PROCEEDINGS OF THE 1ST TIR-FOR SYMPOSIUM.
FROM TERRITORY STUDIES TO DIGITAL CARTOGRAPHY

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UNION ACADÉMIQUE INTERNATIONALE
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TIR-FOR INTERNATIONAL COMMISSION

PROCEEDINGS OF THE 1ST TIR-FOR SYMPOSIUM. FROM TERRITORY STUDIES TO DIGITAL CARTOGRAPHY

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INSTITUT D'ESTUDIS CATALANS
INSTITUT CATALÀ D'ARQUEOLOGIA CLÀSSICA
SOCIETAT CATALANA D'ESTUDIS HISTÒRICS

BARCELONA, 2021

Biblioteca de Catalunya. Dades CIP

TIR-FOR Symposium (1r : 2020 : En línia), autor
Proceedings of the 1st TIR-FOR Symposium : from territory studies to digital cartography. — Primera edició
Ponències i conferències presentades al primer Simpòsium TIR-FOR celebrat en línia els dies 26 i 27 d'octubre de 2020. —
A la part superior de la portada: Union académique internationale, Tabula Imperii Romani, Forma Orbis Romani,
TIR-FOR International Commission. — Bibliografia. — Textos en anglès, castellà, francès i italià
ISBN 9788499656403 (IEC). — ISBN 9788494974700 (ICAC)
I. Prevosti, Marta, editor literari II. Guitart i Duran, Josep, 1946- editor literari III. TIR-FOR International Commission.
IV. Institut d'Estudis Catalans V. Institut Català d'Arqueologia Clàssica. VI. Societat Catalana d'Estudis Històrics VII. Títol
1. TIR-FOR Project 2. Cartografia digital 3. Geografia clàssica — Mapes. 4. Roma — Història — Fonts
528.9:621.3.037.37
912.43(37/38)
94(37)(093)

With contribution of:

Union Académique Internationale
Institut d'Estudis Catalans
Institut Català d'Arqueologia Clàssica
Societat Catalana d'Estudis Històrics, filial de l'Institut d'Estudis Catalans

Carrer del Carme, 47. 08001 Barcelona

Primera edició: desembre del 2021

Text revisat lingüísticament per Tracy Byrne, Hèctor Cesena, Beatrice Krayenbuhl i Giulia Sogno

Editat per Flor edicions, SL

ISBN: 978-84-9965-640-3 (IEC)
ISBN: 978-84-94974-70-0 (ICAC)

Dipòsit Legal: B 20635-2021

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Studies of landscape, settlement and archaeological topography in the development of digital cartography

DOI: 10.2436/15.1000.02.7

From 'Flatland' to the real world. Mapping the landscapes of Cappadocia in the digital age

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Received 9 March 2021· Accepted 15 June 2021

"I call our world Flatland, not because we call it so,
but to make its nature clearer to you, my happy readers,
who are privileged to live in Space".

Edwin A. Abbott, *Flatland. A Romance of Many Dimensions*, London 1884.

Abstract

While conducting research on the historical landscape of Cappadocia (central Anatolia, Turkey) and on its transformation over time (from the Graeco-Roman to the middle Byzantine periods), the need has arisen to approach the archaeological mapping of that territory from a different perspective and from different points of view than those traditionally adopted in the area so far. In particular, exploiting the potential of the 'third dimension' appears to be very useful.

Within this context, the aim of this paper is twofold: a) to discuss some case studies in which the application of a three dimensional approach to archaeological mapping has encouraged new ideas and hypotheses; b) to discuss the next steps taken by our research, devoted to applying a technological approach that aims to develop smart tools to share data among scholars, public bodies and the general public.

Keywords: Cappadocia, digital cartography, Augmented Reality applications, webGIS.

