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CAMPUS

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LiRa

FEASIBILITY STUDY ON THE REDUCTION OF GREENHOUSE GAS EMISSIONS

Plitvice Lakes National Park

List of abbreviations

Abbreviation	Full term
BCR	Benefit-Cost Ratio
CAMPUS	Climate Adaptation Plans for UNESCO Sites
ERDF	European Regional Development Fund
EU	European Union
EUR	Euro (currency code)
GIS	Geographic Information System
LED	Light-Emitting Diode
LIFE	EU Programme for the Environment and Climate Action
MST	Monitoring System Tool
NPV	Net Present Value
UNESCO	United Nations Educational, Scientific and Cultural Organization

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Purpose and Scope of the Study

The purpose of this study is to assess which greenhouse gas emission reduction measures are feasible within the management system of Plitvice Lakes National Park, and how these measures can be linked to existing management documents, climate adaptation, and the protection of the Outstanding Universal Value of the UNESCO site. The study does not consider the Park solely as a natural area, but as a complex operational system that includes nature conservation, visitor reception and transport, hospitality services, accommodation, retail, technical maintenance, facility management, utility infrastructure, spatial monitoring, education, and day-to-day logistics.

Within this framework, emissions are examined across five main areas: visitor mobility and internal transport; the vehicle fleet and operational mobility of the Public Institution; energy consumption in buildings and infrastructure; waste management; and broader operational processes, including maintenance, procurement, digitalisation, visitor flow management, and the prevention of climate-related damage. Particular consideration is given to the fact that Plitvice Lakes is a protected area subject to very strict conservation regimes, meaning that each decarbonisation measure must be technically sound, spatially acceptable, and aligned with nature conservation objectives.

The study builds upon the Plitvice Lakes National Park Management Plan 2019–2028, the Annual Programme for the Protection, Maintenance, Conservation, Promotion and Use of Plitvice Lakes National Park for 2026, the CAMPUS climate context, the participatory results of the Living Lab workshops, the GIS analysis of climate risks, the prioritisation of measures and priority intervention areas, the economic and financial analysis of climate adaptation measures, and the report from the Monitoring System Tool workshop.

Introduction

Plitvice Lakes National Park is the oldest and largest national park in the Republic of Croatia, as well as a UNESCO World Natural Heritage site. The Park's management framework simultaneously includes obligations related to nature conservation, the preservation of the Natura 2000 site, the safeguarding of its Outstanding Universal Value, visitor management, and the provision of conditions for the sustainable use of the area. This framework directly determines how emission reduction measures can be planned and implemented.

The Management Plan states that, in addition to its core activities of protecting, maintaining, and promoting the protected area, the Public Institution also carries out visitor reception, information provision, guided tours, and visitor transport using its own means of transport, as well as hospitality and tourism activities, retail, building management, promotion, market research, and other supporting activities. This clearly indicates that potential sources of emissions are not limited to a single sector but are distributed across the various management functions of the Park.

The Annual Programme for 2026 further confirms the breadth of the operational system. The inventory of movable assets includes passenger cars, buses, vans, trucks, tractors, off-road vehicles, a motorcycle, trailers, electric road vehicles, loaders, vessels, and a pontoon used for passenger transport. Although these data do not allow emissions to be calculated without additional information on fuel consumption, mileage, and propulsion type, they provide a sufficient basis for identifying the sectors in which future monitoring should be established and emission reduction measures should be implemented.

Table 1. Management Areas Related to Greenhouse Gas Emission Reduction

Management Area	Link to Emissions	Relevance to the Study
Visitor transport and internal mobility	Fuel or electricity consumption, organisation of visitor movement, collective transport capacities	The most important area due to the large number of visitors and the sensitivity of the lake zone
Vehicle fleet and technical operations	Official vehicles, work vehicles, off-road vehicles, tractors, delivery, patrols, and maintenance	Important for the gradual introduction of records and the renewal of vehicles towards low-emission solutions
Buildings, hotels, campsites, and hospitality services	Energy consumption, heating, cooling, food preparation, hot water, lighting, and equipment	Important due to the scale of facilities and the potential for energy efficiency improvements
Waste and utility processes	Waste generation, separation, transport, treatment, and disposal	Important for reducing indirect emissions and pressure on the area
Visitor flow management	Reduction of unnecessary movement, relief of the most heavily visited locations, improved visitor information	High potential through organisational and digital measures without major infrastructure interventions
Forest and aquatic ecosystems	Preservation of natural carbon sinks, fire prevention, reduction of damage and remediation interventions	A link between climate resilience and reducing the risk of emission-related consequences of climate events

