Virtual Archaeology Review, **14**(28): 95-109, 2023
https://doi.org/10.4995/var.2023.18652

Received: October 26, 2022
Accepted: December 13, 2022

ABANDONED RURAL PRE-INDUSTRIAL HERITAGE: STUDY OF THE RIAMONTE MILL COMPLEX (GALICIA, SPAIN)

PATRIMONIO PREINDUSTRIAL RURAL ABANDONADO: ESTUDIO DEL CONJUNTO MOLINAR DE RIAMONTE (GALICIA, ESPAÑA)

Pablo Xosé Pouso-Iglesias[a], Gustavo Arcones-Pascual[b,*], Santiago Bellido-Blanco[b], David Villanueva Valentín-Gamazo[b]

[a] Freelance in architecture and agricultural engineering, Ames, 15229, Spain. ppi3675@coeticor.net

[b] Department of Technical Education, Universidad Europea Miguel de Cervantes, Padre Julio Chevalier Street 2, Valladolid, 47012, Spain. garcones@uemc.es; sbellido@uemc.es; dvillanueva@uemc.es

Highlights:

- Graphic tools and virtual reconstruction applied to watermills contribute to their overall understanding as an anthropogenic landscape.
- Virtual reconstruction of the milling mechanisms allows us to understand the mill operation beyond the mere construction preservation.
- The Riamonte mills are an example of a group of canal mills linked to a single dam and with a social typology of inheriting turns to grind.

Abstract:

Each *concello* (municipality) in Galicia is home to a large number of pre-industrial rural heritage assets integrated into the landscape. Among them are the water mills, usually made up of small constructions that are difficult to reuse in their original function. They are not easily compatible with other uses either. Their current state of abandonment requires their cataloguing and correct valorization as pre-industrial archaeological heritage. These constructions must be conceived as interrelated constructive groupings, in their original physical and social context. A good example of this is the unpublished sample of the Riamonte milling complex. Its study, digitalization and virtual recreation by means of computer-assisted graphics have great potential for dissemination to the public and better integration into the nature trail near the riverbed. Graphically presenting archaeological heritage through virtual media helps to promote social understanding in order to raise awareness of the importance of its protection and irreplaceable nature, especially in case of those vestiges lacking sufficient security to survive. Due to the large amount of vegetation around the wall remains, a rigorous planimetric survey of the entire complex was carried out, followed by three-dimensional (3D) modelling of representative elements. In addition, applying a rigorous principle of transparency, a chromatic differentiation is made in the 2D and 3D virtual reconstructions between already existing and newly added elements. Regarding the 3D model, a historical-archaeological evidence scale is used, allowing a graphic identification of the authenticity degree required to provide reliability in the reconstruction of lost or altered parts. This facilitates virtual recreation interpretation among future researchers from different disciplines. The Riamonte mill complex is part of a typology typical of the region, in which the use of virtual models makes it possible to reach the scales of the territory, the building and the machinery, facilitating the correct understanding of this cultural heritage.

Keywords: mill; ethnographic heritage; rural construction; 3D modelling

Resumen:

Cada *concello* de Galicia alberga un buen número de bienes patrimoniales rurales de carácter preindustrial integrados en el paisaje. Entre ellos se encuentran los molinos hidráulicos, constituidos habitualmente por pequeñas construcciones difícilmente reutilizables en su función original; tampoco son fácilmente compatibles con otros aprovechamientos. Su estado de abandono hace necesaria su catalogación y correcta puesta en valor como patrimonio arqueológico previo a la industrialización. Estas arquitecturas deben ser entendidas en la forma de agrupaciones constructivas interrelacionadas, en su contexto físico y social de origen. Buen ejemplo de ello es la muestra inédita del conjunto molinar de Riamonte. Su estudio, digitalización y recreación virtual mediante medios gráficos asistidos por ordenador atesora un gran potencial para su difusión al público y una mejor integración en la senda turística de naturaleza próxima al cauce del río. Dar a conocer gráficamente el patrimonio arqueológico a través de medios virtuales contribuye a favorecer la comprensión social en aras de sensibilizar y concienciar sobre la importancia de su protección y naturaleza irremplazable, en especial aquellos vestigios carentes de la suficiente seguridad de supervivencia. Debido a la gran cantidad de vegetación alrededor de los restos murarios se optó por realizar un riguroso levantamiento

[*] Corresponding author: Gustavo Arcones-Pascual, garcones@uemc.es

planimétrico de todo el conjunto y, posteriormente, el modelado tridimensional (3D) de elementos representativos. Además, siguiendo un riguroso principio de transparencia, se lleva a cabo una diferenciación cromática en las reconstrucciones virtuales en 2D y 3D entre elementos existentes y añadidos. En el caso del modelo 3D se aplica una escala de evidencia histórico-arqueológica que permite una identificación gráfica del grado de autenticidad, necesaria para dotar de fiabilidad a la reconstrucción de las partes perdidas o alteradas. De esta forma se facilita la labor en la interpretación de las recreaciones virtuales entre los futuros investigadores de diferentes disciplinas. El conjunto molinar de Riamonte forma parte de una tipología propia de la región, en la que el uso de modelos virtuales permite alcanzar las escalas del territorio, del edificio y de la maquinaria, facilitando la correcta comprensión de este patrimonio cultural.

Palabras clave: molino; patrimonio etnográfico; construcción rural; modelado 3D

1. Vernacular heritage: water mills

Europe's vast ethnographic heritage was mainly developed in rural areas, subjected to a constant process of abandonment by their populations for decades. This is reflected in the agro-industrial buildings that make up a pre-industrial heritage in an evident process of deterioration and disappearance, which demands its study, cataloguing and enhancement (Ayuga, 1991). To graphically document and digitize these works, thus facilitating their subsequent dissemination, the use of computer-assisted drawing techniques and geographic information systems can complement the traditional methodology and help us to understand everything, from the integration of the infrastructure in the land, to the agricultural machinery used (Pérez-Martín, Herrero-Tejedor, Gómez Elvira, Rojas-Sola, & Conejo-Martín, 2011).

3D modelling allows for documenting historical watermills, presenting hypotheses and disseminating information (García-León, González-García, & Collado-Espejo, 2021), although graphic engineering applied to industrial archaeology can establish other orientations. In this sense, virtual models can be animated, allowing to show the functioning of the mechanisms while simulations facilitate the study of performance or other parameters for dissemination or possible intervention (Rojas-Sola & López-García, 2007a, 2007b). With 3D modelling and simulation, quantitative performance data can be obtained (Castro-García, Rojas-Sola, & De La Morena-de La Fuente, 2015; Pujol, Solà, Montoro, & Pelegri, 2010) which enhance the possibility of addressing rehabilitation and maintenance based on the improvement of water wheels and the reuse of the mill, for example, with application in power generation (Franco, Ferraresi & Revelli, 2019; Quaranta, Pujol & Grano, 2021). In the latter case, each situation must be properly assessed since endogenous factors, such as the existence of original historical mechanisms, and exogenous factors, such as the water flows currently available, must be taken into account, although it is true that maintaining the original function or a compatible use is the commonest and often most feasible form of conservation (International Council on Monuments and Sites [ICOMOS], 2011).

This study focuses on the vernacular heritage of Galician water mill architecture. Among the thousands of mills that populated the Spanish geography, it is estimated that in 1797 more than eight thousand were located in Galicia (Labrada, 1804), favouring this wealth of infrastructure its geography and climate, with a large number of streams and rivers. Depending on various factors, such as the flow of river courses, a number of different typologies were generated at both technological and social levels, with organizations that can only be understood from an overall perspective. Most of these mills, contrary to what may happen in other areas of the Iberian Peninsula, do not constitute singular elements on their own and need to be understood as groupings.

A good example of the above is the case of the Riamonte mills (Fig. 1), which were socially organized as a community due to their dependence on a low-flow stream where water had to be properly managed. These mills have not been in use for decades, mainly due to technological advances and the emergence of new milling systems (Fuentes, García, Ayuga, & Ayuga, 2011). For this reason, it is necessary to preserve the archaeological remains and to show visitors how they were used by the surrounding population and the links they generated among the members of the community. After an emergency intervention in two of the mills in 2003, the interest for similar action in the other eight remaining is limited, but their study is essential for a possible consolidation and their correct dissemination.

