FENIX Toolkit User Manuals





Art-Risk 1.0

USER MANUAL

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1. What is Art-Risk 1.0 and what is it used for?

Art-Risk 1.0 is an application used to assess the vulnerability of architectural complexes by recording the frequency and intensity of alteration indicators present in their structures.

The application is available online for your free use (https://www.upo.es/investiga/art-risk-service/art-risk1/artrisk1) and has been developed by the Pablo de Olavide University (PAI TEP 199) within the framework of the projects "Diagnosis and Cataloguing of Andalusian Architectural Heritage through Risk and Vulnerability Analysis" (UPO.20-01) and "Feasibility analysis and end-user testing of Apps for the prevention and management of fires or natural disasters for the

conservation of movable and immovable Cultural Heritage - PHOENIX 4.0" (PDC2022-033157-I00).

Art-Risk 1.0 allows the user to record the frequency with which indicators of alteration or pathologies present in a fortification built of adobe brick appear. Based on this data, the Art-Risk 1.0 application calculates the intensity of the damage and provides a vulnerability index that helps to determine the state of conservation of the heritage element analysed.

The Art-Risk 1.0 application is a computerised tool based on the Art Risk 1 methodology for risk analysis in heritage environments, developed by the PAI TEP 199 team from the Pablo de Olavide University and tested in the analysis of risk and the state of conservation of heritage environments through various projects (Ortiz & Ortiz, 2016; Moreno, 2023[1]).

2. Basic concepts for using Art-Risk 1.0

To understand Art-Risk 1.0, the user must know the following basic concepts:

1. **MAU:** *MAU* is the acronym for *Minimum Analysis Unit*. The *Minimum Analysis Unit*, hereinafter the *MAU*, is the term that refers to the basic structure, understood as a basic unit of measurement, which together with other *MAU*s and in relation to them, forms an architectural complex. For example: within a walled enclosure formed by a set of towers, walls and access gates, each tower, wall and gate can be understood as an independent *MAU* in which indicators of alteration or pathologies can be identified.

2. **Indicators of alteration or pathologies:** *Indicators of alteration* or *pathologies* are those signs of material modification that occur within a building, and which are symptomatic of the presence of problems that may affect its internal and surface structures. There are 22 *indicators of alteration* or *pathologies* that can affect a structure and that we can record through Art-Risk 1.0 and these are taken from the "Illustrated Glossary on Stone Deterioration Patterns" by ICOMOS.

   Each of these *indicators of alteration* or *pathologies* may have one or several causes produced by internal factors (construction type, incompatibility of materials, construction technique, subsequent interventions, etc.) and / or external factors (precipitation, wind, temperature changes, geotechnics, etc.). For more information, see the glossary of pathologies in Annex 1.

3. **Alteration factors or degradation agents:** The term *alteration factors* or *degradation agents* defines those phenomena or elements that are or may be the cause of the presence of indicators of alteration or pathologies in a property. These may be

[1] Ortiz, R., & Ortiz, P. (2016). Vulnerability index: A new approach for preventive conservation of monuments. *International Journal of Architectural Heritage*, 10(8), 1078-1100.
Moreno, M. (2023) *Nuevas tecnologías geoespaciales aplicadas a la gestión de riesgos en entornos patrimoniales: la preservación de fortificaciones de tapia mediante teledetección, índices de vulnerabilidad y sistemas de información geográfica*. Unpublished Doctoral Thesis, Pablo de Olavide University.

natural and of a climatic nature, in relation to the exposure of the space to various inclement weather conditions, characteristics of the terrain, or social, in relation to the use or disuse of the property and its surroundings. In Art-Risk 1.0, 18 *alteration factors* or *degradation agents* can be recorded in relation to the indicators of alteration or pathologies.

4. **Frequency:** The term *frequency* refers to the regularity or repetition in which an indicator of alteration or pathology appears in an MAU. The *frequency* can be recorded on a scale from 0 to 3, with 0 being the non-appearance of the pathology, 1 being the appearance with low *frequency*, 2 being medium *frequency* and 3 being high *frequency*.

5. **Magnitude:** The term *magnitude* refers to the severity of the impact that each indicator of alteration or pathology represents for a structure or MAU. The *magnitude* varies from 1 to 5 in relation to the different pathologies, depending on whether their presence within a structure is more or less harmful. For example, rubefaction has a *magnitude* of 1, while fracturing has a *magnitude* of 5. This is because the presence of fractures in a structure is much more damaging to it than the presence of rubefaction. The fragmentation pathology is the only one that has a magnitude of 10, which is interpreted as meaning fracture plus displacement, making it the pathology with the highest magnitude of all those present in Art-Risk 1.0.

6. **Intensity:** The term *intensity* refers to the level of deterioration caused by an indicator of alteration or pathology present in a MAU. The *intensity* of the deterioration is obtained from the sum of the *magnitude* of the pathology and the *frequency* with which it has been recorded.

7. **Vulnerability:** The term *vulnerability* defines how vulnerable an MAU or the set of MAUs that form an architectural complex is to potential external dangers. *Vulnerability* would thus be a variable of an internal nature, based on the analysis of the state of the heritage element, which would be based on the pathologies it presents and that are manifested on the surface.

8. **Vulnerability Index (VI):** Expression of the *vulnerability* presented by an MAU or a set of them based on the comparison of the *intensity* of the deterioration (*magnitude* + *frequency*) that the recorded pathologies represent with the *intensity* of the damage that the pathologies would involve in the worst-case scenario, that is, in the hypothetical case that all of the pathologies were present and manifested with a *frequency* of 3.

3. How do I use Art-Risk 1.0?

The Art Risk 1.0 application is divided into two screens that require the user to enter specific data. The screens are consecutive and the application does not allow access to the second screen until data has been recorded on the first screen.

3.1. First screen: Pathology frequency record

The first Art-Risk 1.0 screen allows you to enter basic data about the property you want to analyse and to enter data on the recorded frequency of pathologies by MAU.

At the bottom of the screen is a list of 22 pathologies with their associated magnitude. Below the list, by default, the boxes of the first MAU appear, all marked with the number 0 (Figure 1).

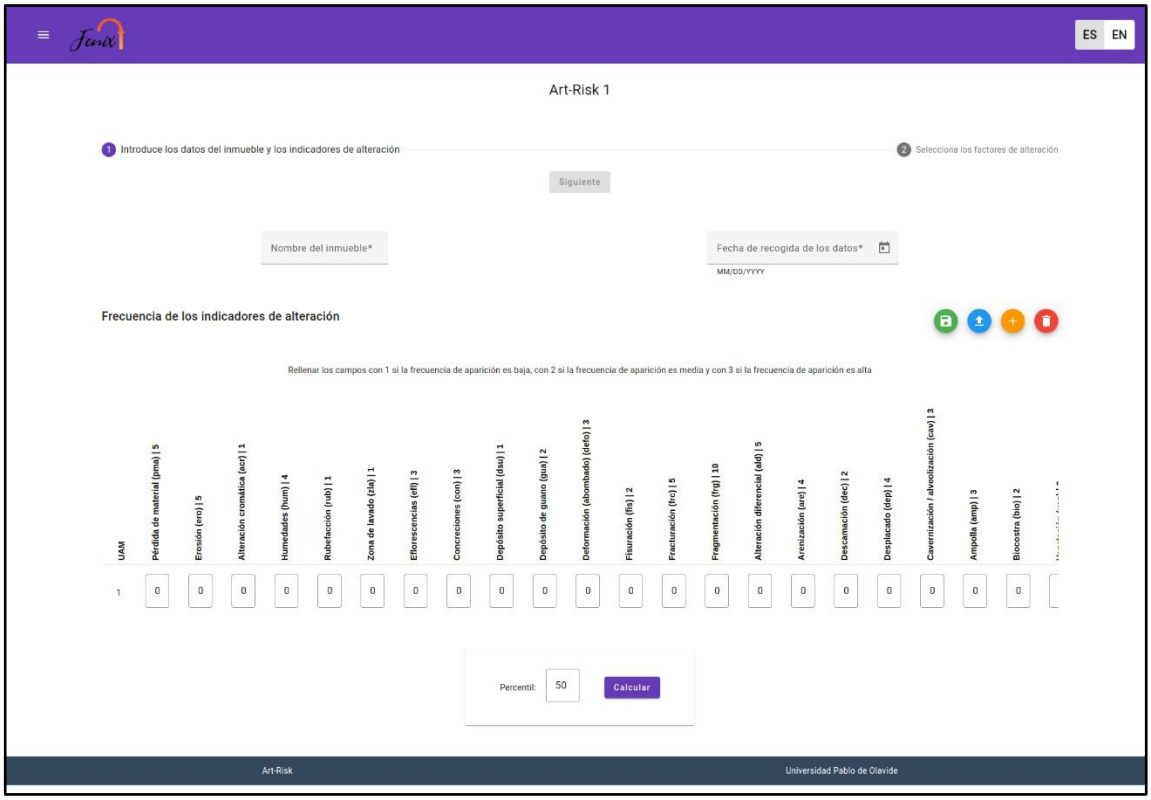


Figure 1. First Art-Risk 1.0 screen in which to enter the property data and the alteration indicators.

The boxes must be filled in with the frequency of appearance of pathologies recorded in each MAU that we analyse. It is essential to fill in all the boxes with 1, 2 or 3, depending on the frequency of appearance of the pathology, or with 0 if the pathology does not appear in the MAU. It is essential not to leave any box blank so that the application can perform its functions.

To add Minimum Analysis Units (MAU), just press the button located above the list of pathologies. On the contrary, the button clears the boxes of the last MAU (Figure

2). In addition, the MAU data can be temporarily saved using the button and loaded back using the button.

Below the list of pathologies and the boxes where the frequency of pathologies present in the MAUs is recorded, we can modify the percentile by which we want to calculate the intensity of damage caused by the recorded pathologies.

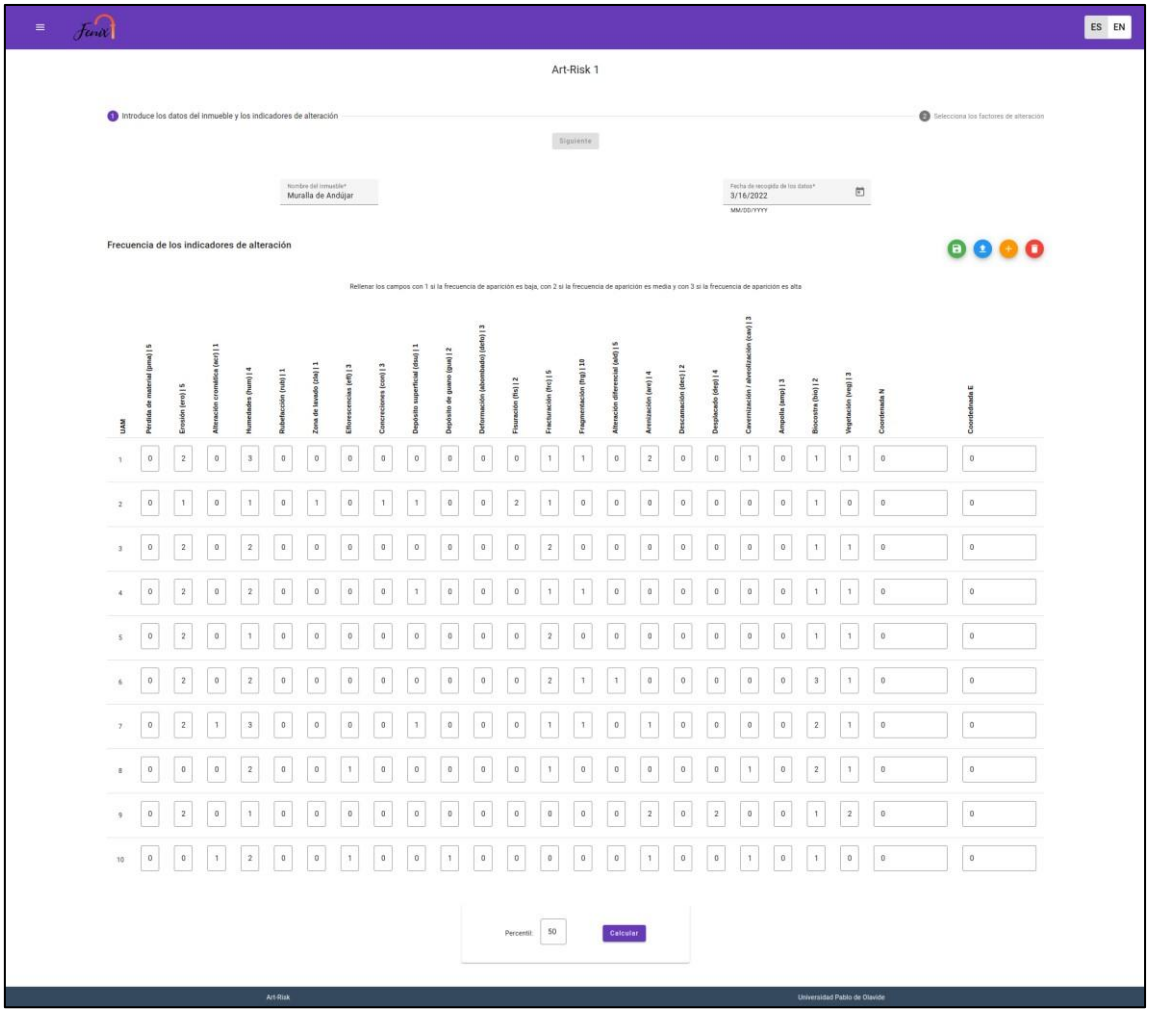


Figure 2. First Art-Risk 1.0 screen with the data and frequencies of alteration indicators recorded in the wall of Andújar (Jaén) marked in the boxes.

By clicking the *calculate* Calcular button, Art-Risk 1.0 calculates the intensity of damage to the property under analysis and breaks down a frequency table and a bar chart in which we can visualise the frequency of pathologies in the property (Figure 3).

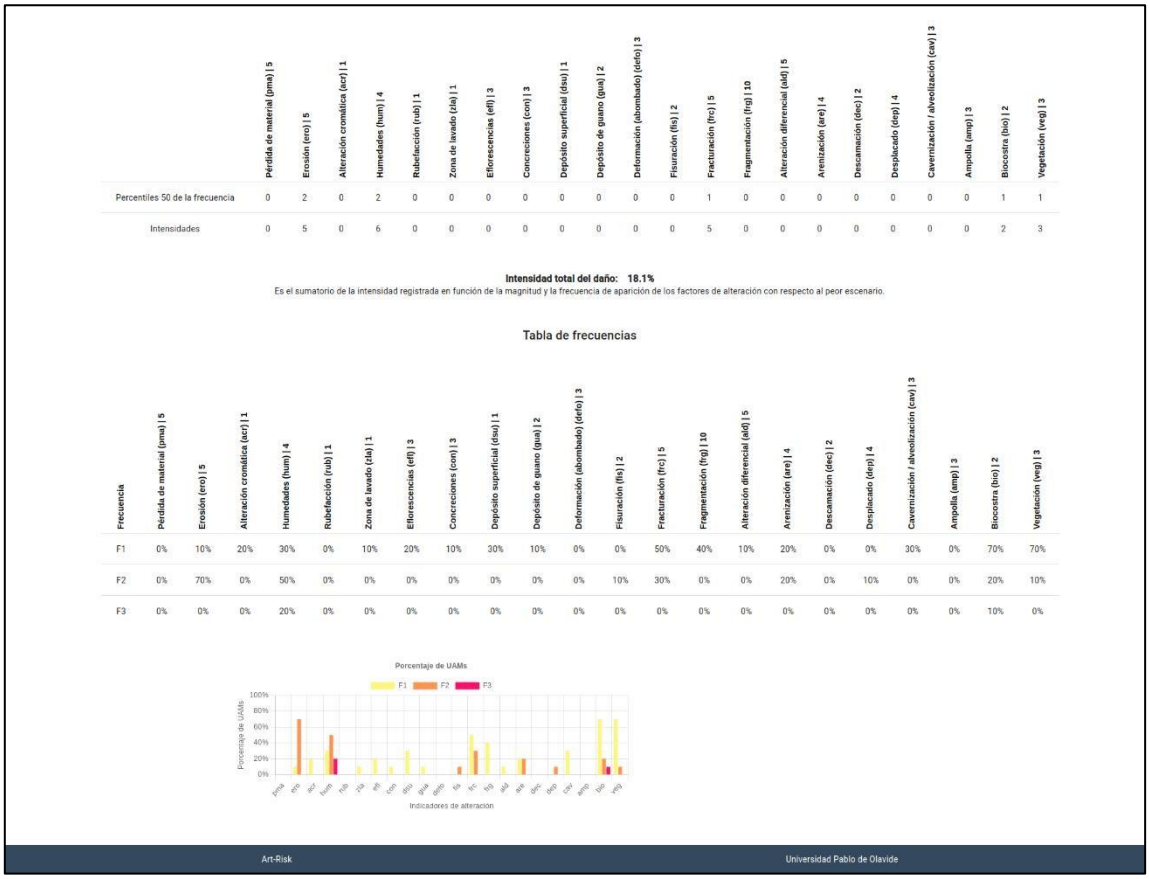


Figure 3. Data on the total intensity of damage caused by the magnitude and frequency of appearance of pathologies and frequency tables of alteration indicators recorded in the wall of Andújar (Jaén).