Climate Context and Rationale for Action

Climate data for the Plitvice Lakes area indicate a moderately warm and humid climate, with cold winters, cooler summers, and precipitation throughout the year. This climatic regime is directly linked to the water system, lakes, watercourses, tufa-forming processes, and forest ecosystems. For this reason, changes in temperature, the amount and distribution of precipitation, and the occurrence of extreme events may have a significant impact on the natural processes that constitute the site's core value.

The CAMPUS climate context indicates an increase in mean annual temperatures, a rise in absolute maximum temperatures, and pronounced interannual variability in precipitation. Under such conditions, measures that simultaneously reduce emissions and increase system resilience become increasingly important. This is particularly relevant to improved mobility management, reduced dependence on fossil fuels, energy efficiency in buildings, more rational infrastructure maintenance, and the preservation of forests as a key natural system for the stability of the area.

The Living Lab process carried out within the CAMPUS project identified biodiversity loss, storms and strong winds, forest fires, soil erosion, drought, and water-related risks as key climate risks. The GIS analysis further showed that the most sensitive zones are located in the central and northern parts of the Park, particularly along the lake system, tufa barriers, and main watercourse corridors. These areas are where hydrological risks, slope processes, fire susceptibility, forest ecosystems, and the highest concentration of visitor infrastructure overlap.

These findings are also important for the greenhouse gas emission reduction study, as they show that low-emission measures cannot be considered separately from risk management. For example, more sustainable internal visitor transport

reduces traffic pressure and emissions, while at the same time helping to guide visitors through sensitive areas. Fire prevention reduces the risk of major biomass losses, emissions from combustion, and subsequent remediation interventions.

The raising and relocation of trails does not reduce emissions directly, but it does reduce damage, repairs, system interruptions, and the need for urgent operational interventions.

Existing Mobility System and Transport-Related Sources of Emissions

Mobility is the most important area of this study, as it encompasses visitor arrivals to the Park, parking, the organisation of movement within the Park, employee transport, field patrols, delivery, maintenance, and emergency movements. The Park already has a well-developed system of internal collective visitor transport, which represents a significant advantage compared with areas where visitor movement primarily relies on individual vehicles.

The Plitvice trains have been used for internal visitor transport since 1977, operating on the 6.5 km Rapajinka – Velika Poljana – Labudovac route. Six train sets are in operation, with each set having 100 seated and 50 standing places. A fleet of electric boats operates on Lake Kozjak, including two smaller boats with a capacity of 50 passengers and six larger boats with a capacity of 100 passengers, while the journey on the longer route takes approximately 20 minutes. These data show that the Park already has important elements of low-emission and collective transport, particularly in the segment of electric boats.

The Annual Programme for 2026 also lists a substantial number of vehicles and transport assets owned by the Public Institution: 21 passenger cars, 6 buses, 12 vans, 2 trucks, 4 tractors, 9 off-road vehicles, 1 motorcycle, 20 other road vehicles used for visitor transport, 9 electric road vehicles, 13 loaders, 9 trailers, 27 vessels, and 1 pontoon.

Table 2. Proposed Emission Reduction Measures within the Mobility System

Mobility Segment	**Proposed Emission Reduction Measures**
Visitor arrivals to the Park	Monitoring of inbound mobility should be established, as this is likely the largest indirect source of emissions.
Parking areas and entrances	Managing time slots, entrances, and visitor information can reduce unnecessary circulation, congestion, and emissions.
Plitvice trains	Collective transport should be maintained and optimised, with the gradual consideration of low-emission propulsion.
Electric boats on Lake Kozjak	Electric boats represent good practice that should be maintained, monitored in terms of energy consumption, and further valorised.
Vehicle fleet of the Public Institution	Basic vehicle-level records are needed, together with a phased fleet renewal plan based on actual use.
Technical and emergency mobility	Electrification is not always technically feasible, but routes can be rationalised, maintenance can be planned more efficiently, and empty runs can be reduced.

