SCIRES it
SCIentific RESearch and Information Technology
Ricerca Scientifica e Tecnologie dell'Informazione
Vol 11, Issue 1 (2021), 195-208
e-ISSN 2239-4303, DOI 10.2423/i22394303v11n1p195

CASPUR-CIBER Publishing, http://www.sciresit.it

PREPARING RURAL HERITAGE FOR ANOTHER KIND OF COVID PANDEMIC: HERITAGE DIGITALIZATION STRATEGIES IN THE ALTO GUADIATO VALLEY AND SUBBETICA OF CORDOBA, SPAIN

José Luis Dominguez-Jiménez, Buenaventura Castilla-Agredano*, Miriam González-Nieto**, Manuel Moreno-Alcaide ***, Antonio Monterroso-Checa **

* University of Córdoba. Patricia Unit for R&D in Cultural Heritage (HUM 882 Research Group) - Córdoba, Spain.
** Universidad Nacional de Educación a Distancia (UNED) Research Grant-Madrid, Spain.
*** University of Málaga. Patricia Unit for R&D in Cultural Heritage - Málaga, Spain.

Abstract

Historically, the province of Cordoba was one of the wealthiest territories in the region of Andalusia, Spain, and left behind a rich heritage that is still largely unknown. Our research team has studied this cultural heritage and developed initiatives for its digitization that have been very successful in transmitting these assets to society. During the current COVID-19 pandemic, the projects have proven to bring numerous socio-economic benefits. In this paper, we discuss the virtualization of this heritage and present the results of the various digital interventions carried out in the province of Cordoba to consolidate a digital landscape that is publicly accessible.

Keywords

COVID-19, Heritage, Virtualization, Virtual Tour, 360° Photography, Virtual Landscape, Rural Tourism, Conservation

1. *Introduction*

In this paper, we present initiatives for the digitization of the heritage of the province of Cordoba using three different strategies: photogrammetry, virtual reality, and 360° visits. The aim of these applications is to make this heritage accessible to society and develop new ways of preserving and disseminating these cultural resources. We hope to promote the use of these tools in the province as a way to revalorize the rural heritage, make historical and archaeological knowledge available to society, and strengthen local economies in preparation for another COVID pandemic.

1.1 The impact of COVID on the advancement of heritage virtualization

Heritage virtualization has been widely used in the management of cultural assets. Although there is some debate as to whether virtual visits will replace on-site visits, it is widely held that virtual visits should not and cannot replace traditional on-site visits (Moreno Sánchez, 2015; Los Principios de Sevilla, 2012, Krakow Charter, 2000; London Charter, 2009; ICOMOS Charter, 2008), but rather serve to support and complement them. Among the main benefits of heritage digitization are conservation, dissemination, and accessibility.

The virtualization of heritage has increased with the development of new software and web networks (Allen et al., 2004; Waas & Zeel, 2013; Baione, Johnson, & Megale, 2019; Badat et al., 2020; Büyüksalih et al., 2020). However, due to its high costs and specific needs, digitization is often not possible. While the world's largest museums and sites have had the capacity to digitize their collections (Ministry of Tourism and Antiquities of Egypt, 2019; Musei Vaticani, 2017; The British Museum), it has been much more difficult for smaller institutions (especially those in rural areas) to make this leap (Massi & Turrini, 2020). However, the development of new technologies, lower costs, and the simplification of processes has democratized the digitization of heritage and its subsequent dissemination.

The current COVID pandemic has served as a catalyst in all fields and driven the development of digitization. In this sense, the closure of most

museums in the world has prompted them to find new ways of "opening their doors" to society. This has led at least 15% of all museums to increase their digital communication and offer new activities to maintain their relationship with the public, either through social networks, websites, gamification projects, or virtual tours (Massi & Turrini, 2020). In this regard, it is worth noting the increase in Internet use throughout the European Union in 2020 (European Commission, 2020). In the United Kingdom, the time spent online has increased by 29%, and 20% more Britons use social networks (Samaroudi, Rodríguez Echevarria, & Perry, 2020). In the case of Spain, 93.2% of the population between 16 and 74 years of age has used the Internet, 2.5 points more than in 2019 (National Institute of Statistics [INE], 2020).

Even so, and despite the opportunity presented by the situation, only 2% of heritage institutions in the United States offered 360° virtual tours or virtual reality experiences. In other countries, such as the United Kingdom, this figure is just 3% (Samaroudi et al., 2020). According to the data, by 2015 only 17% of the cultural heritage held in European institutions had been digitized (Stojićević, 2020). These data indicate that, in spite of the growing trend towards digitization, we are far from being able to transfer a "digitized heritage" to society. However, there is public interest to access digitized data (Stojićević, 2020), thus suggesting that the way forward is to make digitized cultural heritage publicly available.

1.2 COVID and the virtual dissemination of heritage in the rural society of Cordoba

On March 11, 2020, the WHO declared COVID 19 a pandemic (World Health Organization, 2020), which would prove to have a serious impact not only on the world's socio-economic development but also its heritage. A nationwide state of alarm was declared in Spain from March to June 2020 (Royal Decree 463/2020) that ordered all citizens to stay at home. This led to the total closure of all activities, among them museums, archives, libraries, and monuments.

According to the most recent data, as of February 8, 2021, 56 of the 77 municipalities in the province of Cordoba were locked down, making it impossible to visit museums, archaeological sites, and other heritage sites (Junta de Andalucía. Consejeria de Salud y Familias, 2021).

