

Safeguarding coastal and riverine prehistoric archaeological heritage in the face of climate risk

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Executive summary

Portugal's coastal and riverine prehistoric archaeological heritage constitutes a unique archive of human occupation of these territories, currently undergoing continuous and irreversible loss. The floods of February 2026 in the Tagus, Mondego, Sado and Guadiana basins, together with the succession of winter storms along the Atlantic coast, have laid bare the urgency of an integrated policy response. The BLUE HERITAGE project classifies 115 of the 419 inventoried archaeological sites (the full universe encompassing all chronologies) across the three pilot areas as being at identified climate risk (27.4% of the universe), with disproportionate vulnerability among the fluvial and estuarine Mesolithic (83.3% of sites at risk). The Portuguese regulatory framework, however, has yet to integrate climate risk to archaeological heritage in an operational and differentiated manner. The ongoing revision of the ENAAC 2030 and the preparation of the third cycle of the 13 PGRI present a unique opportunity to embed specific technical safeguarding criteria within national climate adaptation instruments.

Recommendations

- Integrate the archaeological sensitivity areas (ASAF, ASAC, ASAR) into territorial management instruments (POC, PGRI, PMAC, PDM);
- Establish the designation "Archaeological Site at Climate Risk", with graded alert levels (monitoring, priority action, imminent loss);
- Operationalise the RISCUS application as an instrument for monitoring and early warning;
- Formalise a national protocol for emergency archaeological response, actionable within 72 hours of extreme climate events;
- Strengthen the Cultural Heritage Safeguarding Fund with a dedicated funding line for "Heritage at Climate Risk";
- Establish national programmes dedicated to the critical archaeological periods at climate risk.

Policy brief addressee(s)

Património Cultural, I.P.; Agência Portuguesa do Ambiente (APA); Comissões de Coordenação e Desenvolvimento Regional (CCDR); Municípios costeiros e ribeirinhos; Autoridade Nacional de Emergência e Proteção Civil (ANEPC); Ministério da Cultura, Ciência e Inovação; Ministério do Ambiente e Energia.

Introduction and Problem Statement

Coastal and riverine prehistoric archaeological heritage is registering mounting losses as a

result of the processes associated with climate change. The sites located in these contexts



document patterns of human occupation, resource exploitation and adaptation to changing environments over thousands of years, constituting an archaeological record of high scientific and historical value. More than a quarter of this record (27.4% of the inventoried sites across the three pilot areas analysed) is at risk of destruction before any intervention to study, record or safeguard it can take place.

The IPCC Sixth Assessment Report (AR6) projects for the Portuguese coast a rise in mean sea level of between 0.28 m and 1.01 m by 2100, accompanied by a projected increase in the frequency and intensity of extreme weather events in southern Europe. For the Portuguese Atlantic seaboard, Antunes, Rocha and Catita (2018, 2019) carried out a local calibration of these values, projecting a sea-level rise of 1.25 m by 2100 and extreme coastal flood levels of 3.40 m over the same horizon. The floods of February 2026, which simultaneously affected

the Tagus, Mondego, Sado and Guadiana basins, together with the succession of winter storms between 2024 and 2026, confirmed the materialisation of these projections, resulting in a declared state of calamity in 68 municipalities and in national economic impacts estimated at €5.3 billion.

Law no. 98/2021 of 31 December (the Climate Framework Law) recognises the state of climate emergency and provides for sectoral and municipal adaptation instruments. The National Strategy for Adaptation to Climate Change 2030 (ENAAAC 2030), the third cycle of national adaptation policy currently undergoing approval, identifies cultural heritage as a sensitive sector. None of these instruments, however, incorporates specific operational measures for archaeological heritage or differentiated technical criteria for risk assessment. It is this gap that the BLUE HERITAGE project seeks to close.

Analysis / Key Findings

Institutional diagnosis

The BLUE HERITAGE project has identified structural weaknesses in the protection of archaeological sites in zones of climate risk, revealing the absence of continuous monitoring mechanisms, of institutional response protocols and of integration into spatial planning instruments. The Endovérico — Information System for Archaeological Heritage, managed by Património Cultural, I.P., does not currently provide for a differentiated designation for sites at climate risk, which constrains the capacity for prioritisation and preventive intervention. This limitation reflects a systemic gap in the national regulatory framework: the ENAAAC 2030, currently undergoing approval, recognises cultural heritage as a sensitive sector but includes no specific operational measures, differentiated technical criteria or dedicated indicators for archaeological heritage; the opinion of the Economic and Social Council on the ENAAAC 2030 (11 March 2026), although it criticises the strategy for remaining excessively programmatic, likewise devotes no separate section to this heritage dimension.