The general objective of this study, which encompasses different disciplines, is to investigate the layout, architecture and mechanisms of the Riamonte mills through 3D models based on previous rigorous planimetric surveys. Two-dimensional and three-dimensional information complements each other, so that it could be used for cataloguing and dissemination. Supported by open-source software, the reconstructions allow visualizing the level of precision through a chromatic scale of historical-archaeological evidence. This meets the concerns and criteria expressed in international documents aimed at guiding virtual archaeology (Denard, 2009; ICOMOS, 2017) which can already be considered a discipline of this science, three decades after Reilly (1990) introduced the term.

(a)

Figure 1: Riamonte mills: a) Mill 1; b) Mill 2; c) Mill 3; d) Mill 4; e) Mill 5; f) Mill 6; g) Mill 7; h) Mill 8; i) Mill 9; j) Mill 10; k) Dam.

(b)

(c)

(d)

(e)

(f)

(g)

(h)

(i)

(j)

(k)

2. Galician mill typology

Traditional mills are very varied and the typological classification can be approached from different points of view. The main distinction is made according to the type of material being ground (Cañas, Arias, & Vicente, 1997), and then according to the nature of the energy they process: manual, wind and hydraulic (river or sea). Due to the geographical and climatic peculiarities of Galicia, most of them are river hydraulics and are used for cereal production, with a clear predominance of those with a horizontal driving wheel, (called *rodicio*), as opposed to those with a vertical drive waterwheel (called *acea*), the former lacking gears in their rotating mechanism. Regarding the aforementioned *rodicio* mills, we can consider the external infrastructure that is used for water to access the device. This way we would have three typologies, as seen in Figure 2: canal, cube and boiler (Barros, 1997; Caamaño, 2006; Llano, 1983; Sampedro, 1990). The canal mill is the most abundant and possibly the oldest type of Galician river mill.

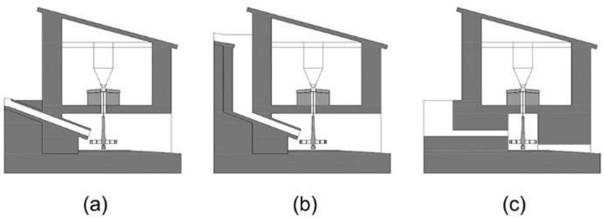


Figure 2: Typologies: a) canal; b) cube; c) boiler.

The general layout of the complex, the shape of each construction and the milling mechanism are linked to the available water flow, the orography and the type of ownership of each mill. Although the grouping of mills arises as a way of taking advantage of the good conditions offered by a given site for the settlement of productive structures, or also, as a way of saving efforts in the construction of new dams by using the existing ones, and thus giving rise to different types of groupings (Barros, 1997; Bas & Varela, 1999), they are also a reflection of the social environment, hence their predominance in Galicia as opposed to isolated mills. Collective organization is reflected in the type of milling that was carried out and, therefore, in the type of ownership: payment in kind and owned by inheritance (Barros, 1997; Rivas, 1997), the latter being the most common in the region.

The previous considerations lead us to take the mills of Riamonte as a representative model of this kind of architecture in Galicia, on which we can develop research that can be extrapolated to other cases, since they are ten hydraulic canal flour mills, with a horizontal wheel, and owned by inheritance. Located in the municipality of Ames (A Coruña), in the place of Vilar (parish of Santa María de Ames) next to the stream of Riamonte, which flows into the Dos Pasos river belonging to the Sar basin (Fig. 3), they shape a unique landscape integrated into a nature tourism path called "The Water Route". A total of eleven mills remains situated along the watercourse, but our study is focused on the ten located on rural land that depended on the same dam and canalization for water supply, and therefore constitute a group (Fig. 4).

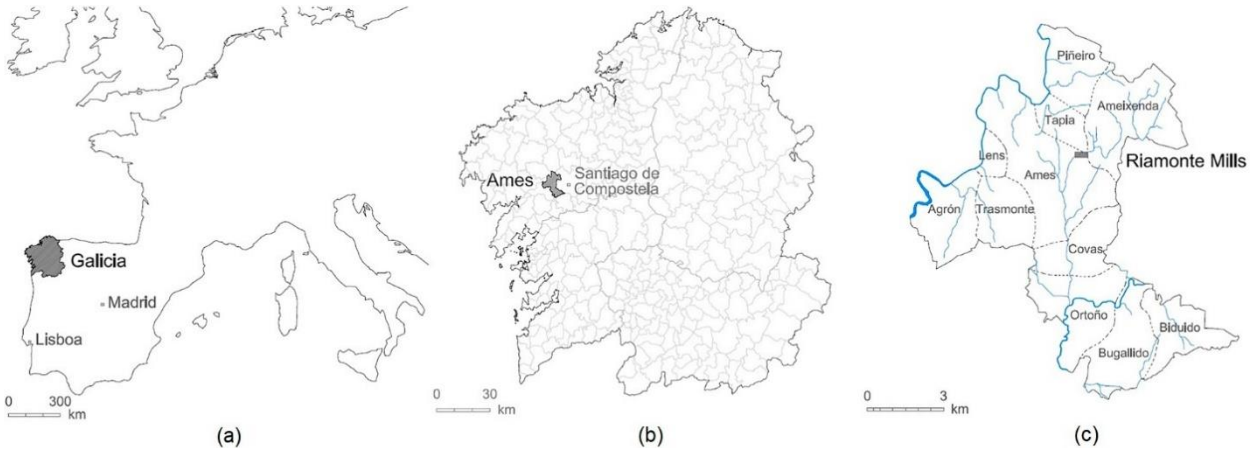


Figure 3: Location of the Riamonte mills: a) Europe; b) Galicia; c) Ames.

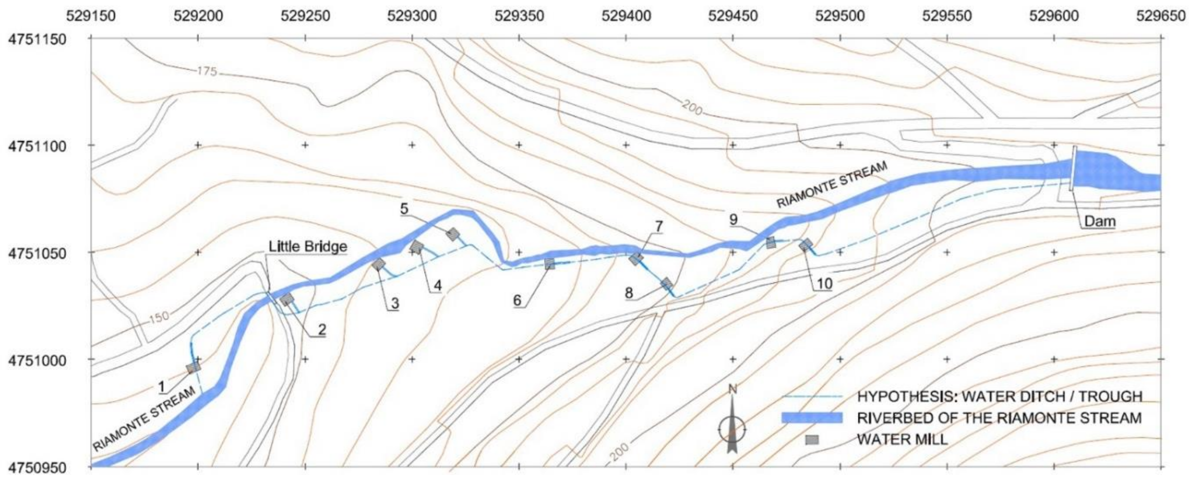


Figure 4: Location of the Riamonte mills: UTM coordinates.

3. Methodology

The research carried out has been based on both primary and secondary sources, with tasks that have involved theory and practice, i.e. bibliographic review, mills' location, their positioning by means of topographical instrumentation and the subsequent planimetric drawing-up study; ending with a 3D recreation of the typical installation of one of the examples.