Cordoba's rich heritage can be found not only in the capital city, but also throughout the province. The numerous heritage sites in the province include El Laderón in the town of Doña Mencía (Moreno Alcaide, Ruiz Montes, Serrano Arnáez, & Fernández García, 2020), Torreparedones in Baena (Monterroso-Checa et al., 2019), Ategua in Santa Cruz (Fuertes Santos, 2017), Mellaria in Fuente Obejuna (Monterroso-Checa, Gasparini, & Moreno Escribano, In Preparation), the Casas de Don Pedro dolmen in Belmez (Gavilán Ceballos, 2004), the Cueva de los Murciélagos in Zuheros (Gavilán Ceballos & Mas Cornellá, 2006), and the castles of Almodóvar del Río (García del Junco, 2000), Belalcázar (León Muñoz, 2014), and Belmez (Monterroso-Checa et al., 2020). In addition, there are approximately 45 museums throughout the region (Directorio de Museos y Colecciones Museográficas de Andalucía, 2021), thus reflecting the desire of local communities to know and preserve their past.

However, despite these conservation efforts, until recently there was no dynamic for the socialization and dissemination of this heritage beyond local borders. Due to the current pandemic, this need has become evident, and many platforms have been created to provide alternatives to on-site visits.

More than a dozen have developed virtual visits posted on the Internet, and an initiative has even been developed in the Subbetica of Cordoba that has enabled virtual visits to the villages of the area. Some examples of this project are virtual visits to the medieval quarter of Cabra, the castle of Hisn Ashar in the town of Iznájar, the archaeological museum of Lucena, or the Roman Villa del Ruedo archaeological site (Turismo de la Subbética, 2020). Other projects have also been developed in the town of Belalcázar (Turismo Virtual Belalcázar, 2020) or in the Alto Guadiato

Fig. 1: Photogrammetric acquisitions at Cerro de Masatrigo (Fuente Obejuna). ©Ager Mellariensis/AEI FEDER HAR

Valley.

2. *Materials and methods*

For this work, a combination of earth observation, remote sensing, photogrammetry and 360° digitization techniques were used as follows.

-LiDAR data and orthophotogrammetric surveys. LiDAR data from the Spanish National Geographic Institute (IGN-Spain) were used. These data are freely available and were used to explore the Alto Guadiato Valley. LiDAR data from the National Aerial Orthophotography Plan of Spain (PNOA) were also used to identify several prehistoric settlements, Roman roads, and other heritage elements. The LiDAR data have a minimum point density of 0.5 points/m2 and an RMSE in Z ≤ 40 cm. Orthophotos with a pixel size of 0.25 m or 0.50 m were also used.

-Remote sensing: thermal, RGB, and DTM acquisitions. A FLIR SC655 thermal sensor with a resolution of 640 × 480 pixels and a NIKON D800E RGB sensor were used to obtain 5133 and 3473 images, respectively. Both sensors were mounted in a Cessna light aircraft flight covering 1040 ha at 250 m above ground level. A second UAV flight was performed to acquire photogrammetric data. For this purpose, a Sony Alpha 5000 20.1 MP RGB sensor was mounted onboard the UAV which flew at 80 m above ground level to capture 809 images of an area of 22.49 ha. This same UAV was used for the photogrammetric acquisition of Belmez Castle. Other points of the Alto Guadiato, including the Tartessian settlement of Sierra Boyera, were explored by UAV using a Phantom 4 Pro (Fig. 1).

Fig. 2: Geomagnetic survey in the ancient city of Mellaria. ©Ager Mellariensis/AEI FEDER HAR 77136-R.

-Land surveys. In addition to the use of LiDAR and remote sensing, geophysical surveys and reconnaissance surveys were conducted to confirm possible new discoveries (Fig. 2).

-An Insta360 Pro 360° camera was used to take 13 panoramic photographs for the digitization of the Doña Mencía museum exhibition hall. Additionally, photo editing and retouching programs such as Gimp, Photoshop, and PhotoScape X were used. 3DVista Virtual Tour was used for the realization of the visits. For the virtual tours of the north of the province, an Insta360 OneX camera and the same software were used.

3. *Results of the implementation of heritage digitization strategies*

3.1. Photogrammetry and 3D modeling

The virtualization of Belmez Castle was done in the framework of the Ager Mellariensis project (AEI FEDER HAR 77136-R). To this end, drone photogrammetry was used to obtain a photorealistic 3D model of the castle and its surroundings (Fig. 3). In addition to the 3D model, a building information modeling (BIM) study was performed, and a historical recreation of the entire environment was carried out (Monterroso-Checa et al., 2020).

A section of the Corduba-Emerita road between Cordoba and Cerro Muriano (today a drover's road known as the Cañada Real Soriana) and the bridge over the Linares stream (Fig. 4) were also researched in depth. Photogrammetry was used (Monterroso-Checa & Gasparini, 2016) to document and digitally preserve some of the sections and surfaces of the road and bridge (Domínguez-Jiménez & González Nieto, 2019). The use of photogrammetry was necessary given the poor state of preservation of the archaeological remains. Because the Cañada Real Soriana is still used as a drover's road and by hikers, the heritage contained in this space has deteriorated, especially the roadbed located near San Cebrián Bajo (Córdoba), part of which was lost in the two years the studies were being conducted. For this reason, we decided to use photogrammetry to preserve a "digital copy" of this scarce asset. To make this resource publicly available, the 3D elements were published on Sketchfab, the world's largest platform for viewing and sharing 3D

documentation, including virtual reality (VR) models.

Fig. 3: Photographic model of the Belmez Castle and hill. ©Ager Mellariensis/AEI FEDER HAR 77136-R.

The project was disseminated in several scientific forums such as the Mellariae Alumni meeting with the contributions "Nuevas herramientas metodológicas para el estudio diacrónico de la vía Corduba-Emerita/Cañada real soriana en la subida a Cerro Muriano (Córdoba)" and "El puente del arroyo de Linares (Córdoba). Estructura, cronología y consecuencias sobre el tránsito de la antigua vía a Emerita"; in the seminar Territorio y viabilidad en al–Ándalus with "Modelos fotogramétricos para el estudio de la rehabilitación medieval de la vía Corduba-Emerita en el entorno del Santuario Linares-Córdoba"; and in the VIII International Summer Course on Archaeology held in Doña Mencía, with "Todos los caminos conducen a Corduba… Los caminos históricos de Córdoba a la Sierra: trazado, estructura y evolución". These studies and the digitization of this heritage caught the attention of the local press, which published news of our research and 3D documentation. Hence, our main objective was achieved, namely, to conserve and disseminate this heritage.