Vehicle Fleet and Operational Mobility

The vehicle fleet and operational mobility of the Public Institution represent an identified source of direct emissions, primarily through fuel consumption by official, off-road, work, delivery, and emergency vehicles. However, at this stage, it is not justified to draw numerical conclusions on emissions, as data are not available for annual mileage, propulsion type for each individual vehicle, actual fuel consumption, and vehicle use by operational task.

Therefore, in this study, the vehicle fleet is addressed as an area for gradual optimisation rather than as a completed emissions inventory. The first step should be a simple and feasible record-keeping system that does not burden the work of individual departments, but provides the data needed for future calculations. The most practical model is vehicle-level record keeping, including: vehicle category, fuel or propulsion type, annual mileage, annual consumption, main purpose, frequency of use, and the possibility of replacement with a low-emission solution.

Particular attention should be given to distinguishing between vehicles that can be relatively easily replaced with electric or hybrid solutions and those that, due to terrain, load requirements, winter conditions, fire protection needs, or technical requirements, must remain robust work and emergency vehicles. In a protected area, the purpose is not to replace all vehicles quickly and administratively, but to gradually reduce emissions where this does not compromise safety, accessibility, nature conservation, or response capacity.

Visitor Mobility

Visitor mobility has the greatest potential for emission reduction, but it is also the most demanding in terms of data requirements. Emissions related to visitor arrivals depend on the mode of arrival, travel distance, vehicle occupancy, the share of buses and organised groups, length of stay, and the distribution of arrivals throughout the day and season. Since these data are not consolidated in the available background materials, this study does not estimate numerical emissions from visitor arrivals, but instead proposes a direction for future monitoring and measures that can be implemented independently of a complete emissions balance.

Priority should be given to measures that simultaneously reduce traffic pressure, improve the visitor experience, and reduce emissions. This includes better pre-

arrival information, timed ticketing, directing visitors towards less congested time slots and entrances, cooperation with transport operators and travel agencies, encouraging organised transport, improving connections with public transport, and optimising parking. In such a model, emission reductions result from reduced congestion, less vehicle idling, less circulation around entrances, and greater use of collective transport.

Energy Use in Buildings and Infrastructure

Energy consumption in Park facilities includes hotels, campsites, restaurants, bistros, shops, souvenir shops, reception areas, sanitary facilities, technical buildings, administrative premises, lighting, equipment, and supporting infrastructure. The Management Plan highlights that the supply of energy sources has not been resolved in accordance with high environmental and energy efficiency standards and foresees the replacement of existing energy plants and the improvement of supply through environmentally acceptable energy sources. This represents a very important starting point for this study.

Since data on energy consumption by individual facility are not available, the analysis is based on the identification of priority groups of facilities and measures. The first step is the energy mapping of facilities, with particular emphasis on the largest consumers: accommodation facilities, hospitality services, kitchens, laundries, heating systems, hot water, and lighting. Measures with the fastest impact can then be defined, such as replacing lighting, regulating heating and cooling, optimising the operation of kitchen and refrigeration equipment, improving hot water management, and systematically maintaining energy systems.

The introduction of renewable energy sources must be planned carefully, as the Park is subject to nature protection and UNESCO site regimes. Solutions must be

spatially discreet, technically reliable, and aligned with conservation rules. In this regard, priority should be given to interventions on existing buildings and systems, energy renovation, and efficient management, rather than large visible interventions in the landscape.

Waste and Operational Processes

Waste management is linked to emissions through waste generation, collection, transport, treatment, and disposal. In the context of Plitvice Lakes, waste is additionally important because it occurs in a highly sensitive area with significant visitor pressure and a large number of hospitality, accommodation, and retail functions. The Annual Programme for 2026 foresees the disposal of special categories of waste, biowaste, food waste, technical waste, laboratory waste, and activities related to the cleaning and maintenance of systems.

