Article

A sustainable approach to tourist signage on (historical) trails

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Abstract: Guiding the visitor to appreciate all aspects of tourist attractions is paramount for building a memorable experience. In the literature, we find many articles exploring the use of sophisticated technologies towards such a goal. The case of wilderness resources exhibits a peculiar aspect, since the presence of human artifacts and the signage, may, in fact, damage the experience, and introduce pollutants as well. In this paper, we consider the case of a natural trail targeted to niche tourism to understand the available options for signage aiming to provide directions, guide the exploration, and warn about dangers. The footprints of the various options are evaluated, and we describe the outcomes of an experimental setup implemented to verify our conclusions' applicability.

Keywords: keyword 1; keyword 2; keyword 3 (List three to ten pertinent keywords specific to the article; yet reasonably common within the subject discipline.)

1. Introduction

Although an official decision is still pending, there is a sound proposal of naming the time we are living as "anthropocene". Behind such a proposal is the recognition that humans have the potential to significantly alter the environment they live in at a global scale.

The problem behind the above fact is that we humans are not able to understand the consequences of the deployment of such a potential, and not even to keep it under control. Even worse, such capabilities are often used aiming at short-term local effects, ignoring long-term global ones, with the risk of a long-term global deterioration. Such an attitude pervades all activities, starting from the most basic ones like the provision of food and homes, and is frequently biased by economical profit.

Leisure activities play a relevant role, since they bring profit to niche businesses. This creates a reinforcement effect which follows the negative dynamic seen above: a leisure activity that per se is neutral (e.g. skying) may have a relevant footprint due to induced effects (ski lifts) which reinforces the success of the activity (easier to practice) bringing more investments and impact. Unlike beneficial effects, which is usually well localized, the negative impact has a very wide spectrum encompassing environmental, social and finally economical domains, as discussed by Patthey in [1].

In an effort to manage such a situation, international agencies promote the "sustainability" keyword as a guideline to the conservation of our habitat. Jeffry Ramsey et al. [2] consider the concept behind the word is "vague and contested but not meaningless" and that it cannot be used without a concrete framework, especially in a normative context. To solve to problem of measuring sustainability, Tom Kuhlman et al. point out a inherent tension in the term between growth and stability. A tension that has been softed by a shift in meaning of the word, which moved from focusing on preservation for an indefinite future to a concept encompassing three "pillars", society, economy and environment, as determinants that need to be protected in the present in view of a future sustainable development.

The authors put into relationship man-made and environmental assets, discriminating the two cases in which a loss in the latter may or may not be compensated by an increment of the former, introducing the terms of *weak* and *strong* sustainability.

The promotion of the human cultural heritage has its stand in such a complex scenario. As noted by Jorge Otero in [3], local communities take advantage of heritage promotion: the preservation activity generates social growth, while tourism provides an extra income that may be re-invested in promotion. However, just like in the sky resorts case mentioned above, the risk of compromising the resource itself exists. Such an interplay rises a question of sustainability even for cultural preservation initiatives, two topics that are usually regarded as in synergy. As in the "World Heritage and Sustainable Development" document by Unesco [4] that calls for actions that "harness the potential of World Heritage properties and heritage in general, to contribute to sustainable development".

This paper originates from such a painful contradiction trying to give an answer to the question: is there a way to unlock the potential of a cultural resource limiting the damage to a social, economic and environmental equilibrium?

The question arises in the course of a project funded by the italian ministry of reasearch aiming at the application of cutting edge technologies to the investigation of karst caves that may have been inhabited in the past, from prehistory to today. Among the results expected from the project there is the definition of a strategy to disseminate research results, and allow non-specialists to visit and enjoy the findings, thus contributing to the economy of rural areas that are severely exposed to de-population. A sustainable strategy is even more crucial given that the geological enviroment of interest is notably fragile, as noted by Aleksander Anticċ et al. in [5].

This paper provides a concept solution of a specific aspect. The solution is conceptual in that it tries to follow a guideline that takes into account as many side details as possible in a way that can be used in other milieu, but very practical in its unfolding. Given the tighly interconnected nature of the situation, we observe how a very specific aspect, the touristic signage, exhibits effects on the society, economy and environment.

2. Unlocking site potentials through signage

The signage used to guide and inform the visitor is of paramount importance and must be carefully designed in order to accomplish its functions while following the guidelines of a sustainable approach.