3.2. Second screen: Degradation agent record

Once the damage intensity has been calculated, the application allows access to the second screen, where the alteration factors or degradation agents can be selected.

To access the second screen, the 

button at the top of the first screen must be clicked.

This screen contains the 18 alteration factors or degradation agents that may be the cause of the indicators of alteration or pathologies recorded within the property (Figure 4).

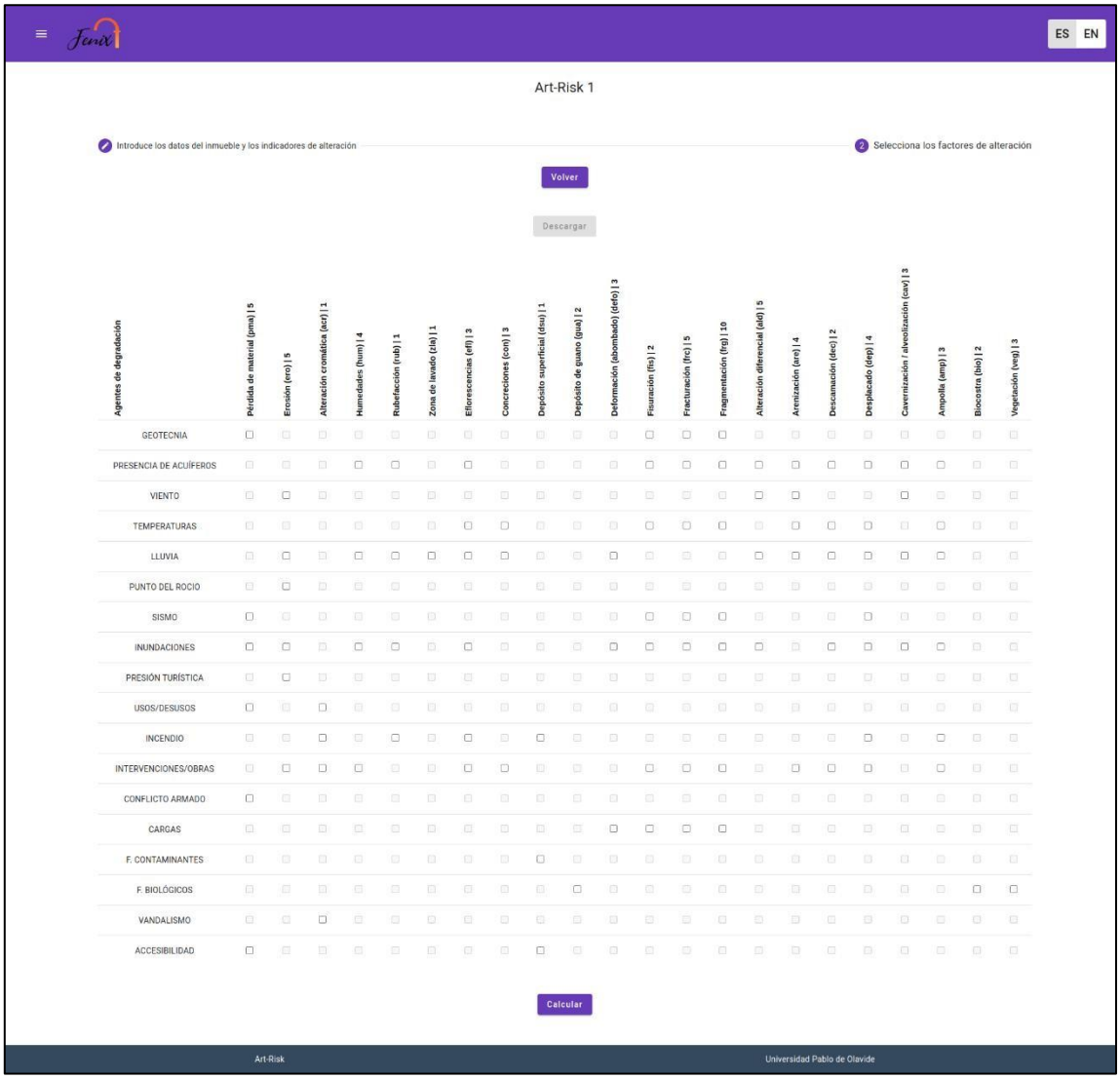


Figure 4. Second Art-Risk 1.0 screen, in which to enter data relating to the degradation agents causing the alteration indicators recorded.

To calculate the Vulnerability Index (VI), the boxes in which the alteration factor or degradation agent that is causing the presence of indicators of alteration or pathologies is indicated must be marked, marking as many boxes as deemed necessary. (Figure 5).

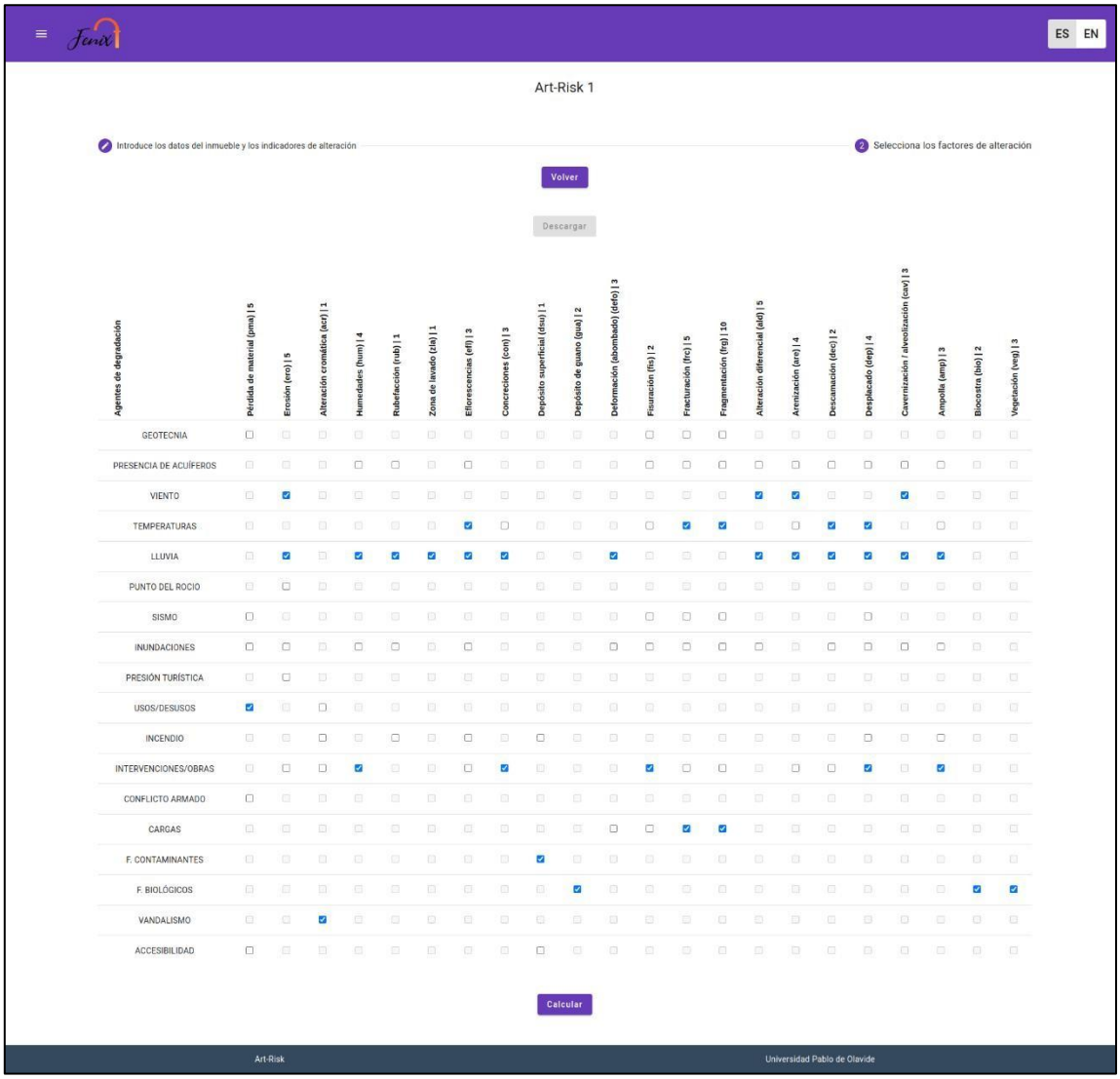


Figure 5. Second Art-Risk 1.0 screen with data relating to the degradation agents causing the alteration indicators recorded in the wall of Andújar (Jaén).

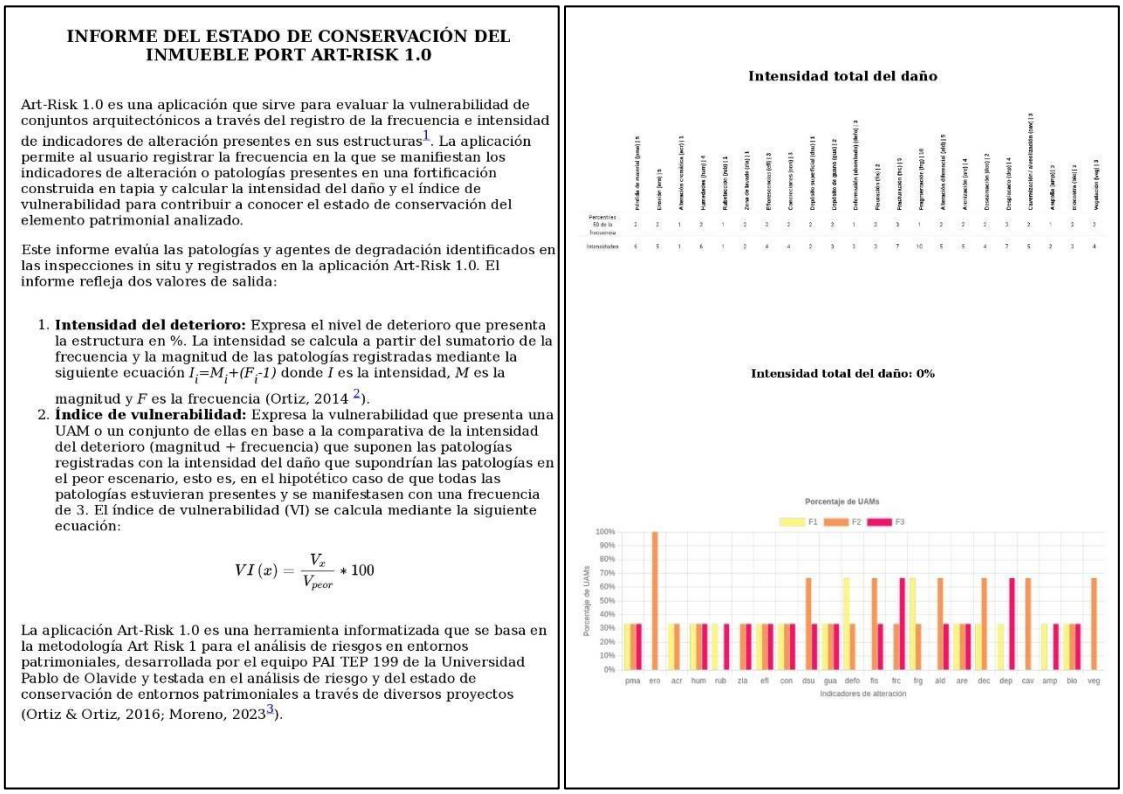
Once the boxes are checked, we can press the Calculate button so that ArtRisk 1.0 provides us with the Vulnerability Index (VI) of the property analysed (Figure 6).



Figure 6. Vulnerability index calculated by the Art-Risk 1.0 application regarding data recorded in the Andújar wall (Jaén).

4. Report

Once the data has been entered and the damage intensity and vulnerability index of the property under analysis have been calculated, the Art-Risk 1.0 application allows you to download a report by pressing the descargar button, generating a document in PDF format with all the information recorded and obtained by the application (Figure 7).



INFORME DEL ESTADO DE CONSERVACIÓN DEL INMUEBLE PORT ART-RISK 1.0

Art-Risk 1.0 es una aplicación que sirve para evaluar la vulnerabilidad de conjuntos arquitectónicos a través del registro de la frecuencia e intensidad de indicadores de alteración presentes en sus estructuras[1]. La aplicación permite al usuario registrar la frecuencia en la que se manifiestan los indicadores de alteración o patologías presentes en una fortificación construida en tapia y calcular la intensidad del daño y el índice de vulnerabilidad para contribuir a conocer el estado de conservación del elemento patrimonial analizado.

Este informe evalúa las patologías y agentes de degradación identificados en las inspecciones in situ y registrados en la aplicación Art-Risk 1.0. El informe refleja dos valores de salida:

1. **Intensidad del deterioro:** Expresa el nivel de deterioro que presenta la estructura en %. La intensidad se calcula a partir del sumatorio de la frecuencia y la magnitud de las patologías registradas mediante la siguiente ecuación $I_i=M_i+(F_i-1)$ donde I es la intensidad, M es la magnitud y F es la frecuencia (Ortiz, 2014 [2]).
2. **Índice de vulnerabilidad:** Expresa la vulnerabilidad que presenta una UAM o un conjunto de ellas en base a la comparativa de la intensidad del deterioro (magnitud + frecuencia) que suponen las patologías registradas con la intensidad del daño que supondrían las patologías en el peor escenario, esto es, en el hipotético caso de que todas las patologías estuvieran presentes y se manifestasen con una frecuencia de 3. El índice de vulnerabilidad (VI) se calcula mediante la siguiente ecuación:

$$VI\,(x) = \frac{V_x}{V_{peor}} * 100$$

La aplicación Art-Risk 1.0 es una herramienta informatizada que se basa en la metodología Art Risk 1 para el análisis de riesgos en entornos patrimoniales, desarrollada por el equipo PAI TEP 199 de la Universidad Pablo de Olavide y testada en el análisis de riesgo y del estado de conservación de entornos patrimoniales a través de diversos proyectos (Ortiz & Ortiz, 2016; Moreno, 2023[3]).

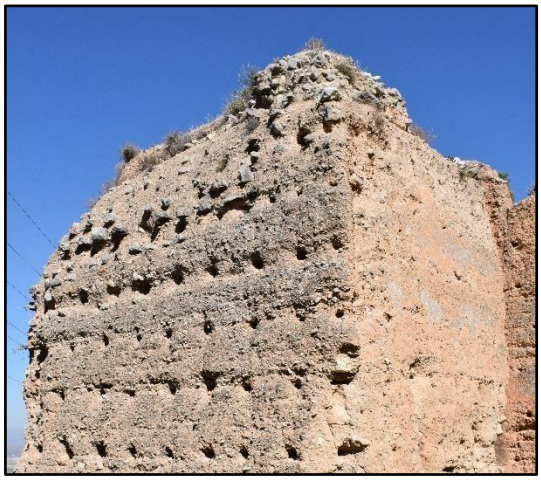
Figure 7. Property conservation status report by Art-Risk 1.0.

Annex 1. Glossary of pathologies

The Art-Risk 1.0 application is designed to analyse the state of conservation of walled enclosures built of abode brick, a type of historical defensive architecture that is particularly abundant on the Iberian Peninsula and in the Mediterranean basin.

Below, we offer the user a glossary of indicators of alteration or pathologies recorded on the surface of various walled enclosures that can serve as an example and reference for the on-site inspection and recording of pathologies in ArtRisk 1.0 by the user[2].

Alteration indicator: Loss of material.	
Empty space where there used to be material.	
Potential degradation agents: Geotechnics, earthquake, floods, uses / disuses, armed conflict, accessibility.	

Alteration indicator: Erosion.	
Loss of the original surface that generates smoothing of the shapes.	

[2] The descriptions of alteration indicators are those set out in: Moreno, M. (2019), *Vulnerability study in urban fortifications. El caso de las cercas defensivas de Sevilla, Carmona and Estepa*, Master's Thesis, Pablo de Olavide University.

Potential degradation agents: Wind, rainfall, dew point, floods, tourist pressure, interventions / works.

Alteration indicator: Chromatic alteration.	
Changes in tone, saturation and / or luminosity on the surface due to painting with ink or other similar products.	
Potential degradation agents: Uses / disuses, fire, interventions / works, vandalism.	

Alteration indicator: Dampness.	
Darkening of the surface due to the presence of water and the adhesion of dust, grime or biological colonies.	
Potential degradation agents: Presence of aquifers, rainfall, floods, interventions / works.	

Alteration indicator: Rubefaction.	
Redness on the surface of materials that persists over a depth of several millimetres. This is a relatively frequent occurrence in sandstones and limestones, and is attributed to the leaching of the iron oxides inside the rock by the action of water.	
Potential degradation agents: Presence of aquifers, rainfall, floods, fire.	

Alteration indicator: Washout area.	
Phenomenon by which the chemical components of the material are separated and transported. It is produced by the frequent and uniform circulation of rainwater over a surface.	
Potential degradation agents: Rainfall.	