Given the dissemination capacity of the Roman road and the interest aroused by the research, we believed it would be convenient to combine

Fig. 4: Photogrammetry of the bridge over the Linares stream (Cordoba). ©Ager Mellariensis/AEI FEDER HAR 77136-R.

reconstruction and dissemination. To this end, we continued to study the road and, after an exhaustive analysis of the roadbed, began to reconstruct this environment in 3D. We also conducted research on Roman mining activity, transportation, and tools to subsequently develop a virtual recreation. The aim of this virtual recreation was to display the research findings in the form of images that could be viewed at a glance, and thus make it easier for the public to understand. In addition, we were interested in countering some widespread stereotypes regarding day-to-day life in the Roman world, such as the idea that all Roman roads were paved, the chariots did not have brakes, or the manner of dress, among others. This 3D reconstruction will be included in a virtual exhibition (Fig. 5) that is currently in its initial stages and which we hope will serve to disseminate this heritage.

Fig. 5: Visual demo of the virtual exhibit prototype. © SensingArqueoRuralCó UCO-FEDER-Junta de Andalucía 2018 -1265775-F

3.2. VR applied to the Alto Guadiato heritage landscape

Thus far we have discussed the need for digitization to make heritage more accessible to citizens, particularly in the current COVID-19 situation. In Cordoba, however, several projects with enormous potential have already been carried out to digitize the rural heritage assets in the province.

Our research team (Patricia Unit for Cultural Heritage R&D, HUM 882 Research Group) is currently working in the Alto Guadiato Valley in the north of the province of Cordoba; an area that stands out for its rich heritage but has been little studied and socialized. For this reason, we conducted an interdisciplinary study to gain a better understanding of the landscape and bring it closer to the public. To this end, we investigated the biotic elements of the ecosystem and explored the area using LiDAR data of the IGN and PNOA and remote sensing (thermal, RGB, and DTM acquisitions). This allowed us to identify previously unknown heritage, including the stretch of the Corduba-Emerita road in Belmez, megalithic monuments, the Tartessian site of Sierra Boyera, and mining settlements. We also identified medieval settlements that have survived to this day and provide evidence of the configuration of the territory (Monterroso-Checa et al., 2020).

Once the data were obtained, and we realized their great visual and narrative potential, we decided to use VR technologies to transmit our findings to the public. As mentioned, some sites, monuments and landscapes have already been virtualized. However, we decided to use a much less common formula in the Alto Guadiato to understand the territory as a whole. Specifically, we created a 3D immersive virtual experience in which an area of more than 60 km in cross-sectional view and 40 km deep was recreated by virtualizing the entire landscape in its different historical phases. This involved developing a direct and large-scale recreation of various historical landscapes, in which the 3D virtualizations of the prehistoric, ancient, and medieval periods were inserted (Monterroso-Checa et al., 2020).

For this purpose, the University of Cordoba commissioned the Lithodomos VR company to design a virtual viewpoint at the Cerro del Castillo of Belmez, from which the entire landscape of the Alto Guadiato can be seen. This viewpoint, called GuadiatVR[1], allows visitors to observe and interact with the landscape and be transported hundreds of years back in time using a virtual reality device (Fig. 6-7).

Viewers can contemplate everything from the Roman city of Mellaria to the towns of Sierra Palacios accompanied by pop-ups that help them to immerse themselves in this heritage (Tapia, 2017; Monterroso-Checa et al. 2020).

Additionally, in 2018 we launched the AeroGlobe GuadiatVR application, which goes a step further as visitors can take a flight in a hot air

[1]GuadiatVR has been designed for use in virtual reality devices and can be downloaded on IOS and Android.