As with energy, it is not possible to make an emissions estimate without data on waste quantities by type, location, and season. Nevertheless, feasible directions for action can be defined: waste prevention, reduction of single-use packaging, better organisation of waste separation at visitor locations, optimisation of collection, reduction of food waste in hospitality services, recording of biowaste, and linking procurement to waste reduction objectives.

Part of the emissions reduction potential also lies in operational processes: planning maintenance routes, digitalising documentation, reducing unnecessary site visits, green public procurement, better stock planning, and extending the service life of equipment. Individually, these measures may not have a major impact, but they are financially and organisationally feasible and help create a culture of low-emission management.

The Role of Forests, Fire, and the Conservation of Natural Carbon Sinks

Forest ecosystems in Plitvice Lakes National Park have multiple roles: they preserve the landscape, stabilise the soil, support biodiversity, influence the water regime, and act as a natural carbon sink. From an emissions reduction perspective, the key priority is not to calculate short-term savings from each individual forest-related measure, but to preserve the stability of forest cover and prevent events that may lead to significant direct and indirect emissions, particularly fires, erosion, remediation works, and loss of forest vitality.

The Living Lab process and the prioritisation of measures clearly identify forest fire prevention, enhanced surveillance, early warning systems, video monitoring, monitoring of tree vitality, and the removal of hazardous trees as important measures. In the context of this study, these measures are considered climate-protective and relevant to emissions reduction, as they contribute to preserving the natural carbon storage capacity of the area and reducing the risk of exceptional emissions associated with fires and ecosystem degradation.

Table 3. Overview of Key Emission Sources and Emission Reduction Potential

Emission Source	Assessment of Significance	Reduction Potential	Priority
Visitor arrivals by private cars and buses	Very high, due to the large number of visitors and travel distances	Encourage organised transport, public transport, better distribution of arrivals, and improved information provision	Very high
Internal visitor transport	High, although a collective transport system and electric boats are already in place	Optimisation of timetables, modernisation of propulsion systems, monitoring of energy use and occupancy	Very high
Official and work vehicles of the Public Institution	Medium to high, depending on intensity of use	Consumption records, route rationalisation, gradual fleet renewal	High
Energy use in hotels, campsites, and hospitality services	High, due to the scale of facilities and year-round operation of part of the system	Energy mapping, efficient equipment, regulation, renewal of energy plants	Very high
Lighting, information systems, and technical infrastructure	Medium	LED lighting, sensors, operational optimisation, consumption management	Medium
Waste and biowaste	Medium, with seasonal peak pressures	Prevention, separation, reduction of food waste, optimisation of collection	High
Forest fires and ecosystem degradation	Very high as a risk of exceptional emissions and loss of carbon sinks	Surveillance, early detection, education, vitality monitoring, and risk management	Very high

Proposed Emission Reduction Measures

The proposed measures have been designed to be feasible within the Park's actual management system. They do not require the immediate preparation of a complete emissions inventory, but rather the introduction of clear implementation steps that will simultaneously reduce emissions, improve management, and generate data for more precise future decision-making.

Table 4. Priority Emission Reduction Measures and Feasibility Assessment

Measure	Implementation Description	Expected Effect	Feasibility
Establishment of a basic emissions record-keeping system	Introduce simple annual records of fuel consumption, energy use, mileage, number of trips, waste quantities, and basic data on visitor mobility.	Provides a basis for a future emissions inventory and more precise prioritisation.	High
Optimisation of internal visitor transport	Monitor train and boat occupancy, number of trips, seasonal loads, and align timetables with visitor flows.	Reduction of empty runs, improved efficiency, and better organisation of visits.	High
Modernisation of the Plitvice trains and supporting infrastructure	When renewing or replacing assets, consider low-emission propulsion systems, energy-efficient solutions, and noise reduction.	Reduced emissions and improved environmental acceptability of internal transport.	Medium
Maintenance and energy monitoring of electric boats	Systematically monitor electricity consumption, capacities, load levels, and	Valorisation of existing low-emission practice	High