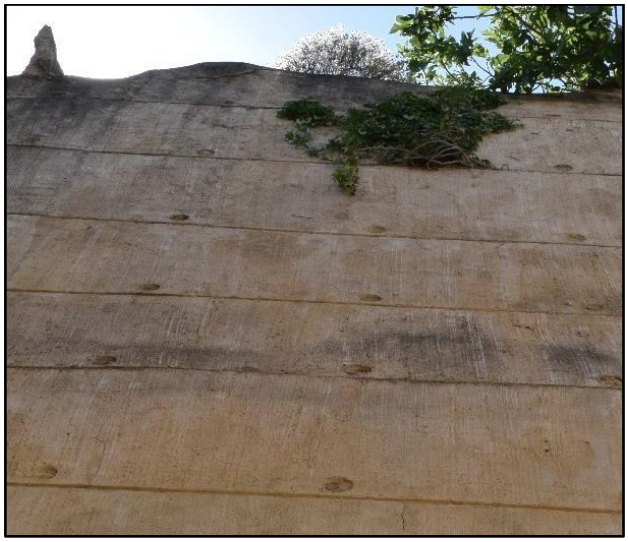
Alteration indicator: Efflorescence.	
Crystalline powdery accumulation, lightly bonded to the support and generally whitish, composed of soluble salts.	
Potential degradation agents: Biological phenomena.	

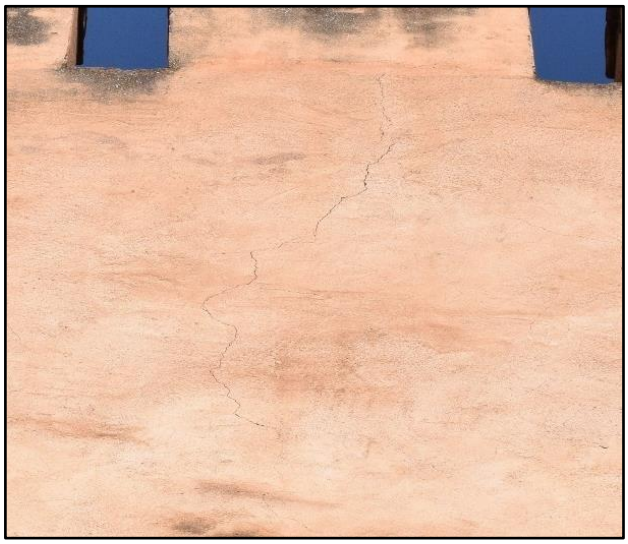
Alteration indicator: Concretions.	
Coherent and irregular accumulation of material on the surface. It may be strongly or weakly attached to the substrate. Indicative of a process of precipitation and subsequent leaching.	
Potential degradation agents: Temperature changes, rainfall, intervention / works.	

Alteration indicator: Surface deposit.	
Fouling due to accumulation of exogenetic material of variable thickness.	
Potential degradation agents: Fire, pollution, accessibility.	

Alteration indicator: Guano deposit.	
Deposit of variable thickness, cohesion and adhesion formed by excreted organic matter (usually by birds and bats).	
Potential degradation agents: Biological phenomena.	

Alteration indicator: Deformation (Bulging).	

Deformation of the shape or volume of the material that causes swelling of the base due to the displacement of soil particles from the core of the wall towards the base.	
Potential degradation agents: Rainfall, floods, loads.	

Alteration indicator: Cracking.	
Formation of discontinuity solutions in the mortar with little or no displacement and separation of parts. The size must be millimetric.	
Potential degradation agents: Geotechnics, presence of aquifers, temperature changes, earthquakes, floods, interventions / works, loads.	

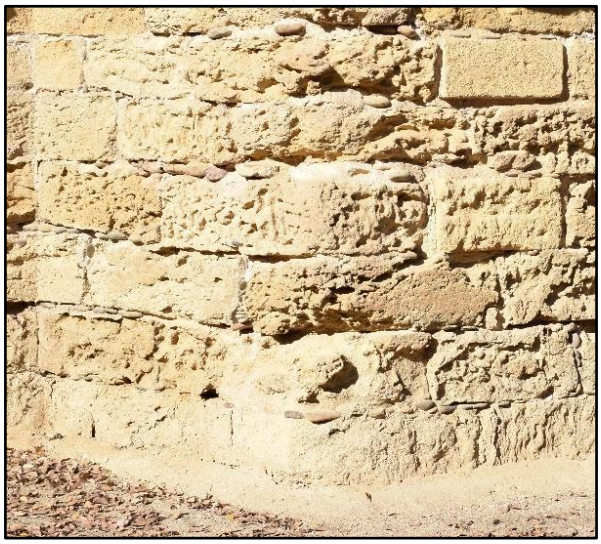
Alteration indicator: Fracturing.	

Formation of discontinuity solutions in the mortar with little or no displacement and separation of parts. The size must be greater than several millimetres.	
Potential degradation agents: Geotechnics, presence of aquifers, temperature changes, earthquakes, floods, interventions / works, loads.	

Alteration indicator: Fragmentation.	
Formation of discontinuity solutions in the mortar with displacement and separation of parts.	
Potential degradation agents: Geotechnics, presence of aquifers, temperature changes, earthquakes, floods, interventions / works, loads.	

Alteration indicator: Differential alteration.	

Subtype of erosion that does not progress equally in different areas. Differential erosion in which the cement or matrix of the stone is lost and some components are left in relief.	
Potential degradation agents: Presence of aquifers, wind, rainfall, floods.	

Alteration indicator: Granular decohesion.	
Detachment of individual grains and aggregates thereof.	
Potential degradation agents: Presence of aquifers, wind, temperature changes, rainfall, interventions / works.	

Alteration indicator: Scaling.	

Physical separation of one or more layers in a laminar manner and parallel to the surface of the wall. The thickness of the peeled off layers must be several millimetres.	
Potential degradation agents: Presence of aquifers, temperature changes, rainfall, floods, interventions / works.	

Alteration indicator: Displacement.	
Physical separation of one or more layers in a laminar manner and parallel to the surface of the wall. The thickness of the detached layers must be several centimetres.	
Potential degradation agents: Presence of aquifers, temperature changes, rainfall, earthquake, floods, fire, interventions / works.	

Alteration indicator: Cavernisation / alveolisation.	

Non-uniform loss of material located on the surface. Formation of rounded cavities or alveoli of variable shape and size.	
Potential degradation agents: Presence of aquifers, wind, rainfall, floods.	

Alteration indicator: Blister.	
Semi-spherical elevations filled with air as a result of the detachment of the outer layer of material.	
Potential degradation agents: Presence of aquifers, temperature changes, rainfall, floods, fire, interventions / works.	

Alteration indicator: Biocrust.	

Biological film composed of colonies of microorganisms.	
Potential degradation agents: Biological phenomena.	

Alteration indicator: Vegetation.	
Growth of plant organisms.	
Potential degradation agents: Biological phenomena.	

Annex 2. Cataloguing card template

Art-Risk 1.0 allows the user to download a cataloguing card template in which to record information of various kinds for the purpose of cataloguing the heritage assets under analysis in a standardised manner.

Like the application, the cataloguing card has been developed for the analysis of fortifications. At the user's initiative, the card may be used to reflect cartographic, photographic, historical or construction information, among others, in order to comprehensively understand the asset being analysed.

Below, the user is offered an example of a cataloguing card completed with real information on the city wall of Andújar analysed within the framework of the project "Diagnosis and cataloguing of Andalusian Architectural Heritage through Risk and Vulnerability Analysis (UPO.20.01)", in February 2022.

CARD NO. 1. Vulnerability study of adobe brick fortifications				
Fortification	City wall of Andújar	**Code Date** 2022 **AND_AND**	February	**Level of protection under heritage law:** Declared a Historic-Artistic Monument (BOE, 125, 05 May 1949). Declared a Site of Cultural Interest (BIC) under the category of Monument (BOE, 155, 29 June 1985).
Sections	Section on Calle Luis Vives Section on Calle Hoyo Section on the Paseo de Colón Tower on the Paseo de las Vistillas			
Municipality	Andújar	**Georeference** 38.03580, -4.05305		**Level of protection under urban planning law:** Level A - Comprehensive protection.

Location plan and sketch of the fortified system



General overview



Almohad period (12th - 13th centuries) and late medieval (14th-15th centuries).

Historical use Defence and tax control of the city.	**Current use** Exempt element. Asset of Cultural Interest. Separating wall.

Description

The city wall of Andújar (AND_AND) is a fortified enclosure of Almohad origin (12th - 13th centuries) with renovations in the late medieval period (14th - 15th centuries) that established a trapezoidal perimeter around the historic centre of Andújar, the former space of the medieval medina. The enclosure under analysis preserves 9 rectilinear walls and square towers attached to the exterior that retain a height of approximately 6 to 8 metres, with one of the towers retaining a height of more than 10 metres. The walls and towers are built from simple adobe brickwork with courses of brick and cladding made of ashlar, masonry and brick.

The preserved wall is divided into four sections: the section on Calle Luis Vives (AND_LVI), the section on Calle Hoyo (AND_CHY), the section on the Paseo de Colón (AND_COL) and the section on the Paseo de las Vistillas (AND_VIS).

The section on Calle Luis Vives (AND_LVI) is made up of three rectilinear walls and two square towers attached to the exterior that are located on Calle Luis Vives. Some of the walls act as dividing walls for modern buildings. The towers and walls are built from simple adobe brickwork and exhibit the remains of brick courses and brick cladding.

The section on Calle Hoyo (AND_CHY) is made up of a square tower attached to the side of a modern building. It is built from simple adobe brickwork and has a brick and masonry cladding at its base.

The section on the Paseo de Colón (AND_COL) is made up of a square tower called Torreón de la Fuente Sorda and a wall to which it is attached. The wall and tower are built of adobe brick, the tower has ashlar cladding and the wall, which acts as a dividing wall of a modern building, has brick and masonry cladding.

The section on the Paseo de las Vistillas (AND_VIS) is made up of a square tower called Torreón de Tavira, attached to a modern building. It is built of adobe brick but has ashlar cladding.

Construction materials	Adobe brick	**Presence of ceramic debris**	**Yes**
Predominantly arid	Ceramic and stone material	**Presence of lime nodules**	Yes
Cladding type	Ashlar, masonry and brick	**Presence of a plinth**	Yes
		Single and / or continuous compartment	Individual
Construction technique		**Maximum height**	**10 metres**

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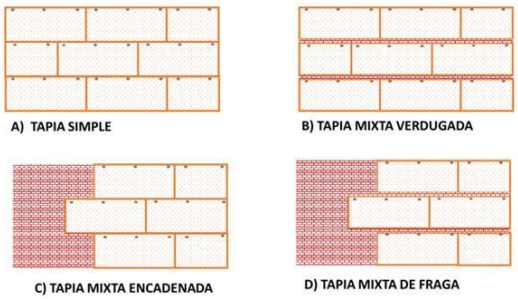
<tr><td colspan="4">
</td><td rowspan="6">Palomino, J. A., & Castillo, J. C. (2015). Transformaciones urbanísticas de Andújar a través de la muralla medieval. Provincial Council of Jaén. Instituto de Estudios Giennenses. https://www.researchgate.net/publication/277059922</td></tr>
<tr><td>A) Simple Adobe Brickwork</td><td>x</td><td>B) Adobe Brick Courses</td><td>x</td></tr>
<tr><td>C) “Chained” Abode Brick</td><td></td><td>D) Forged Abode Brick</td><td></td></tr>
<tr><td>E) Adobe Brick Cladding</td><td>x</td><td>F) Ashlars / brickwork</td><td></td></tr>
<tr><td colspan="4">Materials used in the brick courses and / or chained brick / cladding</td></tr>
<tr><td>Latericium</td><td>x</td><td>Stone material</td><td>x</td></tr>
</table>

Graphic Data



Plan of the fortified complex. Source: Google Earth.



View of the section on Calle Luis Vives
(AND_LVI).

Graphic Data



View of the section on Calle Luis Vives
(AND_LVI).



Overview of the section on Calle Hoyo (AND_CHY).

Graphic Data

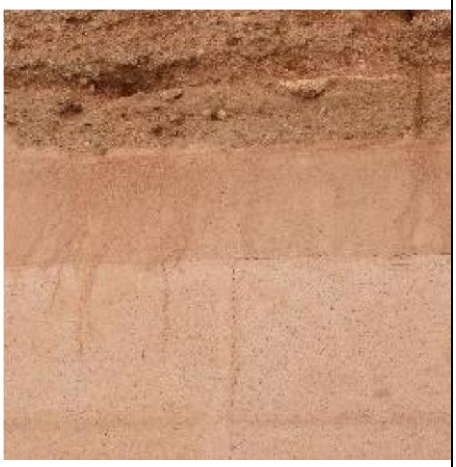


Overview of the section on the Paseo de Colón (AND_COL).

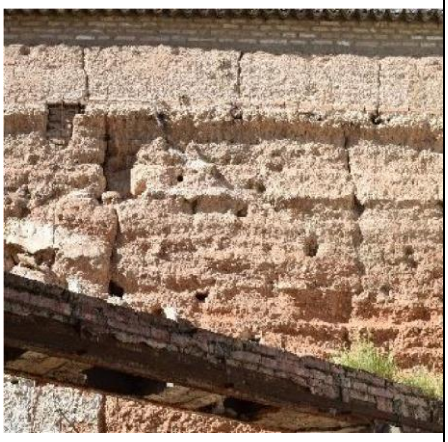


Overview of the section on the Paseo de las Vistillas (AND_VIS).

Visual glossary of alteration indicators present

		
loss of material	**erosion**	**chromatic alteration**
		
dampness	**rubefaction**	**washout area**

		
efflorescence	**concretions**	**surface deposit**

		
guano deposit	**cracking**	**fracturing**

		
fragmentation	**differential alteration**	**granular decohesion**
		
scaling	**displacement**	**cavernisation / alveolisation**

		
blister	**biocrust**	**vegetation**

Diagnosis

The fortification analysed is essentially composed of simple adobe brickwork with a cladding of ashlar, masonry and brick in some parts of its surface.

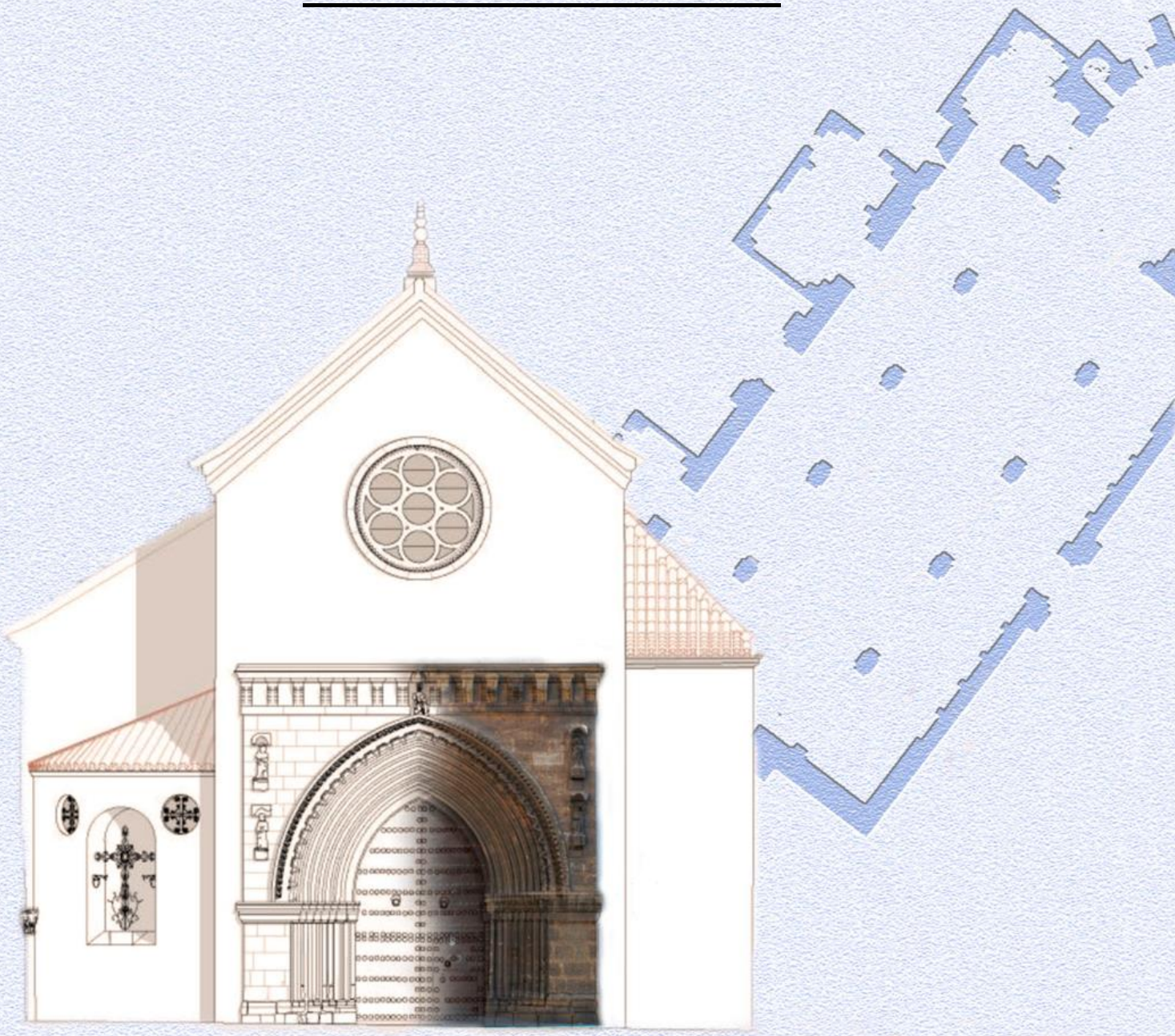
The most common pathologies are dampness (100%), biocrust (100%), erosion (80%), vegetation (80%) and scaling (60%). Fragmentation affects 50% of the MAUs analysed and must be monitored due to the magnitude (10) that this typology presents and its capacity to generate damage to structures.