The functions of signage are twofold

- an effective signage must guide the tourist across the resort. A map represents a starting point to this end, but not all visitors feel comfortable reading a map. The ideal signage should include visible reference points and explicit actions, like "turn right after crossing the stream". A good example of such a signage is the one used by the Italian Alpine Club (CAI), consisting of colored stripes marked on tree bark. The marks are placed in such a way that, standing nearby one of them, the hiker is able to spot the successive on the trail
- a sign should explain the reasons of interest of a site. This includes featuring the site where the sign is installed, but also other nearby points of interest that invite the visitor to continue the visit. In this sense, the CAI signal above is not of use. A simple board with a site name may be sufficient only when the site is sufficiently reknown. Otherwise, a more structured message should be used to explain the reasons why the feature is regarded as relevant.

In our study we consider a range of solutions that help towards a sustainable support to a sustainable tourism, and specifically to the dynamic provision of information during a visit along a natural trail, not covered by Internet connectivity (a *dead zone* using the term used by Pearce and Gretzel [11]). We consider the presence of two stakeholders for the signage itaself [6]: the hosting organization (the *host* for short) which implements a signing installation, and the visitor (or *user*) which extracts useful and enjoyable information from signing devices.

The purpose of such an installation is guiding the *user* in a tour that includes urban streets, buildings, natural trails and caves (this latter being the topic of the project giving financial support to our research). The task of the *host* organization is to provide the *user* with all sorts of information that may guide him across the visit, making it as much profitable and enjoyable as possible. A traditional approach makes use of physical information boards with graphical or textual contents.

Our study starts from pointing out the issues related with such a solution:

- dimensions: the board must be sufficiently large to contain the desired content, taking into account its readability from a distance
- installation logistics: depending on the location, the transportation and placement of a plaque may require a basement or other sorts of supports
- environmental impact: in order to be effective, the plaque has to be prominent, and this may negatively affect the quality of the site
- accessibility for the visually impaired: the plaque is not useful for visually impaired persons
- accessibility for stranger visitors: to limit the size of the plaque, the number of translations must be limited as well
- update limits: to update the content, the plaque must be replaced
- removal logistics: when the board degrades it must be either removed or replaced, which entails waste disposal together with other issues similar to those found during the installation

Such considerations motivate an interest for an alternative way of communication.

2.1. Technology to minimize intrusion

We characterize the problem as an instance of *weak sustainability*: we do not preclude intervention on the environment, but the impact of such intervention must be better than that related with traditional signs. To this end we include in our solution tools that are not part of the site but remain with the user.

During the last decades, we witnessed the diffusion of smartphone devices, and we have no reasons to expect a change in such a trend. Smartphones empower individual communication capabilities, allowing to receive sound, visual and tactile interactions. The relevance of such capabilities for the improvement of a tourist experience have been widely investigated, etiher in urban environments [7] or in a rural milieu [8]. to find ways to exploit such tools in our context. Also in this case we start from the limits of such technology, especially in the case of outdoor activities.

One is related with the diffusion of such a technology, which, although widely available, is not equally familiar to everybody. This is related with *usability*, with a term borrowed from P. Wan in [6]. The second is that several functions depends on the provision of enabling services: for instance, their networking capability is useless if the device cannot reach an enabling infrastructure. So the *applicability limits* of a solution need to be defined.

Starting from the two aspects above we envision the directions towards a successful smartphone-based strategy, keeping in mind the overall sustainability of the approach.

Regarding *usability*, the basic recommendation is to keep the operation as simple as possible, within the experience of the majority of users, without requiring the need of familiarizing with new applications.

The definition of its *applicability limits* is more complex, especially for outdoor activities. In such cases, the provision of a networking infrastructure incurs a severe environmental impact. Consider the installation of antennas to cover a wide area, and the power supply for the radios.

2.2. Related works

The research literature marginally covers the utilization of smartphones for tourist signage purposes.

An exhaustive solution is described by P. Liu in [7], which details an infrastructure that guides the visitors inside an urban milieu. In that case the presence of a pervasive networking facilities is a cornerstone for the whole architecture, that deeply depends on Internet connectivity.

Wan [6] evaluates the quality of signage, without making reference to a specific technology, but with many examples showing physical boards, using as a formal reference the Universal Design Principles [9].

The number of research papers explodes when we extend the range to articles that investigate the impact of smartphones in tourism. The topic *smart tourism* topic is very popular, and covered by several review papers that provide a framework to the vast literature.

A popular research direction covers the social aspects related with the use of the smartphone. W. Tan [10] covers all aspects of a touristic experience related with the smartphone, from the definition of travel destination to assistance during the visit. Much attention is dedicated to the network of connections that is established thanks to the smartphone, which, again, is considered in the Internet, despite the title indicates a nature-based destination, where notably the Internet is not always reachable.

