the practice of tourism policy in Ukraine has been developed. A SWOT-matrix is formed to assess the potential opportunities and threats of responsible tourism.*

***Keywords:*** *sustainable tourism, carbon footprint, ecological economy, transport, decarbonisation, climate adaptation.*

*Туризм є одним із найдинамічніших секторів економіки, який водночас спричиняє суттєве екологічне навантаження. Зростання обсягів туристичних перевезень, особливо авіаційних, значно посилює викиди парникових газів. Це створює нові виклики для реалізації принципів сталого розвитку. У зв'язку з цим зменшення вуглецевого сліду в туризмі розглядається як ключове завдання екологічної економіки та інструмент кліматичної адаптації. Метою статті є обґрунтування економічної доцільності впровадження механізмів зменшення вуглецевого сліду в туристичному секторі як ключового напряму екологічної економіки, а також аналіз можливостей адаптації туристичної індустрії до кліматичних змін шляхом розвитку сталого транспорту, екологічної логістики та низьковуглецевих технологій. У статті досліджено економічні та екологічні аспекти зменшення вуглецевого сліду туристичного сектору в контексті переходу до екологічної економіки. Особлива увага приділяється транспортній складовій як основному джерелу парникових викидів. Проаналізовано чинники, що сприяють зростанню екологічного навантаження, зокрема масові авіаперельоти. Запропоновано систематизований перелік механізмів декарбонізації туризму, згрупованих за напрямами: стратегічними, інфраструктурними, поведінковими, регуляторними та цифровими. Доведено, що декарбонізація туризму є невід'ємною частиною кліматичної політики, здатною забезпечити не лише зменшення викидів, а й економічну стійкість галузі у довгостроковій перспективі. Розроблено модель впровадження зазначених механізмів у практику туристичної політики України. Сформовано SWOT-матрицю для оцінки потенційних можливостей та загроз відповідального туризму. Декарбонізація туризму має розглядатися як невід'ємна частина адаптаційної та кліматичної політики, здатна не лише знизити екологічні ризики, а й забезпечити економічну стійкість галузі у довгостроковій перспективі.*

***Ключові слова:*** *сталий туризм, вуглецевий слід, екологічна економіка, транспорт, декарбонізація, кліматична адаптація.*

**Formulation of the problem.** In the twenty-first century, tourism has transformed into one of the most dynamic sectors of the world economy, providing a significant share of employment, foreign exchange earnings and development of territories. However, alongside the economic benefits, there is a growing environmental burden caused by active tourism activities. One of the most acute challenges in this area is the high level of greenhouse gas emissions associated with transport, which accounts for about 75% of the total carbon footprint of tourism. In particular, air travel and car travel have the highest emissions intensity per unit distance.

In the context of worsening climate change and increasing global regulatory pressure, there is a need to rethink traditional models of tourism development in favour of sustainable practices that integrate economic efficiency and environmental responsibility. Reducing the carbon footprint is seen as a key strategic objective of the green economy, which involves rationalising resource consumption, introducing low-carbon technologies in transport, developing local tourism and changing consumer behaviour.

The research focuses on the economic justification of approaches to decarbonising the tourism industry, assessing the potential for investment in green transport, and developing recommendations for reducing the environmental burden of the tourism sector. This approach allows for synergies between climate policy and tourism development, while maintaining the economic sustainability of the industry.

**Analysis of recent research and publications.** Given the growing role of tourism in the global economy and the simultaneous complication of the problems that accompany its intensive development, there is an urgent need to rethink approaches and find new strategic guidelines. The key scientific provisions on the integration of the concept of sustainable development into tourism activities were laid down in the works of such authors as V. Brych and N. Galysh. Scientists interpreted sustainable tourism as a resource management system that allows meeting the economic, social and aesthetic needs of current generations without violating ecological balance, cultural identity, biodiversity and vital natural processes [1]. Zavarika G.M. et al. systematised theoretical aspects and proposed a theoretical model for the implementation of responsible tourism as a single concept for the development of the industry in the future, based on the law of self-preservation and implemented on the principles of sustainability [2].