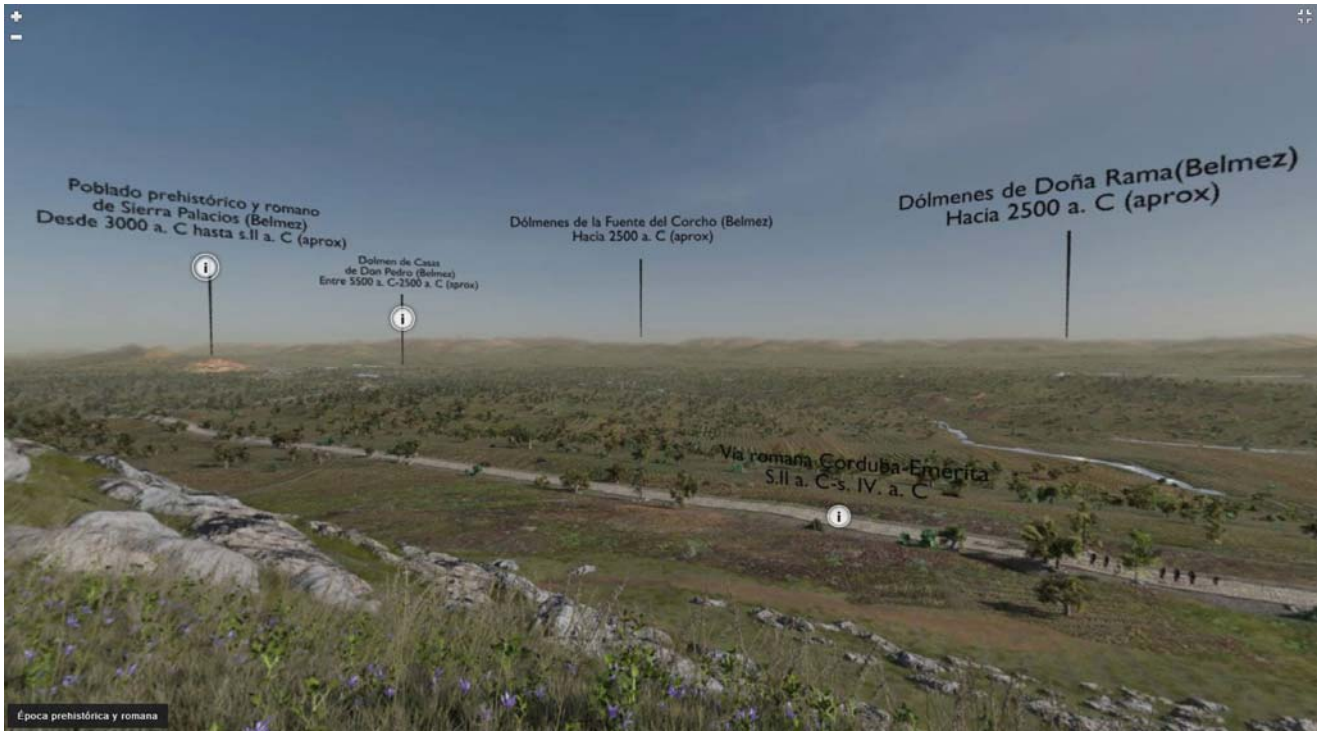

Fig. 6: The GuadiatVR virtual viewpoint. Restitution of the Roman Alto Guadiato landscape. ©Ager Mellariensis/AEI FEDER HAR 77136-R.

balloon through the virtual airspace of the Alto Guadiato (Fig. 8 a-b) to see the Roman city of Mellaria, Belmez Castle, or the Peñón de Peñarroya accompanied by scientific explanations (Gasparini, Moreno-Escribano, & Monterroso-Checa, 2020).

These virtual reality applications have contributed to conserving, expanding, and developing the social potential of this natural and archaeological heritage (Monterroso-Checa & Redondo, 2020) and have had a large public impact. GuadiatVR was presented at the leading International Tourism Trade Fair (FITUR) of Madrid and both heritage resources have transcended academia (Tapia, 2017; Monterroso-Checa et al., 2020). They have been featured in the local, provincial, and national press, as well as on radio programs and Canal Sur, the regional public television outlet[2]. The positive reception of these initiatives clearly demonstrates society's interest in heritage and the applications to access it, as well as the revitalizing capacity of virtualization technologies.

As a result of the success of this project, our research team has directed part of its efforts to studying and digitizing heritage in other recent and ongoing projects which, in the current COVID-19 pandemic, could become a magnificent channel of communication between citizens and their history.

3.3. 360° tours: a tour within everyone's reach

- The virtual museum of Doña Mencía

Following the success of the virtualization projects in the Alto Guadiato, we embarked on a new project in collaboration with the Historical-Archaeological Museum of Doña Mencía. The

Fig. 7: Presentation of GuadiatVR at the European Young Researchers' Night 2018. ©Ager Mellariensis/AEI FEDER HAR 77136-R

[2] A video is freely accessible on the Canal Sur YouTube site.

Fig. 8a-b: Virtual hot air balloon flight over the area of Belmez Castle. ©Ager Mellariensis/AEI FEDER HAR 77136-R

choice of this museum for our first foray into museum virtualization was not random, but in line with our previous interventions to study and document the rural heritage of the province of Cordoba. Founded more than half a century ago, the museum boasts the SICTED tourism quality seal. It houses collections with a total of 23,613 pieces from more than 500 sites in the province, of which only 1,225 are on display. These materials cover the main historical periods from prehistoric times to the 19th century and take visitors on a journey through the history of the region. All these reasons led us to opt for the virtualization of this museum, as a "project 0" that could serve as an example and a guide for future work.

To create a virtual tour of the museum, we decided to use 360° photography, an increasingly common technology for purposes of virtualization. For the virtualization, we were helped by Manuel Gómez of Boise State University (Idaho, USA).

The virtual tour (Fig. 9), which can be accessed from the web and is prepared for VR devices (Fig. 10), enables visitors to browse the exhibition hall and choose the chronological period they are most interested in learning about.

Visits are made intuitively by scrolling through a series of arrows, thus facilitating the experience for those unfamiliar with this technology. There is also a map tool that displays a view cone with the different areas of the museum to help visitors move easily from one point to another. Visual information about the display cases is provided and there are also interactive information icons for each display case with short texts, photographs, and in some cases specific bibliography on the subject to satisfy visitors' curiosity.

This project had a two-fold purpose. Firstly, we wanted to digitize a museum in a rural municipality with a view to making it universally

Fig.9: Virtual tour of the Doña Mencía museum. © SensingArqueoRuralCó UCO-FEDER-Junta de Andalucía 2018 -1265775-F

Fig. 10: Virtual tour of the Doña Mencía museum using a VR device. © SensingArqueoRuralCó UCO-FEDER-Junta de Andalucía 2018 -1265775-F

accessible. Secondly, we were interested in documenting the state of the museum prior to its renovation to exploit the potential of public heritage in the municipalities of the interior of Andalusia under the ERDF Operational Program for Andalusia 2014–2020 for the protection, promotion, and development of cultural heritage (specific objective 6.3.1). Visiting a museum that no longer exists, albeit virtually, is not only an exceptional opportunity, but also an invitation to visit the new museum in such a way that the virtual experience complements in-person visits.

Finally, for purposes of dissemination, the project was presented at the VIII International Summer Course on Archaeology *La Subbética mira a Sierra Morena: el Norte de la provincia de Córdoba desde el Sur* held in Doña Mencía. Our contribution, titled "Divulgación del patrimonio cultural a partir de entornos virtuales," was met with great interest by the attendees.

Given the good reception of the project by the local administration and community, plans are now in place to begin working with the museum and the town on various complementary projects. The first project is the creation of a virtual tour of the new museum similar to the existing virtual tour so that visitors can interact with both. In addition, we are also considering the possible creation of gamification and e-learning activities for children and young people. Among the most viable options are escape rooms, gymkhanas, and animated puzzles for the young ones. Once the visit is finished, it can be used by educators and teachers to explain the history of the town in an entertaining and interactive way.