1. Introduction

The research carried out on the historical landscape of Cappadocia (central Anatolia, Turkey) from the Graeco-Roman to the middle Byzantine periods, on the transformation it underwent over time and on the development of its road network, led to the archaeological mapping of that territory being approached from a different perspective and from different points of view than those traditionally adopted for the area so far. Indeed, the morphological features of Cappadocia – ranging from the mountainous slopes of the Taurus chain to the south, the volcanic massifs of Melendiz Dağları, Hasan Dağı and Göllü Dağı at the heart of the region, the basin of the Kızılırmak river to the north, the thick, extensive tuffaceous deposits of volcano-sedimentary sequences of the 'Fairy Chimneys' area to the east of Nevşehir, and the extensive, fertile plains of the Anatolian plateau (Fig. 1) – encouraged investigation into the potential of the 'third dimension', whether in a 2.5D or real 3D GIS environment. This approach enabled all the Cappadocian morphological features to be 'extruded', enhancing their representation on maps and enabling a multi-parameter interpretation of the archaeological record and an evaluation of its relationship with the surrounding environment.

This paper focuses on some case studies related to the application of a 'three-dimensional

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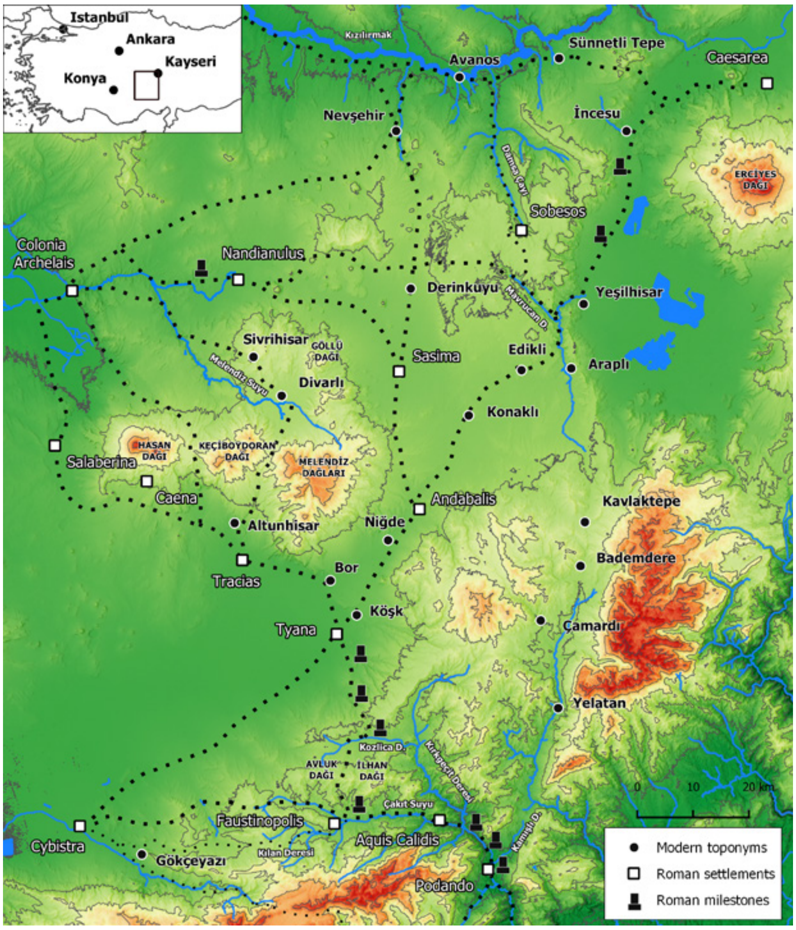

FIGURE 1. Roman Cappadocia (J. Turchetto).

approach' in the analysis of the Cappadocian landscape, and on future research prospects in this sector of Anatolia.