On the other hand, roaming in places not reached by the Internet, or *dead zones* using the words of Pearce and Gretzel in [11], may evoke constrasting feelings, from rewarding to threatening.

More recently, the smartphone has been considered not strictly related with communication. In 2021 A.Slavec et al. investigate the use of cameras [12] while on travel in locations with a relevant cultural heritage in order to sustain its preservation and engage the tourist using location based games, similar to Pokemon Go or geo-caching.

In 2023 V. Rodrigues et al. publish a systematic review of papers considering the interrelationships between tourism and portable digital devices [13]. Although the title evokes a one-way contribution, i.e., the impact of digitalization is assumed to be positive on the quality and the sustainability of touristic offers, in the conclusions the authors reveal awareness for the necessity to address *"the preservation of tourism attractions/sites"* and call for for a *"a holistic approach ... to support a concept that still lacks conceptual and empirical clarification"*.

In that direction we meet the phenomenon of *overtourism*, covered by a significant literature reviewed by Dodds and Butler [14], which focusses on urban tourism and its social consequences. The impact of *overtourism* on resorts that trade on their natural resources is investigated in the case of the Hawaii Islands [15] or CostaRica [16] stressing the impact on the social fabric.

The present paper wants to fill the gap highlighted by Rodriguez, providing a conceptual yet pragmatic approach to a well-defined tourism support aspect, taking into account by design its sustainability. Once a range of relevant solutions has been identified, we proceed to the empirical part: a *proof of concept* implementation that verifies feasibility of a specific solution.

We stress that this article does not aim now at quantifying user satisfaction or the economic revenue associated with the specific solution. Such a target is outside the scope of our research, and indeed the figures that would measure the success of a strategy deserve further investigation. We aim at isolating an issue, proposing a strategy for its solution and implementing a proof of concept for it.

2.3. A simple, low impact solution

We aim at designing a strategy for a sustainable and effective smartphone-based signage.

A straightforward approach concentrates on the wireless capabilities of such a device. Given the premise that the Internet is not reachable, the *host* stakeholder may provide a local network of low power radios covering the region of interest. Small servers connected to the network might provide specific Web services. The approach requires a modest

investment and a marginal environmental impact: for instance, a small device based on the ESP8266 single chip computer (SCC) has a coverage of tens of meters, and a volume in the order of the cm^3. They are able to provide WiFi Access Points as well as Web contents. The ESP8266 has a capacity of 32KB, which are sufficient for an explanatory text and a low resolution image. Other SCCs, like the ESP32, are more powerful but exhibit a higher power consumption.

Power supply dependency is a serious limitation for such kind of solution. A radio transmitter is a rather power consuming device, in the range of Watts. Even if operation is intermittent, the operation of the transmitter cannot be guaranteed for long periods and the host organization should consider the installation of a power generator, which contributes to the economical cost and environmental footprint of the device.

For this reason we do not consider a solution based on an ad-hoc network as a valid competitor against traditional board-based design for reasons related with poor sustainability.

An alternative consists in the utilization of passive devices, like Near Field trasmitters. The transmitting device is flat with the size of a coin and a cost of less than one dollar per piece. The receiving smartphone must be very close to receive the content. The power needed to operate the radio is drained from the smartphone, so that batteries are not needed. The NFC device capacity is in the range of the KBytes, nearly a page on this journal. Its manufacturing requires a smartphone with a specific app.

The NFC technology is currently very diffused, and reading an NFC tag as text requires the installation of an appropriate application. Once the application is running the operation simply consists in approaching the smartphone to the tag: the tag content is transferred to the *user's* device as a chink of text which can be treated as such. The smartphone can read it aloud to compensate user's inabilities or a translator to cope with linguistic issues without need of an Internet connection.

Another solution in the family of passive devices is the QR-tag. Such technique does not require radio communication, but uses the smartphone camera to acquire a graphical code that is translated into text. The capacity of a QR-tag depends on the number of dots in the image, which in turn depends on the size of the code and the smartphone camera characteristics. We may consider that the capacity of a QR-code roughly equals that of an NFC tag. A QR code is larger than an NFC tag of comparable capacity, and manufacturing requires a printer.