The abundant vegetation located in the surroundings, inside and on the walls of the mills acted as visual barriers that prevented the recording of many parts by means of photogrammetry or laser scanning, which is why the use of these means to generate the 3D models of the current state was rejected. In addition, this nature that created the shaded areas was changeable throughout the data collection period. All this added to the fact that no physical intervention was going to be made on the set of mills, so it was decided to carry out an exhaustive two-dimensional survey and then model the elements three-dimensionally.

The initial research phase focused on the consultation of documentary collections on milling, traditional architecture and Galician adjective constructions. Archives of public bodies responsible for the conservation of ethnographic heritage were consulted in order to contrast the published documentation with the actual situation of the buildings. At the same time, a search for information was carried out through oral sources among the residents of the village of Vilar, in order to complement the data collected earlier. The interview with one of Maximino Viaño's grandchildren, who almost two decades ago had rescued part of this oral tradition, stands out (Viaño, 2004).

After the first phases, data was collected in situ, executing exhaustive field work to obtain the topographic and geometric data of the buildings and their location. The device used in the topographic survey was a Leica Viva TS11 5" Total Station, supported on bases previously placed with Leica GS15 GPS and the Global Geosystems GNSS (Global Navigation Satellite System) Network, with a maximum error of 0.05 m, and the Universal Transverse Mercator (UTM) ETRS89 geodetic reference system (Zone 29). The georeferencing work was considered necessary because the mills were not located on the maps found. Once the information on the location and altimetry of the mills was collected, a detailed geometric measurement of the constructions was carried out, complemented by an important photographic collection. Mill 1 was used to generate the georeferenced base and from this area, by dragging the coordinates of the initial base, the points coinciding with the axis of the footpath, the singular elements of the environment and the corners of the mills were raised.

Finally, a two-dimensional graphical survey of the buildings was carried out and the architecture of Mill 6 and the mechanism were recreated in 3D with the open-source software Blender. This digitized graphic and documentary set allows the analysis of proposals for its revaluation, from the drafting of file cards for possible inclusion in the catalogue of the council, to the complement in the informative documentation of the established natural tourist footpath, and even to consider an intervention.

4. Developing

4.1. Documentary references

The geographic dictionary of Pascual Madoz (1845) only indicates the existence of flour mills in the parish, the first direct reference we find being the answer given to Question 17 of the Cadastre of the Marquis de la Ensenada, on April 2, 1753. The answer indicates the name of the mills and who the owners were at the time. In addition, it is stated that they are all canal mills, with black millstones (granite stone), and that the mills in this stream only grind four months a year.

In the rest of the search for historical documentation, in relation to the Riamonte mills, no relevant data were found in archives that might provide some information on past uses. Nor did these constructions appear in the catalogue of the cultural heritage of Ames urban planning.

The information on these mills that appears in the response to the Cadastre of the Ensenada, coincides with the physical reality that can still be studied in the area, but not with the social reality, since these mills were the result of the community coexistence of the age of peasantry and the subsistence economy. The work of milling and its maintenance was carried out by the neighbours under an exploitation system agreed upon by all.

In the twinned mills, the right to grind was divided into shifts, pieces and half pieces that are equivalent to a certain number of hours of weekly use. This right of production was individualized and each owner disposed of the part that corresponded to them as they wished. The rights were inventoried and awarded to the heirs like any other property, so much so that the Galician Civil Law Act (2006) regulates the coparcenary or co-ownership of the “heir mills”.

4.2. Location and configuration

The names of the mills, according to Maximino Viaño (2004), together with the UTM coordinates for their geographic positioning are shown in Table 1. In addition, we have included the built and useful areas of the milling room, the surface of the lower chamber, and the clear height of each room. In the case of the clear heights of the milling area (mills 4 to 10), they are considered because there is currently no cover. As for the lower chamber, we have provided the current height, without excluding the sediment layer.

The ten hydraulic flour mills studied belong to the type of ownership by inheritance and depend on the same dam and canal, with an average slope on the path that joins the mills of 11.7% and a difference in level between mill 1 and 10 of 43.5 m (Fig. 5). The dam is made of local stone masonry (granite and granodiorite) and mortar, and currently consists of a spillway pipe and an upper walkway rendered with Portland cement. In this construction, we would find the catchment area from which the water would be taken through a water ditch to the trough of the first mill (Mill 10). Then it would pass through its lower chamber and enter through the second (Mill 9), and so on, except in the mills 5 to 2 in which the water would be diverted towards the riverbed. It should be noted that, in the area of the little bridge, formed by a stone slab, the water would be channelled over the stream, leaving traces on some adjoining stones, since the last mill (Mill 1) is on the right riverside (Fig. 6).

Table 1. Name of the mills, UTM coordinates and areas.

Num.	*Denomination (Galician language)*	*UTM coordinates (X / Y)*	*Built area of grinding floor / Useful area of milling room / Free area of the lower chamber (m²)*	*Clear height: Milling room, max. / Milling room, min. / Lower chamber (m)*
01	*O de Ortoño*	529197.899 / 4750996.111	22.69 / 11.90 / 4.05	2.56 / 1.84 /1.19
02	*O da Pontella*	529241.537 / 4751028.052	23.15 / 12.15 / 5.25	2.96 / 2.13 / 1.39
03	*O Novo*	529284.440 / 4751044.330	20.40 / 10.87 / 4.56	2.47 / 1.73 / 1.13
04	*O da Xustiza*	529302.201 / 4751052.362	23.57 / 13.53 / 4.70	2.28* / 2.30* / 1.16
05	*O Caleado de Vilar*	529319.202 / 4751058.471	21.37 / 11.57/ 5.81	2.69* / 1.73* / 0.87
06	*O da Pedra*	529364.299 / 4751044.531	20.88 / 11.33 / 5.34	3.31* / 2.22*/ 1.39
07	*O Caleado de Lamas*	529404.677 / 4751047.253	22.89 / 12.87 / 4.55	2.81* / 1.91* / 1.25
08	*O Vello*	529418.806 / 4751035.108	17.81 / 8.89 / 5.30	2.85* / 1.88* / 1.35
09	*O Casarello*	529467.538 / 4751054.765	19.02 / 9.86 / 3.87	2.64* / 1.96* / 1.09
10	*O de Arriba de Todo*	529483.996 / 4751053.387	20.87 / 10.91 / 4.27	2.57* / 1.86* / 1.01

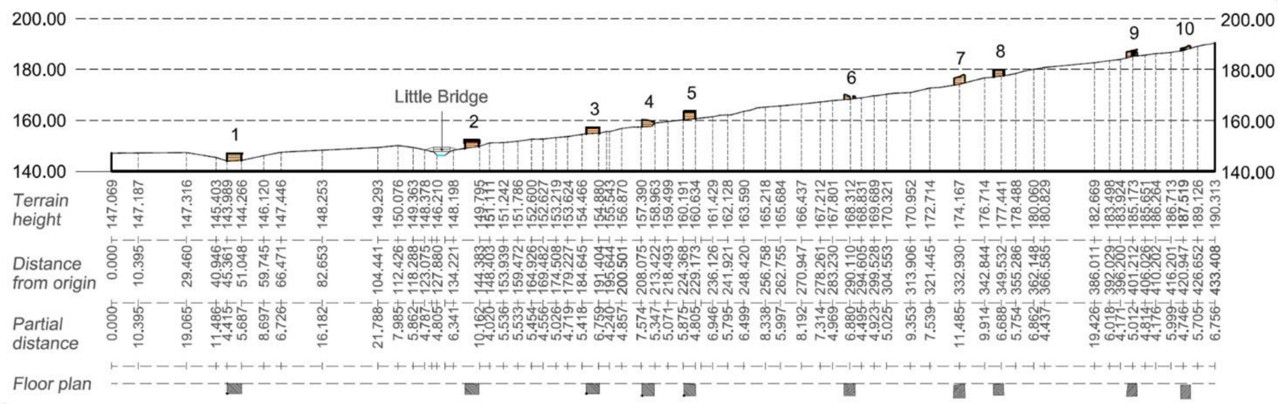


Figure 5: Section in the axis of the Water Route.

Figure 6: The little bridge (*pontella*).