2. Cube-shaped Cappadocia

An initial approach dealt with the southern sector of Cappadocia, attempting to analyse the layout of the Roman route recorded in both the *Itinerarium Burdigalense* (577, 7 - 578, 4, p. 93 Cuntz) and the *Itinerarium Antonini* (145, 1-4, p. 20 Cuntz), leading from the pass of the Cilician Gates (the only natural passageway between the Mediterranean coastal strip of Cilicia and the Anatolian plateau) to the colony of *Tyana* (corresponding to the modern town of Kemerhisar). The fact that this route would have run along the longitudinal valley of the Çakıt Suyu and would have then turned northwards, passing through the col of the Avluk Dağı and avoiding the narrow, dangerous gorge in Kırkgeçit Deresi (meaning 'the valley of the forty bends'), had already been suggested by archaeological and topographical evidence detectable *on* the ground (Turchetto, 2018a). In this case, the aim was to further validate this hypothesis at a GIS-driven level, via evidence *from* the ground and its specific features.

Such confirmation resulted from an analysis of a 3D simulation generated from ASTER GDEMS[2],

2. The Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Models (GDEMs) provide a global digital elevation model at a spatial resolution of 1 arc second (approximately a 30-metre horizontal posting at the equator) and 1 × 1 degree tiles. These DEMs are available free of charge and can be downloaded from *EarthExplorer*, the United States Geological Survey website (https://earthexplorer.usgs.gov/). ASTER GDEM is a product of METI and NASA.

whose cells had been previously aggregated (Fig. 2). The resulting output was effectively not a realistic simulation of the area but a 3D cubic representation of the territory which meant that the elevation data could be viewed as a series of steps along the two routes in question, running along the valleys of the Kırkgeçit Deresi (darker line) and of the Çakıt Suyu (lighter line). The former is forced to cross a series of drops and rises, which would have made it difficult to walk along, while the latter route, albeit in a mountainous setting, is easier to follow, both uphill and downhill; the steepness seems to remain more or less constant along most of the route and there are no sharp differences in height to tackle (Turchetto, Salemi, 2014).

3. Visible and invisible Cappadocia

Furthermore, it appeared potentially interesting to investigate the central Cappadocia volcanic area between Aksaray and Kemerhisar, in which a series of fortresses had been built on the top of rocky spurs to escape the Arab incursions in Anatolia (mid-8th to mid-10th centuries AD), "…directed almost entirely at the border districts of the empire and their hinterland [and] aimed chiefly at the collection of booty and at damaging Byzantine morale…" (Haldon, Kennedy, 2004: 145; see also Métivier, 2008; Kennedy, 2010: 175-178; Eger, 2014). In particular, our aim was to better understand the relationship between those same defensive structures and the routes crossing the district, as well as the role played by the landscape within the settlement strategies of the Byzantine empire.

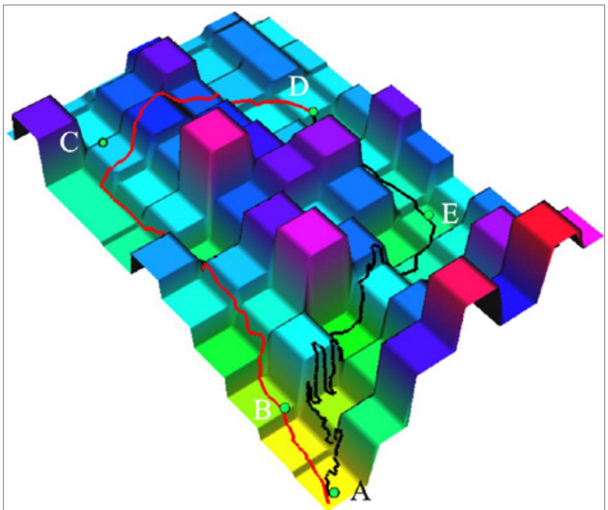

Figure 2. 3D cubic model of southern Cappadocia (view: from south-east). The darker line corresponds to the Kırkgeçit Deresi valley route, the lighter line to the Çakıt Suyu valley route. A = Tahta Köprü; B = Çiftehan/*Aquis Calidis*; C = Zeyve/*Faustinopolis*; D = Eminlik; E = Başmakçı (J. Turchetto).