-Virtual tours of the north of the province

Our group is currently working on a project to research and disseminate the archaeological, historical, and cultural heritage of the Alto Guadiato Valley. As part of this project, we are designing a series of interactive 360° museum tours of the most significant archaeological sites in the region that can be visited separately in the near future or as part of an intelligent macro-landscape in the longer term. These interactive tours will include much of the informative materials elaborated to date and will cover various lines of scientific research. This would allow visitors to access a range of cultural and archaeological content, as well as content related to the environment, nature, flora and fauna, and other elements. With this ambitious premise, we intend to create a holistic and organic tour of the Alto Guadiato heritage that can be accessed from an interactive map of the area by both visitors and the local community.

Given the good results of the digitization of the Doña Mencía museum, we decided to use the same software to create additional virtual tours. We are currently in the development phase of various tours and in the revision phase of four: the Almohad fortress of El Vacar, the Casas de Don Pedro dolmen, the Iberian *oppidum* of Sierra Boyera, and the Corduba-Emerita road in Puente Nuevo (Fig.11a-b-c). None of these sites have been restored or rehabilitated and they are not accessible to the public. Therefore, the only way to visit them is by means of our virtual tours. In addition, to bring the public closer to these heritage sites, which remain almost unknown either due to their location or the fact that they have been discovered very recently, we are in the process of elaborating explanatory texts and photographic and other multimedia material that will accompany the different visits.

Another series of virtual visits are in an earlier stage of development, including Belmez Castle, the ancient Roman city of Mellaria (Fuente Obejuna), and the La Loba mine, while the work begun in Doña Mencia and the Municipal Historical Museum of Fuente Obejuna is ongoing. The aim of these initiatives is to disseminate the heritage of this region and attract visitors from other parts of the province.

These new visits include a series of interconnected tours that link various sections of the Corduba-Emerita road and parts reused in the 16th century with the ancient city of Corduba and Mons Marianus (Fig. 12); once an important mining and commercial area of which remains still

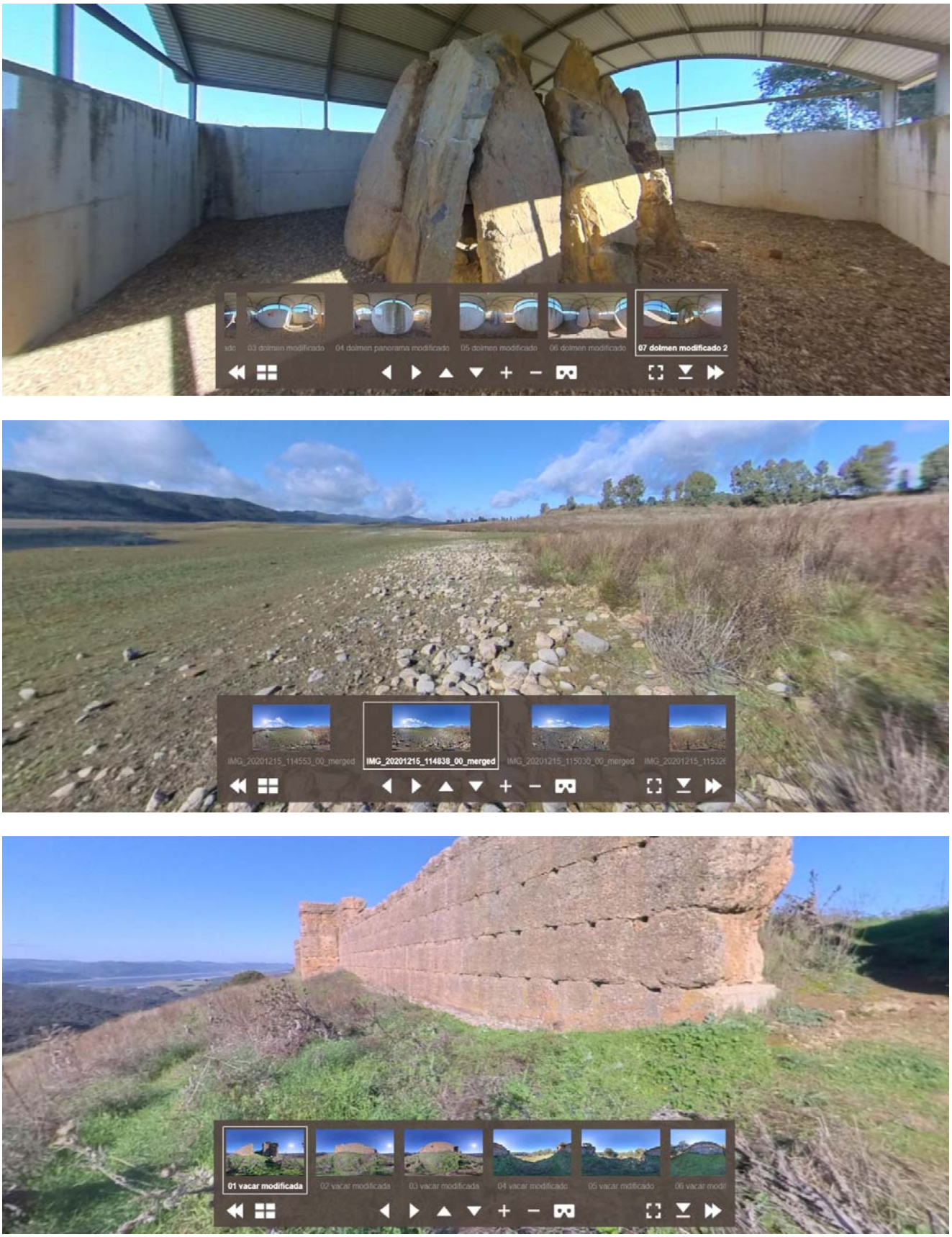

Fig.11a-b-c: 360° views of the Casas de Don Pedro Dolmen, Corduba-Emerita causeway, and Vacar Castle. ©Ager Mellariensis/AEI FEDER HAR 77136-R.