To ensure the sustainable development of ecotourism, Zamula I. V. and Kirilyuk D. R. proposed approaches to its organisation that will contribute to the preservation of natural areas and reduce the negative impact on the environment (in particular, the development and implementation of environmental policy by tourism entities, preservation of natural, social and cultural diversity, raising the level of environmental education of visitors, promoting minimisation of pollution, eliminating excessive resource consumption), as well as regional economic and social development of the country [3]. Gaponenko G. I. et al. proposed the formation of a model of sustainable tourism development, which focuses on the sustainability of the environmental, economic, cultural and social spheres, taking into account the ranking of sustainable development factors depending on the level of sustainability [4].

Modern scientific research pays considerable attention to the analysis of the concepts of sustainable tourism development, in particular, ecological tourism is highlighted as one of the priority areas for achieving a balance between the economic feasibility of tourism activities and the need to preserve the natural environment. Emphasis is placed on the importance of integrating environmental principles into tourism planning, and sustainable tourism is viewed not only as an economic category, but also as a component of climate change adaptation and biodiversity protection policies [5; 6].

Despite the growing number of publications, the economic dimension of reducing the carbon footprint of tourism, in particular in terms of assessing the effectiveness of green investments, environmental taxation mechanisms, climate pricing and emissions

compensation, remains underdeveloped. This indicates the need for further interdisciplinary research at the intersection of tourism studies, environmental economics and public administration.

**Formulation of the purpose of the article.** The purpose of the article is to substantiate the economic feasibility of introducing mechanisms for reducing the carbon footprint in the tourism sector as a key area of ecological economics, as well as to analyse the possibilities of adapting the tourism industry to climate change through the development of sustainable transport, environmental logistics and low-carbon technologies.

**Presentation of the main material.** Transportation is the primary source of $CO_2$ emissions in tourism, making it one of the main challenges on the path to achieving sustainability. Airplanes and cars, in particular, generate the most greenhouse gases per unit of distance, which increases the carbon footprint of travelers. In the context of sustainable tourism, this aspect requires significant attention, as transportation, including air travel and car journeys, creates the greatest environmental strain (Fig. 1). The sharp increase in international travel due to more affordable airfares has only exacerbated the problem: from 2005 to 2016, transportation-related emissions in tourism grew by more than 60% and continue to rise.

Therefore, it is important to consider these facts when developing sustainable tourism strategies. Reducing the use of air travel, optimizing logistics, and implementing environmentally friendly vehicles can significantly lower the carbon footprint of tourism and help adapt to climate change. Investments in green technologies for transportation, such as electric buses or trains, could be key to achieving a more sustainable and eco-friendly tourism industry.

Thus, climate-friendly tourism is becoming essential to sustainable development and environmental responsibility within the industry. Climate-friendly tourism involves the development of tourist practices that minimise the negative impact on the environment, contribute to the preservation of natural resources and reduce greenhouse gas emissions [7].

This concept covers various aspects, from choosing sustainable means of transport to supporting eco-friendly hotels and running tours that include education about the importance of environmental protection. Given the intensity of climate change and the increasing demands for nature conservation, the tourism industry must actively adapt to the new realities, and climate-friendly tourism will become one of the key elements of this transformation.

