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Scenics Roads and Augmented Reality in the Sierra del Aramo (Asturian Central Massif)

I. INTRODUCTION

The Sierra del Aramo is in the central Asturian area 20 km to the SW of Oviedo from where it extends along about 15 km to the south with meridian direction. It is a mid-mountain unit of the Asturian Massif (Gamoniteiro peak, 1,791 m), on the northern slopes of the Cantabrian Mountains, in a section elevated above the pre-coastal basins and inland valleys that is popularly known as the Central Mountain in reference to its outstanding relief and its regional location. Specifically, Mormo, Riosa and Quirós extend their territorial domains over the Aramo, although other neighboring municipalities enjoy their usufruct at the same time. The location of this limestone ridge at the northern end of the Asturian massif implies that it is under the metropolitan influence in the medium of the regional centrality. It is a space of traditional agro-silvo-pastoral use that is undergoing profound transformations due to its mountain and rural idiosyncrasy in the urban periphery. Therefore, the knowledge of its landscape takes on all its relevance, as an expression of a historical evolution and a state of the territory, much more if we take into account its human colonization verified since Prehistory and its natural wealth, in advance undervalued.

The objective of this publication is to analyze and disseminate the heritage values of the Sierra del Aramo landscape, in order to contribute to the development of a scientific tourism interested in the knowledge and enjoyment of the nature of the landscape. For this, a geographical-tourist itinerary is designed, made up of the best stretches of scenic roads and panoramic viewpoints. The information and interpretation of such places is offered by AR for mobile devices, in order to spread the pedagogical virtues and the socioeconomic potential of this tool.

II. METHODOLOGY

The methodology applied in this work combines the panoramic and scenic vision offered by scenic roads and AR, a digital technological instrument that facilitates the analysis and explanation of the nature and dynamics of the landscape through virtual images. The procedure followed in the designation of the scenic road sections consists of three specific phases: selection of the territorial area through which the itinerary passes, taking into account, among other factors, the landscape quality, the proximity to urban areas, the conditions of visibility and good accessibility; field work in which the roads and asphalt tracks of the Sierra del Aramo were covered, in order to choose those sections of greatest scientific interest; organization of the itinerary by characterizing the distinctive features of the scenic road sections.

Various types of interactive resources have been made for the development of AR content. First, spherical views generated with the 3DVista Virtual Tour software. In these 360º views, complementary information of various kinds has been included, including multimedia, which allow readers an immersive learning. Another resource used has been digital elevation models (DEM) or, where

appropriate, surfaces (MDS) made from LIDAR data from the National Geographic Institute, processed with the Lastools, Saga GIS and QuantumGis software. The result obtained has been three-dimensional digital models visible from mobile devices. Several three-dimensional models have also been made using photogrammetry, for this the Agisoft Metashape software has been used and later they have been uploaded to the Sketchfab platform so that they are accessible online. Finally, an aerial photography comparator has been made that uses the JuxtaposeJS javascript.

III. RESULTS

1. The scenics roads

The itinerary has its starting point in La Vega, capital of the council of Riosa, which is easily accessed by the AS-231 road from the N-630. As it is a circular route around the Sierra del Aramo, it can be started from other places although, in any case, it is recommended to follow it in a clockwise direction along 4 sections. Three other sections have also been included outside of this ring road passing through asphalt tracks that access the highest points of the range, with a high landscape value. The whole of the road is in good condition and all the roads and highways that compose it are passable with cars and other passenger transports that are not large tonnage. However, extreme caution is recommended because, despite the low altitude, the relief is abrupt and characterized by significant slopes that impose steep slopes and sharp curves, which can be invaded by wild and domestic animals.

A) Riosa's strecht

This first section has a total length of 19.2 km and crosses the council of Riosa from north to south. It corresponds to the basin of the homonymous river and its tributaries well fed by the multiple springs that arise in the contacts between the limestones of the Aramo and the impermeable materials of the Central Carboniferous Basin. Indeed, the landscape is largely explained by water and lithological materials. The water currents have been primed with the easily erodible rock, constituted to a large extent by soft layers of shale and sandstone, triggering small landslides that are found in all siliceous slopes, as well as large mass movements. In this way, huge volumes of rocks lost their balance due to the basal scouring action of the rivers and were deposited down the slope, completely modifying the relief. On the other hand, among the plant formations there are abundant riverside forests and other riparian communities with appetite for situations of edaphic humidity, which alternate with plantations of chestnut and oligotrophic oak forests with birch.