A preliminary check verifies compliance with the Universal Design Principles [9]:

- *Equitable use* is tighly related to the smartphone technology, which is itself considered a vehicle for equitability,
- *Flexibility in use* is enabled by the computing capabilities of the device, which allows listening to the info instead or reading, translating the information in a different language, or storage for later use,
- *Simple and intuitive use* holds since the operation requires a single application, possibly already installed since useful in many circumstances, and tag reading requires a single touch
- *Perceptible information* is a critical requirement, which contrasts with the aim of keeping low the environmental intrusion. This point will be further discussed in the section devoted to the implementation
- *Tolerance for error*: there are no margins to use the device in a way that compromises user safety. The deliberate or accidental release of the passive device into the environment determines a minor pollution
- *Low physical effort* holds, although the user needs to carry the smartphone
- Size and Space for approach and use have to be carefully considered. In the case of the NFC the smartphone needs to be nearly in touch with the passive device, while the QR-code must be in line of sight and frameable without effort

Such minimalistic solutions (see figure 1) compares well with other solutions that make use of the user's smartphone. There is a trade-off concerning capacity, but in many
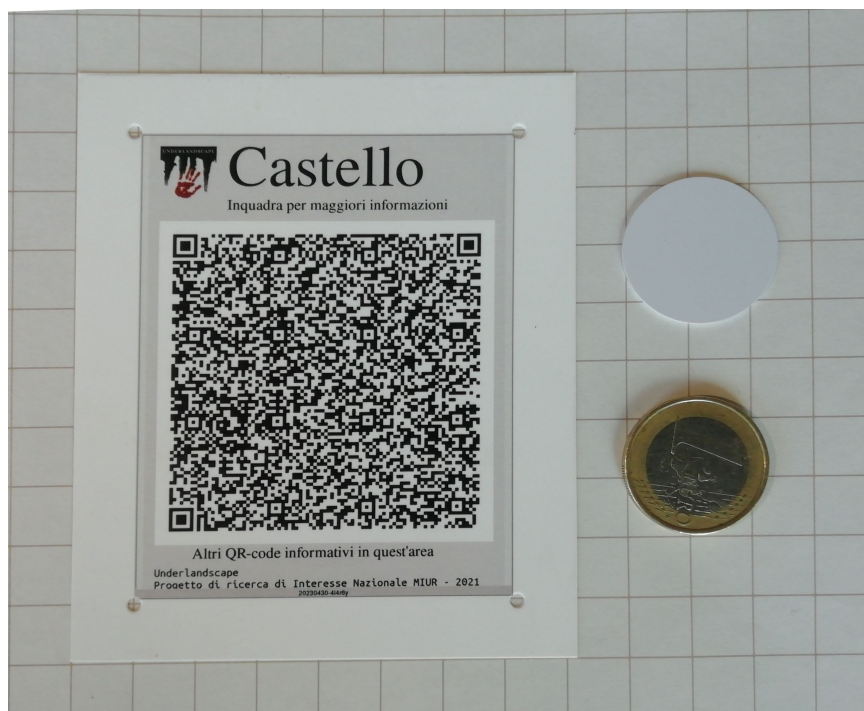
Figure 1. An NFC coin, a QR-code card used in the project, and a 1 Euro coin by comparison on a paper with a square of 1cm

circumstances a capacity of 2-300 words is sufficient to convey the description of the site, or provide directions for the the visit. If capacity limits are not an issue, a solution based on NFC or QR-codes exhibits a number of advantages:

- does not require any power supply
- has a limited impact on the landscape
- does not entice theft
- has a negligible cost
- is durable
- produces a limited quantity of waste when disposed
- content can be stored for usage when the user reaches a zone covered by the Internet

The two passive technologies of choice exhibit the following features, that may make one of them preferable for a specific application:

- an NFC-tag is smaller than a QR-tag
- writing an NFC-tag requires a smartphone, while the QR-tag needs a printer
- reading an NFC-tag operates at near-to-contact distances, while QR-codes can be read from meters away

For a signage application the QR-tag is preferable because a noticeable size is needed. In addition, keeping the tag out of reach prevents vandalisms and misuse.

In conclusion, we have reasons to select a QR-code based solution as a good candidate for a smartphone-based signage. We now consider how it it copes with the limits of a traditiona board-based approach (as listed in table **??**):

- dimensions: a 2-300 characters QR-code has a dimension in the order of 100 cm^2
- logistics: QR-code board can be installed on any sort of pre-existent or natural support
- impact: the board has a minimal interference with the landscape and may easily go un-noticed if not properly advertised
- accessibility for the visually impaired: the text can be read aloud
- international: the text can be translated
- update: the board can be easily replaced when the content becomes obsolete

- disposal: the card releases a limited quantity of pollutants related with ink support (paper or plastic)

There are two relevant trade-offs that the host needs to resolve. One is related with the visibility of the tag. The trade-off is among visuali impact, and visibility. The other is related with monitoring tag utilization. This may be useful for all sorts of planning activities, and is discussed in section 4.

3. Materials and Methods

As anticipated in the introduction, our study wants to provide a proof of concept for a sustainable solution in a concrete setup. To comply with such an holistic approach, we need to start from the definition of the operation context.