In this respect, the *Analysis of Visibility* (Murrieta-Flores, 2014; Llobera, 2015), which would have enabled us to define the width and extension of the 'in-view' areas provided by each fortress regarding the territory beneath them, seemed to fit our purposes well (Turchetto, Salemi, 2017). Indeed, by applying a cumulative *Viewshed Analysis*[3] (with a 4 km buffer)[4], a series of binary viewshed raster maps were processed for each fortress, which acted as a lookout against Arab attacks. In this way, we managed to gain information about which portions of the landscape were visible from these lookouts and the stretches of the roads that could be monitored visually from the fortresses themselves.

As a result, the subsequent application of a directional visibility analysis, aimed at investigating the degree of control exercised by the fortresses in relation to eight main directional zones (north, north-east, east, south-east, south, south-west, west and north-west), produced a series of 'cones of visibility' that offered the chance to determine the dominant (or preferred) direction in which each fort provided a better and more effective view.

The results confirmed what the Byzantine written sources record regarding the strategy to

3. In this case, the QGIS viewshed analysis plugin elaborated by Zoran Čučković was applied (https://www.zoran-cuckovic.from.hr/QGIS-visibility-analysis/).

4. Such a radius falls within the visual range suggested by similar archaeological studies (Murrieta-Flores, 2014, with earlier bibliography) and, as has been directly verified in the field in Cappadocia, this fits well with the aims of the research and the features of the landscape in question. Further analyses were carried out by means of *Fuzzy Viewshed Analysis*, aimed at determining the different degrees of visibility of the roads from the fortresses and thereby the gradually increasing degree of control exercised over the route as it approached the fortress (Titti, Turchetto, Salemi, 2018, with previous bibliography).

be adopted against Arab raids. Indeed, the GIS-based analysis (Fig. 3) revealed the centrality of these fortresses and the importance of the garrisoning system within the Arab/Byzantine guerrilla tactics, in which the careful observation of enemy movements without being seen proved to be strategic and essential. The directional viewshed analysis highlighted the fact that settlement choices related to the forts were not determined by chance. On the contrary, they reflected what the new offensive/defensive strategy required; i.e. to provide the largest possible view of the whole territory and, in particular, of any access points which would enable enemies to enter that mountainous area and use the routes running across it.

4. Historical and potential paths

A third geomatic exercise was represented by the application of the *Least Cost Path Analysis* (Turchetto, 2018a, 131-143). As is known, on the basis of a raster map that determines the 'cost' of travelling across its cells, this GIS-based analysis enables the identification of the least cost path (or LCP; i.e. a potential route) between two points, a source and a destination (Herzog, 2014).

Within this framework, we carefully generated the cost surface, modelling this according to different parameters, including attractors (such as settlements or springs) and detractors (lacustrine or marshy areas); facilitators (such as slopes) and obstacles (mainly rivers) (Citter, Arnoldus-Huyzendveld, 2011: 86-99; Arnoldus-Huyzendveld, Citter, Pizziolo, 2016; Patacchini, Nicatore, 2016).

The first two parameters "…act at a distance…", in the sense that they help to determine the layout of the pathway by attracting or diverting the route and making it more or less direct and short. The last two factors, on the other hand, act "…directly on the ground", conditioning the itinerary at every single cell of the cost surface (Patacchini, Nicatore, 2016: 671). Each of these parameters can be properly rasterised and added to the others via the GIS *Raster Calculator* tool, which can also be used to determine the percentage (and therefore the relative weight) of each factor within the final calculation. The result is represented by a cumulative cost surface, "…whose cells express the degree of advantage or disadvantage to moving in that context". In other words, the higher the values of the cells, the more expensive the path passing through them (Patacchini, Nicatore, 2016: 671).

