



D.2.3.1_Climate Change Adaptation Plans and counter-measures

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County - LIRA*

UNESCO World Heritage Site: Plitvice Lakes

1. Summary at a glance

The Climate Change Adaptation Plan for Plitvice Lakes National Park sets out a practical route for protecting the natural processes and management systems on which the World Heritage property depends. It brings climate considerations into the Park's existing planning framework and links conservation, visitor safety, infrastructure management and long-term monitoring.

The Plan is built around a simple premise: climate adaptation at Plitvice Lakes is inseparable from the conservation of the lake system, tufa-forming processes, forest ecosystems, biodiversity and the wider karst landscape. The priority is not only to respond to individual extreme events, but to maintain the ecological and hydrological conditions that sustain the site's Outstanding Universal Value.

1979 Year of inscription on the UNESCO World Heritage List	71% Share of analysed walking trails located in areas exposed to hydrological risk
23 Adaptation measures assessed and ranked for implementation	3 Spatial priority zones guiding where measures should be focused

HEADLINE FINDINGS

Strategic purpose	Preserve the Outstanding Universal Value of Plitvice Lakes while improving the resilience of natural systems, visitor infrastructure and routine management.
Main climate pressures	Warming, drought, wildfire risk, precipitation variability, high-water events, torrential flows, storms, strong winds and erosion.
Highest spatial exposure	The central lake system, tufa barriers, water corridors and the most intensively used sections of the visitor system.
First implementation focus	Hydrological adaptation of trails and bridges, protection of tufa and habitats, wildfire prevention and early detection, and long-term ecosystem monitoring.
Method	Existing management framework + climate evidence + Living Labs + GIS analysis.
Delivery principle	Use monitoring results to update priority areas and adjust measures through annual work plans and management procedures.



2. The site and the values to be safeguarded

Plitvice Lakes National Park, established in 1949 and inscribed on the World Heritage List in 1979, is defined by the interaction of water, carbonate rock, air and living organisms. This interaction drives the formation of tufa barriers and shapes the system of lakes, waterfalls and watercourses. Forests, grasslands, karst and speleological systems form the wider ecological setting that supports these processes.

The Park is also a highly visited protected area. Walking trails, wooden boardwalks, bridges, boat landings and transport facilities provide controlled access, but many of these elements are located close to water or within areas exposed to flooding, erosion and treefall. Climate adaptation therefore has to protect natural dynamics while maintaining safe and workable visitor routes.

Climate sensitivity of the main site values

Site value	Why it matters	Principal climate sensitivity
Tufa barriers	The process that shapes the lakes and waterfalls and underpins the World Heritage value.	Changes in water regime, water quality, flow conditions and microclimate.
Lakes and watercourses	The core hydrological system and the defining landscape feature.	Intense rainfall, high-water levels, drought and altered inflow patterns.
Forest ecosystems	Protect the catchment, regulate the microclimate and provide habitat.	Wildfires, drought, storms, windthrow, pests and soil degradation.
Biodiversity and habitats	Reflect ecosystem integrity and ecological stability.	Habitat change, invasive species and disruption of ecological relationships.
Visitor infrastructure	Supports controlled access, interpretation and visitor safety.	Flooding, erosion, windthrow, damage and temporary loss of access.

Planning context

International: UNESCO climate action for World Heritage and protection of Outstanding Universal Value.

European: EU Strategy on Adaptation to Climate Change.

National: Croatian Climate Change Adaptation Strategy to 2040 with a view to 2070, the Nature Protection Act, and the Climate Change and Ozone Layer Protection Act.

Regional and local: Lika-Senj County climate programme and the Park Management Plan 2019-2028.



3. Climate evidence and principal risk chains

The Plitvice Lakes area has a temperate oceanic climate with warm summers (Cfb), cold winters and precipitation throughout the year. Elevation, forest cover, karst relief and the enclosed lake valleys create marked local and microclimatic differences. Long-term indicators point to warming, higher summer maxima, milder winter extremes, variable snow cover and pronounced year-to-year differences in precipitation.

Observed tendencies and management implications

Climate signal	Observed tendency	Implication for adaptation
Mean temperature	Long-term warming and more frequent above-average years.	Greater sensitivity of forests, habitats and the hydrological regime, need for long-term monitoring.
Summer maxima	Episodes of high summer temperatures and increased heat stress.	Higher wildfire risk and additional pressure on visitors during hot periods.
Winter minima	Recent milder extreme minimum temperatures.	Possible changes in snow duration, snowmelt and seasonal runoff.
Precipitation	Strong annual variability, including exceptionally wet years.	High-water events, torrential flows, erosion and reduced trail accessibility.
Snow cover	Variable number of days with snow cover.	Effects on seasonal hydrology, soil conditions and visitor operations.