	maintenance of electric boats.	and improved system efficiency.	
Phased fleet renewal plan	For each vehicle category, assess its actual purpose, intensity of use, and possibility of replacement with an electric, hybrid, or more efficient vehicle.	Reduction of direct emissions without compromising operational safety.	Medium
Rationalisation of official and technical trips	Plan routes, combine tasks, reduce empty runs, and use digital maintenance work orders.	Rapid organisational savings in fuel and time.	High
Energy mapping of facilities	Collect energy consumption data by facility and function, identify the largest consumers, and determine priority interventions.	Basis for energy savings and investments.	High
Energy efficiency measures in buildings	LED lighting, heating regulation, equipment optimisation, efficient hot water systems, and maintenance of energy systems.	Reduction of energy consumption and operating costs.	High
Gradual renewal of energy plants and heating systems	Align with the Management Plan and spatial constraints; give priority to more environmentally acceptable energy sources.	Greater long-term impact on energy-related emissions.	Medium
Waste prevention and separation	Reduce single-use packaging, improve waste	Reduction of indirect emissions	High

	separation, monitor biowaste and food waste.	and pressure on the area.	
Green procurement and local products	In procurement, give priority to durable, repairable, and energy-efficient products, as well as local supply chains where possible.	Reduction of indirect emissions and strengthening of local sustainability.	Medium
Forest fire prevention and forest conservation	Surveillance, alert systems, video monitoring, education, vitality monitoring, and timely removal of hazardous trees.	Preservation of carbon sinks and reduction of the risk of major emissions from fires.	High

Linkages with Climate Adaptation Priorities

The emission reduction measures presented in this study are not intended as a separate package to be implemented independently of the existing CAMPUS measures. On the contrary, their greatest value lies in linking emission reduction with measures that have already been identified as priorities for strengthening the Park's resilience. This creates a dual effect: it reduces the climate footprint of management while also strengthening the resilience of natural systems and visitor infrastructure.

Table 5. Linkages with Climate Adaptation Priorities

Priority Adaptation Measure	**Link to Emissions and Management**
Installation of fire lookout points and fire alert systems	Prevents major damage, exceptional emissions from fires, and loss of the forest carbon sink.
Strengthening forest control and surveillance	Early detection of fires and degradation reduces the risk of emergency interventions and remediation works.
Relocation of trails and footbridges from flood-prone zones	Reduces the frequency of remediation works, emergency interventions, and disruptions to the visitor system.
Raising trails and bridges to a higher level	Reduces damage from high water levels and the need for repeated works.
Monitoring of fauna and habitats	Does not reduce emissions directly, but supports timely ecosystem management.
Monitoring tree growth and water availability	Contributes to preserving forest vitality and natural carbon sinks.
Natural forest development with the removal of hazardous trees	Preserves forests and visitor safety while reducing the risk of exceptional events.
Control of invasive species and pests	Preserves ecosystem stability and the resilience of natural habitats.

Technical, Operational, and Financial Feasibility

The technical feasibility of the measures depends on the type of intervention. Organisational measures, such as consumption record keeping, trip optimisation, monitoring the occupancy of internal transport, and process digitalisation, can be implemented relatively quickly and with limited investment. Infrastructure measures, such as the renewal of energy plants, fleet replacement, modernisation of the Plitvice trains, energy renovation of buildings, and the raising of trails, require phased implementation, project documentation, financial planning, and alignment with protection regimes.

Operational feasibility is good if the measures are introduced gradually and through existing departments. The greatest risk does not lie in technical impossibility, but in introducing measures without sufficiently clear data, without ownership of indicators, and without linking them to the regular work of departments. For this reason, it is important that each measure has a simple indicator, a responsible department, and a realistic timeframe.

The financial analysis of climate adaptation measures for Plitvice Lakes National Park estimates the total investment value of the package of measures at EUR 14.54 million, with indicative annual operating costs of approximately EUR 480,000. The largest share of costs relates to infrastructure adaptation, particularly the relocation and raising of trails and bridges, while ecological monitoring, surveillance, and preventive management measures are financially less demanding, but very important for long-term risk management.

In this study, the economic and financial analysis is used as an important basis for assessing feasibility. It does not represent a direct calculation of greenhouse gas emission reductions, as consolidated data on fuel consumption, energy use, waste, and mobility are not yet available for such a calculation. Its value lies in

showing the financial framework, the order of magnitude of investments, economic justification, and the possibilities for phased implementation of measures that simultaneously increase the resilience of the Park and create the preconditions for low-emission management.