Once the 'potential route' was obtained, we followed a postdictive approach: instead of asking *whether* a connection existed between two points, the key question was to grasp *why* the potential routes followed those precise paths. By modulating the relative weights of the different parameters considered and comparing the routes reconstructed on a historical/archaeological basis with the GIS-driven paths, we could better understand which factors (anthropic or natural) played a major role in determining the roads' layout. Such an approach, in fact, allowed us to investigate why a potential path did (or did not) match with the corresponding archaeo-historical route. Moreover, as our intention was not to discover or identify the path of a road but, more simply, to compare the results of a traditional approach with those obtained via a GIS analysis, the various criticisms arising from the challenge of investigating the past (its landscape, cultural aspects and perceptions) by means of a modern tool could be avoided. As has been well highlighted, "…we are not obliged to choose between enthusiastic acceptance and paralysing scepticism. We can use these merely as tools, out of a set of many" (Patacchini, Nicatore, 2016: 671).

As far as the Cappadocian road system is concerned, a set of ASTER GDEM (Global Digital Elevation Models) was used to create the cost surface. The values of the slope raster maps were reclassified and divided into 7 discrete classes in order to adapt the gradients to real movements and to operational cognitive maps of past social actors (indeed, it is well-known that slight changes in slope are not even perceived when walking or, generally speaking, moving along a track). A finer-graded subdivision was made for the 0% to 20% range and a coarser classification was given to the 20%-40% slope values, whereas with a value over 40% the path was considered impracticable; no further distinctions were considered necessary. Additionally, each type of slope was assigned a specific cost, ranging from 1