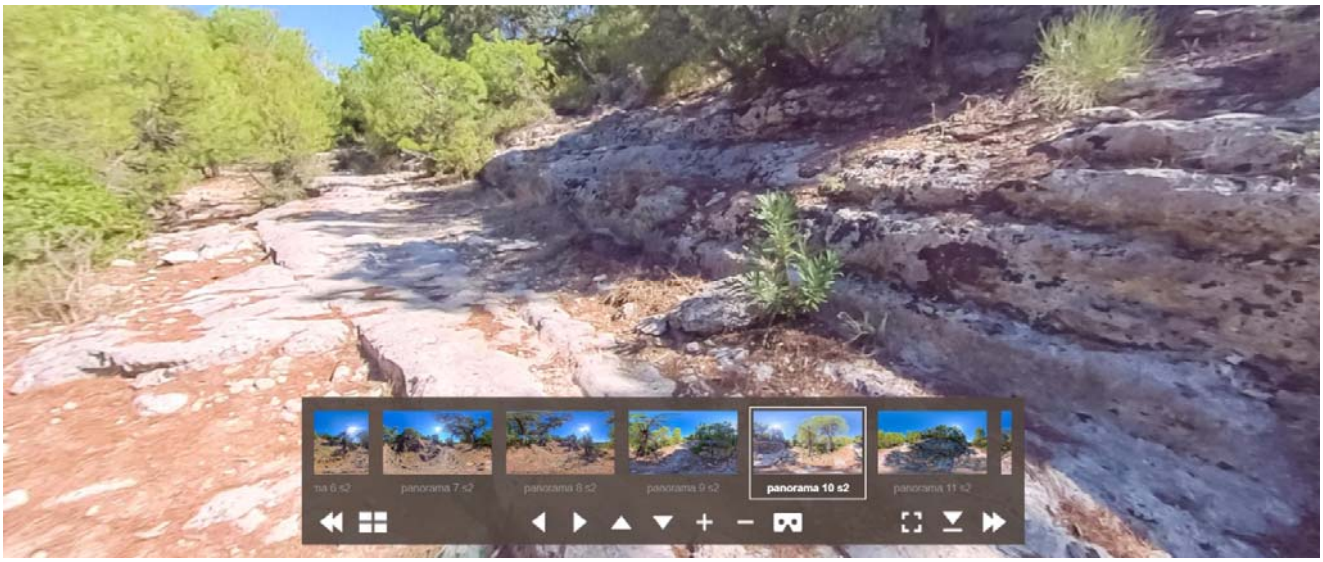

Fig.12: 360° visit to the Loma de los Escalones, Corduba-Emerita road. ©Ager Mellariensis/AEI FEDER HAR 77136-R.

survive in the landscape. To achieve this, we have digitized the most important points that, joined together, will enable us to simulate the transit along the old road. We hope that this virtual visit will be used in the future to disseminate the unique heritage of the Sierra Morena mountains of Cordoba.

4. *Discussion and conclusions*

Several results of the proposed virtualization strategies are worth highlighting. The first is the digital preservation of endangered heritage, such as the bridge over the Linares stream, the pavement of the Cañada Real drover's way, and the landscape of the Alto Guadiato Valley. Secondly, the heritage has been universalized as it is now accessible on the web to anyone, thus overcoming the barriers faced by small rural municipalities face to make their heritage known. This universalization entailed the creation of inclusive heritage spaces and environments that are accessible to people with reduced mobility, who otherwise would not be able to enjoy them in situ.

From a sociocultural perspective, the project has heightened the interest of the local inhabitants in their own heritage, as the research results have been made available to the cultural and educational authorities of the province for the community to learn about its own history.

The team has also made a concerted effort to disseminate the research findings through the creation of apps such as GuadiatVR, virtual reality travel experiences, 3D models, and virtual tours; all of which are being implemented in the area, either on municipal websites or by teachers in the classroom.

Fuente Obejuna is a good example of how these initiatives and techniques can be applied. Following our research, the town has recently focused its efforts on bringing to light and preserving the Roman city of Mellaria. To this end, several cultural events and activities have been organized, such as the exhibition of Roman tableware *A la mesa en Mellaria. Exposición de vajilla romana de la Colección Mellariense*, the symbolic refoundation of the Roman city (Scientific Culture and Innovation Unit. University of Cordoba, 2017), and the acquisition by the town council of the Cerro de Masatrigo (Fuente Obejuna and Aldeas Ayuntamiento, 2020) where the original city was located to turn it into an archaeological, tourist, and cultural attraction (Fig. 13a-b). Such initiatives, together with others to digitize the heritage of the province of Cordoba, open new opportunities and serve to revitalize the territory both economically and culturally.

From an economic viewpoint, the results cannot yet be quantified as the COVID-19 restrictions have impeded us from implementing the project. However, given the success of previous projects, such as those in Fuente Obejuna, we expect that the digitization of heritage will boost the local economy and attract cultural tourism once the project is consolidated.

Despite the good results achieved over the course of the project, several aspects remain to be perfected, which involve a series of challenges: the completion of the work in progress; the greater

Fig.13a-b: Exhibition of Roman tableware in Mellaria and visit to the Cerro de Masatrigo. ©Ager Mellariensis/AEI FEDER HAR 77136-R.

implementation of augmented and mixed reality resources in future virtualizations; the development of an appropriate methodology for the proper dissemination of the material; and the implementation of educational content and e-learning techniques in both present and future projects.

However, the project has entailed a quantitative leap in the number of digitized heritage assets in the province. This has translated into the preservation of cultural heritage that is often threatened by the passage of time and ensured its projection into the 21st century in terms of both conservation and dissemination.

Our work is already showing good results, and ongoing projects promise to hold even greater potential for the future of the region, as these new heritage digitization strategies not only serve to consolidate digital virtual landscapes, but also provide the opportunity to learn about, enjoy, and interact with history. This is the path our team has taken by combining the study of heritage with its transmission to society, thus turning historical wealth into economic wealth; a wealth that will surely be able to withstand the threat of any other future "COVID" or circumstance.