Finally, mining, the activity of extraction of mineral resources has been imposed directly and indirectly on the agrosilvopastoral mosaic, conditioning local socioeconomic dynamics especially in the last century and, therefore, the landscape, in which infrastructures have also been generated (the mines themselves and their elements, workers' houses for miners, etc.) and complete landscape units of high interest such as the Cordal de Cuba and the Llosoriu or in Llamo.

B) Quirós's strecht

On the AS-230 road we head west towards Bárzana - Proaza, which for 13 km will bring us closer to the capital of Quirós. It is a good road, wide and safe, although mountain, dominated by the Alto de La Cobertoria (1,173 m) and frequently invaded by domestic animals that graze freely. The landscape is characterized by its spectacularity as it is a privileged balcony, used already in Prehistory. Its montane section is also framed by large areas of grass and scrub, coniferous plantations (*Pseudotsuga menziesii*, *Chamaecyparis lawsoniana*, *Larix* sp. pl., *Pinus radiata*) and mature nemoral formations of great ecological value. In fact, it constitutes a good catalog of habitats of community interest in all strata.

Descending towards the bottom of the valley, olive groves and oligotrophic beech, oak and chestnut trees also hide the traces of an important coal mining operation, which has dotted some slopes with openings and mining dumps, while explaining the presence of high-value buildings cultural. The valley is closed by a verticalized limestone wall cut by a small gorge that has served to dam the water from the Valdemurio reservoir. Several types of willows, such as white (*Salix alba*), alders and poplars, are crowded around this, which make up a rich ecosystem cataloged by the European Union in its list of habitats of community interest (code 91E0).

C) Proaza and Santo Adriano's strecht

Eight kilometers further north on the AS-228 you reach Villanueva, in the municipality of Santo Adriano. The road runs through the valley of the Trubia river,

crossing the town of Proaza where there are edaphic conditions that make it possible to conserve holm oaks, helped by the sheltered situation and a sub-Mediterranean microclimate. In this area, there are also traces of human groups from the first settlers of the Trubia valley, 35,000 years ago. At kilometer 11 of the road, there is a detour to the right towards the AS-360 with signs indicating its direction to the Las Xanas Gorge. This place is protected as a Natural Monument, it is a Point of Geological Interest and has been proposed as a geomorphosite next to La Coruxeda, since it constitutes a natural heritage of the first order. On the carbonate materials there is an alternation of rounded rocky cones, dead valleys and clogged depressions, a karst landscape extensively deforested and successfully colonized by the calcicole gorse of *Genista hispanica* subsp. *occidentalis* (habitat of community interest code 4090).

D) Morcín's strecht

The Morciniego stretch can also be called Devonian because it runs through the valleys carved in materials from that geological period, framed by Namurian limestone. Indeed, the MO-5 road takes us east through the Morcín council, crossing the slates, sandstones and Devonian marls of a broken anticline structure to the town of El Campo and the Los Alfilorios Reservoir between meadows separated by hedges and villages. This reservoir collects the water from the eastern springs of the Aramo by means of a complex engineering infrastructure, as well as from one water conveyance from Lindes (via Quirós and Riosa), to supply the city of Oviedo.

On the slopes the scrubbing process is observed through the immense areas occupied by ferns and heaths-gorse, as well as the growth of small forest masses from the gullies. The landscape is wild, riddled with ferns, young ash and maple forests, mixed nemoral formations of deciduous planes, naturalized chestnut trees and riverside communities. These plant formations grow on the abandoned parcel and the mountains at the head of the Morcín river, where there is also a water catchment and infrastructure for transporting it, including a pumping station.

E) Angliru's strecht

The climb to L'Angliru is a milestone in cycling culture. From the recreational area of Viapará, which is accessed by Morcín (MO-1) or Riosa (RI-5 and RI-2), a vertiginous road crosses a steep 800 m drop (from approximately 700 to more than 1,500 m) in just over 2 linear km. However, the section covers a total distance of 8.4 km on a well asphalted route in which, however, extreme caution must be exercised. Plant succession advances throughout this sector on disused meadows. The geomorphological dynamics of slopes has been very intense due to the steep slopes and the presence of very old cemented deposits, periglacial scree, landslides and mass movements is common. From 1,400 m above sea level, the culminating platform of the Aramo is reached, where a karst landscape dotted with sinkholes, old dry and hanging riverbeds and rocky outcrops carved with karren extends without interruption. The millenary cattle activity has turned these areas into summer pastures and in them sheepfolds with traditional buildings and small water reservoirs are located.