The broader package considered 23 climate adaptation measures grouped according to fire risks, water-related risks, drought, biodiversity loss, and the resilience of forest ecosystems. For the purposes of this study, particular importance is given to measures that have a dual effect: they reduce climate risk while also reducing future operational interventions, remediation works, damage, resource consumption, and exceptional emissions arising in crisis situations.

Table 6. Financial Framework for Measure Implementation and Its Relevance to Emission Reduction

Financial Element	**Value / Scope**	**Relevance to the Emission Reduction Study**
Total indicative value of the package of measures	Approximately EUR 14.54 million	Shows that the main measures cannot be considered merely as minor organisational activities, but as part of a serious investment cycle focused on resilience and low-emission management.
Annual operating costs	Approximately EUR 480,000 per year	Related to system maintenance, monitoring, preventive measures, and ongoing management; they can be linked to MST indicators and regular work programming.
Largest investment component	Relocation and raising of trails and bridges, renewal of sensitive infrastructure	These are primarily adaptation measures, but they reduce repeated remediation works, emergency interventions, and pressure on operational resources.
Financially less demanding measures	Monitoring, records, surveillance, preventive management, indicators	These measures should be implemented first, as they create the data and organisational basis for later emissions quantification.
Potential sources of financing	EU funds, the LIFE Programme, ERDF, the Cohesion Fund, national sources, the Park's own revenues, international cooperation	Enable phased implementation without shifting the entire burden onto the regular operations of the Public Institution.

The financial analysis places particular emphasis on the distinction between financial and economic justification. Measures aimed at protecting nature, ecosystems, forests, water resources, and visitor infrastructure do not necessarily generate new direct revenue that could be assessed as a commercial return on investment. Nevertheless, they create economic value through avoided damage, the preservation of tourism attractiveness, ecosystem stability, the safeguarding of UNESCO status, visitor safety, and the reduction of future remediation costs. For this reason, a negative financial net present value does not mean that the project is weak, but rather that it represents an investment in a public good, justifying the use of public, European, and international sources of financing.

Table 7. Indicators of Justification for Measure Implementation

Indicator	Value from the Economic and Financial Analysis	Explanation
Reference period	20 years	The measures should be considered over the long term, as their benefits are reflected in avoided damage, system stability, and a reduced need for remediation works.
Economic net present value	Positive, approximately EUR 15–40 million	The project generates economic value when benefits for the ecosystem, tourism, safety, and heritage are taken into account.
Economic BCR	2.0–3.7	Each euro invested generates approximately EUR 2 to 3.7 in economic value.
Economic internal rate of return	9–14%	Indicates that the project is economically justified and resilient to changes in assumptions.
Financial NPV	Negative, approximately EUR –18.25 million	Expected for public good projects; confirms the need for co-financing.
Economic payback period	8–12 years	The investment is economically justified through reduced damage and preserved benefits, rather than through new commercial revenue.

The economic context of UNESCO status is particularly important. The financial analysis states that revenues from entrance tickets and fees in 2025 amounted to approximately EUR 31.3 million, while revenues from services amounted to around EUR 20.8 million, totalling approximately EUR 52.1 million per year. Although the impact of a potential deterioration of UNESCO values cannot be precisely quantified without a separate study, it is clear that a significant part of the Park's economic stability is based on the preserved natural value of the site. In this sense, investments in fire prevention, the resilience of water and visitor infrastructure, monitoring, and ecosystem conservation should be viewed as protection of the Park's fundamental development and financial value.

Table 8. Scenario Analysis and Justification for Measure Implementation

Scenario	**Assumption**	**Result**	**Implementation Conclusion**
Optimistic	Growth in tourism-related benefits and a lower extent of damage	Economic NPV of around EUR 40 million; BCR of around 3.7	The measures generate a very strong economic effect.
Baseline	Reference assumptions regarding costs and benefits	Economic NPV of around EUR 25 million; BCR of around 2.6	Implementation is economically justified.
Pessimistic	Costs 20% higher and benefits 25% lower	Economic NPV of around EUR 11 million; BCR of around 1.5	The project remains justified even under less favourable circumstances.
Without project	No investment, subsequent remediation costs	Negative economic outcome; BCR below 1	The riskiest scenario is delaying implementation.