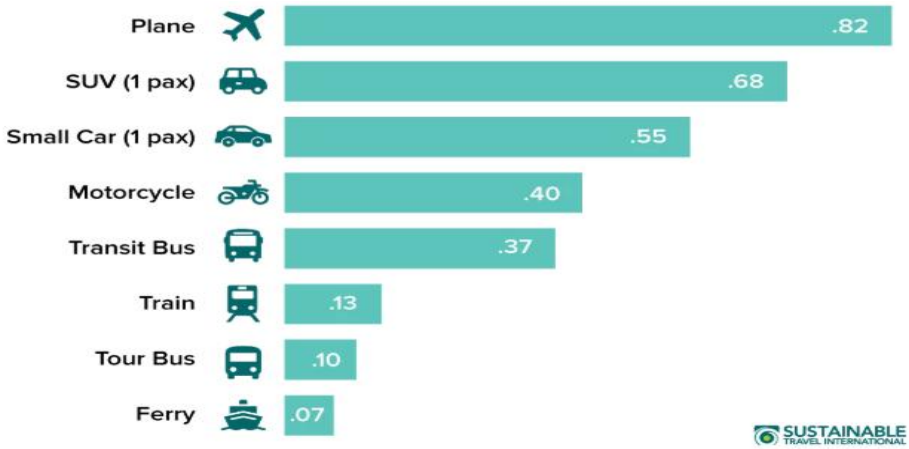


*Figure 1. Emissions by mode of transport, pounds of CO2e emitted per passenger per mile (2020)*

*Source: [11]*

An equally important principle of ecotourism is raising tourists' awareness about environmental issues, sustainable development and nature conservation. It will contribute to the economic development of local communities, create new jobs, and support local businesses, particularly in the hospitality, transport, and eco-products sectors. Tourists should behave responsibly, avoiding actions that may be offensive or destructive to local customs and traditions [8].

To effectively raise the environmental awareness of tourists, it is essential to systematically assess the opportunities and challenges that arise along the way. To achieve this, it is advisable to use a SWOT analysis, which will identify strengths and weaknesses, as well as potential opportunities and threats related to responsible tourism development. (Fig. 2). Such an assessment will help to formulate strategies for implementing effective educational initiatives and supporting environmentally friendly practices among tourists.

Strengths include reducing the negative impact on nature and economic development of local communities. At the same time, weaknesses are related to low tourist awareness and the need for high costs for educational programmes. Opportunities include the growing demand for sustainable tourism and the development of new eco-destinations, while threats include the disregard for environmental principles and the negative impact of mass tourism. Identifying these factors allows us to formulate strategies for effectively implementing environmental education and responsible tourism initiatives.

The SWOT analysis allows us to identify both the potential and limitations for implementing decarbonisation strategies in the tourism sector. On the one hand, the strengths include Ukraine's high natural resource potential, growing demand for ecotourism, support from international organisations, and the availability of green technologies. At the same time, weaknesses include fragmented sustainable transport infrastructure, limited consumer environmental awareness, and insufficient environmental legislation in the tourism sector.