The architecture of the mill consists of a rectangular milling room, which is adapted to the orography (Fig. 7), with a mono-pitch roof, an entrance door and, in some cases, a small window facing the trough. Below, there is a space through which the water that moves the horizontal wheel passes. As for the construction, the foundation is supposed to be filled with local stone on which the load-bearing walls of ordinary masonry are raised, using carved stones in the singular points such as lintels and jambs. In addition, there are remains of lime plaster on the wall surfaces. The horizontal structure between the milling room and the lower chamber is made of granite flagstones, while the roof would have been built with rafters and planks, on which curved ceramic tiles would have been placed.

In the Riamonte mills, a single door opens in the milling room near one of the corners, with a width between 0.70 and 0.84 m (2.5 to 3 Castilian feet) and a height of 1.67 to 1.95 m (6 to 7 Castilian feet), in which the woodwork has virtually disappeared. Furthermore, in mills 1, 2, 4 and 8 there was a small hole in the wall, oriented towards the channel, which would allow the water to be observed and sometimes access to the flow closure rod. Lastly, on the inner wall of mills 3, 7 and 8, as well as on the outer face of mills 4, 5 and 7, there is a corbeled stone that was used to facilitate the raising and lowering of the sack of flour.

The rotation mechanism of the mills had a vertical axis, the water impulse in the lower chamber would come out of the funnel intake and was received in the curved blades of the horizontal wheel that transmitted the rotation to the wooden axle-tree, which was attached to the iron spindle by means of wooden wedges and iron hoops (Fig. 8). There are two supporting pieces of the horizontal water wheel, a swivel attached to the axle-tree (the pivot) which rests on another barely mobile (footstep) both made of stone. Under the footstep, there is a wooden crossbar, the lighter staff, which forms part of the vertical displacement mechanism that allows to increase or reduce the separation between the runner stone (upper-millstone) and the bed stone (under-millstone), being activated from the milling room through the bridge tree, which ends in a cross piece of wood: the sword.

The connection of the rotation and grinding mechanism was made with the iron spindle, which crossed the flagstones and the bed stone through the eye and a bearing, joining the runner stone (with diameter 3½ Castilian feet, 0.97 m) through the iron rind that transmits the rotation. In the milling room there were other complementary elements such as the wooden hopper, with the shoe and the shaker arm, hanging from the cross-trees or beams in the roof; the wooden vat (Fig. 9) and, in some cases, the crane (cantilever) for millstone maintenance.

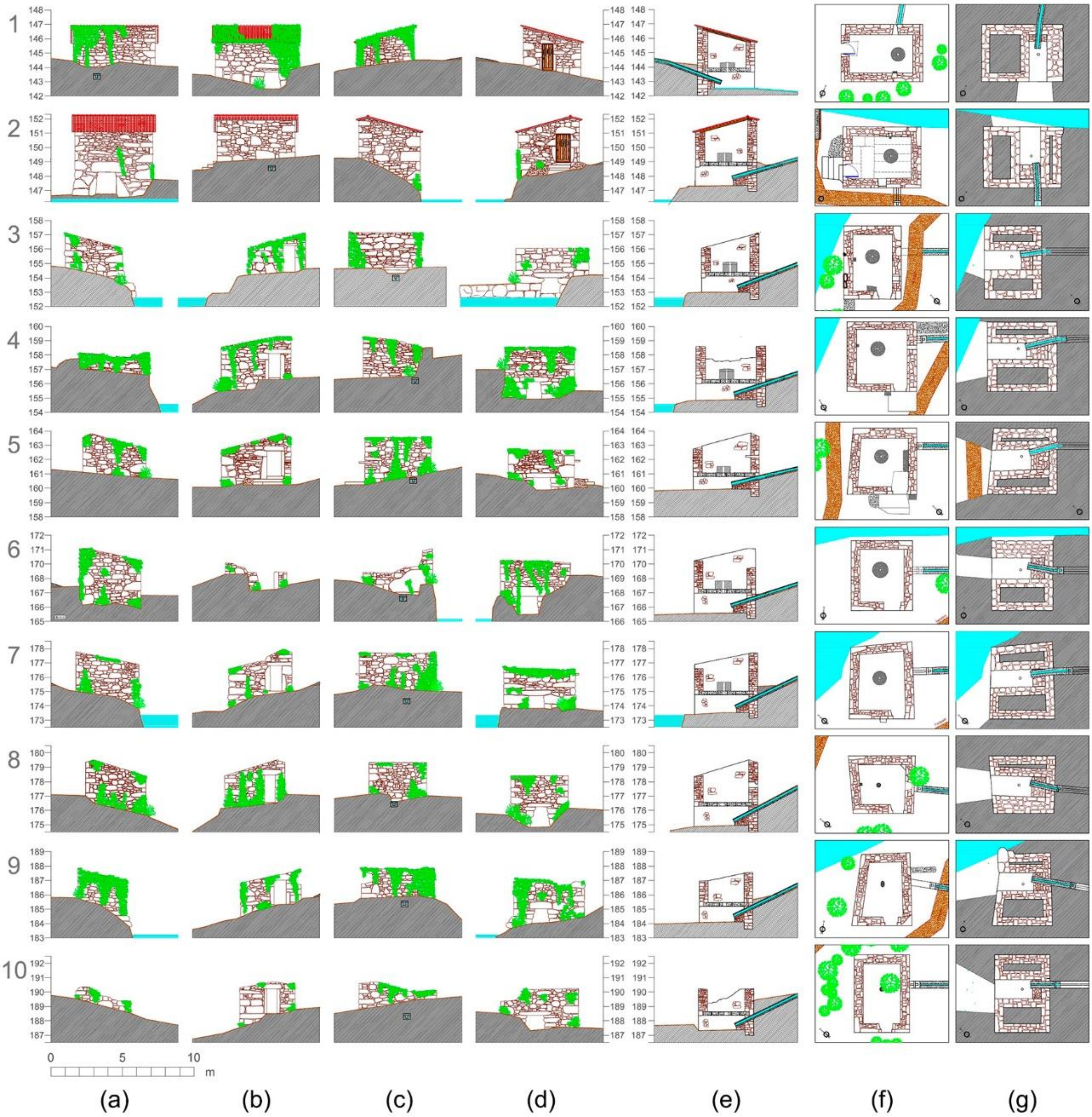
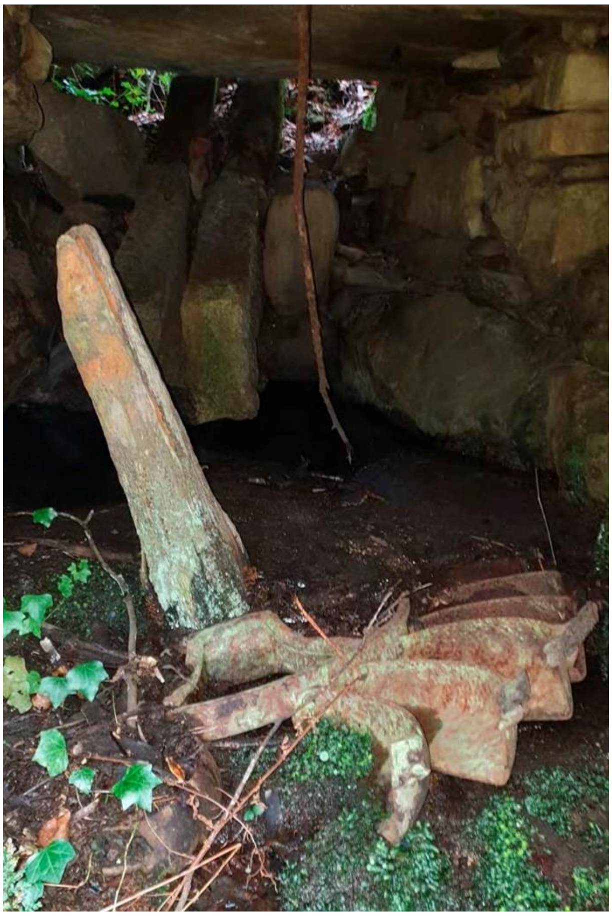


Figure 7: 2D current state: a) North elevation; b) South elevation; c) East elevation; d) West elevation; e) Section; f) Milling room plan; g) Lower chamber plan.