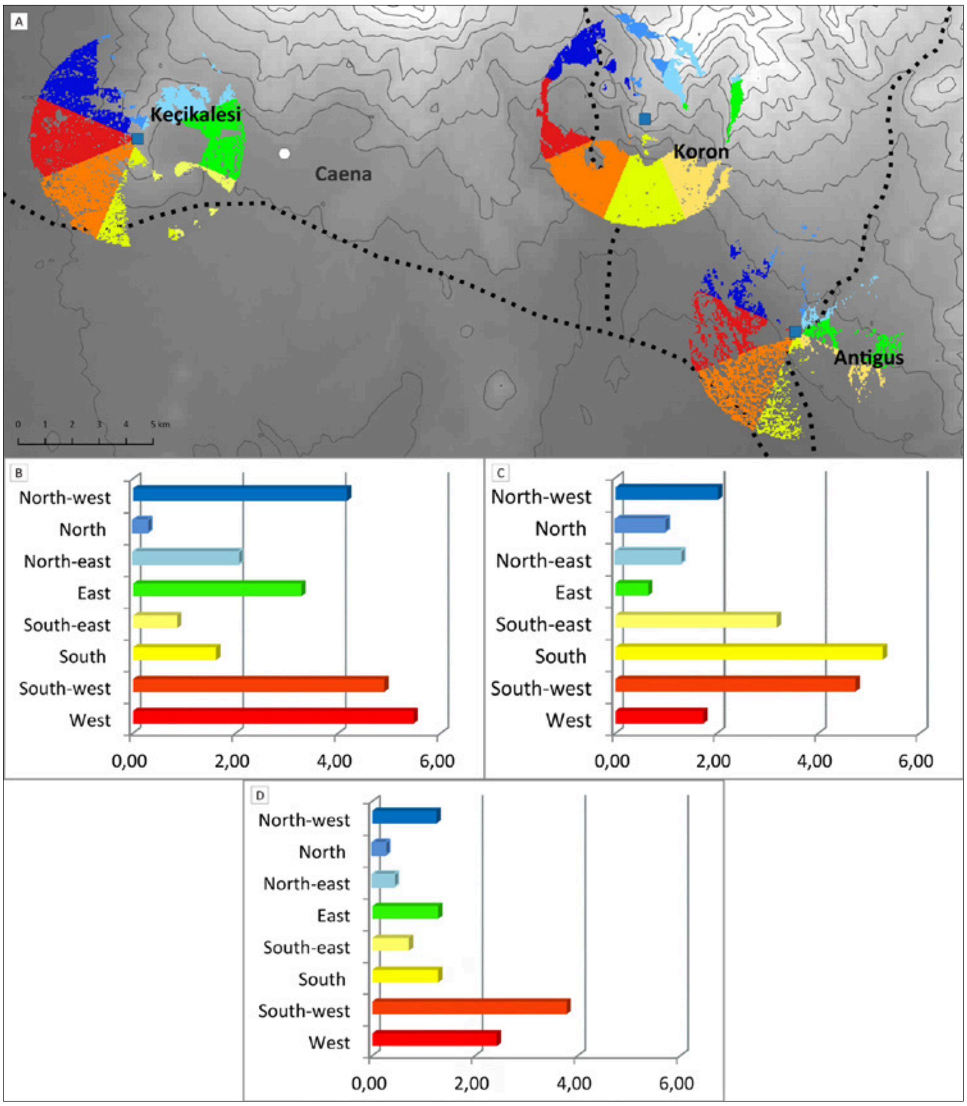

FIGURE 3. A = Directional visibility cones generated from the fortresses of Keçikalesi, *Koron* and *Antigus*; B, C and D = Graphs of the visible square kilometres within each cone of visibility, generated, respectively, from the fortress of Keçikalesi, *Koron* and *Antigus* (modified from Turchetto, Salemi 2017).

(equivalent to the least costly value) to 100 (the costliest value).

At first, the least cost paths were generated as a connectivity network between the main settlements of central-southern Cappadocia, considering exclusively natural factors (slope, presence of marshy or lacustrine areas and rivers). Afterwards, anthropic elements (for example, settlements which acted as attractors within the landscape) were added as well, in order to verify how these might alter the level of correspondence between the potential paths and historical routes.

Most of the least cost paths, generated on the basis of natural parameters only, followed more or less the same direction as their respective historical routes. All this confirms, from my point of view, the existence of natural corridors which, maintaining their role as a route over time, became traditional pathways whose relevance was constantly highlighted by long-lasting settlement patterns and choices. This is the case, for example, of the potential path linking Aksaray and Kayseri, which passes close to Nevşehir and Avanos, running in close proximity to the mid-course of the Kızılırmak river (Fig. 4, black line); or to the least cost path connecting Kayseri to Kemerhisar, which traverses the Yeşilhisar plain, passes by Araplı and continues along the eastern sector of the plain of Niğde (Fig. 5, black line).

In both cases, a more accurate matching between historical and potential routes could depend on other parameters which, in my view, are not exclusively represented by the ancient settlements or stopping places distributed along the roads. Obviously, if we add these to the cost surface (as dots on a map), the GIS-derived results will perfectly match the itineraries proved by archaeo-topographical data; it is simply a matter of connecting points, one after the other. It is necessary, however, to emphasise that settlement location choices may differ greatly from the factors taken into consideration when planning a major important road, especially during the Roman period. In fact, during that period important centres (*civitates* or *municipia*) were often not located *on* the most important thoroughfares but a certain distance away, being connected to these via a series of link roads.

Returning to the main issue and considering what might have played a specific role in determining the precise road layout, one possible answer could be the attraction exercised by a series of highly selective natural passage points that could funnel human movement and improve interconnectivity between the different sectors of central and southern Cappadocia as well as stretches of the various routes of the Cappadocian road network.

Rather than focusing on a single route, it could therefore be more useful to think about a hierarchically networked system of communication (shifting from a local to a regional perspective), which a given road was part of. In this respect, with reference to the Aksaray-Kayseri road, attributing a certain weight to the settlement of Nevşehir (to be plausibly identified with the fortress of *Hisn Sundus* mentioned by the Arabic sources, located at the northern opening of the natural valley linking the Derinkuyu basin with the Kızılırmak; Turchetto, 2018b: 208) and one to the *tumulus* of Çeç (marking a pivotal point along the southern bank of the Kızılırmak and the road to *Ancyra*/Ankara; Thierry 2016), the resulting cost path appears to be more in line with the historical route we have proposed (Fig. 4, grey line). Similarly, with regard to the Kayseri-Kemerhisar route, what probably makes the difference and allows for a closer match between the historical and potential paths is the attraction exercised by the Mavrucan Deresi valley, which permitted an effective connection with the Derinkuyu basin and central Cappadocia (Fig. 5, grey line). Not by chance, the valley's eastern 'entrance' was safeguarded and protected by the Byzantine fortress of Zengibar Kalesi (Hild, Restle, 1981: 219-221; Cassia, 2004: 156-157), still visible in the 19th century when it was mentioned as the 'Black Camel Castle' by William Francis Ainsworth on the occasion of a journey he made on horseback across central Cappadocia, between Aksaray and Yeşilhisar (Ainsworth, 1842, I: 210).