F) Gamoniteiro's strecht

One of the most unique aspects of the Sierra del Aramo is that it can be reached with almost any vehicle. We ascend this narrow but well-preserved road through pastures, heaths-gorse with heather, shrub formations of hawthorn, sloe, rose and hazelnut trees and some beech patch, which grow on the carboniferous shales and sands of the Lena group. To the remains of old mining works (galleries, increased chasms, dumps) are added here also the presence of archaeological sites. Arriving at the limestones of the Aramo, the geological structures are very evident: the fractures, the thrusts and the great inflection of the antiform Los Veneros in the massive Valdeteja Formation. The limestones of the mountain are bare and there is hardly any chasmophytic vegetation and some shrubs in the crevices, highlighting the presence of yews that cover the rocks and some areas extensively occupied by the *Genista occidentalis* gorse. The limestone is full of karren resulting from the dissolution of calcium carbonate such as the grooves that are called rillenkarren. The bottoms of the valleys and sinkholes are filled with decalcification clays and in some there are iron nodules and even allochthonous materials (quartzite, slate, sandstone edges). The grasses cover the most developed edaphic formations, although they are shallow, while the psychroxerophilic grasses are concentrated on very fine layers of somewhat stony soils.

G) Peña del Alba's strecht

The proposed seventh section is formed by the road that goes up to Peña del Alba. It is a road that runs be-

tween towns and villages with its consequent meadows, crops and small forests in the areas less prone to agriculture (*Quercus pyrenaica* and chestnut trees). Salcedo and Villar de Salcedo present a good sample of raised granaries and *paneras*, in the Villaviciosa style, with painted decoration (geometric motifs and human figures). On the opposite slope are the Xagarín and Los Tallos coal mines, already hidden under a dense tree canopy of beech and white oak (*Quercus petraea*). The lowest area of the valley is covered by chestnut trees and riverside forests that develop along the Los Molinos stream that, obviously, owes its name to hydraulic mills such as the Molín de La Perica. At the top, is the Hermitage of Alba that presides over the mountain limestones over the entire council of Quirós. In addition, it offers extraordinary views of the central sector of the Aramo and the siliceous blind valley of Mortera de Salcedo, where the hydrographic network joins under the ground through the sinkholes of Covachos and Agüeras.

2. Virtual overlooks (augmented reality)

For the tour of the scenic road, 6 virtual viewpoints implemented by AR materials have been selected. These can be obtained through mobile devices to document the itinerary with geographic-tourist data or serve for the virtual, pedagogical and informative visit.

A) Alto de L'Angliru

L'Angliru is a cattle mountain pass popularized as a result of the celebration in 1999 of the end of the stage of the Vuelta Ciclista a España, which has been followed by other editions, which stands out for the hardness of the ascent. From Alto de L'Angliru, located at 1,550 m a.s.l., the richness and variety of karst forms carved in the mountain limestones of the extensive cacuminal platform and other mixed ones linked to cold processes can be contemplated, specifically, to the participation in its modeling of snow such as snow pits, which make it a geomorphosite. In particular, the rocky cones, funnel-shaped sinkholes and lapiaces in pinnacles of Valdesiniestro, the dry valley of Xanzana and the karst alleys and snow pits of Arandanal-Morterín stand out. Another notable feature of the landscape are the lively pastures of Festuco-Brometea that cover the calcareous rocky with their green mantle, dotted with species of great ecological value such as the relict *Anemone narcissifolia* L. Although at present this place lacks forest formations, nevertheless, the pedoanthracological surveys carried out in L'Angliru reveal that the yew trees colonized this place at least 3,450 years ago BP, that is, in the Bronze Age.