5. Analysis and diagnosis

The vernacular heritage stems from a way of building of the community itself that responds to functional, social and environmental requirements, with a strong local character linked to the area. It is a heritage that will only survive if it is appreciated by the community and especially by the new generations (ICOMOS, 1999). In the case of unused mills sets, the perspective for their understanding has changed at a physical and social level, since the interrelation with the natural environment in which it is located is very direct and, on the other hand, current human activity has lost such interconnection, so it needs to be properly explained to guarantee the survival of this cultural heritage (Hognogi, Marian-Potra, Pop, & Mălăescu, 2021). Therefore, any intervention must be preceded by a careful analysis of its form and organization.

The mill complex modifies the natural environment, both in terms of the riverbed through dams and water ditches, and in the accesses (paths and footpaths); it is an anthropogenic landscape with territorial value (Brykala & Podgórski, 2020). During the second half of the 20th century, when the mills were abandoned as a result of the general industrialization process, until today, the Riamonte stream has been retaken by nature, as can be seen in the orthophotos of the National Geographic Institute, from the so-called American Flight of 1945, when all the buildings were visible, to the present day, when they are covered by leafy vegetation (AMS, 1945; AMS, 1956; IGN, 1983; IGN, 2001; IGN, 2020). Beyond



(a)

(b)

Figure 8: a) Wheel of Mill 6; b) 3D reconstruction of the wheel-house.

the decontextualization of the built rural heritage with respect to its original physical context, the process of naturalization of the environment near the riverbed, together with the nature tourism route, offers an opportunity for the survival of the assets, provided that they are adequately disseminated among tourists and the residents of Ames (Gallou, 2022). To this end, the use of graphic information developed, combined with other descriptive means, is essential for communication, understood in its dimensions of disclosure, dissemination, presentation, and interpretation (Raies, 2021).

(a)

(b)

Figure 9: a) Millstones of Mill 3; b) 3D reconstruction of the milling room.

Vernacular constructions, while they remain in use, constitute a living element that evolves at a social level, an example of which is the name given to each mill. During the long life of the Riamonte complex, not only has the physical environment evolved. It can also be seen that the names of only two of the mills have been preserved since 1753 before their abandonment (Ensenada, 1753): the New (*O Novo*) and the Old (*O Vello*). Only the most commonly used words have survived, forgetting those mill designations with an origin based on names of owners or places, with less persistence over time. The existence of a generic denomination indicating the interrelationship between the people who used to grind in each mill is also a good way to define a grouping (Leal, Cuesta, & Sanmartín, 1995).

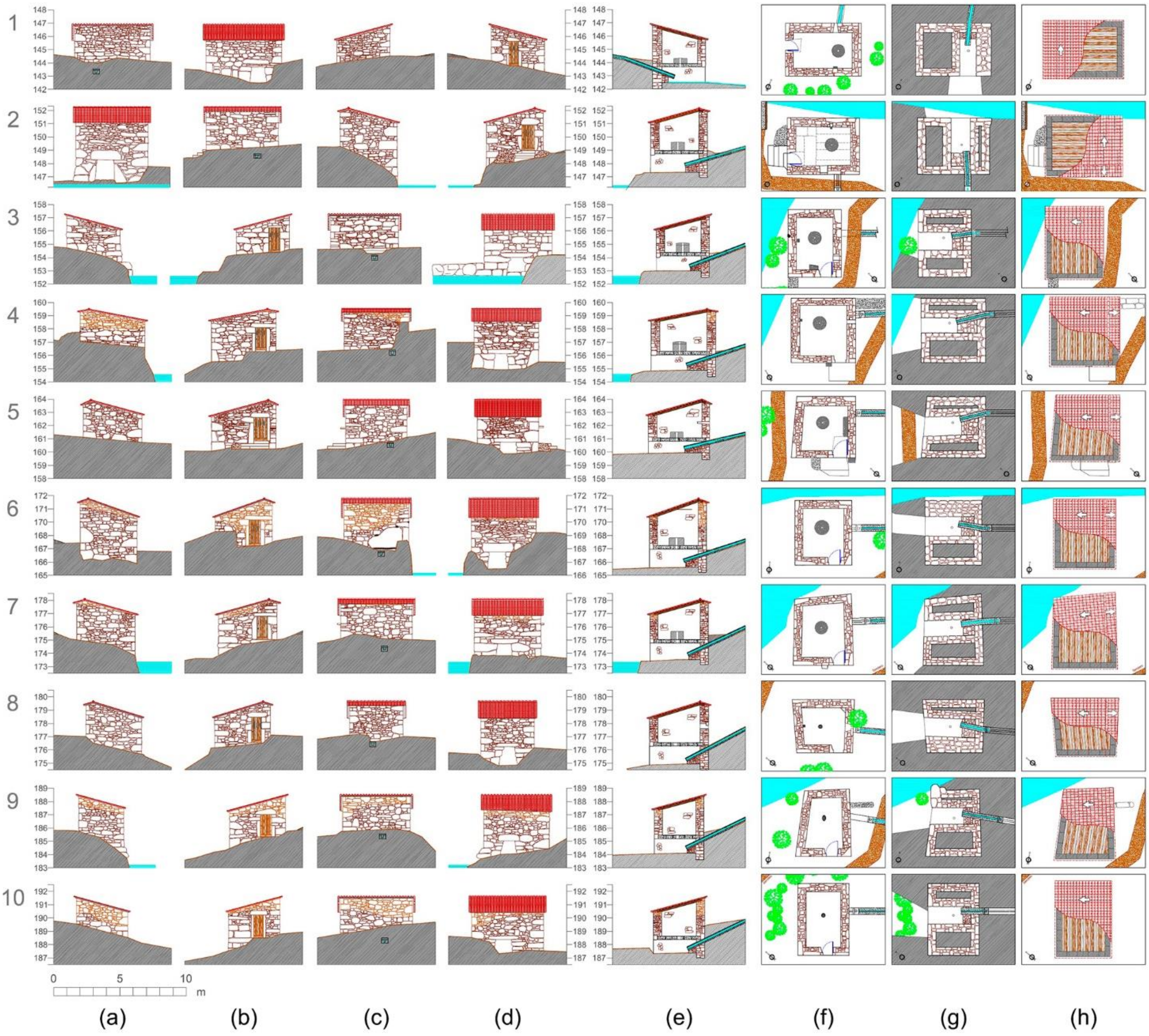


Figure 10: 2D Reconstruction: a) North elevation; b) South elevation; c) East elevation; d) West elevation; e) Section; f) Milling room plan; g) Lower chamber plan; h) Roof plan.

Although at least eighteen flour mills were built in the parish, the study of groupings is considered a correct methodology, except in those cases where the mill was completely isolated. Otherwise, it is understood that a decontextualization would occur in any type of intervention: restoration, consolidation or communication, which would prevent correct understanding at a constructive and social level. In this case, among the ten mills dependent on the same dam, in 2003 mills 1 and 2 were intervened under the direction of Marcelino Portals Coto, since it was necessary to guarantee the survival of the constructions.

Only the two restored mills preserve their roofs, while the other ones still maintain the masonry walls and the nearby trough. Regarding the mechanism, only the horizontal wheel persists, half-buried, in Mill 6, the rest of them have been looted. Similarly, the bedstone remains in mills 1 to 8 and the runner stone in 3 and 4, being black or ordinary millstones, carved with granite for grinding any type of grain: corn, rye, wheat, barley or beans, and there are no descriptions of white millstones made with more resistant quartzite rocks. In addition, some masonry walls are in a very poor state of conservation, in the case of mills 6, 9 and 10. It is in the area of conservation where digitalization and developed planimetric graphic documentation become relevant and, in the field of the looted mechanisms, 2D (Fig. 10) and virtual 3D recreation (Fig. 11) allow the understanding of construction that is currently empty, thus avoiding costly immobile recreations. Currently, the digitization and accessibility of content are very important issues in the conservation process (Versaci, Cardaci, & Fauzìa, 2016). While it is true that public and commercial repositories of 3D models have significant shortcomings, such as those studied by Champion & Rahaman (2020), for example, within the EU-funded digital library (Europeana) specific initiatives have been developed with applications that will allow sharing 3D models, such as Share3D, which relies on a generic hosting and visualization service provider. Tools that have been tested for educational, research and creative purposes, would require a greater boost to increase the scarce content.