5. Future prospects

With reference to the next steps to be taken by the research we are still carrying out (or planning to carry out) as part of the *Cappadocia Landscape Archaeology Project* (CLAP), most of the activities are related to an attempt to disseminate our results among scholars but also (and especially) among the general public. In this respect, we have been developing some tools which can help users to experience history and archaeology in a more direct, stimulating and involving way, fostering the potential of digital interactive technologies and deepening our knowledge of the Cappadocian historical landscape.

One initial digital product is the *Peutinger mApp*, an Augmented Reality (AR) application for mobile devices which can be used to 'decipher' one of the most fascinating, and not easily understandable, pictorial representations of the ancient world, the *Tabula Peutingeriana* or Peutinger Map. This is the medieval copy of an original map which can be dated back to the 5th century AD, representing all the territories

FIGURE 4. Historical and potential paths between Aksaray and Kayseri. The dotted line is the path reconstructed on an archaeological and topographical basis; the black line is the LCP generated via a cost surface with the cells’ values defined by the slope; the grey line is the LCP generated via a cost surface combining natural and anthropic factors (slope 50%; tumulus of Çeç 25%; Nevşehir 25%) (J. Turchetto).

known at that time with evident macroscopic cartographic distortions due to the parchment used to make the map, which is 34 centimetres wide and nearly 7 metres long (Bosio, 1983; Rathmann, 2018).

Our smartphone/tablet application will act as a lens through which it will be possible to visualise the modern place names, making them pop up on top of and in correspondence with the vignettes and their ancient toponyms; and to find out today’s geographical features in correspondence with the ones depicted on the map (mountain chains, lakes, rivers, forests, etc.). This textual layer, moreover, will also be implemented via images, photographs and 3D models which, in a certain way, will link the features of the Peutinger Map to those of ‘the real world’, thereby helping to take the observer on a virtual tour of Cappadocia and its changing landscapes.

Again in terms of engaging the public through the application of smart technologies, a second output from our research will provide a scaled 3D printed model of central and southern Cappadocia. Instead of using complex (and often expensive) immersive systems, this solid, touchable object will represent the bare surface over which a series of virtual models will be displayed and visualised by means of an AR app for personal mobile devices. Our aim, indeed, is to develop different ‘informative layers’ which can be selected or adjusted to meet the user’s degree of knowledge/curiosity, including: a) a realistic characterisation of the morphological features of the Cappadocian landscape; b) an updated distributive map of the main archaeological sites and findings; c) a dynamic evolution of the road network from the Roman to the Seljuk period; d) the integration of a series of 3D models of significant archaeological and architectural evidence, virtually reconstructed to enable the user to view them within their topographical context (for example, the Roman aqueduct of *Tyana*/Kemerhisar, a selection of Byzantine fortresses in the Melendiz Dağları area, the medieval Seljuk caravanserais of Doğala Han and Dolay Han, whose remains are still visible today on the plain of Derinkuyu).