BIA 2015-64878-R

ART-RISK Investigation Project
Artificial Intelligence applied to the Preventive Conservation of Heritage Buildings

USER MANUAL

Software ART-RISK 3.0



Seville, December 2019

ART-RISK Research Project, Artificial Intelligence applied to the Preventive Conservation of Heritage Buildings (BIA 2015-64878-R)

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In application of Law 3/2007, of 22 March, for the effective equality of women and men, any mention in these guidelines of persons, groups, etc., whose gender is masculine, will refer to the neutral grammatical gender, including, therefore, the possibility of referring to both women and men.

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1. Introduction. Art-Risk Project

The assessment of the state of conservation of heritage buildings is an interdisciplinary scientific practice based on knowing the symptoms, anomalies and/or pathologies that cultural assets present in order to design an intervention plan that fulfils their needs as much as possible. In relation to this discipline, **preventive conservation** studies the risks of heritage buildings, i.e. it aims to ascertain the threats and the probability of their occurrence (**hazards**), the current state of conservation (**vulnerability**) to **assess risk as a function of vulnerability and threats** to the asset. The aim is therefore to minimise possible future degradation and thus prolong the useful life of the movable or immovable property under analysis.

The **Art-Risk** project '*Artificial intelligence applied to the preventive conservation of heritage buildings*' (BIA2015-64878-R) has been funded by the Spanish Ministry of Economy and Competitiveness and the European Regional Development Fund, with the key objective of designing computational tools based on artificial intelligence models to promote decision-making focused on the preventive conservation of historical heritage.

During these projects, an interdisciplinary team composed of architects, conservator-restorers, chemists, biologists, geologists, historians, archaeologists, building engineers, computer engineers, pharmacists, mathematicians, etc. worked on new vulnerability and hazard analysis procedures. The team has developed tools based on the experience of experts from different disciplines in the heritage conservation sector. Expert opinions have been systematically and repeatedly collected using the DELPHI forecasting method, so that decision-making is supported by interdisciplinary scientific criteria. The end result is tools for conservation and intervention decision-making that minimise the risk of heritage loss when there is a large number of heritage buildings to be conserved.

These new procedures use a multi-scenario approach to analyse risk. Environmental and climate change hazards can be assessed, together with the level of use of the building and its static-structural hazards, using historical data relating to the functional lifetime of the building.

During the projects, several tools and models have been developed and improved, ART-RISK 1, ART-RISK 2 and ART-RISK 3, applicable to different construction methodologies (churches, walls and bastions, contemporary buildings, etc.) as well as different settings (Spain, Portugal, Chile, Colombia, Cuba, Peru, etc.).

The Art-Risk methodology has been validated and presented to the scientific community through different papers and articles with references on the project's website.

The ART-RISK 1 and ART-RISK 3 models use geographic information systems to carry out analyses related to the territory.

In this report, we present the registered software **Art-Risk 3.0 (Andalusian territorial intellectual property registration number SE-967-19)**, that is free to use, which helps decision-making for the preventive conservation of a group of heritage buildings, which helps decision-making for the preventive conservation of a group of heritage buildings, and is useful in policies of land use planning, urban planning and managing historic heritage. This tool features the innovation of including a transversal vision that includes the heritage, urban, architectural and cultural value, the analysis of the environmental surroundings and the socio-demographic situation of the site. All this allows the user to make a decision on intervention priorities based on objective criteria, which facilitates the conservation of heritage elements.

The current version (**Art-Risk 3.0**) has been designed and tested for churches in Spain and Colombia, and can be used throughout Spain.

For more information on the Art-Risk Project, please visit the website:

https://www.upo.es/investiga/art-risk/

2. Art-Risk 3.0 software

2.1. The ART-RISK 3.0 model

The **Art-Risk 3.0** software is a tool designed for the preventive conservation of heritage buildings that is implemented in artificial intelligence (Xfuzzy 3.3) and based on geographic information systems. The software is designed to compare a list of buildings and rank them according to their conservation requirements.

This free software combines the manual input of data by the user with the automatic output of other data based on location through the use of Geographic Information Systems (GIS) technology.

The input data is divided into six groups, as defined in Figure 1. This classification is based on two essential concepts when assessing a property: hazard and vulnerability. According to UNESCO [1], risk is the product of hazard and vulnerability. Threats are phenomena that may cause damage or disruption to cultural assets. This factor is sometimes replaced by the term hazard [2], which refers to the likelihood of a threat occurring. Hazards can be natural or human-induced, such as in the case of an earthquake or armed conflict. Vulnerability is the susceptibility or responsiveness of cultural property to hazards, so vulnerability relates to the degree of intrinsic weakness of the cultural asset. Finally, the service life depends on the hazards, vulnerability and management of the building in terms of maintenance.

These variables have been combined following the formula shown in Figure 2, in which the inference relationships are established by consulting experts using the DELPHI model [3].

To use this software, a previous inspection visit to the buildings under study is required, and the location and assessment of the technician(s) in charge of the analysis must be entered into the tool.

To use this software, training on the tool and sharing criteria of buildings is recommended.

[1] UNESCO (2014) Gestión del riego de desastres para el Patrimonio Mundial, pp.8-9.
[2] H.S. Stovel (2009) Programa de Desarrollo de Capacidades para el Caribe para el patrimonio mundial (CCBP), Módulo 3, Gestión de la preparación ante el riesgo. UNESCO, p.6.
[3] Astigarraga, E. (2002). El método Delphi. San Sebastián: Unviersidad de Deusto.

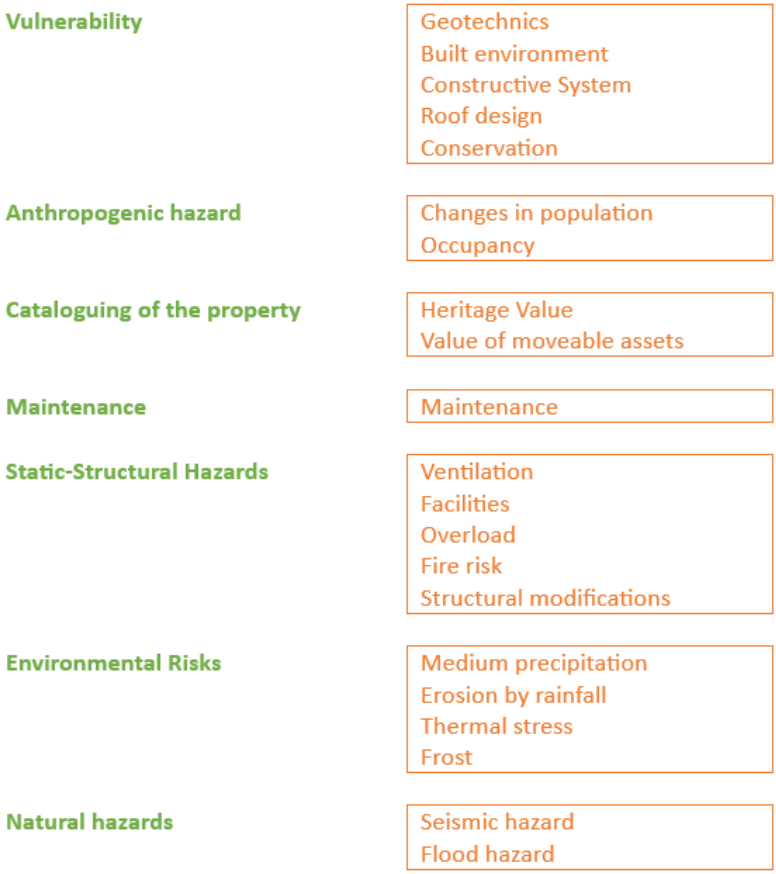


Figure 1: Art-Risk 3.0 software input variables depending on the nature of the variable, specifying whether this is an automatic variable associated with the location coordinates, or a manual variable which requires assessment and input by the user.

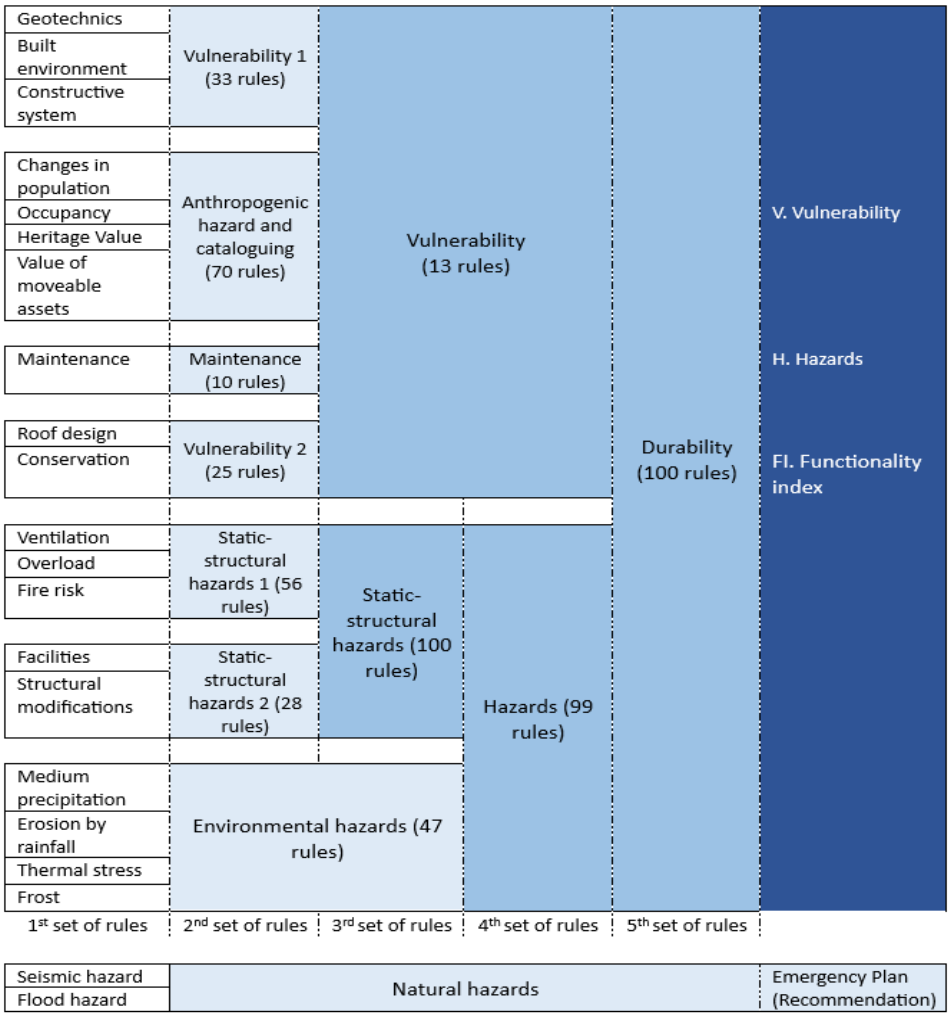


Figure 2: Structure of the relationship and hierarchy between variables of the Art-Risk 3.0 methodology.

For each building that is evaluated, the tool returns 5 output data to the user much like a calculator:

1. Vulnerability assessment of the property
2. Assessment of identified environmental hazards affecting preventive conservation
3. Functionality index assessment
4. Seismic hazard assessment based on geographical location
5. Flood hazard assessment based on geographical location

These assessments make it possible to prioritise the buildings under study according to conservation needs.

2.2. The computer interface

The software can be accessed via the following link:

https://www.upo.es/investiga/art-risk-service/art-risk3/index_en.html

The user interface consists of 4 main pages: introduction, user guide, the tool itself and contact form (Figure 3).

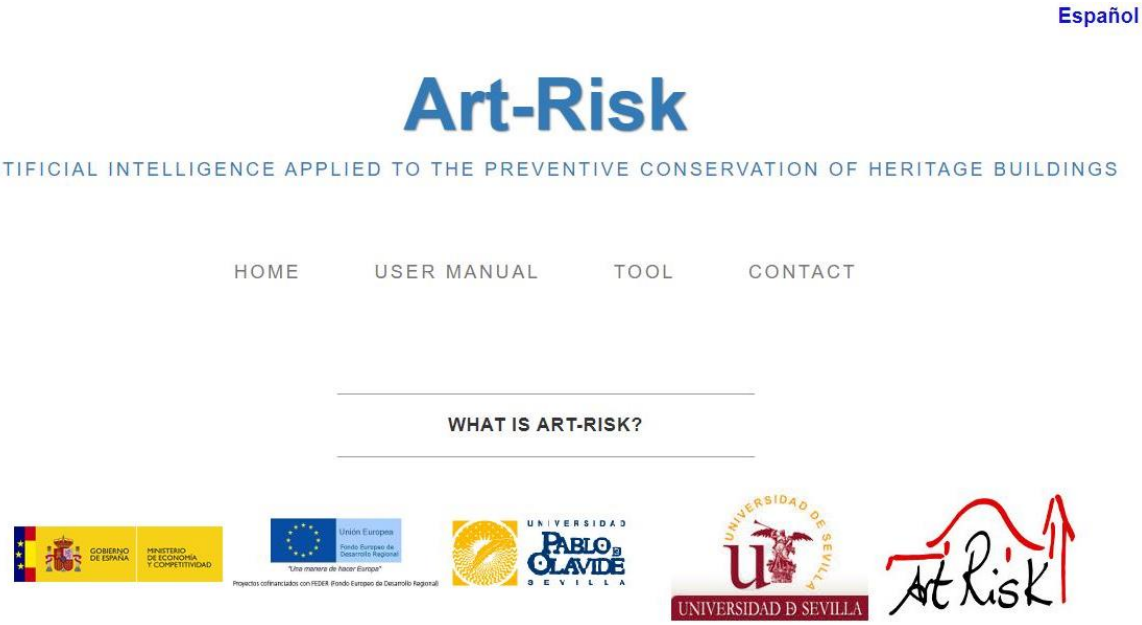


Figura 3. Página de inicio de la aplicación Art-Risk 3.0

To start the analysis of a building, click on the 'Tool' tab. This screen displays 19 numerical input variables (Figure 4) with values ranging from 1.0 (most favourable value) to 5.0 (most unfavourable value).

First, enter the geographical coordinates of the property under study. The coordinates must be in WGS84 (EPSG:4326) format, which is the default format used in OpenStreetMaps and GoogleMaps. So, the latitude and longitude coordinates must be expressed in decimal degrees. Alternatively you can click on the 'Select coordinates' button to search and click on the location of the building on a map of Spain.

Once the coordinates have been entered using either method, you must click on the 'Validate coordinates' button. If there are no errors in the coordinates and a valid geographical location within Spain has been selected, the Geotechnics, Medium precipitation, Rain erosion by rainfall, Thermal stress, Frost, Seismic hazard and Flood hazard variables will be automatically assigned a value. These 'automatic variables' cannot be edited or entered manually by the user.

Next, you must manually enter the values of the remaining variables in the system. The values for each input factor should be between 1.0 and 5.0. To facilitate the assessment of these variables, we recommend reading section 3 (Input variables. Ranking and assessment mode) of this manual.

Finally, click on the 'Submit' button in the 'Results' section to obtain the vulnerability, hazard and functionality index. If, once you have obtained the result you need to change the value of any of the variables entered manually, you can do so and press the 'Submit' button again. The results obtained are automatically updated. The 'Clear all' button resets all variables and clears the last results obtained. Select it only when you have finished the assessment of one building and want to start assessing the next building.

For the interpretation of the results, see section 4 (Output variables) of this manual.



Figure 4. The main tool consisting of 14 manual input variables (in black) and 5 automatic property geolocation variables (in grey), and the resulting values (vulnerability, hazard and functionality index).

3. Input Variables. Ranking and assessment mode

The Art-Risk 3.0 software application supports a total of 21 manually entered variables. The following tables show the qualitative and quantitative definition of each of them, as well as a brief description to facilitate their understanding and assessment.

We recommend taking a training courses and reading this section carefully to understand it before working with the tool, especially for manual input variables to be able to assign the values objectively.

Vulnerability
1. Geotechnics
Five criteria have been established to classify building conditions according to the terrain in each area. To this end, we used the existing documentation at the Spanish Geological and Mining Institute.