Observed tendencies and management implications

Drought and heat Forest stress, reduced water availability, higher wildfire susceptibility and possible changes in habitat condition.
Intense rainfall and high water Flooding of visitor corridors, damage to trails and bridges, torrential transport and local erosion.
Storms and strong winds Windthrow, hazardous trees, trail obstruction, damage to infrastructure and secondary erosion on slopes.
Hydrological change Pressure on lake dynamics, aquatic habitats and tufa-forming processes.
Ecological change Habitat shifts, invasive species, grassland succession and pressures on sensitive species and populations.



4. Spatial risk picture and priority intervention zones

GIS analysis shows that climate-related pressures are unevenly distributed. The highest concentration of overlapping risk occurs in and around the central lake system, along water corridors and tufa barriers, and where visitor infrastructure is located close to water. Forested slopes and areas with southern exposure form a second major risk pattern, linked to drought, wildfire, storms and erosion.

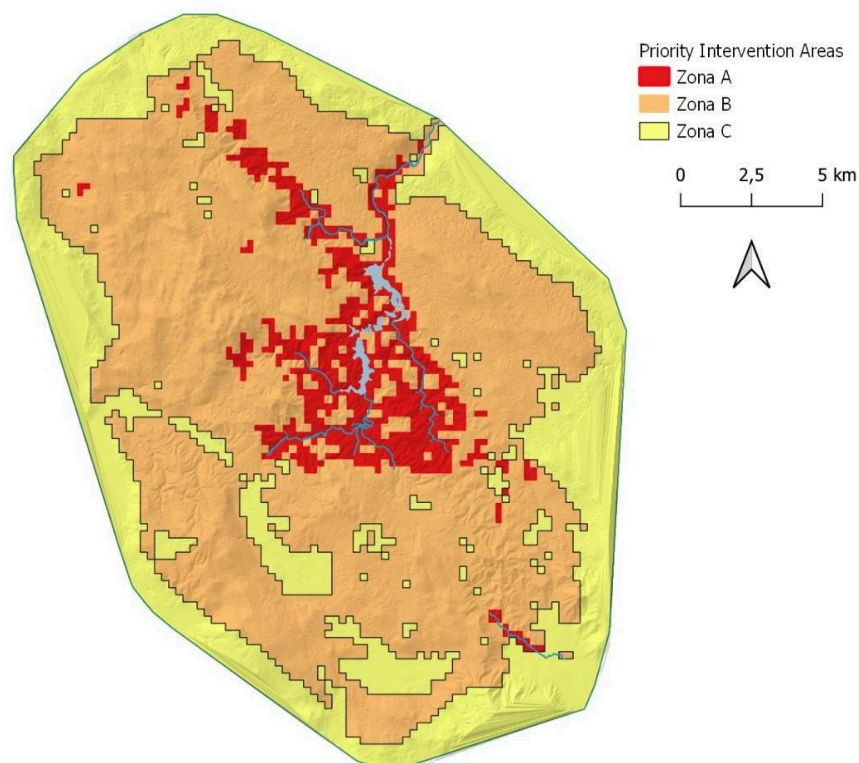


Figure 1. Priority areas for climate change adaptation interventions. Source: GIS analysis in the Climate Change Adaptation Plan.

Zone	Priority	Main characteristics	Direction of intervention
A	Very high	Central lake system, tufa barriers, water corridors and the most heavily used visitor sections.	Hydrological risk reduction, trail and bridge adaptation, tufa monitoring, visitor safety and protection of sensitive processes.
B	High	Forested and sloping areas with pronounced wildfire, storm and erosion risk.	Forest surveillance, wildfire protection, tree vitality monitoring and erosion prevention.
C	Medium	Peripheral areas with fewer overlapping risks.	Preventive management, long-term monitoring and integration into routine maintenance.



5. Evidence gathered through the CAMPUS process

Five specific objectives

No.	Specific objective	Core achievement indicator
1	Reduce wildfire risk and improve the safety of forest ecosystems.	Operational surveillance points, alerts, patrols and educational activities.
2	Reduce the exposure of infrastructure to hydrological risks.	Length of adapted or relocated trails and bridges, closures due to high water.
3	Preserve tufa barriers, aquatic ecosystems and habitats.	Monitoring results for water, habitats, tufa and key species.
4	Increase forest resilience to drought, storms and slope processes.	Tree vitality assessments, hazardous-tree interventions and experimental plots.
5	Integrate climate risks into the Park's regular management.	Updated GIS database, annual reporting and incorporation into work plans.

Four implementation packages

Hydrological safety and visitor infrastructure	Relocate or raise vulnerable trails and bridges, establish high-water closure protocols and use repeated damage records to guide redesign.
Wildfire prevention and forest resilience	Strengthen surveillance and early detection, monitor tree vitality, maintain natural forest development and remove hazardous trees where visitor safety requires it.
Protection of tufa, habitats and biodiversity	Restore tufa and habitats where justified, monitor fauna and key species, control invasive species and maintain ecological continuity.
Long-term knowledge and adaptive management	Use dendrometers, permanent plots, updated GIS records and annual reporting to refine priorities and management responses.