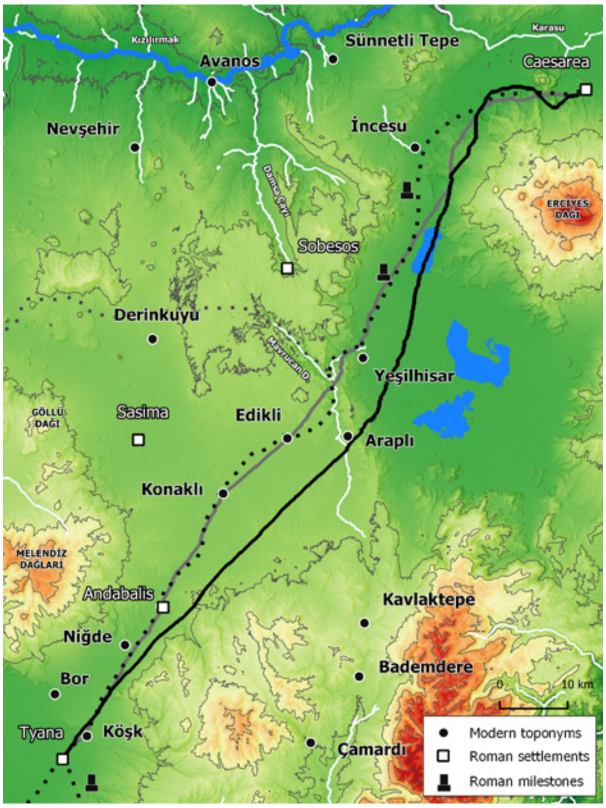

FIGURE 5. Historical and potential paths between Kayseri and Kemerhisar. The dotted line is the path reconstructed on an archaeological and topographical basis; the black line is the LCP generated via a cost surface with the cells' values defined by the slope; the grey line is the LCP generated via a cost surface combining natural parameters and the 'attraction' exercised by the Mavrucan Deresi valley (slope 85%; marsh area 5%; attractor 10%) (J. Turchetto).

Finally, a third aspect, strictly related to and integrated with the ones just mentioned, is represented by the development and implementation of the CLAP webGIS through the open-source software Lizmap. This platform will interactively display the archaeo-topographical data gathered during our research and share these with scholars, Turkish public institutions, tourists and also the general public. To date, it consists of a series of layers containing data on a) the main settlements of the Graeco-Roman period within the territory of the modern provinces of Aksaray, Nevşehir, Kayseri and Niğde (a basic database with toponyms, typology of the archaeological evidence, their chronology, their visibility/accessibility, a brief description of what can be seen today and a list of general bibliographical references); b) the Roman milestones of Cappadocia; c) the tracks of the routes which, following our reconstructions, made up the road network of Graeco-Roman Cappadocia. A future step will address the integration of data on the archaeological heritage of pre-Roman, Byzantine and Seljuk Cappadocia, the historical cartography of the area (for example, the *Map of Asia Minor to illustrate the Journeys of W. I. Hamilton Esqr. 1836-1837*, by John Arrowsmith, 1844; the *Specialkarte der Asiatischen Turkey* by Joseph Grassl, 1860 and the *Soviet Military Topographic Maps* of the 1970s) and relevant information on the landscape, roads and communication networks, traditions and aspects of daily life that can be gathered from the travelogues of the English, French and German explorers who travelled across the Anatolian plateau between the 15th and 20th centuries (Turchetto, 2018a: 71-88).

6. FINAL CONSIDERATIONS

The digital cartography applications developed within the framework of our research in Cappadocia will be openly shared, following a technological approach to cultural heritage (and, in general terms, to education) which is widespread nowadays and whose potential can no longer be questioned (Luna, Rivero; Vicent, 2019).

Hopefully, the outputs we have been developing will be useful to researchers and scholars who could also contribute to the further implementation of the datasets, but also useful for Turkish public bodies which will have at their disposal a series of tools for more conscious landscape planning and a better strategy to develop the region in terms of sustainable tourism.

These digital cartography applications will enhance both our knowledge and the appeal of the cultural heritage of less well-known areas of Cappadocia. In this respect, they will help to promote alternative tourism which can move beyond the traditional destinations, nowadays exclusively limited to the overcrowded areas of the 'Fairy Chimneys' whose volcanic-ignimbrite formations are now being destroyed at a frantic pace due to the mass tourism initiatives offered to millions of people visiting the region in the summer (Mosser, 2020).

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