B) Cuesta de Riosa

In Fresneo, located in the interfluvium that separates the Llamo and Juncar valleys, there is a complete view of the Cuesta de Riosa. From this excellent vantage point you can see the traces of the intense periglacial activity that, even today, continues modelling the steep eastern slope of the Sierra del Aramo. The snow avalanches that play a fundamental role in the morphological configuration of the landscape are especially relevant. Among the disturbing effects produced by snow avalanches, it is worth highlighting the impact on the distribution and structure of the forest cover, which in this sector of the Cuesta de Riosa materializes in a vast area completely deforested of 370 ha in extension, between 700 and 1,600 m a.s.l. Another excellent viewpoint that allows us to carefully contemplate the southern sector of the Cuesta de Riosa is in the Mestas. From there you can see the escarpments associated with the thrust of Namurian limestone on the siliceous materials of the Westphalian and the semicircular scar of the El Fresno formed as a result of the mass movement of Llamo, which finally deviates the path of the homonymous river. Other notable elements of historical-patrimonial value are the mining town of Rioseco and the prehistoric mining galleries of La Campa les Mines, where the working of copper and cobalt dates back to the 4th millennium BP and in which yew was used not only as teas lighting, but also as firewood to start the mineral through the fire-setting system.

C) La Cobertoria

To the south of the Aramo a mountainous alignment of meridian direction extends that connects this unit with the Cantabrian watershed. It is the Cordal de Lena, made up of mostly siliciclastic materials, which separates the Quirós and Lena basins with altitudes between 1,200 and 1,450 m a.s.l. Its lowest point, at the southern termination, is Collaú la Cobertoria (1,179 m a.s.l.) that has traditionally served as communication between valleys and that gives its name to the top of the AS-230 road, as well as the promontory that serves as connection with the Sierra del Aramo. From the latter, which culminates in Mesqueru (1,328 m a.s.l.), there is an excellent panoramic view of the Asturian Central Mountain. This reason is, without a doubt, one of the reasons why the first Neolith-

ic settlers chose it to perform their funeral rites and certify the colonization of the mountain spaces of this area. It is worth mentioning the tumulus and the semicircle of stelae at Los Fitos, as well as the Mata'l Casare dolmen, among other archaeological finds of great relevance to the region and the understanding of human groups and the evolution of the landscape.

D) Gamoniteiro

The Gamoniteiro, located at 1,791 m a.s.l., constitutes the highest summit of the Sierra del Aramo and an excellent viewpoint. From the culminating platform, the rocky cones of La Gamonal, Moncuevu and Barriscal can be seen to the N, while in the central part the southern termination of the dry valley of Vallongo can be seen and, in the foreground, a deep depression with a semicircular slope of 140 m of unevenness formed by a nivo-karstic niche. At the exit of said depression there is a mass movement deposit subjected to periglacial processes, in which various solifluction lobes are distinguished that move towards the bottom of the dry valley of Cruz del Fresno. There are also fields of sinkholes, lapiaces in pinnacles and filled with detrital materials of foreign origin, as well as a great abundance of ferruginous nodules. Towards the South we can distinguish the extensive and elongated dry valley of Cubiello-Los Veneros, arranged in a NW-SE direction, whose bottom is filled with a large amount of clays and these ferruginous concretions. Finally, it is worth highlighting the herbaceous tapestry that covers the substrate of this summit, made up of high-altitude grasslands of *Festuca burnatii* St-Yves, which colonize shady areas subjected to greater climatic rigors. On the opposite slope exposed to the sun, a very extensive bush of the endemic *Genista legionensis* (Pau) Laínz and some psychroxerophilic grasses develop on the rocky ground.

E) Peña del Alba

The Alba hill, with the peak of the Peña at 1,308 m a.s.l., presents excellent views of the Quirós valley and the Sierra de Sobia. Continuing the massive carbonate outcrop to the north are the Champaza (1,454 masl) and Pelitrón (1,562 masl) peaks, in this western foothills of the Aramo, with their slopes regularized by erosion to the nascent and abundant scars of mass movements to the west, with nivation niches, paths and scree. The limestones are mostly bare although interesting rupicolous vegetation (habitat of community interest code 8210) populates the fissures of the rock sometimes colonized by some communities of calcareous gorse, and even eutrophic shrub formations and small oak clumps. Towards the central part of the Aramo there is a valley excavated in the shales, siltstones and sandstones of La Candemuela and La Majúa, members of the San Emiliano carboniferous formation. It has been suspended, above 1,000 m of altitude, after the drainage network has been captured by sinks, chasms and underground galleries that transport the water to the other side of the limestone massif, so that it flows from springs and karst springs. It is a beautiful place, full of sinkholes of subsidence, with abundant grasslands and heath-gorse, from where you can access the dead valleys of the culminating platform, crowned by the Gamoniteiro, by cattle tracks.