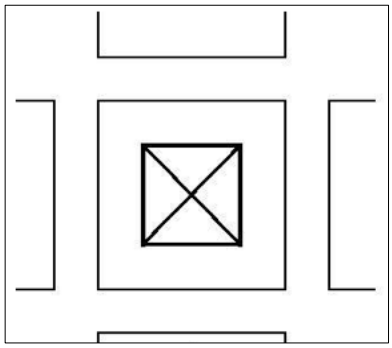
Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Optimal ground conditions in terms of stability
2.0 Acceptable	Favourable ground conditions in terms of stability
3.0 Medium	Acceptable ground conditions
4.0 Regular	Unfavourable ground conditions
5.0 Unfavourable	Very unfavourable ground conditions

Additional comments:
Automatic output variable based on the general geotechnical map made by the Geological and Mining Institute of Spain in 1974, scale 1:200.000. The criteria selected to establish the construction conditions are lithological, geomorphological, hydrological and geotechnical (bearing capacity, seating and various geotechnical), classified into 5 different areas: • Area 1 - Land with optimal building conditions. • Area 2 - Land with favourable building conditions. • Area 3 - Land with acceptable building conditions. • Area 4 - Land with unfavourable building conditions. • Area 5 - Land with extremely unfavourable building conditions.

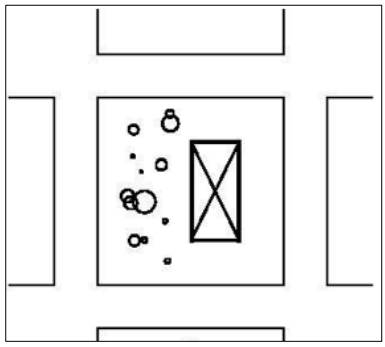
Vulnerability
2. Built environment
Five classification criteria have been established according to the organic growth, extensions, substitutions, aggregations and divisions that have conditioned and modified the state of the partition walls of the heritage buildings. To a greater or lesser extent, this can lead to accessibility problems and easements of all kinds.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Building without surrounding constructions
2.0 Acceptable	Building without surrounding constructions, but there could be gardens or trees
3.0 Medium	Buildings with a building attached their party wall
4.0 Regular	Buildings with two buildings attached to their party walls
5.0 Unfavourable	Buildings with at least three buildings attached to their party walls and difficult access

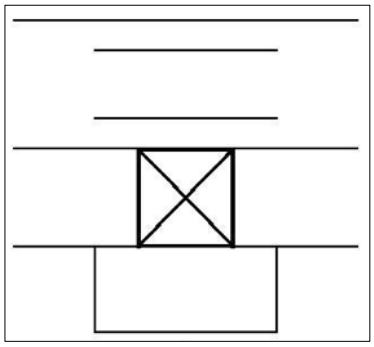
Graphical description



Rating of 1,0



Rating of 2,0



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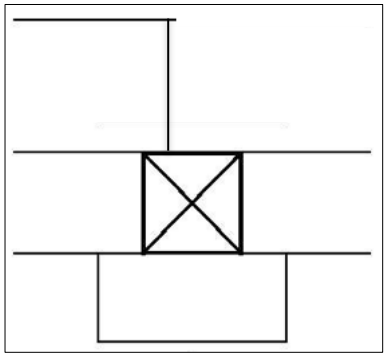

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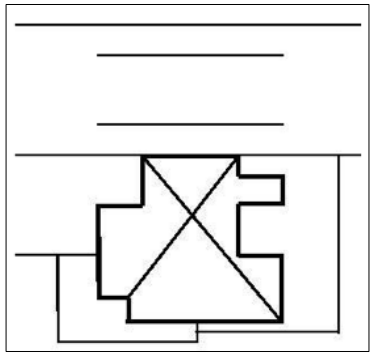
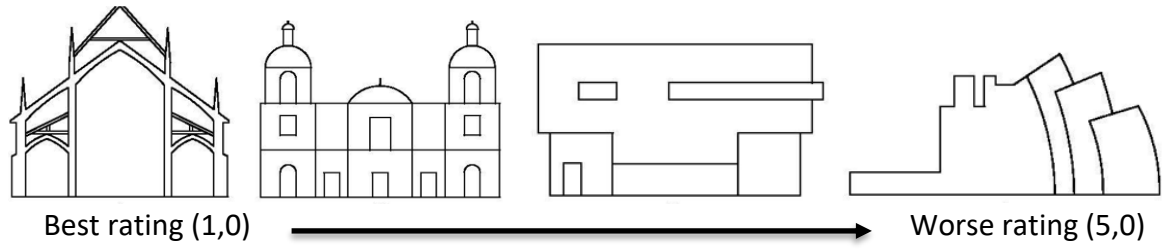


Rating of 5,0

Vulnerability
3. Constructive system
Five classification criteria have been established based on the number of building systems. The constructive system is understood as the set of functional and constructive requirements throughout the useful life of a building: structural, façade, walls, roofs, interior layout, finishes, etc. The greater the number of constructive systems, the more vulnerable the building becomes.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Highly homogeneous constructive system
2.0 Acceptable	Homogeneous constructive system
3.0 Medium	Heterogeneous constructive system
4.0 Regular	Constructive system with some complex framework
5.0 Unfavourable	Constructive system with a large amount of complex framework

Graphical description



Additional comments:	**Additional comments:**
A highly homogeneous constructive system is one that uses the same material throughout the construction, guaranteeing compatibility, and employs simple and stable architectural forms. As more material typologies or more complex architectural forms are used, building systems tend to become more heterogeneous and with more complex frameworks.	

Anthropic Hazards
4. Changes in population
Increases or decreases in population influence the number of people directly related to the property. In general, declines in population mean fewer resources and monuments being abandoned, thus potentially leading to building deterioration. Five classification criteria have been established based on changes in the population.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Growth greater than 15%
2.0 Acceptable	Variations between 0% and 15%
3.0 Medium	Variations between -5% and 0%
4.0 Regular	Decline between -10% and -5%
5.0 Unfavourable	Population decline below -10%

Additional comments:

Population changes should be calculated over a time span of at least 5 years.



Turruncún (La Rioja, Spain).

Example of a municipality that has suffered a decrease in population.



Teruel (Aragón, Spain)

Example of a municipality that has experienced population growth.

Anthropic Hazards
5. Heritage Value
Five classification criteria have been established according to the degree of legal protection and/or the social, cultural and/or liturgical significance of the building.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Very high historical value, which is recognised with some special level of protection.
2.0 Acceptable	Tall building, more than 100 years old
3.0 Medium	Medium construction quality
4.0 Regular	Low, poor construction quality
5.0 Unfavourable	Very low, of no artistic historical interest

Additional comments:
We recommend consulting the cataloguing of the properties under study.

Cataloguing
6. Value of movable assets
Five classification criteria have been established based on the property's contents. This value is based on the degree of legal protection, or its social, cultural and liturgical significance.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Very high-value movable assets
2.0 Acceptable	High-value movable assets
3.0 Medium	Medium-value movable assets
4.0 Regular	Low-value movable assets
5.0 Unfavourable	Very low-value movable assets

Additional comments:
We recommend consulting the cataloguing of the properties under study.

Cataloguing
7. Occupancy
Five classification criteria have been established based on the degree of occupancy of the building and the level and number of activities carried out within in.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Very high level of activities in the building (daily activities)
2.0 Acceptable	High level of activities in the building (weekly activities)
3.0 Medium	Medium level of activities in the building (monthly activities)
4.0 Regular	Low level of activities in the building (some sporadic annual activity)
5.0 Unfavourable	No activities in the building (no yearly activities)

Maintenance
8. Maintenance
Five classification criteria have been established based on the scheduled actions that have an impact on the good state of conservation of the building, including whether there is technical staff in charge on a permanent basis.

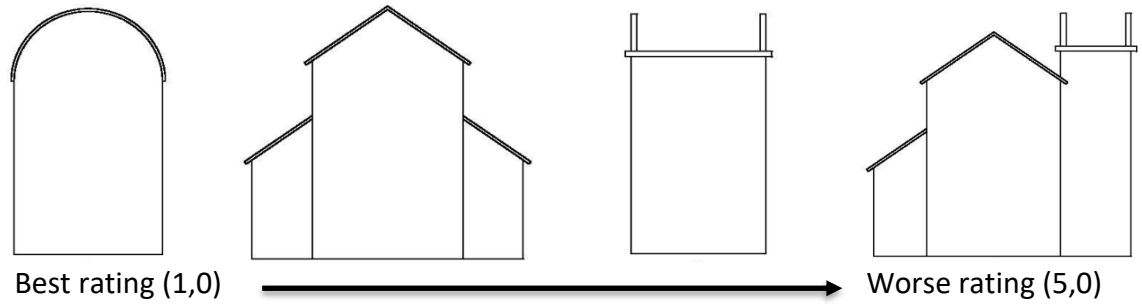
Quantitative assessment	**Description of the input parameters**
1.0 Favourable	There is a maintenance plan, short/medium term actions scheduled and there is personnel in charge
2.0 Acceptable	There is a maintenance plan, short/medium term actions scheduled and no personnel in charge
3.0 Medium	There is a maintenance plan, no short/medium term actions scheduled and no personnel in charge
4.0 Regular	There is no maintenance plan, no short/medium term actions scheduled and no personnel in charge
5.0 Unfavourable	Building without resources for maintenance

Additional comments:
We recommend consulting building maintenance personnel and/or building users and/or owners. Check the state of conservation of the roof and water drainage, cleaning of roofs and bell towers, capillary damp, interior condensation, walls, cracks and fissures, etc.

Vulnerability
9. Roof design
Five classification criteria have been established based on the degree of difficulty of water drainage on roofs, which generally depends on constructional and geometrical modifications over time. The vulnerability of the building is highly conditioned by the speed with which roof water is drained and the simplicity of the design.

Quantitative assessment	Description of the input parameters
1.0 Favourable	Very fast water drainage
2.0 Acceptable	Fast water drainage
3.0 Medium	Normal water drainage
4.0 Regular	Slow water drainage
5.0 Unfavourable	Very slow or complex water drainage

Graphical description:



Additional comments:
For the assessment of this variable, you must take into account all the roofs of the building and how they interrelate with each other. Five levels of complexity of the roofs have been established based on how water is drained: Level 1 (Favourable): The roofs are sloping and there are no meeting points. Level 2 (Acceptable): The roofs are sloping and there are some meeting points. Level 3 (Medium): The roofs are sloping, but there are several meeting points. Level 4 (Regular): The roofs feature flat surfaces. Level 5 (Unfavourable): The roofs feature flat surfaces and many meeting points

Vulnerability
10. Conservation
Five classification criteria have been established based on the different parts that make up the building (facade, party walls, roofs, foundations, structure, installations, accessibility, etc.) and their level of conservation.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Optimal conservation
2.0 Acceptable	Normal conservation
3.0 Medium	Requires conservation
4.0 Regular	Requires significant conservation
5.0 Unfavourable	Abandoned building

Additional comments:
We recommend that the general inspection and assessment be carried out by specialist technicians. This section requires a joint evaluation of the elements of the building (facade, party walls, roofs, foundations, structure, installations, accessibility, etc.) and their level of conservation…

Static-Structural Hazards
11. Ventilation
Natural ventilation of buildings reduces water condensation problems. Five classification criteria have been established based on the ventilation of the building, taking into account the actual possibilities and use of the building. The analysis must include all areas.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	There is permanent natural cross ventilation in all areas of the building
2.0 Acceptable	There is permanent natural cross ventilation in some areas of the building
3.0 Medium	There is only permanent natural cross ventilation when the building is in use
4.0 Regular	There is no permanent natural cross ventilation in the building
5.0 Unfavourable	Completely closed-off or abandoned building

Additional comments:
Natural cross ventilation implies that there are windows, doors or other systems on all facades of the building that open daily and allow the building to be ventilated. This is the best possible condition.

Static-Structural Hazards
12. Facilities
Five classification criteria have been established based on the degree to which the facilities meet current standards for water supply and sanitation, electricity and active fire protection.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	All facilities are compliant and operational
2.0 Acceptable	Some facilities are compliant and all are operational
3.0 Medium	Some facilities are compliant and some are operational
4.0 Regular	No facilities are compliant and some are operational
5.0 Unfavourable	No facilities are operational

Additional comments:
Inspections should be carried out by specialists trained in this type of survey. We also recommend meeting with the owners or those responsible for the maintenance of the building.

Static-Structural Hazards
13. Fire risk
Five classification criteria have been established based on the likelihood of a fire occurring, and the potential speed and intensity of spread.

Quantitative assessment	Description of the input parameters
1.0 Favourable	Non-flammable structure and low fire load
2.0 Acceptable	Non-flammable structure and medium fire load
3.0 Medium	Flammable structure and low fire load
4.0 Regular	Flammable structure and medium fire load
5.0 Unfavourable	Flammable structure and high fire load

Additional comments:
The presence of any wooden structure, pillars, beams, coffered ceilings, etc., as well as altars and movable goods are valued. This section also takes into account the presence of curtains, tapestries, etc. that can easily spread fire. Five risk levels have been established based on the materials used: Level 1 (Favourable): Buildings made of stone or other non-combustible material, which do not have wooden elements such as altarpieces, benches, etc. Level 2 (Acceptable): Buildings made of stone or other non-combustible material, which have some wooden elements such as altarpieces, benches, etc. Level 3 (Medium): Buildings with combustible construction elements, such as wooden beams, but without other wooden elements such as altarpieces, benches, etc. Level 4 (Regular): Buildings with both combustible construction elements and some goods made of this material, such as altarpieces, benches, etc. Level 5 (Unfavourable): Buildings with a multitude of construction elements (beams, coffered ceilings, columns, etc.) and goods (wooden altarpieces, tapestries, benches, etc.) made of combustible materials.

Static-Structural Hazards
14. Overload
Five classification criteria have been established based on the use of the spaces, both by people and the facility, furniture and equipment, which affect the durability of the building.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Use overloads are lower than the original ones
2.0 Acceptable	Use overloads are the same as the original ones
3.0 Medium	There are new overloads of different use than the original ones that generate a medium load
4.0 Regular	New overloads resulting in high additional weight
5.0 Unfavourable	New overloads of use resulting in heavy additional weight, e.g. warehouse space

Additional comments:

You should know and/or analyse the evolution of the building over time, mainly in relation to changes in use that would imply a change in the transmission of static loads and loads maintained over long periods of time.





An example of a changes in loads is the transformation of one of the galleries of the old ablation courtyard of the Great Mosque of Seville (Patio de los Naranjos of the current cathedral), which housed the Chapter and Columbine Library from 1563. In this case the overload is not only caused by the architectural remodelling, but mainly by the weight of the volumes and incunabula stored there.

Static-Structural Hazards
15. Structural modifications
Five classification criteria have been established based on the extensions or reforms of any type carried out throughout the building's lifespan and have partially or substantially changed the initial load for which the building was planned and constructed.

Quantitative assessment	Description of the input parameters
1.0 Favourable	No changes have been made
2.0 Acceptable	Small symmetrical and balanced modifications aimed at strengthening the original structure
3.0 Medium	Large symmetrical and balanced modifications
4.0 Regular	Disorderly modifications of minor organic growth
5.0 Unfavourable	Large modifications with no organisation

Additional comments:

Structural modifications are generally detrimental to the pre-existing structure, transferring new burdens to the heritage building. They are related to building extensions, organic and unplanned structural modifications, as well as properties attached to the outer walls of heritage buildings.



An example of a structural modification due to the opening of a new door in the epistle aisle of the Church of Santiago (Seville, Spain) in the second half of the 20th century.

Environmental threats
16. Medium precipitation
Five classification criteria have been established based on the amount of rainfall per unit area (m^2)

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Very low risk (< 600 mm)
2.0 Acceptable	Low risk (600 mm - 750 mm)
3.0 Medium	Medium risk (750 mm - 1000 mm)
4.0 Regular	High risk (1000 mm - 1200 mm)
5.0 Unfavourable	Very high risk (> 1200 mm)

Additional comments:
Map based on data from the Iberian Climate Atlas of the State Meteorological Agency (Ministry of Environment and Rural and Marine Affairs, Spain). Updated in 2000. For calculating the values of this normal, the State Meteorological Agency follows the recommendations established by the WHO (World Health Organisation) for data and criteria validation to be adopted in the absence of such data. These values are also given for a period of 30 years. The map has been divided into 5 different zones according to the average annual rainfall: • Area 1 – Rainfall below 600 mm/m^2 • Area 2 – Rainfall between 600 y 750 mm/m^2 • Area 3 – Rainfall between 750 y 1000 mm/m^2 • Area 4 – Rainfall between 1000 y 1200 mm/m^2 • Area 5 – Rainfall above 1200 mm/m^2

Environmental threats
17. Erosion by rainfall
Five classification criteria have been established based on the rainfall intensity. Brief rainfall, generally of moderate or heavy intensity, often accompanied by wind.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Minimal risk areas (< 7)
2.0 Acceptable	Low risk areas (7 - 8)
3.0 Medium	Medium risk areas (8 - 9)
4.0 Regular	High risk areas (9 - 10)
5.0 Unfavourable	Maximum risk areas (> 10)

Additional comments:

The erosion by rainfall map was made using the torrential rain index map provided by the Ministry of Public Works (Spain) in the Standard 5.2-IC on Surface Drainage in the Roads Regulations (updated in 2016). The torrential rain index is calculated as the ratio between the rainfall intensity in one hour and the average rainfall intensity in 24 hours. Based on this index, 5 different areas are established:

- Area 1 – Less than 7
- Area 2 – Between 7 and 8
- Area 3 – Between 8 and 9
- Area 4 – Between 9 and 10
- Area 5 – More than 10

Environmental threats
18. Thermal stress
Variable related to temperature variations in a short period of time

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Minimal risk (< 6)
2.0 Acceptable	Low risk (6 – 7)
3.0 Medium	Medium risk (7 – 8)
4.0 Regular	High risk (8 – 10)
5.0 Unfavourable	Very high risk (10 – 12)

Additional comments:

Thermal oscillation map (National Geographic Institute, Spain).
Five areas have been established based on the average daily temperature variation, which is obtained from the annual average value of the difference between the extreme daily temperatures (maximum and minimum) recorded during the year.