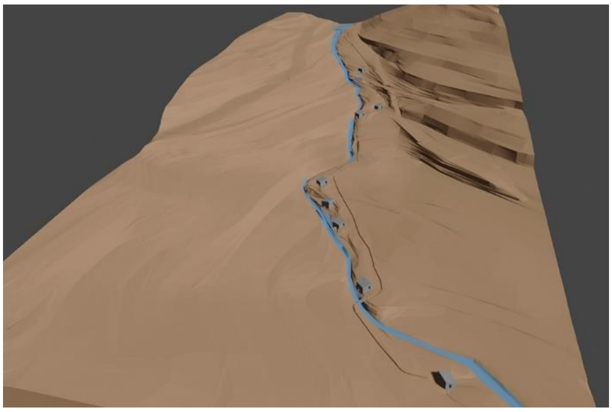
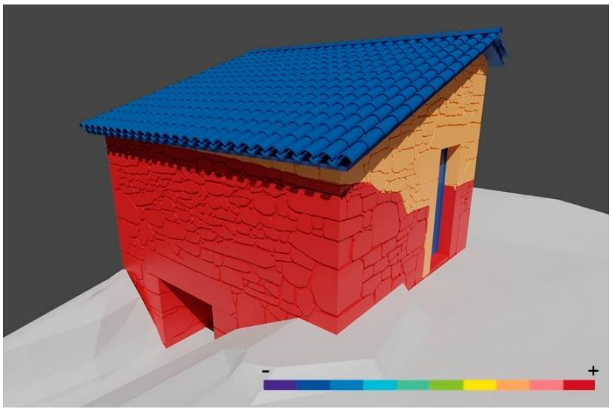


Figure 11: The stream of Riamonte, surrounding land.

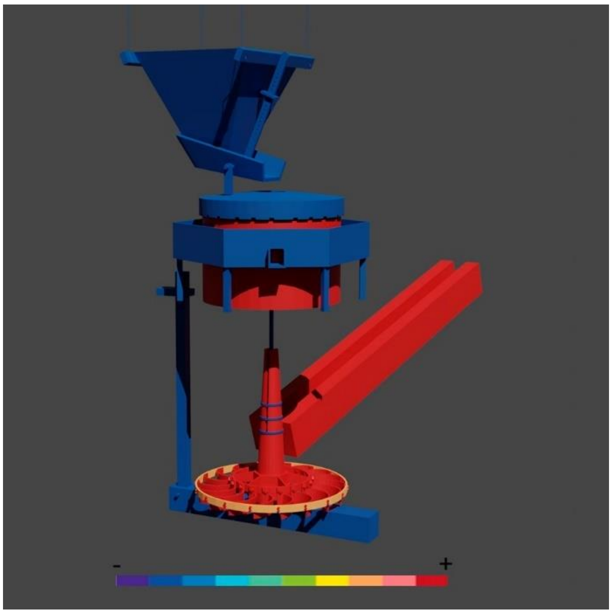


(a)

(b)

Figure 12: 3D reconstruction of Mill 6: a) Chromatic scale depicting historical/archaeological evidence; b) Textures.

3D models in Blender can be provided with textures and movement that create a sense of realism, and can be intended for the general public. In addition, virtual reconstruction allows the incorporation of a historical-archaeological evidence chromatic scale (Table 2) related to the reconstructive units (RU) into which the mill has been previously divided, as shown in Table 3. In this case, the architecture (Fig. 12) and mechanism (Fig. 13) of the mill are virtually reconstructed. In the pictures, the historical-archaeological evidence scale used is that of Aparicio & Figueredo (2016), inspired by the virtual reconstruction of the port area of the Byzantium 1200Project (Clifford, Kostenec & Berger, 2009), which has been used in combination with reconstructive units, as in other recent studies (Aparicio-Resco, García, Muñiz-López, & Fernández-Calderon, 2021; Cáceres-Criado, García-Molina, Mesas-Carrascosa, & Trivino-Tarradas, 2021; Cáceres-Criado, García-Molina, Mesas-Carrascosa, & Trivino-Tarradas, 2022; Cots, Vilà, Diloli, Ferré, & Bricio, 2018; Rodríguez-Hernández, Álvarez-Sanchís, Aparicio-Resco, & Maté-González, 2021). The use of this system facilitates the work of other researchers, allowing future reinterpretations in the event of finding more historical documentation of the mills (written, graphic or photographic) that the inhabitants of Ames may have.



(a)

(b)

Figure 13: 3D mechanism of Mill 6: a) Chromatic scale depicting historical/archaeological evidence; b) Textures.

The Riamonte mills are a clear example of the risks posed by the National Plan for Traditional Architecture (Benito & Timón, 2014) since, as in other vernacular constructions, they need better cataloguing and dissemination to avoid their devaluation and improve awareness. In order not to lose this hydraulic heritage, it

Table 2. Scale depicting historical/archaeological evidence (Aparicio-Resco & Figueiredo, 2016).

Level of evidence		*Description*	*Colour (RGB; CMYK; Hex)*
1		Imagination. (Although in natural and historical contexts, elements are imagined).	R120 G54 B140; C65 M90 Y0 K0; #78358B
2		Conjecture based on similar structures. (Based on comparable architecture or element elsewhere).	R0 G79 B159; C100 M70 Y0 K0; #004F9E
3		Basic textual reference. (Simple textual description, just indicative).	R0 G139 B206; C85 M3#0 Y0 K0; #008ACD
4		Descriptive textual reference. (Based on detailed textual description regarding dimensions, materials, colours, etc.).	R91 G197 B242; C60 M0 Y0 K0; #5BC5F1
5		Simple graphical reference. (Based on simple representation in art).	R108 G190 B153; C60 M0 Y50 K0; #6CBD98
6		Detailed graphical reference. (Based on detailed and objective representation in art).	R175 G202 B11; C40 M0 Y100 K0; #AFCA0A
7		Basic archaeological information or simple base plans. (Simple archaeological evidence or basic plans and elevations).	R255 G229 B0; C0 M5 Y100 K0; #FFE500
8		Strong archaeological and documental evidence in photographs and detailed plans. (Based on precise measurements documented in photographs and detailed plans).	R245 G160 B87; C0 M45 Y70 K0; #F5A057
9		Still existing (or partially existing) with modifications. (Based on structures still existing though altered in a later stage).	R237 G108 B126; C0 M70 Y35 K0; #ED6C7D
10		Still existing in its original form. (Based on structures which exist to this day in their original shape).	R183 G25 B24; C20 M100 Y100 K10; #B61918

Table 3. Reconstructive units of Mill 6.

RU	*Level of evidence*	*Name*	*Description*
1		Surrounding land	Carried out from topographic plans and photographs
2	10	Wall in the wheelhouse and the milling room	Ordinary masonry walls made of local stone
3	8	Upper walls in mill room	Remains of the collapse of the upper part of the wall next to the mill
4	2	Roof	Ceramic curved tiles on rafters and wooden planks. Eave formed by pieces of local stone
5	10	Floor above lower chamber	Flagstones of local granite on the wheelhouse and the floor
6	2	Mechanism: supplementary	Hopper (*moega*), shoe (*quenlla* or *adella*), shaker arm (*tarabelo*) and vat *(caixa da fariña*). Ethnographic parallels (Barros, 1997)
7	2	Grinding mechanism	Runner Stone or upper-millstone (*moa*), rind or rynd (*segorella*) and bearing (*buxa*)
8	10	Mechanism: fixed stone	Bed Stone or under-millstone (*pé*). Existing remains in the mill room (*tremiñado*)
9	2	Rotation mechanism: axis	Iron spindle (*beo*), stone pivot (*grilo* or *agulla*), stone footstep (*obradeira* or *rá*) and iron hoops (*argolas*). Ethnographic parallels (Barros, 1997; Caamaño, 2006)
10	10	Rotation mechanism in the lower chamber	Horizontal water wheel of iron (*rodicio*) with curved blades (*penas*) and the wooden axle-tree (*touzo*). Existing remains in the wheel-house (*inferno*)
11	8	Mechanism: outer part of curved blades	External iron ring (*aro*) of the curved blades in the horizontal water wheel. Partial signs on the outside of the existing wheel in the lower chamber
12	2	Lifting mechanism	Lighter staff (*arrieiro*), bridge tree (*erguedoiro*) and sword (cruz). Ethnographic parallels (Barros, 1997; Caamaño, 2006)

is essential to have databases or general catalogues that can systematically collect information, since many lack specific studies (Vila, 2021), and those found are of unconnected areas, not carried out under common parameters (Viéitez & Vidal, 2002; Abraira, 2002; Leal, 1999; Pagán, 2003; Lema & Mouzo, 2007). In this sense, computer-assisted graphics and 3D modelling are elements that can be used for the possible cataloguing (inventorying) of the mills' heritage within the current urban planning regulations of the municipality, as well as for their valuation by the community, in the latter case being accessible through Web repositories or other digital media (Delgado Anés & Romero Pellitero, 2017; Nishanbaev, 2020).