This section is devoted to the description of the economical and social context where we are going to operate, as well as the historical backgound representing the heritage resource we want to promote. Next we will discuss the technical detail of the solution.

The geographical area of interest are the surroundings of Casoli, a small village in a mountaineous region in the north of Tuscany, in Italy. The area fall within the municipailty of Bagni di Lucca, in the province of Lucca. The archaeological team of our project formerly realized the municipal archaeological map in 2021 [?], thus assessing the reasons of interest for the heritage and the geomorphological features of the area.

3.1. The natural and cultural resources of Casoli and its vicinity

Bagni di Lucca is located on the north-eastern boundary of the Province of Lucca, in Val di Lima, and is part of the Media Valle del Serchio district. With its mountains it marks the historical border with the Modena and Pistoia area, it is very rich in potential for its naturalistic, archaeological and historical heritage, both expressed and as yet unexpressed. Thanks to the archaeological map the main sites of interest from prehistoric to contemporary times in this municipality are catalogued, photographed and georeferenced.

From a historical-geographical point of view, this area is identified with the Lima stream and its tributaries, that impress to the area a particular geomorphology, very impervious despite the modest hilly elevations.

The Lima stream has characterised the history of Bagni di Lucca since ever: some of the oldest evidence of human presence in the valley has been found along its ancient river terraces, such as caves and rock shelters frequented since the Palaeolithic age; the manufacturing industry (paper mill, flour mills and, in recent times, energy production) have exploited the since the Middle Age until the 1980s [? ? ?].

On the naturalistic side, the region of Bagni di Lucca encompasses an incredible concentration of biodiversity, counting no less than three sites of the Natura 2000 Network [?] European Economic Community (EEC) initiative.

There are three SCIs-SACs (Sites of Community Interest and Special Areas of Conservation) located in the area north of the Lima stream, corresponding to the Apennine portion, covering 23% of the municipal surface:

- the limestone areas of Val di Lima and Balzo Nero;
- Monte Prato Fiorito-Monte Coronato-Valle dello Scesta;
- Orrido di Botri.

The latter is also a SPA (Special Protection Area) and the Orrido di Botri State Reserve is located within it [?]. It is therefore a natural heritage with a fragile balance that needs to be preserved.

In recent years, the main tourist attractions have concentrated on the Lima stream, with some associations and private entities promoting outdoor experiences, particularly fluvial sports, such as canyoning, rafting and sup. Others important tourist attraction are trekking and hiking, supported by a network of path tracked by local CAI (Club Alpino Italiano).

In recent years the community opened two entirely new trails:

Figure 2

- the Alta Via dei Pastori (2019), a ring around Monte Prato Fiorito that takes up the ancient grazing route, and
- t the Sentiero degli Avi (2020), a ring that from Montefegatesi reaches Monte Coronato [?]

Another recently developed project (2019) is the expansion of the Saint Bartholomew's Path, which runs through the territory of Pistoia, with a variant that from Popiglio continues in five stages in the municipality of Bagni di Lucca to Pieve di Controne, acting as the 'Lucca gateway' to the Path [?].

Such initiatives led to a considerable revival of interest among Italian and international hikers for the area, especially for the Apennine side of the valley.

We see the opportunity to improve the valorisation and enjoyment of this area by applying a slow tourism approach and involving the community, especially in the southern part of the municipality, which is still little frequented, more hilly and therefore less travelled by the trail network. We propose the creation of geo-itineraries characterised by the rediscovery of the historical roads, partly well-preserved, which connected the villages with the valley bottom and between them, including those sites of interest that encapsulate the history of this area, starting with the caves.

3.1.1. An historical perspective of an italian mountain site

The hill village of Casoli is located south of the Lima stream. The name of the hill (*"Tanette", in italian small lair* reveals the presence of karstic cavities, some inhabited between the Paleolithic and the Iron Age and used also as stations on the trans-Apennine routes [? ? ? ? ?].

Ceramic fragments dated between the 3rd century B.C. and the 1st-2nd century A.D. prove that Ligurian populations occupied the region scattered and in small nuclei. The dedication of the Latin colony of Lucca in 180 B.C. marked a decisive turning point in the Romanisation of the area and, shortly after, the definitive subjugation of the Ligurian populations, accompanied by a rapid acculturation [? ?].

We have little evidence of roman settlements in the mountainous hinterland, and the scarce archaeological traces are concentrated in the cave of Buca La Piella, investigated in 1975 by the Centre for Archaeological Studies of Lucca; it has two entrances joined by a walkable tunnel and rooms of discrete dimensions that overlook the outside. In addition to numerous faunal remains and fragments of locally produced common pottery, twenty bronze coins belonging to the 3rd century AD, bronze and lead objects were found [? ? ?].