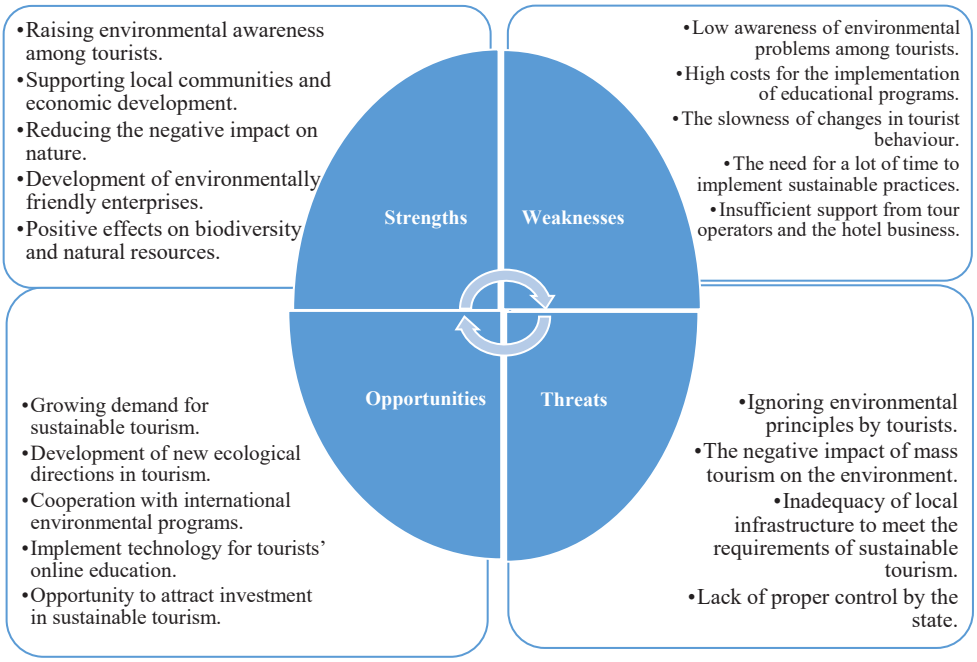


*Figure 2. SWOT analysis of responsible tourism*

*Source: created by the author*

Opportunities include attracting funding through climate funds, developing domestic tourism, introducing digital tools, and increasing the popularity of socially responsible travel. However, threats are posed by global challenges: climate change risks, transport price instability, competition from countries with strong ecotourism infrastructure, and increased emissions due to the massification of travel [9,10].

In view of this, the next logical step is to reorient from diagnostic analysis to the development of specific mechanisms of influence, which should be not only technologically possible, but also economically feasible and socially acceptable. Based on the principles of ecological economics and the Sustainable Development Goals (SDGs), a systematic list of key mechanisms for reducing the carbon footprint of tourism has been compiled, grouped by functional areas of action: transport transformation, energy efficient infrastructure, behavioural changes, regulatory instruments, and digitalisation.

This approach provides an integral vision of the system, where each area operates within a single logic – reducing the impact of tourism activity on the climate and ecosystems, while maintaining the economic viability of the industry.

A systematic list of key mechanisms for reducing the carbon footprint in the tourism sector, grouped by areas of action in accordance with the principles of green economy and sustainable development:

1. Transport transformation. Implementation of low-carbon modes of transport: development of electric transport (electric buses, trains), bicycle infrastructure, use of biofuels. Reducing air dependence: encouraging short- and medium-distance rail travel instead of domestic air travel. Optimisation of tourist routes: reduction of unnecessary transport, logistics planning with minimal $CO_2$ emissions.

2. Energy efficiency and infrastructure. Energy-efficient hotels and tourist facilities: use of renewable energy sources (solar panels, heat pumps), implementation of Green Key, EU Ecolabel certificates, etc. Reduced resource consumption: reasonable water consumption, energy-saving lighting and appliances, and reuse of materials. Climate-adaptive construction: ecological zoning, use of local materials, natural ventilation.

3. Behavioural and educational mechanisms. Informing tourists about their carbon footprint and ways to reduce it (navigation, mobile applications, eco-labelling). Encouraging environmentally responsible choices: offering ‘green routes’, discounts for train travel or accommodation in certified hotels. Supporting local tourism: reducing dependence on long-distance transport and developing regional tourism products.

4. Economic and regulatory instruments. Carbon pricing: introduction of tourist environmental fees or taxes on $CO_2$ emissions. Subsidies and tax breaks for businesses investing in decarbonisation (electric transport, renewable energy). Emissions offsetting mechanisms: carbon offsetting programmes that allow tourists to compensate for their footprint by investing in eco-projects (reforestation, energy efficiency). Institutional support for sustainable tourism: implementation of sustainable management standards (GSTC, ISO 14001), development of public-private partnerships.

5. Digitalisation and innovation. Digital services to assess the environmental impact of travel. Big data to optimise tourist flows and reduce the burden on transport. Smart tourism as a concept of safe, efficient and environmentally friendly tourism based on the latest technologies.

We propose a model of mechanisms for reducing the carbon footprint in the tourism sector of Ukraine, adapted to the realities of the green economy and climate challenges (Fig. 3).

1. Key strategic objectives: Development of the National Low Carbon Tourism Strategy until 2035. Integration of the goals of the European Green Deal and the UN Sustainable Development Goals (SDG 12, 13) into tourism. Establishing indicators of carbon efficiency of tourism at the regional level.

2. The main tasks of the infrastructure level: Development of a green transport and hotel network. Investments in railway and electric transport infrastructure on tourist routes.