6. Overall implementation priority

The Plan combines the score assigned through the Living Lab process with a spatial coefficient. Zone A has a coefficient of 1.20, Zone B and Park-wide measures 1.10, and Zone C 1.00. The resulting value determines the sequence of implementation and helps direct funding and project preparation towards measures with the strongest combined case.

Measures in the highest and very high categories

Rank	Measure	Primary area	Overall priority
1	Relocation of trails and footbridges away from flood-prone areas	Zone A	6.00 - Highest



Rank	Measure	Primary area	Overall priority
2	Raising trails and bridges to a higher level	Zone A	6.00 - Highest
3	Restoration of tufa barriers and habitat renaturalisation	Zone A	5.80 - Highest
4	Temporary closure of visitor sections during high-water events	Zone A	5.76 - Highest
5	Fire lookout towers and fire detection and alert systems	Zone B / C	5.50 - Highest
6	Forest surveillance, early detection and education	Zone B / C	5.50 - Highest
7	Fauna monitoring as an indicator of ecosystem condition	Park-wide	5.50 - Highest
8	Dendrometers for tree growth and water availability	Zone B / C	5.50 - Highest
9	Permanent experimental plots for long-term monitoring	Zone B / C	5.50 - Highest
10	Natural forest development with removal of hazardous trees	Zone B / C	5.23 - Very high
11	Protection and monitoring of plant and animal species	Park-wide	5.06 - Very high
12	Continuous monitoring of habitats and populations	Park-wide	5.06 - Very high
13	Video surveillance systems for wildfire detection	Zone B / C	5.03 - Very high

7. Monitoring and adaptive management

Monitoring is organised at two levels. Implementation monitoring confirms whether activities have been carried out, effectiveness monitoring examines whether they have reduced exposure, improved preparedness and supported conservation. Results should be used to revise spatial priorities and adjust the next annual cycle of measures.

Monitoring area	Core indicators	Frequency	Lead / partners
Wildfire risk	Patrols, alerts, response time, operational lookout and video systems, education.	Annual and seasonal	Park Public Institution, fire and civil protection services, County.
Hydrological risk and infrastructure	Vulnerable/adapted trail length, closures, damage records and repair time.	Annual and after events	Park Public Institution, maintenance, rescue service as required.
Tufa and aquatic ecosystems	Condition of tufa, water levels, water quality and changes at sensitive sites.	Several times a year	Park Public Institution, scientific and expert institutions.



Monitoring area	Core indicators	Frequency	Lead / partners
Forests and tree vitality	Dendrometer data, plot condition, hazardous trees, windthrow and drought impacts.	Seasonal and annual	Park Public Institution, forestry and scientific experts.
Biodiversity and habitats	Key species trends, grassland condition, invasive species, populations and habitats.	Annual or taxon cycle	Park Public Institution, expert and conservation institutions.
Integration into management	Updated GIS database, measures in annual work plans and implementation reports.	Annual	Park Public Institution, LIRA and project partners as required.

8. Delivery, governance and financing

The Plan is intended to work through the Park's existing management system. Climate risk should become a standard criterion when infrastructure is reconstructed, rehabilitated or relocated, and the priority-zone map should be used to sequence inspections, prepare project applications and align interventions with protection requirements.

Governance roles

Plitvice Lakes National Park Public Institution	Lead implementation, monitoring, visitor management and integration into regular management.
Lika-Senj County and LIRA	Regional coordination, alignment with climate/development programmes and preparation of funding applications.
Public nature conservation institutions	Habitat monitoring, protection and exchange of expert information.
Fire and civil protection services	Prevention, alerting and response to wildfires and extreme events.
Croatian Mountain Rescue Service and police	Visitor safety, emergency response and access coordination.
Scientific and expert institutions	Monitoring of tufa, water, forests, habitats and climate indicators.
Local communities and area users	Prevention, education, field observations and support for implementation.

Financing logic

Regular budget of the Public Institution	Maintenance, inspections, planning, basic monitoring and response protocols.
Environmental Protection and Energy Efficiency Fund	Adaptation, education, monitoring and nature conservation projects.



European Union programmes	Larger infrastructure, green and blue solutions and international cooperation.
Interreg and cross-border programmes	Pilot actions, tools, monitoring and cooperation among World Heritage sites.
National nature conservation and civil protection programmes	Wildfire prevention, risk management and protection of protected areas.
Scientific research projects	Long-term plots, dendrometers, fauna monitoring and tufa research.

9. Executive conclusions

The Plan provides a clear shift from climate-risk awareness to routine climate-resilient management. Its central contribution is the link between the Park's most important natural values, mapped areas of vulnerability, stakeholder priorities and a measurable implementation portfolio. The first actions should concentrate on hydrological safety in Zone A, wildfire prevention and forest resilience in Zone B, and Park-wide ecological monitoring. Over time, monitoring results should determine where measures are strengthened, redesigned or extended.