In Longobard and Carolingian times, Lucca's Val di Lima was one of the three administrative districts into which the mountains were divided and was called "fines Contronenses" [? ? ?]. The only find from this period is the Grotta di Arzale, a rock shelter that opens up north-west of Casoli [?].

The first attestation of the settlements of Casoli and Lacu (Lake) dates back to the 10th century [? ?]. Most documents of this period show the fractioning and alienation of

ecclesiastical heritage in favour of the city aristocracy, securing an accumulation of funds and power that was to form the basis of the subsequent domains [? ? ?].

Written sources mention a castle in Casoli from 1180, but its foundation must be earlier. Between the 13th and 15th centuries, the fortification was at the centre, along with the other castles of the Val di Lima, of clashes between Lucca, Pisa and Florence, with alternating fortunes, as it was a strategic border area for the power of Lucca. Today, very little is preserved and the area has been partly inhabited [? ?].

The same document from 1180 mentions the church of San Donato, located in the main square of the village of Casoli. The current structure dates back to the 12th-13th centuries, with subsequent renovations. Initially dedicated only to San Donato, it acquired the double dedication after the abandonment of the church of Sant'Andrea de Lacu. The latter is located on a plateau to the east of Lake Casoli and is attested from 1260 [? ? ?], but already in 15th century we learn of its state of abandonment [? ?]. This was probably due to the depopulation of the lake area and the simultaneous strengthening of the town of Casoli, which was fortified and better protected during this unstable phase.

Today, the romanesque church of Sant'Andrea de Lacu is in a state of decay, with a rectangular plan, ending on the east side with a semi-circular apse. Inside, there is a reused element of the previous building, testifying to an older origin, probably contemporary with the ancient settlement of Lacu (Lake) mentioned in sources from the 10th century and no longer visible today.

In the early modern age, villages of the area experienced a progressive architectural renewal, which still largely characterizes the settlements today. Within Casoli, a series of residential buildings with imposing dated portals are preserved, some with courtyards, and mansions that denote a discrete deployment of resources by wealthy social classes. Also dating from the modern era is the Madonna di Castello Oratory, characterised by an entrance eclosure and located along the cobbled road that traces the ancient route between the village and the summit area of the medieval castle [?].

Along the road that led toward Lucchio crossing the area of Casoli Lake there are the chapel of Madonna di Col di Piano and two "metati" referable to the contemporary age, used for drying chestnuts. Referred to as the "bread tree," chestnut fruits and the flour derived from them were a staple of the mountain diet until the mid-1900s [? ?].

3.1.2. The socio-economical context of Casoli and its vicinity

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3.1.3. Sites and trail's state of art

As explained in the previous section, the area around Casoli has a long history witnessed by architectural and geological features: it is therefore a good candidate for our case study. In the rest of this section we define the features of interest, and report about their accessibility.

The cave named *Buca La Piella* is the foremost site from an archeological point of view. It is located in a fascinating environment outside conventional circuits, which is why it is less frequented and consequently less compromised. It is reachable leaving a marked path to follow the bed of the Lima river. The way is dotted with minor karsic caves, and the *Buca La Piella* is reachable climbing up on a steep slope in the wood on the right of the Lima river.

Not far from the *Buca La Piella* on the same side of the river is another karst cave named *Antro dell'Ugola*. It is reachable following a faint and intermittent track that departs from a marked path. It is craracterize by a suspended geological formation reminding an uvula, hence the name.

Both caves are going to be analyzed in the course of the Underlandscape project [?], and findings can further enhance the interest for both sites.