- Area 1 – The difference is less than 6 degrees Celsius.
- Area 2 – The difference is between 6 and 7 degrees Celsius.
- Area 3 – The difference is between 7 and 8 degrees Celsius.
- Area 4 – The difference is between 8 and 10 degrees Celsius.
- Area 5 – The difference is between 10 and 12 degrees Celsius.

Environmental threats
19. Frost
Fenómeno meteorológico que produce un descenso de la temperatura ambiente a niveles A meteorological phenomenon that causes the temperature to drop below the freezing point of water.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Minimal risk (< 10 days)
2.0 Acceptable	Low risk (10 days - 20 days)
3.0 Medium	Medium risk (20 days - 80 days)
4.0 Regular	High risk (80 days - 125 days)
5.0 Unfavourable	Maximum risk (> 125 days)

Additional comments:
The map is based on the data obtained from the document Risk Maps: frost and hours of cold in peninsular Spain (period 2002-2012) of the Spanish State Meteorological Agency (Ministry of Agriculture, Food and Environment, Spain). Updated in 2015. To calculate the values of this normal, the State Meteorological Agency has used data on daily minimum temperatures between 2001 and 2012. The map has been divided into 5 different areas according to the annual average number of days with minimum temperature below 0 degrees Celsius (at least 10 years): • Area 1 – Less than 10 frost days per year. • Area 2 – Between 10 and 20 frost days per year. • Area 3 – Between 20 and 80 frost days per year. • Area 4 – Between 80 and 125 frost days per year. • Area 5 – More than 125 frost days per year.

Natural hazards
20. Seismic hazard
Probability of an earthquake occurring in a specific geographical area during a given time interval and involving ground accelerations.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Minimal risk areas (< 0.04 g)
2.0 Acceptable	Low risk areas (0.04 g – 0.08 g)
3.0 Medium	Medium risk areas (0.08 g – 0.12 g)
4.0 Regular	High risk areas (0.12 g – 0.16 g)
5.0 Unfavourable	Maximum risk areas (> 0.16 g)

Additional comments:

Seismic hazard map according to the Seismic Resistant Construction Standard: General Part and Building (NCRS-02) of the Ministry of Public Works (Spain). Updated in 2000.
The map has been divided into five areas based on the seismic acceleration expressed in gravity (g).

- Area 1 – Less than 0,04g
- Area 2 – Between 0,04 and 0,08g
- Area 3 – Between 0,08 and 0,12g
- Area 4 – Between 0,12 and 0,16g
- Area 5 – More than 0,16g

Natural hazards
21. Flood hazard
It's defined as water occupying areas that are normally free from water, due to overflowing rivers, torrents, torrential rains, etc.

Quantitative assessment	**Description of the input parameters**
1.0 Favourable	Minimal risk areas. (No flooding).
2.0 Acceptable	Low risk areas. (Return period 500 years)
3.0 Medium	Medium risk areas. (Return period 100 years)
4.0 Regular	High risk areas. (Return period 50 years)
5.0 Unfavourable	Maximum risk areas. (Return period 10 years)

Additional comments:

Map based on the data provided by the National Flood Mapping System of the Ministry of Agriculture and Fisheries, Food and Environment (Spain). Data updated in June 2017. Five areas have been defined based on the return period; their delimitation is expressed according to the following classification:

- Area 1 - Territory with a return period greater than 500 years. Delimitation of 26,9% of main watercourses and 3,5% of all watercourses.
- Area 2 - Territory with a return period of 500 years. Delimitation of 22,3% of main watercourses and 2,9% of all watercourses.
- Area 3 - Territory with a return period of 100 years. Delimitation of 33,3% of main watercourses and 4,4-5% of all watercourses.
- Area 4 - Territory with a return period of 50 years. Delimitation of 36,2% of main watercourses and 4,7% of all watercourses.
- Area 5 - Territory with a return period of 10 years and areas defined as watercourse.

4. Output variables

The interpretation of each value obtained in the 'Results' section is described below:

Vulnerability	Actions
Low Vulnerability (<35)	The building is in excellent condition.
Medium Vulnerability (75-35)	The building has certain pathologies and conditions that should be studied in depth.
High Vulnerability (>75)	The building is in a poor state of conservation.

Hazard	Actions
Low Hazard (<35)	Acceptable level of environmental hazards
Medium Hazard (75-35)	Medium level for external environmental hazards.
High Hazard (>75)	High level for external environmental hazards.

Functionality index	Actions
High functional life (>75)	Optimum conditions of functionality.
Medium functional life (75-35)	Periodic inspections are required to ensure an acceptable level of functionality by specialist technicians.
Low functional life (<35)	Unacceptable level of functionality.

The overall assessment of the building should be made by comparing the values obtained for each variable. The following table shows possible value combinations, as well as some recommendations to improve the conservation of the cultural property under study, although the assessment and associated data are required.

Don't forget that this methodology is designed to be applied to a group of buildings and not to individual buildings.

Vulnerability	Hazard	Functionality index	Recommendations
			According to the inspection carried out, the building is in good condition and is not subject to significant external hazards during the assessment. It is advisable to draw up a preventive maintenance and conservation plan with annual monitoring. The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 10 years, or after disasters such as flooding, fire, earthquakes, etc.
			According to the inspection carried out, the building is in a good state of conservation, but it is recommended that specific measures be taken to reduce the main agents of environmental degradation through a Preventive Conservation Plan with annual monitoring and to improve the maintenance of the building and its facilities The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 5-10 years, or after disasters such as flooding, fire, earthquakes, etc.
			According to the inspection carried out, the building is in optimum conservation conditions, but it is subject to a high level of environmental hazards according to the model studied. It is advisable to take specific measures to reduce the agents of environmental degradation by means of a Preventive Conservation Plan with annual monitoring. The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 5 years, or after disasters such as flooding, fire, earthquakes, etc.
			According to the inspection carried out, it is recommended to intervene on the pathologies detected in the medium term (5-10 years). The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 5-10 years, or after disasters such as flooding, fire, earthquakes, etc.
			According to the inspection carried out, it is recommended to intervene on the pathologies detected in the medium term (5-10 years). It is advisable to implement specific measures to reduce the key agents of environmental degradation by means of a Preventive Conservation Plan with annual monitoring. The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 5-10 years, or after disasters such as flooding, fire, earthquakes, etc.

Vulnerability	Hazard	Functionality index	Recommendations
			According to the inspection carried out, it is recommended to intervene on the pathologies detected in the medium term (5-10 years). The building is subject to a high level of environmental risks according to the model studied. It is advisable to take specific measures to reduce the agents of environmental degradation by means of a Preventive Conservation Plan with annual monitoring. The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 5 years, or after disasters such as flooding, fire, earthquakes, etc.
			Based on the inspection carried out, it is recommended that an in-depth study be carried out by qualified personnel to check the safety of all the elements that make up the building. A short-term intervention plan (1-2 years) is recommended to ensure the integrity of the cultural property and its functionality. The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 1-2 years, or after disasters such as flooding, fire, earthquakes, etc.
			Based on the inspection carried out, it is recommended that an in-depth study be carried out by qualified personnel to check the safety of all the elements that make up the building. A short-term intervention plan (1-2 years) is recommended to ensure the integrity of the cultural property and its functionality. It is advisable to implement specific measures to reduce the key agents of environmental degradation by means of a Preventive Conservation Plan with annual monitoring. The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every 1-2 years, or after disasters such as flooding, fire, earthquakes, etc.
			Based on the inspection carried out, it is recommended that an in-depth study be carried out by qualified personnel to check the safety of all the elements that make up the building. A short-term intervention plan (1-2 years) is recommended to ensure the integrity of the cultural property and its functionality. It is advisable to implement specific measures to reduce the key agents of environmental degradation by means of a Preventive Conservation Plan with annual monitoring. The assessment and vulnerability calculation should be updated in case of changes or interventions. It is advisable to reassess the building every year, or after disasters such as flooding, fire, earthquakes, etc.

Vulnerability	Hazard	Functionality index	Recommendations
			Based on the inspection carried out, it is recommended that an in-depth study be carried out by qualified personnel to check the safety of all the elements that make up the building. The building requires urgent intervention (1 to 2 years), as well as reducing the main agents of environmental degradation through a preventive conservation plan.

For the Seismic hazard and Flood hazard values, follow these recommendations:

Value	Recommendation
5	Draw up an emergency plan and perform annual drills.
4	Draw up an emergency plan and performing annual drills is recommended.
3	Draw up an emergency plan and perform drills at least every two years.
2	Draw up an emergency plan based on the benefits of implementing a system that minimises the consequences of a disaster.
1	According to the model studied, no special actions are necessary for seismic or flood hazards.

5. Contact form

For any questions or clarifications you can contact the Art-Risk Project team through the 'Contact' tab (Figure 5). The fields 'name and surname' and 'email' are mandatory. You can write your query in the 'message' section. Once you have filled in the form, enter the validation code and click on the 'submit' button.

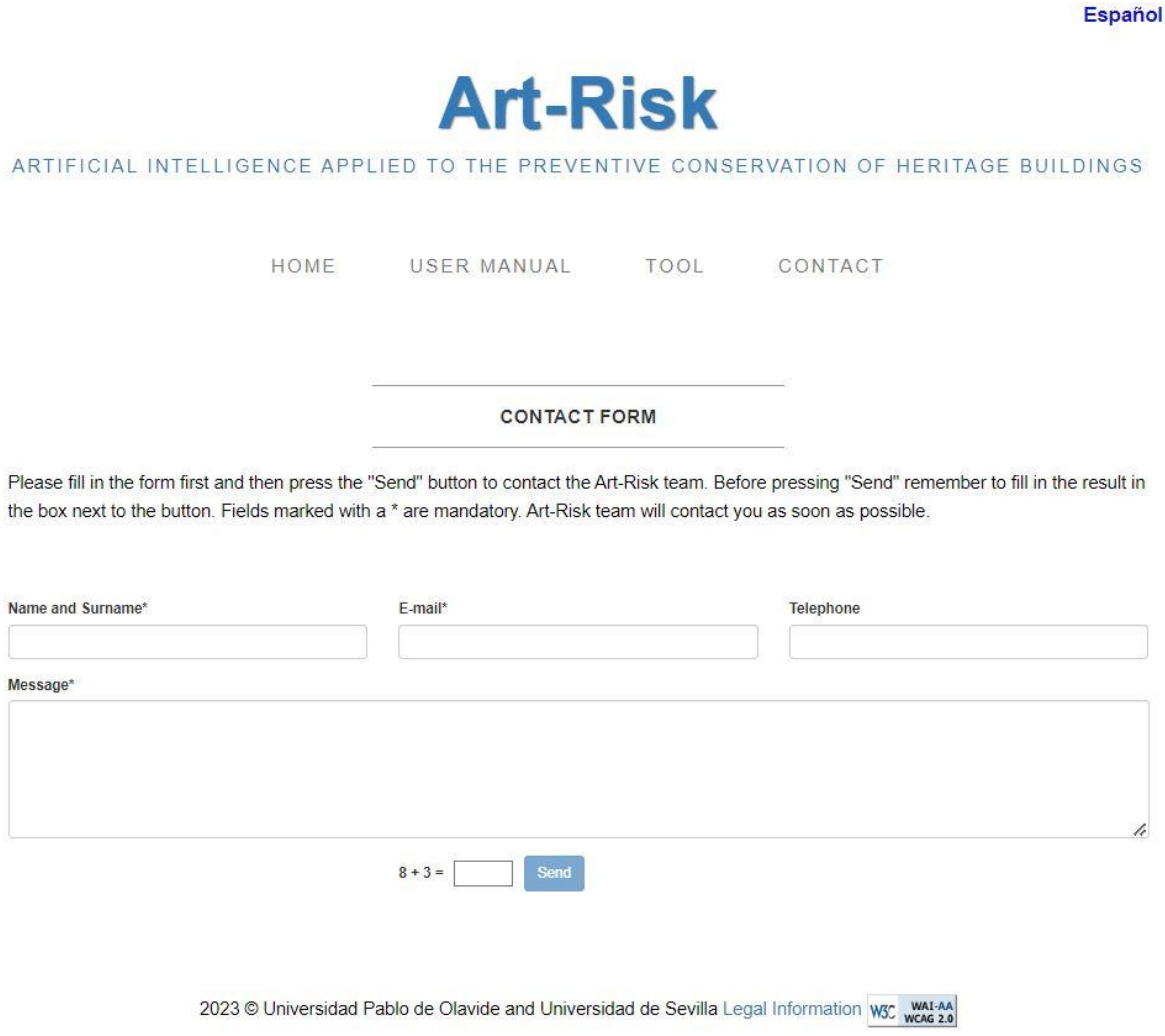


Figura 5. Pestaña de contacto.

6. FAQs

- On what kind of devices is it possible to use the Art-Risk 3.0?

  The web interface is adapted for use on mobile devices with small screens (tablets and mobile phones). This makes it easier to assess a building on site.

- Is an internet connection required to use the Art-Risk 3.0?

  This software application is located on a web server and therefore requires an internet connection. If you do not have an internet connection during the inspection visit, we recommend you use the form in Annex 1 for data collection, and enter the data into the application when you have an internet connection.

- Do you need to download any files to use this tool?

  The Art-Risk 3.0 application works online via a web link, so there is no need to download any files to your device.

- Does it cost anything to use Art-Risk 3.0?

  Art-Risk 3.0 software application works with GIS technology and requires an internet connection. We only ask that, if you use the tool, you cite the project in your reports and acknowledgements as Art-Risk Project (BIA2015-64878-R, RETOS project of the Spanish Ministry of Economy and Competitiveness and the European Regional Development Fund).

- Can the model be adapted to the specific characteristics of the type of assets I manage?

  If you would like us to customise the tool to your heritage management needs, you can contact us at ... Once we have established the scope, we will send you a quote.

- Is the data stored?

  This interface acts as a calculator, but in future updates data storage and visualisation will be possible.

ANNEX 1

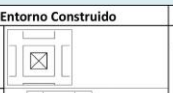
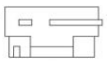
Recommended model form for manual data collection in technical inspections. It includes the 14 input variables for each building to be assessed. Please remember to enter the data into the tool afterwards.