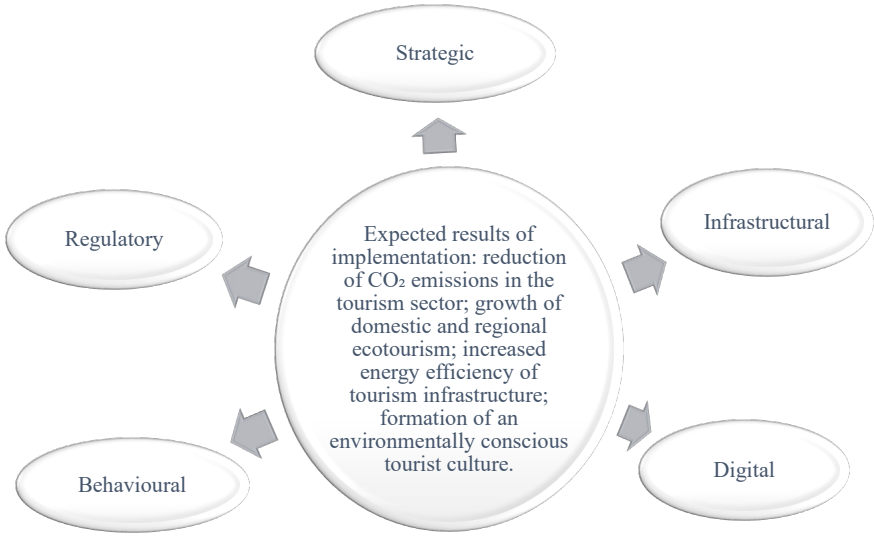


*Figure 3. Model for implementing carbon footprint reduction mechanisms in the tourism sector*

*Source: compiled by the author*

Subsidising eco-hotels that implement renewable energy, energy efficiency and certification (Green Key, ISO 14001). Development of micromobility: bicycle routes, electric scooters, electric buses in resort towns.

3. Behavioural measures: Changing consumer culture. Educational campaigns on the carbon footprint of travel (through booking websites, tour operators). Stimulation of domestic and local tourism through bonus programmes, tax rebates. Implementation of emission compensation systems: 'green tickets', donations to forests, alternative projects.

4. The main tasks of the digital level. Smart solutions for sustainable tourism. Emissions monitoring platforms for hotels, airlines, and tourists. Integration of Big Data and GIS for analysing transport routes, forecasting the load on destinations. Mobile applications for choosing eco-friendly travel alternatives.

5. Key regulatory objectives. Legislative and fiscal incentives. Green taxation for air travel and mass tour operators (emission tax). Preferential taxation for green businesses in tourism. Mandatory environmental certification of tourist facilities.

Expected results of the implementation of the model of mechanisms for reducing the carbon footprint in the tourism sector: reduction of $CO_2$ emissions in the tourism sector by 30–40% by 2035; growth of domestic and regional ecotourism by 50%; increased energy efficiency of tourism infrastructure; formation of an environmentally conscious tourist culture.

**Conclusions.** In the context of growing climate threats and increasing environmental responsibility of businesses, reducing the carbon footprint of the tourism sector is not only an environmental but also an economic strategic task. Tourism, which is both a source of development and a factor of pressure on the environment, requires a systemic rethinking of its operating models. According to the analysis, the transport component generates the largest load, accounting for up to 75% of all tourism $CO_2$ emissions. Given this, mobility optimisation, the introduction of low-carbon technologies and the greening of tourism infrastructure are key areas of decarbonisation in the industry.

The proposed model for implementing carbon footprint reduction mechanisms demonstrates that a combination of transport reform, regulatory policy, digital innovations,

and educational tools can form a viable basis for the transition to sustainable tourism within the green economy. At the same time, an important prerequisite for the successful implementation of such approaches is the coordination of efforts of the state, business and the public, as well as the integration of climate criteria into tourism strategies at all levels.

Thus, decarbonisation of tourism should be considered as an integral part of adaptation and climate policy, which can not only reduce environmental risks but also ensure the economic sustainability of the industry in the long term. Further research should focus on economic and mathematical modelling of the effects of green technologies, as well as on institutional assessment.

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