These indicators further confirm the rationale for gradual implementation. The first measures should be those that quickly generate data and reduce risk: record keeping, monitoring, surveillance, maintenance planning, improved coordination between departments, and optimisation of internal mobility. Larger interventions, such as infrastructure adaptation of trails, modernisation of the transport system, and energy renovation of buildings, should be prepared in phases, with clear project documentation and links to funding sources.

For emission reduction measures, priority should be given to a sequence in which low-cost measures with a strong organisational effect are introduced first, followed by measures that require project preparation and investment planning, and only then larger infrastructure interventions. Such an approach enables part of the emission reductions to begin immediately, while more complex interventions are prepared in accordance with nature protection requirements and available sources of financing.

Table 9. Feasibility Assessment

Group of Measures	Technical Feasibility	Financial Requirements	Recommended Sequence
Records and indicators	High	Low	Immediately, as a prerequisite for all other measures
Optimisation of internal transport	High	Low to medium	Short term, through organisation and monitoring
Rationalisation of official trips	High	Low	Short term, through internal procedures
Energy mapping of facilities	High	Low to medium	Short term, before larger investments
LED lighting, regulation, and efficient equipment	High	Medium	Short to medium term
Renewal of energy plants and heating systems	Medium	High	Medium to long term
Fleet renewal	Medium	Medium to high	In phases, according to vehicle age and purpose
Modernisation of trains	Medium	High	In phases, following an analysis of propulsion systems and costs
Infrastructure adaptation of trails and bridges	Medium	High	In phases, according to priority risk zones

Monitoring and Indicators

The Monitoring System Tool represents a suitable basis for monitoring climate risks, environmental changes, and the effects of measures in the area of Plitvice Lakes National Park. The MST workshop was held on 5 May 2026 in Gospić, with an emphasis on the application of monitoring systems in the management of UNESCO sites. Participants identified the condition of forests, fire prevention, flood-prone zones, biodiversity, water levels, air quality, habitats, invasive species, and aquatic ecosystems as important monitoring areas.

For the purposes of this study, it is proposed that the existing MST framework be supplemented with indicators related to low-emission management. This does not mean creating a parallel system, but rather gradually incorporating additional data into the same logical monitoring framework. The indicators must be simple, repeatable, and feasible for the departments responsible for collecting them.

Table 10. Proposed Indicators for Monitoring Emissions and Sustainable Mobility

Monitoring Area	Proposed Indicators	Frequency	Possible Responsible Units
Vehicle fleet	Fuel consumption by vehicle category; mileage; number of electric/low-emission vehicles; number of official trips	Annually, with monthly internal records	Technical Service, Finance, Management
Internal visitor transport	Number of train and boat trips; estimated occupancy; energy/fuel consumption; seasonal loads	Seasonally and annually	Visitor Reception and Internal Transport Service
Inbound visitor mobility	Mode of arrival; share of private vehicles, buses, and organised groups; use of public transport; parking load	Seasonally, through surveys and digital data	Visitor Reception Service, Marketing, external associates
Energy consumption	Electricity and thermal energy consumption by facility; energy source; cost; implemented efficiency measures	Monthly and annually	Technical Service, Hotel Operations, Finance
Waste	Quantity of waste by type; biowaste; food waste; technical waste; locations of generation	Monthly and annually	Technical Service, Hospitality Services, authorised waste collectors
Forests and fires	Number of patrols; number of alerts; response time;	Seasonally and annually	Nature Protection Service, nature

	areas under surveillance; condition of risk zones		rangers, fire brigade
Water-related risks and infrastructure	Number of days with high water levels; number of trail closures; length of vulnerable sections; number of damages and remediation works	After events and annually	Nature Protection Service, Technical Service, Expert Services
Biodiversity and habitats	Status of key species; invasive species; habitat vitality; fauna monitoring and dendrometers	According to monitoring protocols	Expert Services, scientific institutions

Phased Implementation Plan

The implementation of measures should be organised in three phases. The first phase must be simple and feasible without major investments. It serves to establish data collection and introduce rapid organisational improvements. The second phase includes the preparation and implementation of medium-complexity technical measures. The third phase relates to larger infrastructure and investment interventions that require project documentation, permits, financing, and alignment with protection regimes.