Inspected building: _____

Date: _____

Technician in charge: _____

I. VULNERABILIDAD

Geotecnia			Entorno Construido			Sistema Constructivo			Diseño de Cubierta			Conservación		
1	1,0	Muy favorable	1	1,0		1	1,0		1	1,0		1	1,0	Conservación óptima
2	2,0	Favorable	2	2,0		2	2,0		2	2,0		2	2,0	Conservación normal
3	3,0	Aceptable	3	3,0		3	3,0		3	3,0		3	3,0	Necesita conservación
4	4,0	Desfavorable	4	4,0		4	4,0		4	4,0		4	4,0	Necesita una importante actuación de conservación
5	5,0	Muy desfavorable	5	5,0		5	5,0		5	5,0		5	5,0	Edificio en estado de abandono

II. RIESGOS ANTRÓPICOS

Modificación de la población			Valor patrimonial		
1	1,0	> 15%	1	1,0	Muy alto, Bien de interés Cultural (BIC), protegids
2	2,0	0% a 15%	2	2,0	Alto, edificio con edad superior a 100 años
3	3,0	-5% a 0%	3	3,0	Media calidad constructiva
4	4,0	-10% a -5%	4	4,0	Bajo, escasa calidad constructiva
5	5,0	< -10%	5	5,0	Muy bajo, sin ningún interés

III. CATALOGACIÓN

Valor mueble			Ocupación		
1	1,0	Gran valor	1	1,0	Muy alta
2	2,0	Alto valor	2	2,0	Alta
3	3,0	Medio valor	3	3,0	Media
4	4,0	Bajo valor	4	4,0	Baja
5	5,0	Muy bajo valor	5	5,0	Edificio sin actividad

IV. MANTENIMIENTO

Mantenimiento		
1	1,0	Plan de Mantenimiento, acts. programadas a corto/medio plazo y personal encargado
2	2,0	Plan de Mantenimiento, acts. programadas a medio/corto plazo, no hay personal encargado
3	3,0	Plan de Mantenimiento, no acts. a medio/corto plazo, no personal encargado
4	4,0	No Plan de Mantenimiento, no actuaciones a corto/medio plazo y no personal encargado
5	5,0	Edificio sin recursos para acciones de mantenimiento

V. RIESGOS DE ESTÁTICO - ESTRUCTURALES

Ventilación			Instalaciones			Sobrecargas de uso			Riesgo de fuego			Modificación estructurales		
1	1,0	Existen ventilación natural cruzada y permanente en todos los espacios	1	1,0	Todas las instalaciones están conforme a norma y en funcionamiento	1	1,0	Sobrecargas de uso son menores a las originales	1	1,0	Estructura incombustible y baja carga de fuego	1	1,0	No se ha producido ninguna modificación
2	2,0	Existe ventilación natural cruzada en algunos espacios	2	2,0	Algunas instalaciones están conforme a norma y todas funciona	2	2,0	Sobrecargas de uso son igual a las originales	2	2,0	Estructura incombustible y media carga de fuego	2	2,0	Modificaciones simétricas y equilibradas de pequeña entidad tendentes a reforzar la estructura original
3	3,0	A veces existe ventilación natural cruzada cuando el edificio está en uso	3	3,0	Algunas instalaciones están conforme a norma y funcionan	3	3,0	Existen nuevas Sobrecargas de uso a las originales	3	3,0	Estructura combustible y baja carga de fuego	3	3,0	Modificaciones simétricas y equilibradas de gran entidad
4	4,0	Sólo existe ventilación cruzada en ningún caso	4	4,0	Nada está conforme a norma y algunas funcionas	4	4,0	Nuevas Sobrecargas que originan un gran peso adicional	4	4,0	Estructura combustible y media carga de fuego	4	4,0	Modificaciones desordenadas de crecimiento orgánico
5	5,0	No existe ventilación cruzada en ningún caso	5	5,0	Las instalaciones no están en funcionamiento	5	5,0	Nuevas Sobrecargas de uso, por ejemplo espacios destinados a uso de almacén	5	5,0	Estructura combustible y alta carga de fuego	5	5,0	Grandes modificaciones sin ningún tipo de orden

VI. RIESGOS MEDIOAMBIENTALES

Precipitación media			Erosión por lluvia			Estrés térmico			Heladas		
1	1,0	Riesgo muy bajo (< 600 mm)	1	1,0	Zonas de riesgo mínimo. (< 7)	1	1,0	Riesgo mínimo	1	1,0	Riesgo mínimo (< 1 día)
2	2,0	Riesgo bajo (600 mm - 750 mm)	2	2,0	Zonas de Riesgo bajo. (7 - 8)	2	2,0	Riesgo bajo	2	2,0	Riesgo bajo (1 día - 5 días)
3	3,0	Riesgo medio (750 mm – 1000 mm)	3	3,0	Zonas de Riesgo medio. (8 - 9)	3	3,0	Riesgo medio	3	3,0	Riesgo medio (5 días - 20 días)
4	4,0	Riesgo Alto (1000 mm - 1200 mm)	4	4,0	Zonas de Riesgo alto. (9 - 10)	4	4,0	Riesgo Alto	4	4,0	Riesgo Alto (20 días - 60 días)
5	5,0	Riesgo muy alto (> 1200 mm)	5	5,0	Zonas de Riesgo máximo. (> 10)	5	5,0	Riesgo Máximo	5	5,0	Riesgo máximo (> 60 días)

VII. RIESGOS NATURALES

Riesgo por sismo			Riesgo de Inundación		
1	1,0	Zonas de riesgo mínimo. (< 0.04 g)	1	1,0	Zonas de riesgo mínimo. (No inundables).
2	2,0	Zonas de Riesgo bajo. (0.04 g - 0.08 g)	2	2,0	Zonas de Riesgo bajo. (Periodo de retorno 500 años)
3	3,0	Zonas de Riesgo medio. (0.08 g - 0.12 g)	3	3,0	Zonas de Riesgo medio. (Periodo de retorno 100 años)
4	4,0	Zonas de Riesgo alto. (0.12 g - 0.16 g)	4	4,0	Zonas de Riesgo alto. (Periodo de retorno 50 años)
5	5,0	Zonas de Riesgo máximo. (> 0.16 g)	5	5,0	Zonas de Riesgo máximo. (Periodo de retorno 10 años)

Observaciones:

Art-Risk 5



MANUAL DE USUARIO

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1. ¿Qué es Art-Risk 5 y para qué sirve?

Art-Risk 5 es una aplicación que sirve para la conservación preventiva de entornos patrimoniales y el monitoreo del impacto provocado por peligrosidades climáticas. Esta aplicación está disponible online para su libre uso (https://artrisk50.users.earthengine.app/view/art-risk5) y ha sido desarrollada por la Universidad pablo de Olavide (IPRUPO2023-010).

Art-Risk 5 calcula y cartografía valores estadísticos de precipitación, temperatura y densidad de vegetación para periodos temporales concretos utilizando las series de imágenes satelitales GSMAP, CHIRPS, PERSIANN, MODIS y SENTINEL. Además, seleccionando unas coordenadas concretas sobre la cartografía elaborada, permite obtener gráficas con los cambios registrados durante los últimos 20 años. Su uso permite tener una visión más clara de los cambios registrados en los patrones climáticos a escala local y de los posibles nuevos peligros que afrontan los entornos patrimoniales.

2. Secciones de Art-Risk 5

La interfaz de usuario de Art-Risk 5 está dividida en tres secciones principales: un panel de control izquierdo (fig.1A), un mapa interactivo (fig.1B) y un panel de resultados derecho (fig.1C).



Figura 1. Interfaz de Art-Risk 5. 1a) panel de control izquierdo; 1b) mapa interactivo; 1c) panel de resultados derecho.

2.1. Panel de control izquierdo

Desde este panel se eligen el periodo de análisis, las variables meteorológicas y el área de interés. Cada sección cuenta con un botón con un signo de interrogación para desplegar una ayuda con información sobre los campos, las características de los satélites empleados y el método para calcular los valores consultados.

El panel está formado por 5 subsecciones: descripción de la herramienta, periodo de análisis, variables climáticas, área de interés y controles panel derecho (fig. 2).

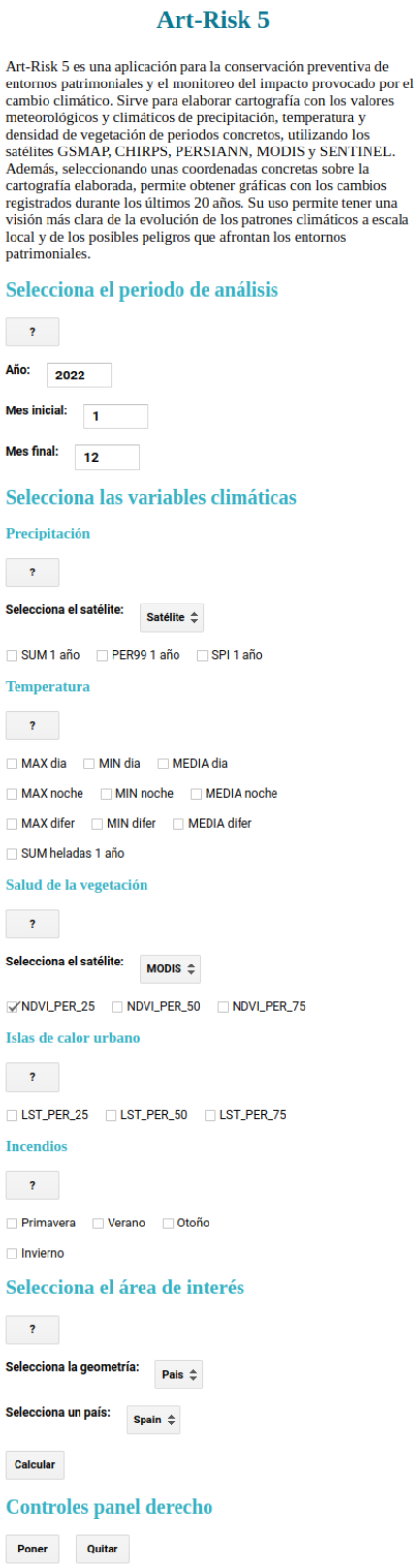

Figura 2. Panel izquierdo de la aplicación

2.1.1. Descripción de la herramienta

Es el primer texto que aparece en la parte superior del panel izquierdo. Esta subsección incluye el nombre de la aplicación, una breve descripción de esta y dos enlaces, uno que lleva a la versión en inglés y otro que ofrece más información sobre la metodología Art-Risk.

2.1.2. Periodo de análisis

En la subsección *periodo de análisis* (fig. 3) hay 3 entradas de texto que permiten indicar el año y los meses inicial y final del periodo a analizar.

La herramienta permite estudiar los años comprendidos entre 2002 y 2022, ambos incluidos. Los valores de los meses seleccionados deben estar en dentro del rango 1 (enero) a 12 (diciembre), ambos incluidos. Para que la herramienta funcione correctamente es necesario que el valor del mes final sea siempre igual o mayor al del mes inicial.

En caso de no respetar estas condiciones, la aplicación mostrará un error indicando que se proporcionen valores válidos.

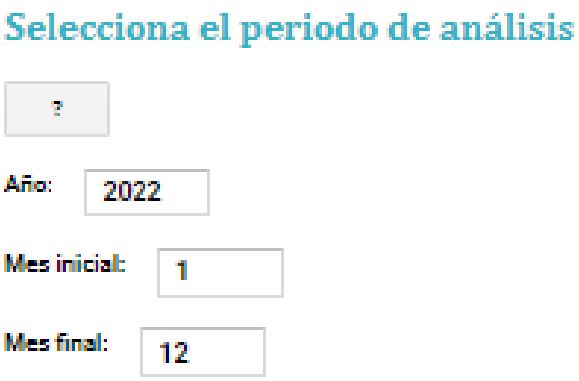

Figura 3. Selector de variables de tiempo

2.1.3. Variables climáticas

Esta subsección se subdivide en otros 3 apartados: Precipitación, temperatura y salud de la vegetación. Dentro de estos apartados están los checks con los que seleccionar las variables meteorológicas que se quieren calcular.

Es posible seleccionar un mínimo de 1 variable y un máximo de 3, que pueden combinarse entre las variables de los tres apartados (precipitación, temperatura y salud de la vegetación).

2.1.3.1. Precipitación

Este apartado cuenta con un selector de satélite (fig. 4) para poder elegir entre los posibles satélites a utilizar. Además, dispone de 3 controles que sirven para elegir las variables que se quieren cartografiar (fig. 5).

Satélites disponibles

- **CHIRPS:** Hazards Group InfraRed Precipitation With Station Data ofrece datos entre latitudes 50°S y 50°N. Tiene una resolución espacial de 0.05° (5566

metros) y una resolución temporal de 1 día (https://developers.google.com/earth-engine/datasets/catalog/UCSB-CHG_CHIRPS_DAILY).

- **PERSIANN:** Estimation From Remotely Sensed Information Using Artificial Neural Networks-Climate Data Record, ofrece datos entre latitudes 60°S y 60°N. Tiene una resolución espacial de 0.25° (27830 metros) y una resolución temporal de 1 día (https://developers.google.com/earth-engine/datasets/catalog/NOAA_PERSIANN-CDR).

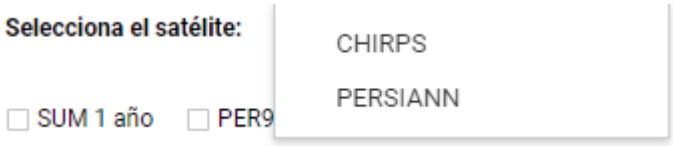

Figura 4. Selector de satélites de precipitación

Controles

- **SUM 1 Año:** calcula las precipitaciones acumuladas para el periodo seleccionado. Los valores son expresados en mm.
- **PER99 1 Año:** calcula el percentil 99 de las precipitaciones diarias acumuladas para el periodo seleccionado. Sirve para identificar la intensidad de las lluvias extremas. Los valores son expresados en mm.
- **SPI 1 año:** calcula el Índice estandarizado de precipitación (SPI) para el periodo seleccionado. Expresa los valores según una escala normalizada entre -2 y +2, y sirve para identificar sequías.



Figura 5. Sección de precipitación

2.1.3.2. Temperatura

Esta sección cuenta con 10 controles (fig. 6), que sirven para elegir las variables que se quieren cartografiar. Para el cálculo usa la serie satelital MODIS Landsurface Temperature. Tiene una resolución espacial de 250-500-1000 metros y una resolución temporal de 1 día (https://developers.google.com/earth-engine/datasets/catalog/MODIS_061_MOD11A1).

Controles

- **MAX día:** calcula la temperatura en superficie terrestre (LST) diurna máxima para el año seleccionado. Los valores son expresados en °C.
- **MIN día:** calcula la LST diurna mínima para el periodo seleccionado. Los valores son expresados en °C.
- **MEAN día:** calcula la LST diurna media para el periodo seleccionado. Los valores son expresados en °C.
- **MAX noche:** calcula la LST nocturna máxima para el periodo seleccionado. Los valores son expresados en °C.
- **MIN noche:** calcula la LST nocturna mínima para el periodo seleccionado. Los valores son expresados en °C.
- **MEAN noche:** calcula la LST nocturna media para el periodo seleccionado. Los valores son expresados en °C.
- **MAX difer:** calcula la diferencia de LST diaria máxima entre el día y la noche para el periodo seleccionado. Los valores son expresados en °C.
- **MIN difer:** calcula la diferencia de LST diaria mínima entre el día y la noche para el periodo seleccionado. Los valores son expresados en °C.
- **MEAN difer:** calcula la diferencia de LST diaria media entre el día y la noche para el periodo seleccionado. Los valores son expresados en °C.
- **SUM heladas 1 año:** calcula el sumatorio de los días que registran temperaturas nocturnas inferiores a 0°C para el año seleccionado. Sirve para identificar la ocurrencia de heladas. Los valores son expresados en número de días.



Figura 6. Sección de temperatura

2.1.3.3. Salud de la vegetación

Esta sección dispone de un selector de satélite (fig. 7) para poder elegir el satélite a utilizar. Además, cuenta con 3 controles (fig. 8), que sirven para elegir las variables que se quieren cartografiar.

Satélites disponibles

- **MODIS MOD13A1.061:** satélite Modis ofrece datos mundiales de índices de vegetación. Tiene una resolución espacial de 500 metros y una resolución temporal de 16 días.
- **SENTINEL 2:** satélite Sentinel 2 ofrece datos mundiales de reflectancia en superficie. Tiene una resolución espacial de 20 metros y una resolución temporal de 5 días (https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S2_SR_HARMONIZED).



Figura 7. Selector de satélites de Salud de la vegetación

Controles

- **NDVI_PER_25:** calcula el percentil 25 del Índice de Vegetación de Diferencia Normalizada (NDVI) para el año seleccionado. Sirve para identificar los valores más bajos de salud y densidad vegetativa.
- **NDVI_PER_50:** calcula el percentil 50 del Índice de Vegetación de Diferencia Normalizada (NDVI) para el año seleccionado. Sirve para identificar los valores medios de salud y densidad vegetativa.
- **NDVI_PER_75:** calcula el percentil 75 del Índice de Vegetación de Diferencia Normalizada (NDVI) para el año seleccionado. Sirve para identificar los valores más elevados de salud y densidad vegetativa.

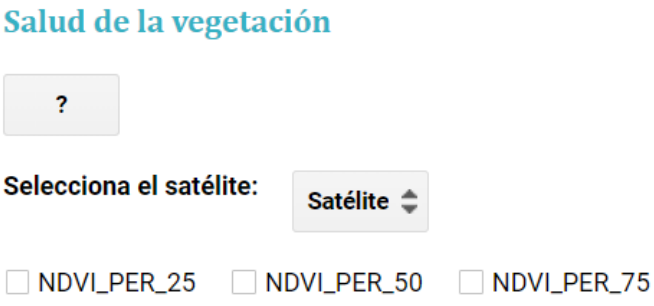

Figura 8. Sección de Salud de la vegetación

2.1.4. Área de interés

Esta subsección cuenta con un selector para elegir el tipo de geometría que se usará para definir el área en la que se quieren cartografiar las variables analizadas (fig. 9). Hay dos opciones: Polígono dibujado o País (fig. 10).

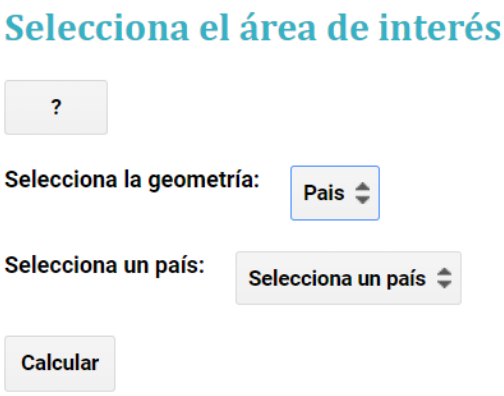

Figura 9. Sección de Área de interés

Opciones

- **Polígono dibujado:** esta opción permite definir o dibujar el polígono a analizar (fig. 12). Las herramientas de dibujo se localizan en la esquina superior izquierda del mapa.
- **País:** esta opción permite acceder a un desplegable en el que seleccionar el país que se desea analizar. Los nombres de los países están en inglés y es posible buscar el país tecleando su nombre mientras el selector está abierto (fig. 11).



Figura 10.Selector de tipo de área de interés



Figura 11. Selector de país desplegado



Figura 12. Selección de polígono dibujado

2.2. Mapa interactivo

En la región central de la aplicación se encuentra el mapa interactivo. A través de este mapa se visualiza la cartografía generada a partir de las opciones de cálculo seleccionadas en el panel izquierdo.