Methodology and instruments developed

The project's methodological response was structured around four operational axes applied

to three pilot areas representative of the dominant geomorphological regimes of the Portuguese coastline and lower river courses: Salvaterra de Magos (Tagus alluvial plain); Loulé (low sandy coast); and Vila do Bispo (cliffs in Palaeozoic schists and Mesozoic limestones). A methodology comprising three adapted versions was developed: the fluvial Archaeological Vulnerability Index (IVA), the Coastal Archaeological Vulnerability Index (IVCA) and the hybrid event-based IVCA, calibrated exclusively from the peer-reviewed scientific literature available for the national territory (Antunes et al., 2018, 2019; Marques, 2008; Teixeira, 2014). From this analytical matrix three operational cartographic designations were derived, conceived for integration into Portuguese territorial management instruments: ASAF (fluvial), ASAC (coastal) and ASAR (cliff).

The project's intervention unfolded across four complementary operational axes:

1. **Heritage risk diagnosis**, combining geospatial, environmental and archaeological data, drawing on GIS, remote sensing and supervised learning to identify patterns of vulnerability. The results

are consistent with the documented historical evidence for the Tagus valley (the 1966 flood, Roche, 1974) and for the Algarve leeward coast (changes in sediment transport since 1971–74 following the construction of the Vilamoura marina and the Quarteira groynes);

2. **Development of the mobile application RISCUS – Alert System for Archaeological Heritage at Risk**, a prototype validated in the field by the scientific team and designed for the georeferenced recording of occurrences and timely support for technical action. Its operationalisation at national scale requires institutional co-development, drawing on consolidated models such as SCAPE/SCHARP (Scotland) and CITiZAN (England);
3. **Drafting of heritage contingency plans**, articulating safeguarding, institutional response and legal framing (Law no. 107/2001 of 8 September; Decree-Law no. 78/2023 of 4 September; Law no. 98/2021 of 31 December);
4. **Production of technical manuals and capacity-building activities**, directed at municipal technical staff, civil protection structures and heritage bodies.

These solutions were conceived to be replicable, of relatively low cost and of immediate applicability in the national context.

Quantitative results

The application of the IVA/IVCA methodological family to the 419 archaeological sites inventoried across the three pilot areas classifies 115 sites (27.4%) as being at identified climate risk, of which 27 (6.4%) are at critical risk of total loss. The most substantively significant result is the geomorphological asymmetry of the Portuguese Mesolithic sub-universe, which is distributed across two typologies with radically distinct profiles of heritage exposure: the fluvial and estuarine Mesolithic, represented by the Muge Shell Middens in Salvaterra de Magos, with 10 of its 12 sites at heritage risk (83.3%); and the oceanic coastal Mesolithic, represented by the sites of the south-western Algarve in Vila do Bispo, with only 2 of its 28 sites at identified risk (7.1%). This asymmetry, anchored in the geomorphological settlement configuration of each sub-universe, lays bare the disproportionate vulnerability of the Muge Shell Middens (designated a National Monument by Decree no. 16/2011), one of the densest Mesolithic landscapes known in Atlantic Europe. The February 2026 flood episode, mapped by Copernicus EMS (activation EMSR864), reached the Tagus, Mondego, Sado and Guadiana basins, with 688.4 km² of inundated area in the Abrantes–Tagus Estuary ARPSI. In the Tagus valley, four Mesolithic sites were effectively submerged outside the official perimeter of this ARPSI, demonstrating that the regulatory cartography in force, although technically sound, presents margins of uncertainty in its marginal areas that may be objectively exceeded in real extreme events

Figure 1 – Neolithic site of Praia do Forte Novo, Loulé. March 2025.



Source: Carlos Duarte Simões, 2025.

Policy Options and Recommendations

The safeguarding of coastal and riverine archaeological heritage in the face of climate change falls within the constitutional duties of the Portuguese State. Article 9(e) of the Constituição da República Portuguesa establishes as a duty of the State, simultaneously, the protection and enhancement of cultural heritage, the defence of nature and the environment, the preservation of natural resources and the assurance of proper spatial planning — that is, precisely the four dimensions in which the challenge identified here is inscribed. Article 3 of Law no. 107/2001 of 8 September reinforces this framework by declaring the knowledge, study, protection, enhancement and dissemination of cultural heritage to be a duty of the State, the Autonomous Regions and the local authorities. In view of the growing vulnerability of archaeological heritage and the manifest loss already under way, this constitutional and legal framework underpins the need for a national safeguarding programme, articulated with the Estratégia Nacional de Adaptação às Alterações Climáticas 2030 (ENAAC 2030), Law no. 98/2021 of 31 December (the Climate Framework Law), and the second-cycle Flood Risk Management Plans (Council of Ministers Resolution no. 63/2024 of 22 April), which expressly recognise cultural heritage as an affected receptor. Six policy options are proposed, complementary and capable of phased implementation:

- **Integrate the archaeological sensitivity areas into territorial management instruments.** The designations ASAF (Fluvial Archaeological Sensitivity Area), ASAC (Coastal Archaeological Sensitivity Area) and ASAR (Cliff Archaeological Sensitivity Area) should be integrated into the Coastal Zone Programmes (POC), Flood Risk Management Plans (PGRI), Municipal Climate Action Plans (PMAC) and Municipal Master Plans (PDM), under a legal regime of administrative easement coordinated among Património Cultural, I.P., the APA, the CCDR and the municipalities.
- **Establish the designation "Archaeological Site at Climate Risk".** The introduction of a differentiated designation within the Information System

for Archaeological Heritage, with three alert levels (monitoring, priority action, imminent loss), will enable the technical prioritisation of interventions and the systematic monitoring of the most vulnerable sites.