Table 11. Proposed Timeline for the Implementation of Measures

Phase	Period	Content	Expected Result
Phase 1	0–12 months	Establishment of basic records; mapping of emission sources; fuel and mileage records; initial energy mapping; waste monitoring; definition of MST indicators; optimisation of official trips.	Clear initial overview of emission sources and a prepared monitoring system.
Phase 2	1–3 years	Low- and medium-cost energy measures; optimisation of internal transport; phased fleet renewal plan; improvement of waste separation; seasonal monitoring of inbound mobility; linking with Living Lab and GIS priorities.	Visible reductions in consumption and improved operational efficiency.
Phase 3	3–7 years	Renewal of energy plants and heating systems; modernisation of vehicles and trains; infrastructure adaptation of trails and bridges; larger investments in low-emission solutions; regular emissions balance.	Structural emission reduction and integration of low-emission management into the Park's regular system.

Implementation Risks and Mitigation Measures

The greatest implementation risk is the lack of a consolidated database. Without data on fuel consumption, energy use, waste, and visitor mobility, it is difficult to monitor the actual effects of the measures. This risk can be mitigated through a simple, gradual, and realistic record-keeping system that does not require perfection in the first year, but rather the consistent collection of the most important data.

The second risk relates to spatial, conservation, and environmental constraints. In a national park and UNESCO site, it is not acceptable to introduce every technical solution simply because it is low-emission. Each measure must be aligned with the conservation of natural values, landscape, tufa-forming processes, habitats, and the visitor experience. This applies particularly to renewable energy sources, infrastructure, transport solutions, and works near the lake system.

The third risk is the financial complexity of larger measures. The renewal of energy plants, modernisation of vehicles, infrastructure adaptations of trails, and renovation of buildings require significant funding. This risk can be mitigated through phased implementation, the combination of the Park's own resources with national and EU funding sources, and the prioritised implementation of measures with the highest benefit-cost ratio.

Final Feasibility Assessment

The reduction of greenhouse gas emissions in Plitvice Lakes National Park is feasible if it is established as a gradual management process rather than a one-off technical intervention. The Park already has several important advantages: a developed system of internal collective visitor transport, electric boats on Lake Kozjak, a number of electric road vehicles, a strong planning framework, well-defined climate adaptation priorities, a GIS risk analysis, a financial analysis of measures, and the Monitoring System Tool as a basis for monitoring.

The economic and financial analysis further supports the conclusion that the implementation of measures should not be postponed until a complete emissions inventory has been prepared. Such an inventory is necessary for the precise measurement of effects, but measures that reduce resource consumption, strengthen fire prevention, reduce damage from high water levels, and improve operational efficiency already have clear management and economic justification.

The key shortcoming at this stage is not the lack of measures, but the lack of a consolidated emissions record-keeping system. For this reason, the first recommendation concerns the systematic collection of data on fuel, energy, waste, internal transport, and visitor mobility. Without such data, measures can still be implemented, but their effects will be difficult to quantify. By establishing this type of record-keeping system, the Park can move from a qualitative assessment to an actual annual emissions balance.

The most feasible short-term measures are: the establishment of emissions indicators, optimisation of internal transport, rationalisation of official trips, energy mapping of facilities, basic energy efficiency measures, improved waste monitoring, and integration with the MST system. In the medium term, the greatest potential lies in the phased renewal of the vehicle fleet, modernisation of

internal transport, energy renovation of buildings and heating systems, and the organisation of visitor mobility. In the long term, the greatest strategic value lies in integrating low-emission management into all annual programmes, investments, and decisions concerning the development of the visitor system.

The study therefore concludes that emission reduction in Plitvice Lakes National Park is feasible, but it must be aligned with the Park's fundamental purpose: the conservation of natural processes, tufa barriers, the water system, forests, biodiversity, and Outstanding Universal Value. The best approach is not to consider emissions in isolation, but to link decarbonisation with climate resilience, visitor management, energy efficiency, and ecosystem protection.

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