FUNDING: This research was funded by Junta de Andalucia R&D Programe PAIDI UCO-FEDER 2018 throught the project: *Métodos de teledetección y de mínima invasión para la revalorización de los paisajes arqueológicos y la cultura material de ámbito rural en la provincia de Córdoba* (SensingAqueoRuralCó) REF. 1265775-F.

ACKNOWLEDGEMENT: The authors would like to thank Martha Gaustad for the translation and correction of the article.

REFERENCES

Allen, P., Feiner, S., Troccoli, A., Benko, H., Ishak E., & Smith, B. (2004). Seeing into the past: creating a 3D modeling pipeline for archaeological visualization. In *Proceedings. 2nd International Symposiumon 3D Data Processing, Visualization and Transmission* (pp. 751-758). Thessaloniki, Greece: IEEE. https://doi.org/10.1109/TDPVT.2004.1335038

American Research Center in Egypt. Tomb of Menna in the Theban Necropoli. Retrieved from https://my.matterport.com/show-mds?m=vLYoS66CWpk

Badat, L., Vidal, V., Pioli, L., Honorio, L., & Ribeiro Dantas, M. A. (2020). An IIoT edge environment as a main support to a 3D reconstruction virtualization application. In *Workshop emClouds e apliçoes* (pp. 1-12). Porto Alegre: Sociedade Brasileira de Computação

Baione C., Johnson T.D., & Megale C. (2019). Communicating archaeology at Poggio del Molino: 3D virtualization and the visitor experience on and off site. In A. Luigini (Ed.), *Proceedings of the 1st International and Interdisciplinary Conference on Digital Environments for Education, Arts and Heritage. EARTH 2018. Advances in Intelligent Systems and Computing* (pp. 681-690). Cham, Switzerland: Springer.

British Museum. The museum of the world. Retrieved from https://britishmuseum.withgoogle.com/

Büyüksalih, G., Kan, T., Özkan, G.E., Meriç, M., Isın, L., & Kersten, T.P. (2020). Preserving the knowledge of the past through virtual visits: From 3D laser scanning to virtual reality visualisation at the Istanbul Çatalca İnceğiz caves. *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science*, *88*, 133-146.

Camino Fuertes Santos, Mª. (2017). Ategua. Las grandes campañas de excavaciones de los años 80 del siglo XX. The acropolis. *ROMVLA*, *16*, 7-76.

Canal Sur Turismo. Retrieved from: https://www.youtube.com/watch?v=TDq-IVNqdIY

Directorio de Museos y Colecciones Museográficas de Andalucía (2021). Retrieved from https://www.juntadeandalucia.es/organismos/culturaypatrimoniohistorico/areas/museos-arte/directorio-museos.html

Domínguez Jiménez, J.L., & González Nieto, M. (2019). Modelos fotogramétricos para el estudio de la rehabilitación medieval de la vía Corduba-Emerita en el entorno del Santuario Linares (Córdoba). *Antiqvitas*, *31*, 21-30.

European Commission (2020). Use of internet and online activities [Website]. Retrieved from https://shorturl.at/eABP7

Fuente Obejuna y Aldeas Ayuntamiento. Retrieved from https://fuenteobejuna.es/el-consistorio-mellariense-adquiere-los-terrenos-donde-se-ubico-la-antigua-ciudad-de-mellaria-para-convertirla-en-un-recurso-economico-y-turistico/

García del Junco, F. (2000). El castillo de Almodóvar del Río (Córdoba). Una primera aproximación a su historia y restauración. *Anales de la Arqueología Cordobesa, 11*, 233-253. https://doi.org/10.21071/aac.v0i.11274

Gasparini, M., Moreno-Escribano, J.C., & Monterroso-Checa, A. (2020). Photogrammetric acquisitions in diverse archaeological contexts using drones: Background of the Ager Mellariensis Project (north of Córdoba-Spain). *Drones*, *4*(3),47. https://doi.org/10.3390/drones4030047

Gavilán Ceballos, B. (2004). El Alto Valle del Guadiato durante la Prehistoria reciente: El poblamiento Neolítico y Calcolítico. *Espacio, Tiempo y Forma, Serie I, Prehistoria y Arqueología*, *16-17*, 119-160. https://doi.org/10.5944/etfi.16-17.2003.4753

Gavilán Ceballos, B., & Mas Cornellá, M. (2006). La cueva de los murciélagos de Zuheros (Córdoba): hábitat y santuario durante el neolítico antiguo. Hogares, "papaver somniferum" y simbolismo. *SPAL*, 15, 21-37. doi:10.12795/spal.2006.i15.02

GuadiatVR. Retrieved from: www.uco.es/guadiatvr

ICOMOS Charter (2008). Charter for the interpretation and presentation of cultural heritage sites. General Assembly of ICOMOS, Québec, Canada. Retrieved from https://www.icomos.org/charters/interpretation_e.pdf

Junta de Andalucía Consejería de Salud y Familias. Informe COVID-19 en Andalucía [Report]. Retrieved from http://www.juntadeandalucia.es/institutodeestadisticaycartografia/salud/COVID19.html

León Muñoz, A. (2014). Las fortalezas de Belalcázar. *PH: Boletín del Instituto Andaluz del Patrimonio*, *86*, 82-87.

The London Charter (2009). Retrieved from https://www.londoncharter.org/

Lopez-Menchero, V. M., & Grande, A. (2011). The principles of the Seville Charter. In *CIPA symposium proceedings* (pp. 2-6), Prague, Czech Republic: CIPA Heritage Documentation.

Massi, M., & Turrini, A. (2020). Prossimità virtuale o distanza fisica? Trasformazione digitale e co-creazione del valore ai tempi del COVID-19/Virtual proximity or physical distance? Digital transformation and value co-creation in COVID-19 times. *Il capitale culturale, Supplementi*, *11*, 177-195.