- **Operationalise the RISCUS application as an instrument for monitoring and early warning.** The prototype developed and validated in the field by the scientific team should be scaled up for national use, through institutional co-development among Património Cultural, I.P., the CCDR and the municipalities. The application ensures the georeferenced recording of occurrences, timely support for technical action and the production of systematic data for risk monitoring.
- **Formalise a national protocol for emergency archaeological response.** The creation of a procedure actionable within 72 hours of extreme climate events, involving Património Cultural, I.P., the Autoridade Nacional de Emergência e Proteção Civil (ANEPC), the CCDR and the municipalities, with a pre-mobilised team and a simplified authorisation procedure under Decree-Law no. 164/2014 of 4 November, will make it possible to respond to the critical window for post-event archaeological intervention, which is at present non-existent.
- **Strengthen the Cultural Heritage Safeguarding Fund with a dedicated funding line for "Heritage at Climate Risk".** The creation of a specific line within the Fund (Decree-Law no. 138/2009 of 15 June), co-financed by the Environmental Fund and aligned with the Regional Operational Programmes of Portugal 2030, will make it possible to finance emergency excavation, 3D recording, preventive conservation and the training of municipal technical staff, equipping the heritage system with the financial means necessary for the implementation of the remaining recommendations.
- **Establish national programmes dedicated to the critical archaeological periods at climate risk.** The documented vulnerability of the fluvial and estuarine Mesolithic of the lower Tagus, with 83.3% of sites at heritage risk in the Muge Shell

Middens, constitutes the paradigmatic example of this need. The model applies to any chronological or typological assemblages that may prove to display a similar concentration of risk through the convergence of climatic exposure and geomorphological settlement configuration, with dedicated programmes of documentation, monitoring and study under the coordination of Património Cultural, I.P. in articulation with the scientific teams specialising in the respective period.

These options can be implemented in a phased manner, drawing on instruments already in place (ENAAAC 2030, PGRI, POC, the

Environmental Fund) and seizing the policy window opened by the revision of the ENAAAC 2030 and by the third cycle of the PGRI (2028–2033). Their adoption responds directly to the recommendation of the Economic and Social Council, which in its opinion on the ENAAAC 2030 (2026) underscores legislative and operational simplification as a condition for the effectiveness of adaptation measures. It likewise reinforces the coherence between climate, spatial planning and archaeological heritage preservation policies, equipping Portugal with instruments comparable to those of the Heritage at Risk Register (England), the SCHARP programme (Scotland) and the Climate Vulnerability Index for Cultural Heritage promoted by UNESCO and ICOMOS.

Conclusion

The growing vulnerability of coastal and riverine archaeological heritage to climate change constitutes an unavoidable challenge for public policy in Portugal. The extreme events of the past twelve months — notably the succession of storms along the Atlantic coast between the winter of 2024–2025 and early 2026, and the floods of February 2026 in the Tagus, Mondego, Sado and Guadiana basins, with a declared state of calamity in 68 municipalities and a national economic impact estimated at €5.3 billion — demonstrate that the absence of preventive, coordinated and territorially anchored mechanisms of action places at risk sites of high historical and scientific value, whose loss is irreversible. As the opinion of the Economic and Social Council on the ENAAAC 2030 (2026) underscores, the prevention and anticipation of risk prove, in the medium and long term, to be more economically efficient and socially fairer than ex post responses — a principle that applies with particular acuity to archaeological heritage, since its destruction, unlike that of other public goods, cannot be offset by reconstruction.

The BLUE HERITAGE project demonstrates the technical feasibility of operational solutions adapted to the national reality, developed in

collaboration with local authorities and the CCDR Algarve. The RISCUS mobile application, the heritage contingency plans, the protocols for inter-institutional cooperation and the proposed creation of the designation "Archaeological Site at Climate Risk" constitute concrete instruments, of relatively low cost and ready to be integrated into the existing arrangements for spatial planning, civil protection and climate adaptation, subject to the institutional co-development required for their national scaling.

The policy window of opportunity is exceptional: the imminent approval of the ENAAAC 2030, the start of the preparatory work for the third cycle of the PGRI (2028–2033) and the creation of the Agência do Clima, I.P. (Decree-Law no. 122/2024 of 30 December) converge on a unique moment for operationalisation. The adoption of these solutions makes it possible to reinforce, in an effective manner, the integration of heritage safeguarding into municipal adaptation plans, territorial management instruments and regional resilience strategies, helping to ensure that archaeological heritage does not become one of the silent victims of the climate crisis.

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