6. Conclusions

Despite national, regional and local regulations that promote the protection of heritage, rural constructions, such as the Riamonte mills, are physically disappearing and, what is more serious, they are being forgotten by the community itself, thus losing the local identity of the place where they were born. The cataloguing of these buildings and the provision of adequate means for them to be appreciated within their context, at the time and with the social organization in which they were created, is essential for their permanence in our memories. Conventional graphic surveys and 3D recreation are necessary tools to support the subsequent communication and dissemination of this heritage.

The Riamonte mill complex is part of a cooperative system, unusual in other Iberian regions, which can be seen in the grouping of mills dependent on a single dam. The use of the mill established economic relations between the owners and even set specific schedules in some periods of their daily activities, being observed by the population as a social, familiar and functional asset in an agrarian economy close to subsistence and with a clear coexistence with the place. It is essential to understand the mill within its social function and links with the territory in order to address its subsequent protection. Only by understanding the mill groupings as elements of a whole, i.e. an ensemble, will it be possible to propose optimal conservation strategies.

Nowadays, except for experts in molinology, these pre-industrial architectures are not understood as a socio-cultural asset, nor as a necessary element, due to the current way of inhabiting the land. Moreover, their functioning is rarely understood by the general population. It is therefore of paramount importance to rediscover this heritage to the public so that any technical and economic effort aimed at its preservation may be fruitful. In this regard, the proximity of the Riamonte Mills to the road between Santiago de Compostela and Finisterre, just two kilometers from the Roman Bridge of Aguapesada, offers a good opportunity to complement the informative contents of the nature tourism of the Water Route with those of the vernacular architecture and the social use of the mills.

This study on the Riamonte mills complex addresses everything from its implementation in the landscape to the architecture and engineering of the units and can serve as a basis for addressing its understanding, protection, management and communication of its heritage values.

References

Abraira Pérez, M. A. (2002). *Muíños nas terras de Redondela. Estudio etnolóxico dos muíños de auga*. Vigo, Spain: Diputación Provincial de Pontevedra.

AMS. (1945, October 4). *Vuelo americano Serie A* [aerial photographs], H0094_126_159 [photogram]. 1:43.000. Army Map Service. Centro Cartográfico y Fotográfico (CECAF) del Ministerio de Defensa. Retrieved from https://fototeca.cnig.es/fototeca/

AMS. (1956, August 1). *Vuelo americano Serie B* [aerial photographs], Roll 165, 15634 [photogram]. 1:32.000. Army Map Service. Centro Geográfico del Ejército de Tierra (CEGET). Retrieved from https://fototeca.cnig.es/fototeca/

Aparicio-Resco, P. & Figueiredo, C. (2016). El grado de evidencia histórico-arqueológica de las reconstrucciones virtuales: hacia una escala de representación gráfica. *Revista Otarq: Otras arqueologías, 1*, 235-247. Retrieved from http://revistas.jasarqueologia.es/index.php/otarq/article/view/96

Aparicio-Resco, P., García Álvarez-Busto, A., Muñiz-López, I., & Fernández-Calderón, N. (2021). Reconstrucción virtual en 3D del Castillo de Gauzón (Castrillón, Principado de Asturias). *Virtual Archaeology Review, 12*(25), 158-176. https://doi.org/10.4995/var.2021.14940

Ayuga Téllez, F. (1991). Evolución de la edificación agraria en España. Su incidencia en el paisaje rural. *Informes de la Construcción, 43*(416), 39-52. https://doi.org/10.3989/ic.1991.v43.i416.1362

Barros Justo, R. (1997). *Muiños de río nas terras de Pontevedra*. Pontevedra, Spain: Diputación Provincial de Pontevedra.

Bas López, B. & Varela Vilariño, X. (1999). *Os muíños.* Vigo, Spain: Ir Indo Edicións.

Benito Martín, F. & Timón Tiemblo, M. P. (2014). El Plan Nacional de Arquitectura Tradicional: instrumento de salvaguardia de un patrimonio en peligro. *Patrimonio Cultural de España, 8*, 43-66.

Brykala, D. & Podgórski, Z. (2020). Evolution of landscapes influenced by watermills, based on examples from Northern Poland. *Landscape and Urban Planning, 198,* 103798. https://doi.org/10.1016/j.landurbplan.2020.103798

Caamaño Suárez, M. (2006). *Galicia, as construccións da arquitectura popular. Patrimonio etnográfico de Galicia.* A Coruña, Spain: Hércules de Ediciones.

Cáceres-Criado, I., García-Molina, D. F., Mesas-Carrascosa, F. J., & Trivino-Tarradas, P. (2021). Graphic representation of the degree of historical-archaeological evidence: the 3D reconstruction of the “Baker’s House”. *Heritage Science, 10,* 33. https://doi.org/10.1186/s40494-022-00670-0

Cáceres-Criado, I., García-Molina, D. F., Mesas-Carrascosa, F. J., & Triviño-Tarradas, P. (2022). New approach for optimizing the interpretation and representation of the degree of historical-archaeological evidence in the virtual reconstructions. *Virtual Reality*. https://doi.org/10.1007/s10055-022-00707-6

Cañas Guerrero, I., Arias Sánchez, P., & Vicente Álvarez, I. (1997). Riqueza y variedad de las construcciones agrarias gallegas: los molinos de agua en el municipio de Begonte, Lugo/España. *Informes de la Construcción, 48*(447), 25-38. https://doi.org/10.3989/ic.1997.v48.i447.973

Castro-García, M., Rojas-Sola, J. I., & de la Morena-de la Fuente, E. (2015). Technical and functional analysis of Albolafia waterwheel (Cordoba, Spain): 3D modeling, computational-fluid dynamics simulation and finite-element analysis. *Energy Conversion and Management, 92*(1), 207-214. https://doi.org/10.1016/j.enconman.2014.12.047

Champion, E. & Rahaman, H. (2020). Survey of 3D digital heritage repositories and platforms. *Virtual Archaeology Review, 11*(23), 1–15. https://doi.org/10.4995/var.2020.13226

Clifford, P., Kostenec, J., & Berger, A. (2009). *Byzantium 1200*. http://www.byzantium1200.com

Cots, I., Vilà, J., Diloli, J., Ferré, R., & Bricio, L. (2018). Virtual archaeology: from archaeological excavation to the management and diffusion of heritage. Les Cases de la Catedral (Tortosa) and the protohistorical settlement of La Cella (Salou), Tarragona. *Virtual Archaeology Review*, *9*(19), 102–113. https://doi.org/10.4995/var.2018.9754

Delgado Anés, L. & Romero Pellitero, P. (2017). La arqueología virtual, generadora de recursos para la comunicación y participación. In L. Bocanegra Barbecho & A. García López (Eds.), *Con la Red. Creación, investigación y comunicación cultural y artística en la era Internet* (pp. 193-214). Granada, Spain: Universidad de Granada, Downhill Piblishing (NY). Retrieved from http://hdl.handle.net/10481/48875

Denard, H (ed.) (2009). *The London Charter for the computer-based visualisation of cultural heritage*. www.londoncharter.org (accessed: December 2022) King’s College London.