Podemos movernos por el mapa clicando sobre él y desplazando el ratón y, además, contamos con varias utilidades integradas. En la esquina superior derecha cuenta con:

- **Selector de vista satelital o cartográfica:** Permite alternar la vista básica del mapa entre imágenes cartográficas e imágenes satelitales. Por defecto, la opción seleccionada es “Mapa”, para la vista cartográfica.
- **Botón Pantalla completa:** Permite cambiar el mapa a modo pantalla completa para observarlo sin las secciones laterales.

En la esquina superior izquierda cuenta con:

- **Opciones de dibujo:** 5 botones que permiten alternar entre los modos de desplazamiento, adición de marcadores (no se utiliza en la aplicación), dibujo de líneas, dibujo de formas y dibujo de rectángulos. Estas opciones se utilizan para dibujar una geometría como área de interés si no se escoge un país.
- **Zoom:** Debajo de las opciones anteriores se encuentran dos botones con

los símbolos “+” y “-“ para aumentar o reducir el zoom del mapa. Esta acción también puede realizarse mediante la rueda del ratón.

Una vez generada la cartografía, en el mapa aparecerán, además de las utilidades mencionadas anteriormente, una serie de leyendas correspondientes a cada una de las capas de las variables calculadas con su escala de colores y los valores máximo y mínimo registrados en el área de interés seleccionada (fig. 13).

También aparece una nueva opción a la izquierda del selector de vista satelital o cartográfica, identificada con el nombre “Layers” donde se puede desactivar o dar opacidad a las distintas capas de la cartografía generada (fig. 13).

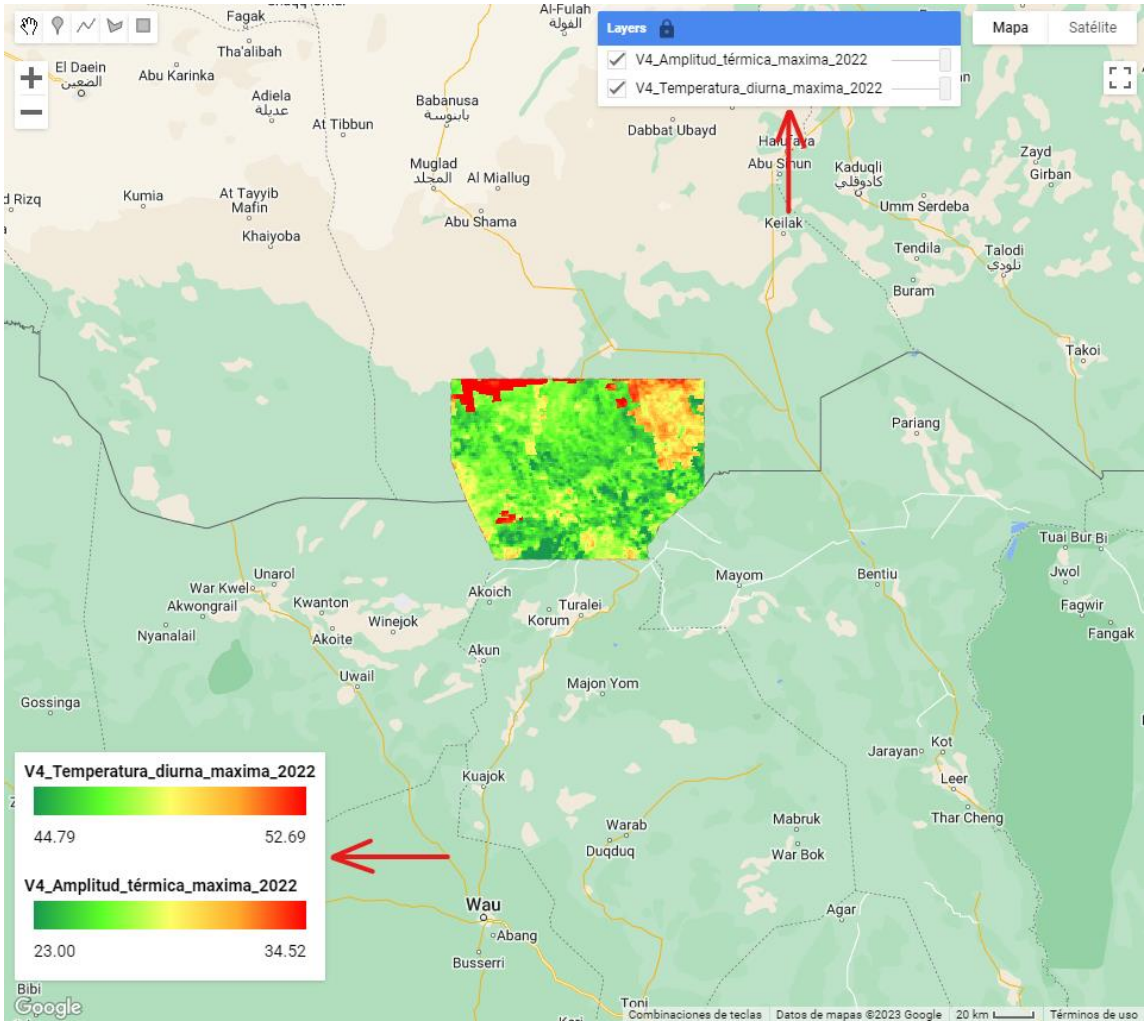

Figura 13. Capas y Leyenda

2.3. Panel de resultados derecho

Se ubica en el lateral derecho de la aplicación y aparece una vez que se seleccionan las variables de estudio en el panel de control izquierdo y se pulsa el botón calcular. Consta de dos subsecciones: *descarga de capas,* para descarga la cartografía elaborada*;* y *gráfica,* para visualizar y descargar series temporales de las variables analizadas.

2.3.1. Descarga de capas

Esta subsección incluye los enlaces con los nombres de las capas cartográficas calculadas. Haciendo clic en estos enlaces se abre temporalmente una nueva pestaña en el navegador y se inicia directamente su descarga en formato geotiff.

2.3.2. Gráficas

Cuando se hace clic sobre cualquier punto del área de interés de la cartografía generada, aparece una nueva sección en el panel derecho, que es la sección de gráficas (fig. 14).

En esta sección pueden consultarse las series temporales asociadas a las variables de cada una de las capas a lo largo del periodo completo sobre el que trabaja la aplicación. En la mayoría de los casos el año con el que inicia la serie es 2002, aunque en algunos satélites como Sentinel el año es posterior y se corresponde con la fecha de puesta en órbita del satélite.

Si se cierra la sección de control izquierda con los botones del panel derecho, al abrirla de nuevo será necesario volver a hacer clic sobre el punto de interés para que las gráficas vuelvan a aparecer. Es por ello por lo que, en el caso de que se quiera visualizar la cartografía con más detalle, se sugiere que se haga uso de la utilidad de pantalla completa del mapa (fig. 13).

El botón ubicado en la esquina superior derecha permite agrandarlas en una nueva pestaña y descargarlas en formato csv, svg y png.



Figura 14. Panel izquierdo. Enlace de descarga y gráfica de una serie

3. Ejemplo de uso de Art-Risk 5.

A continuación, se describen los pasos a seguir para analizar la lluvia acumulada

y la ocurrencia de heladas en el año 2015 en Andalucía y evaluar como estos condicionantes climáticos influyeron en los valores mínimos de salud de la vegetación que registraron las zonas naturales y demás áreas verdes.

En primer lugar, hay que seleccionar el año y los meses a analizar en la subsección *periodo de análisis* del panel izquierdo (fig. 15). Se indica el año que se quiere analizar (2015) y para calcular el año completo se coloca 1 como mes inicial (enero) y 12 como mes final (diciembre).

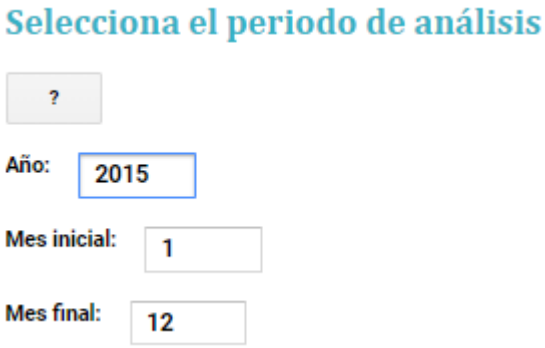

Figura 15. Selección del periodo de análisis

A continuación, se seleccionan las variables climáticas a analizar en la subsección *Variables climáticas*.

La lluvia acumulada se analiza seleccionando el control SUM 1 año, las heladas seleccionando el control SUM heladas 1 año y la salud mínima de la vegetación seleccionando el control NDVI_PER_25 (fig. 16).

Si alguna de las entradas de la aplicación no está cumplimentada correctamente o si hay seleccionadas más de 3 variables de análisis aparecerá un mensaje de error en la parte superior de la sección mapa que ayudará a localizar el problema y solucionarlo.



Figura 16. Selección de las variables climáticas

A continuación, se selecciona el área de interés. Para poder analizar Andalucía seleccionamos la opción "polígono dibujado" (fig. 17)(fig. 18) y mediante el uso de la herramienta de dibujar forma (fig. 19), ubicada en la parte superior de la sección *mapa*, perfilamos Andalucía (fig. 20).

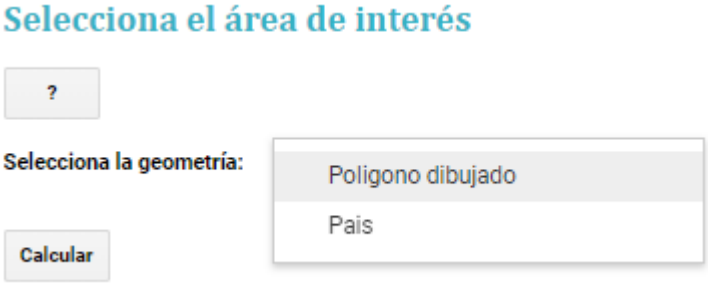

Figura 17. Selección área de interés

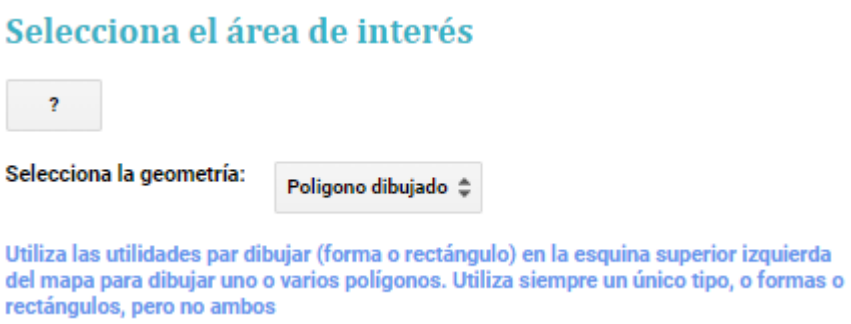

Figura 18. Selección de polígono dibujado

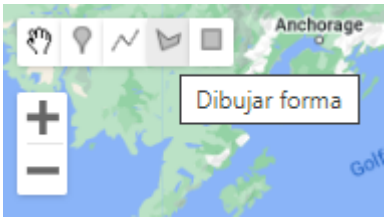

Figura 19. Dibujar forma

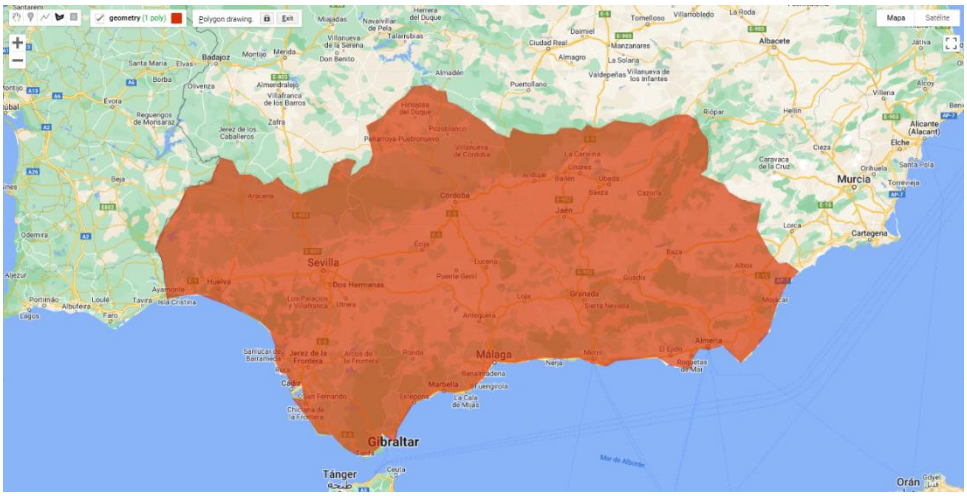

Figura 20. Dibujo del polígono región Andalucía

Una vez dibujado el polígono, sólo hay que pulsar el botón “Calcular” que se encuentra en la parte inferior del panel izquierdo. Automáticamente, la aplicación realizará los cálculos necesarios, incluirá las capas con la cartografía obtenida sobre la sección mapa y desplegará el panel derecho los enlaces des descarga de las distintas capas de cartografía en formato GEOTIFF (fig. 20).

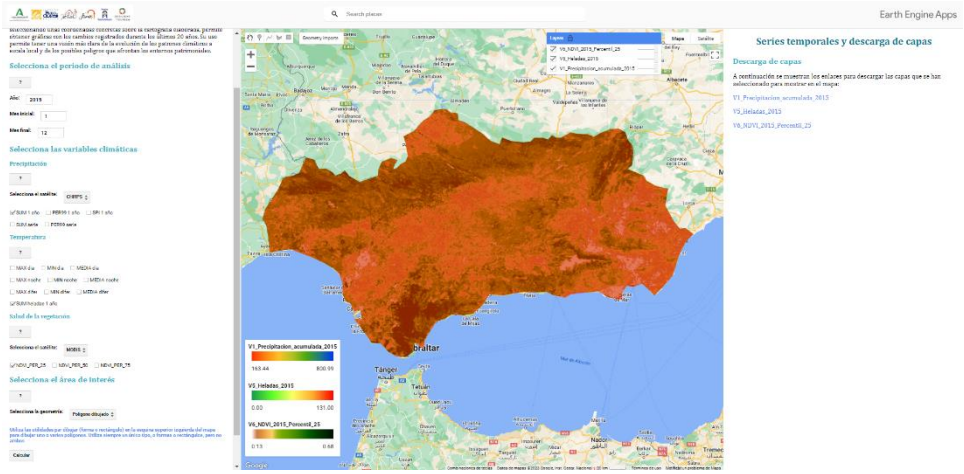

Figura 21. Resultado de calcular las capas para el polígono

Finalmente, si se hace clic sobre un punto que se encuentre dentro de área de interés, aparecerán bajo los enlaces de descarga de capas, una serie de gráficas asociadas a las series temporales de las capas que se han dibujado (fig. 21). Pulsando la flecha que está en la esquina superior derecha de cada grafico se pueden descargar los datos en formato CSV, SVG o PNG.

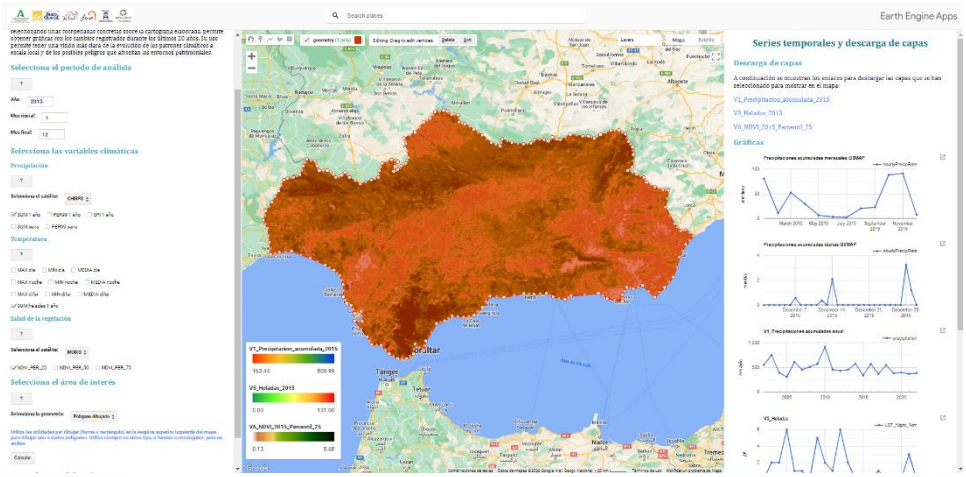

Figura 22. Resultado final con capas y gráficas del polígono dibujado

Si se desea ver un ejemplo de uso que incluya la interpretación de la cartografía y gráficas obtenidas en Art-Risk 5 puede consultar el siguiente artículo:

Moreno, M., Barea, R., Castro, L., Cagigas, D., Ortiz, R. y Ortiz, P. (2024) Climate Change monitoring with Art-Risk 5: New approach for environmental hazard assessment in Seville and Almería Historic Centres (Spain), in *Structural Integrity Procedia.* URI: https://hdl.handle.net/11441/157054