Qui aggiungerei notizie sugli altri punti in cui sono stati collocati i QR-code, correlandoli alla descrizione storica
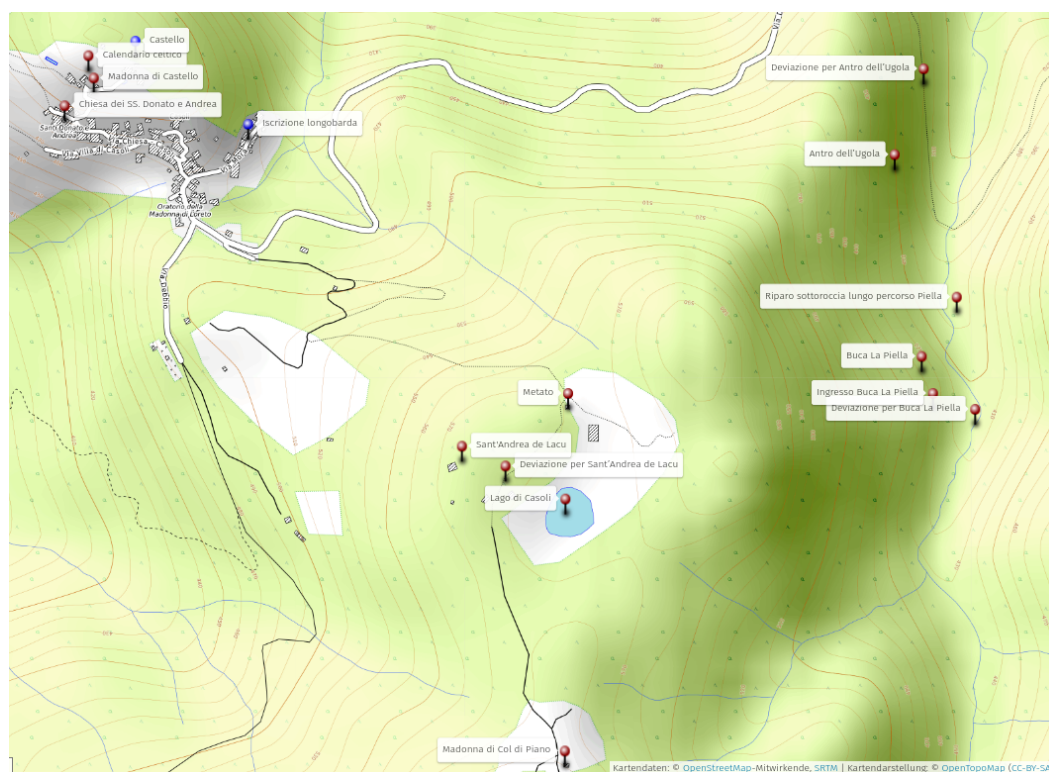
Figure 3. Map with QR-tag positions

3.2. *Implementing a QR-based signage*

To test our signage proposal, we placed on the field several cards carrying QR codes. Se the list in Table 1.

A card sample is in Figure 2. On the top there is the logo of the funding project, a descriptive title (*Castle* in english) and concise directions for use *Scan fo further information*). Under the QR-code is the notice that other QR-codes are present in the vicinity, and a reference to the funding project.

The tag is printed on Synaps™, a non-biodegradable polyester synthetic film by Agfa-Gevaert NV. Agfa documents the production process giving guarantees of sustainability [**?**]. According to Agfa, Synaps is more sustainable than laminated paper. From previous experience it is also more durable.

To keep the environmental footprint as leightweight as possible, the tags are tied to pre-existent structures, like trees or poles. The tag is tied with a thin biodegradable string.

The text encode on the QR-tag (in figure 4a) contains the main text with 614 characters (100 words) and a URL 86 characters long. The URL is useful only if the Internet is reachable, and brings to a new page containing a map with the location of all the tags (Figure 4b) and a short survey form. Note that, while the QR-tag content is always available, the URL is reachable in locations with broadband coverage. In our case, during a recon to the *Piella* cave none of the smartphones of the participants received sufficient broadband network signal.

We placed QR-tags both along the trail and at sites of interest; the former are placed at detours and, at more complex points, at close range so that from one you can see the next, as per the CAI standard [**?**].

They can therefore have either the function of a simple signpost to indicate the continuity of the trail, or be scanned to read the written indications recorded within it, which are more accurate and precise.

This approach ensures that the tourist is guided through the visitor experience and, at the same time, that the impact of signage on the environment is reduced compared with traditional boards, as explained in section 2.1.

Name	Long	Lat	URL Key	Length
Buca La Piella	10.68361	44.03667	t5ysrm	476
Calendario celtico	10.66985	44.03986	my0kp8	484
Castello	10.67062	44.04004	4l4r6y	597
Chiesa dei SS. Donato e Andrea	10.66947	44.03928	lwtyx6	632
Iscrizione longobarda	10.67244	44.03906	60m75s	369
Lago di Casoli	10.67761	44.03468	xqjpbk	369
Madonna di Castello	10.66994	44.03960	qlci89	395
Madonna di Col di Piano	10.67760	44.03173	3w44wr	414
Metato	10.67764	44.03591	sbgnl0	660
Sant'Andrea de Lacu	10.67592	44.03530	fxq83v	657
Antro dell'Ugola	10.68296	44.03871	mprs0w	226
Deviazione per Antro dell'Ugola	10.68343	44.03971	e4n2js	88
Deviazione per Buca La Piella	10.68427	44.03573	hve4pj	139
Deviazione per Sant'Andrea de Lacu	10.67663	44.03507	13uav3	200
Ingresso Buca La Piella	10.68358	44.03592	5ahvp8	190
Riparo sottoroccia lungo percorso Piella	10.68397	44.03704	kwr1wx	286