Ensenada (1753, April 2). Respuestas Generales del Catastro del Marqués de la Ensenada. 1750-1754. Feligresía de Santo Thome de Ames. *Portal de Archivos Españoles (PARES) del Ministerio de Cultura y Deporte*. Retrieved from http://pares.mcu.es/Catastro/servlets/ServletController?ini=0&accion=0&mapas=0&tipo=0

Franco, W., Ferraresi, C., & Revelli, R. (2019). Functional analysis of Piedmont (Italy) ancient water mills aimed at their recovery or reconversion. *Machines, 7*(2), 32. https://doi.org/10.3390/machines7020032

Fuentes, J. M., García A. I, Ayuga, E., & Ayuga, F. (2011). The development of the flour-milling industry in Spain: analysis of its historical evolution and architectural legacy. *Journal of Historical Geography, 37*(2), 232-241. https://doi.org/10.1016/j.jhg.2010.10.002

Gallou, E. (2022). Heritage and pathways to wellbeing: From personal to social benefits, between experience identity and capability shaping. *Wellbeing, Space and Society, 3*, 100084. https://doi.org/10.1016/j.wss.2022.100084

García-León, J., González-García, J. A., & Collado-Espejo, P. E. (2021). Documentation and modelling of a hypothetical reconstruction of the first Roman watermill in Hispania. *Virtual Archaeology Review, 12*(25), 114–123. https://doi.org/10.4995/var.2021.15316

Hognogi, G. G., Marian-Potra, A. C., Pop, A. M., & Mălăescu, S. (2021). Importance of watermills for the Romanian local community. *Journal of Rural Studies, 86*, 198-207. https://doi.org/10.1016/j.jrurstud.2021.05.031

ICOMOS. (1999). *Carta del Patrimonio Vernáculo Construido, 1999*. International Council on Monuments and Sites. Retrieved from https://www.icomos.org/images/DOCUMENTS/Charters/vernacular_sp.pdf

ICOMOS. (2011). *Joint ICOMOS-TICCIH Principles for the Conservation of Industrial Heritage Sites, Structures, Areas and Landscapes. The Dublin Principles*. International Council on Monuments and Sites. Retrieved from https://ticcih.org/about/about-ticcih/dublin-principles/

ICOMOS. (2017). *Principles of Seville. International Principles of Virtual Archaeology*. International Council on Monuments and Sites. Retrieved from https://icomos.es/wp-content/uploads/2020/06/Seville-Principles-IN-ES-FR.pdf

IGN. (1983, November). *Vuelo Interministerial* [aerial photographs], A-0004_0094_00D_0014 [photogram]. 1:18.000. Instituto Geográfico Nacional- Ministerio de Hacienda. Retrieved from https://fototeca.cnig.es/fototeca/

IGN. (2001, August 12). *Vuelo Quinquenal* [aerial photographs], 26362 [photogram]. 1:40.000. Instituto Geográfico Nacional. Ministerio de Fomento. Retrieved from https://fototeca.cnig.es/fototeca/

IGN. (2020, June 22). *Vuelo del Plan Nacional de Ortofotografía Aérea (PNOA)* [aerial photographs], 053-02828 [photogram]. Pixel size 0.18 m. Instituto Geográfico Nacional. Ministerio de Fomento. Retrieved from https://fototeca.cnig.es/fototeca/

Labrada, J. L. (1804). *Descripción económica del Reyno de Galicia. Por la Junta de Gobierno del RL. Consulado de La Coruña*. Ferrol: Imprenta de Don Lorenzo José Riesgo Montero.

Leal Bóveda, J. M. (1999). *Hórreos, molinos y fuentes de la Tierra de Viveiro*. Lugo, Spain: Diputación Provincial de Lugo.

Leal Bóveda, J. M., Cuesta Colado, R., & Sanmartín, A. (1995). *Guía para o estudio dos muíños de auga das Terras de Caldas de Reis*. Vigo, Spain: Diputación Provincial de Pontevedra.

Lema Suárez, X. M. & Mouzo Lavandeira, R. (2007). *O conxunto etnográfico dos batáns e muíños do Mosquetín, na Terra de Soneira. Outros batáns, folóns ou pisóns de España e Portugal*. Vimianzo, Spain: Seminario Estudos Comarcais da Costa da Morte.

Ley 2/2006, de 14 de junio, de derecho civil de Galicia. *Boletín Oficial del Estado, 191, de 11 de agosto de 2006, 30073-30100.* Retrieved from https://www.boe.es/buscar/act.php?id=BOE-A-2006-14563

Llano Cabado, P. (1983). *Arquitectura Popular en Galicia*. Santiago de Compostela, Spain: Colexio Oficial de Arquitectos de Galicia.

Madoz, P. (1845). *Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar*. *Tomo II*. Madrid: Est. Literario-Tipográfico de P. Madoz y L. Sagasti.

Nishanbaev, I. (2020). A web repository for geo-located 3D digital cultural heritage models. *Digital Applications in Archaeology and Cultural Heritage, 16*, e00139*.* https://doi.org/10.1016/j.daach.2020.e00139

Pagán Vázquez, G. (2003). *Muíños de Xabriña*. Pontevedra, Spain: Editorial Diputación Provincial de Pontevedra.

Pérez-Martín, E., Herrero-Tejedor, T. R., Gómez-Elvira, M. A., Rojas-Sola, J. I., & Conejo Martín, M. A. (2011). Graphic study and geovisualization of the old windmills of La Mancha (Spain). *Applied Geography, 31*(3), 941-949. https://doi.org/10.1016/j.apgeog.2011.01.006

Pujol, T., Solà, J., Montoro, L., & Pelegri, M. (2010). Hydraulic performance of an ancient Spanish watermill. *Renewable Energy, 35*(2), 387–396. https://doi.org/10.1016/j.renene.2009.03.033

Quaranta, E., Pujol, T., & Grano, M. C. (2021). The repowering of vertical axis water mills preserving their cultural heritage: techno-economic analysis with water wheels and Turgo turbines. *Journal of Cultural Heritage Management and Sustainable Development*. https://doi.org/10.1108/JCHMSD-03-2021-0040

Raies, A. (2021). La difusión del patrimonio arqueológico a través de las nuevas tecnologías: la reconstrucción de las baterías y el campo de batalla de Vuelta de Obligado (Buenos Aires, 1845). *Anuario de Arqueología, 13*(13), 87-103. https://doi.org/10.35305/aa.v13i13.84

Reilly P. (1990). Towards a Virtual Archaeology. In S. Rahtz and K. Lockyear (Eds.), *Computer Applications in Archaeology* (pp. 133-139). Oxford: Tempus Reparatum.

Rivas Quintans, E. (1997). *O muíño*. Ourense, Spain: Grafo Dos.

Rodríguez-Hernández, J., Álvarez-Sanchís, J. R., Aparicio-Resco, P., & Maté-González, M. A. (2021). Reconstrucción virtual en 3D del “Torreón” del oppidum de Ulaca (Solosancho, Ávila): mucho más que una imagen. *Arqueología de la Arquitectura, 18*. https://doi.org/10.3989/arq.arqt.2021.015

Rojas-Sola, J. I. & López-García, R. (2007a). Engineering graphics and watermills: Ancient technology in Spain. *Renewable Energy, 32*(12), 2019-2033. https://doi.org/10.1016/j.renene.2006.10.013

Rojas-Sola, J. I. & López-García, R. (2007b). Computer-aided design in the recovery and analysis of industrial heritage: Application to a watermill. *International Journal of Engineering Education, 23*(1), 192-198.

Sampedro Fernández, A. (1990). *Todos os muiños da terra galega*. Vigo, Spain: Asociacion Galega para a Cultura e a Ecoloxía.

Versaci, A., Cardaci, A., & Fauzìa, L. R. (2016). Recovery and conservation of old water milles in Central Sicily. *Procedia – Social and Behavioral Science, 225*, 15-26. https://doi.org/10.1016/j.sbspro.2016.06.004

Viaño, M. (2004). *Os muiños de Riamontes. Contos da miña aldea.* Vigo, Spain: Concello de Ames.

Viéitez Castro, J. A. & Vidal Méndez, R. (2002). *Muíños do Concello de Meaño*. Pontevedra, Spain: Diputación Provincial de Pontevedra.

Vila Vilariño, M. P. (2021). Evaluación de riesgos para el patrimonio hidráulico. *Anales de Edificación, 7*(1), 50-61. https://doi.org/10.20868/ade.2021.4770