F) Los Alfilorios

The Alfilorios reservoir was inaugurated in 1990 after a construction process that began in the 1960s and ended in 1983, with the aim of supplying drinking water to the central area of Asturias, especially Oviedo. Its name is due to the three homonymous towns (de Abajo, de Arriba and del Medio) that existed where it was designed. The reservoir collects the waters of the Barrea River, as well as the catchments of the Riosana and Morciniega slopes of the Aramo. It is a place of unequaled landscape and aesthetic quality as it is located in the Devonian valleys guarded by the limestones of La Mostayal, Peñerudes, Monsacro and the Sierra del Aramo, whose eastern slope serves as an excellent backdrop. The village grounds, composed mainly of meadows closed by hedges and some chestnut trees, offer the typical Asturian bocage, with a soft relief, with green meadows and some silicicular shrub formations and riverside. Towards the north, on the contrary, the Namurian limestones present an abrupt appearance despite the low altitude, with dominance of the rocky outcrop over the calcareous plant communities that try to colonize it.

IV. DISCUSSION

The itinerary through scenic roads implemented with AR is a training tool and for ecotourism, which provides geographical knowledge of various subjects and is framed in a context of knowledge society and sustainable local development. The Sierra del Aramo is a space rich in natural heritage and landscape. This is demonstrated by the project since the end of the last century of being declared

a Protected Landscape within the Network of Protected Spaces of the Principality of Asturias and other unique proposals. This mountain unit allows us to develop new methodologies for the enhancement of cultural and natural heritage (design of itineraries, scenic roads and AR) and, at the same time, takes advantage of them to show these values and favor an appropriate use, their care and conservation. Indeed, the itinerary is a very useful tool for the promotion and development of ecotourism, since it favors the scientific dissemination of knowledge about the territory, the development of environmental-heritage sensitivity, the appreciation of the landscape, as well as the generation of new tourist, pedagogical and didactic resources.

It is what we have carried out with the help of AR. This tool has been endowed with continuous innovations and technical improvements that have contributed to the evolution of this technology to the present day. Its potentiality is evident from scientific, technical, didactic and tourist applications, being especially suitable for the dissemination of results resulting from scientific research and, specifically, as an instrument for the dissemination of the dynamics of the landscape, as long as it is supported correctly on the technological pillars (appropriate and accessible technical solutions) and the content (scientific quality, successful formats). In the same way, it must be adapted to the receiving public, trying to bring the most exhaustive scientific knowledge to any user. This research on the Aramo equipped with digital resources for AR is a good example of how to make information more accessible in an effective way, especially if we take into account the current process of world globalization and the new pedagogical trends.

V. CONCLUSIONS

Since the signing of the European Landscape Convention in 2000, society's awareness of the importance of landscape as an essential element of heritage, natural and cultural, has increased significantly. The landscape is also a valuable resource that can contribute to the development not only of social welfare, but even economic, provided that initiatives based on conservation and sustainability are applied. One of them is undoubtedly scientific tourism, which constitutes a growing sector very interested in combining both knowledge and enjoyment of the nature of the landscape, however, it requires selected and explanatory routes that show and facilitate the understanding of the content in an enjoyable and didactic way. This work has designed an itinerary through the Sierra del Aramo that contributes to the dissemination and knowledge of its natural heritage, combining the scenic vision of the scenic roads and the application of AR on mobile devices, which facilitates the interpretation of the structure, the nature and dynamics of the landscape. Specifically, the Sierra del Aramo route, which begins in La Vega, the capital of Riosa, runs through seven stretches of scenic road in which a series of stops have been selected that have significant and high-quality views, which become viewpoints that allow a more peaceful contemplation and even encourage a small foray through the territory. Indeed, a total of six viewpoints have been chosen that house the most unique qualities of each landscape road and through which the main heritage values of the landscape of the Sierra del Aramo are analyzed and interpreted, also serving as a model to promote development ecotourism in mountain areas.