Merino, A., Márquez, C., & González, R. (2018). 3D App: The sculptural cycle of the Torreparedones forum (Baena, Córdoba). *Virtual Archaeology Review*, *9*(19), 89-101.

Ministère de la Culture. Retrieved from https://archeologie.culture.fr/lascaux/es

Ministry of Tourism and Antiquities of Egypt. Retrieved from https://egymonuments.gov.eg/en

Monterroso-Checa, A., & Gasparini, M. (2016). Aerial archaeology and photogrammetric surveys along the Roman way from Corduba to Emerita: Digitalizing the Ager Cordubensis and the Ager Mellariensis. *SCIRES-IT - SCIentific RESearch and Information Technology*, *6*(2). Retrieved from http://dx.doi.org/10.2423/i22394303v6n2p175

Monterroso-Checa, A., Gasparini, M., & Moreno Escribano, J.C. (in Print). Corduba y el desarrollo de su aurífero conventus. Rural/Urban boom en el Valle del Guadiato en época romana. In Scheedin, P. & Lehmann, J., *Explaining the Urban boom,* Serie Iberica Arqueológica 13. Madrid, Spain: DAI.

Monterroso-Checa, A., & Redondo, A.J (2020). Investigación digital para el fomento del patrimonio arqueológico del Alto Guadiato. El Mirador Virtual del Cerro del Castillo de Belmez. *NORDON*, *1*, 6-10.

Monterroso-Checa, A., Redondo-Vila, A., Gasparini, M., Hornero, A., Iraci, B., Martín-Talaverano, & Zarco-Tejada, P.J. (2020). A Heritage Science Workflow to Preserve and Narrate a Rural Archeological Landscape Using Virtual Reality: The Cerro del Castillo of Belmez and Its Surrounding Environment (Cordoba, Spain). *Applied Sciences*, *10*(23). https://doi.org/10.3390/app10238659

Monterroso-Checa, A., Teixidó, T., Gasparini, M., Peña, J.A, Rodero, S., Moreno, J.C., & Morena J.A. (2019). Use of remote sensing, geophysical techniques and archaeological excavations to define the Roman amphitheater of Torreparedones (Córdoba, Spain). *Remote Sensing*, 11(24), 2937 https://doi.org/10.3390/rs11242937

Moreno Alcaide, M., Ruiz Montes, P., Serrano Arnaz, B., & Fernández García, I. (2020). Cambio, adaptación y resilencia en el yacimiento de arqueológico de el Laderón (Doña Mencía, Córdoba, España). Estudio de la *terra sigillata* procedente del sector 4 del *oppidum* íbero-romano. In Viegas, C. (Ed.) *Rei Cretariae Romanae*

Fautorum: Acta 46 Congressus tricesimus primus Rei Cretariae Romanae Fautorum Napocae habitus MMXVIII (pp. 77-82). Oxford, England: Archaeopress. https://doi:10.2307/j.ctv1gt94kk

Moreno Sánchez, I. (2015). Interactividad, interacción y accesibilidad en el museo transmedia. *Zer*, *20*(38), 87-107.

Musei Vaticani (2017). Virtual Tour list. Retrieved from https://www.museivaticani.va/content/museivaticani/es/collezioni/musei/tour-virtuali-elenco.html

National Institute of Statistics (INE) (2020), *Population using the Internet (in the last three months). Type of activities carried out on the Internet*. Retrieved from https://shorturl.at/ruIUZ

Rome Museum. Guided tour of the Domus Aurea with virtual reality. Retrieved from https://www.rome-museum.com/domus-aurea-guided-tour-with-virtual-reality.php

Royal Decree 463/2020 of March 14th declaring the state of alarm in Spain to manage the COVID-19 health crisis. Ministerio de la presidencia, relaciones con las cortes y memoria democrática. *Boletín Oficial del Estado*, 67, 25390-25400.

Samaroudi, M., Rodriguez Echavarria, K., & Perry, L. (2020). Heritage in lockdown: Digital provision of memory institutions in the UK and US of America during the COVID-19 pandemic. *Museum Management and Curatorship, 35*(4), 337-361. https://doi.org/10.1080/09647775.2020.1810483

University of Cordoba, Scientific Culture and Innovation Unit (2017). *Long life to Mellaria. Fuente Obejuna recovers the history of the Roman city of Mellaria in a symbolic ceremony of civic re-foundation*. Retrieved from https://www.uco.es/investigacion/ucci/es/noticias-gen/item/1798-larga-vida-a-mellaria

Sketchfab (2020), Vias cordobesas. Retrieved from https://sketchfab.com/joseluisdominguez

Stojićevic, M. (2020). Importance of cultural heritage digitization in the era of Covid-19. *Преглед НЦД*, *36*, 13-21.

Tapia, R., (2017). Un mirador para ver la ciudad de *Mellaria*. La realidad virtual muestra el pasado romano del Alto Guadiato. *Estratos*, 119, 40-41.

The tomb of Nefertari (2021). 3D & VR. Retrieved from https://www.nefertaritomb.com/3d

Tour virtual al Museo Histórico-Arqueológico de Doña Mencía. Retrieved from https://dmvt.s3-us-west-2.amazonaws.com/index.htm

Turismo de la Subbética (2020). Virtual Tour. Retrieved from http://360.miwebsocial.com/turismodelasubbetica/

Turismo Virtual Belalcázar (2020). Blog del Ayuntamiento de Belalcázar. Retrieved from http://ayuntamientodebelalcazar.blogspot.com/2018/01/turismo-virtual-de-belalcazar.html

Waas, M., & Zell, D. (2013). Practical 3D photogrammetry for the conservation and documentation of cultural heritage. In *International Conference on Cultural Heritage and New Technologies, CHNT* (pp. 1-13). Viena, Austria.

World Health Organization (2020). *WHO Director-General's opening remarks at the media briefing on COVID-19*. Retrieved from https://www.who.int/es/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020