Table 1. The QR-tags placed around Casoli. The URL key is a random code that appears in the web page linked to the QR code. The Length refers to the description in the QR-code and is in characters.
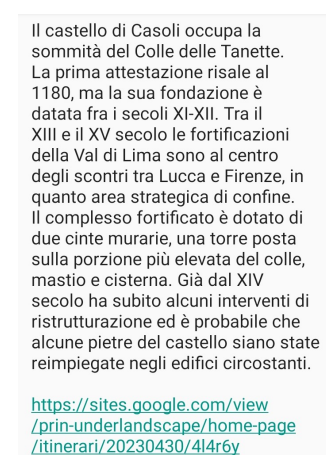
(a) QR-tag content

(b) Linked page: the map
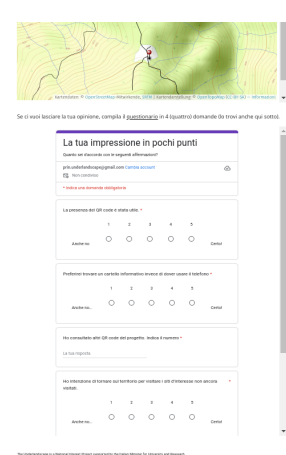
(c) Linked page: survey form

Clearly, our methodology does not aim to replace CAI signage, which is recognized throughout the country and is very effective, especially in terms of horizontal typology, but at the very least it is repurposed to complement it in order to provide more detailed information at multiple levels of interest, from short text to in-depth information on the project site. In addition, being able to read the written directions along the path can be of great help to even the most inexperienced hikers, particularly on unclear and not-quite-visible trails such as the one we suggested to reach Buca La Piella.

4. Results and discussion

Our point is to evaluate all aspects of a signage system addressing the guidance of visitors in a rural area with a cultural heritage to be protected and exploited at the same time.

The selected site exhibits the aspects of interest: a history that goes back to the Paleolithic Era, human artifacts as well as natural formations that witness past events. The site is not included in mass turism circuits, but is not far from touristic site. It is exposed to depopulation by absence of productive activities. (**Mariagrazia per favore conferma o nega**).

Studying site heritage we found reasons of interest by a motivated, non-casual visitor: a cave inhabited since the pre-history with a difficult but viable access, a village with historical buildings, nearby sites dating back to the Middle Ages.

The task of guiding the visitor and tell the location story has been left in charge to a dozen of QR-code tags placed at key locations. The costo of the QR-codes amounts to a few Euros for the printing service, but finding a shop with an appropriate printing device was not easy.

The production of the graphical file was based on a simple script taking a geojson file as input and producing an image with all the QR.codes ready for printing on an A0 sheet.

The preparation an implementation of the signage was therefore simple and with a low cost, but required a solid and pre-existent knowledge of the site.

We include three stakeholder communities in the evaluation of the response to the initiative. We do not speak about *success* since the initiative is deliberately soft, and an outcome is expected in years, and its evaluation as successful or not will pose new questions. So we are content to see if the stakeholders regarded the initiative as an intrusion, as helpful, or simply neutral.

We considered four stakeholder communities:

- *the residents* the local community that currently inhabits the site
- *entrepreneurs* who currently have a business in the site
- *administrators* that are in charge of managing the site resources and that, at due time, will respond to the two stakeholders above, and finally
- *the users*, those that come to Casoli to visit the Village or La Piella and that we find the QR-codes on their way

The category of the users escapes an evaluation since the QR-tag does not record reading operations. We added to the text message in the QR-tag an external link, that we monitor for the number of hits on pages dedicated to the specific tag: however this feedback certainly underestimates the number of times the tag is read. In figure

5. Conclusions

There is a demand for low-power devices able to manifest themselves to the visitor and to monitor...

Pagina di destinazione	Sessioni
3w44wr	4
e4n2js	4
fxq83v	4
t5ysrm	4
mprs0w	3
4l4r6y	2
kwr1wx	2
lwtyx6	2
sbgnl0	2
BM6cAj	1
8tml9x	1
bm6caj	1
xqjpbk	1

Table 2. Number of hits per URL linked to a tag]

of the funders in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish the results must be declared in this section. If there is no role, please state "The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results".

Sample Availability: Samples of the compounds ... are available from the authors.

Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three letter acronym
LD	Linear dichroism

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