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Assessing the positional accuracy of perceptual landscape data: A study from Friuli Venezia Giulia, Italy

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Abstract

Online GIS-based applications that combine mapping and public participation to collect citizens' voices on their surrounding environment are a way to collect original spatial data that do not already figure in authoritative data sets. However, these applications, relying on non-expert users, might produce spatial data of insufficient quality for the purpose for which they are collected. This article presents an approach for assessing the positional accuracy of vague landscape features, using the results from a map-based survey completed by a group of volunteers in the Friuli Venezia Giulia region of Italy. The spatial section of the survey, gathering both georeferenced data and textual information on the mapping activity, allows the assessment of whether there is a correspondence between the mapped features and the intended map locations. The findings reveal a greater accuracy among participants in completing the mapping activity relating to degraded sites than to those of beauty.

1 | INTRODUCTION

An increasing interest in online applications that collect spatial data through public participation is evident both in scientific investigation and in decision-making. The greater connectivity of individuals to the internet, the growing familiarity of internet users with interactive maps, the existence of affordable and easy-to-use online applications for spatial data collection, and, not least, public authorities' growing willingness to favor active public involvement, are all conditions for this upward trajectory. Since the 1990s, the term "public participation geographic information systems" (PPGIS) has entered the geographic scientific vocabulary to define applications that combine mapping and public participation to produce new knowledge aimed especially at informing planning and policy issues (for a review, see Brown & Kyttä, 2014; Sieber, 2006). In particular, when the focus is on values and preferences for places belonging to everyday reality, these participative methods assist in revealing sensitive local issues where people may have contrasting views (Pocewicz & Nielsen-Pincus, 2013).

Various aspects need to be controlled and considered when soliciting the collection of place-specific information. Operatively, these mapping approaches require participants to characterize a study area by identifying spatially where a certain attribute of interest is positioned (this is the case for most applications) or by expressing whether certain pre-identified areas have the feature of interest (e.g., Al-Kodmany, 2001; Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013; Tyrväinen, Mäkinen, & Schipperijn, 2007). Depending on the application, the subjects can be landscape values, special places, development preferences, perceived environmental impacts and activities, for example. Perhaps the most interesting cases are when people can choose among points, lines and polygons to identify the location of the attribute of interest on a given map. This approach best exploits their knowledge of the study area, as lines and polygons (rather than exclusively points) can potentially better depict the full spatial extent of the feature to map.

In the case of multiple geometric objects, we first observe that individuals do not have a standard way of associating a geographic entity to a spatial feature. For example, a feature such as a castle, which in a real visual experience can undoubtedly be associated with a polygon when the observer is at a short distance, is commonly represented by a point on a map at a 1:100,000 scale, but with a larger-scale map the attribute can be identified using either points or polygons. In research, the predominant geometry has been points (Pánek, 2018), probably because this geometry is "easy for participants to understand, simple to process and analyze" (Besser, McLain, Cerveny, Biedenweg, & Banis, 2014, p. 147). However, the use of this geometric object, in the absence of other information, means it is impossible to know the spatial extent of the mapped feature. While these considerations on the geometric features of the contributed data are generally important for those launching the mapping initiative, they may be irrelevant for those entering the data. A participant might assign importance to contributing to the PPGIS application, rather than being concerned about the quality of their mapping exercise (e.g., Ali & Schmid, 2014; Girres & Touya, 2010; Hetch, Kunze, & Hahmann, 2013; Jackson et al., 2013).

Spielman (2014) observed that a significant barrier to understanding the "true" added value of user-generated maps came from the fact that map quality should be assessed in relation to both the credibility of the mapping contributors and the quality of the individual contributions. Existing research focuses mostly on the second perspective, by assessing the precision of the marker placement and the accuracy in mapping the geographic feature. Brown (2012, p. 290) described the concept of precision as "a measure of the exactness in placing the PPGIS markers". This is influenced by the support and tools used for mapping (i.e., the map scape and the marker size, when paper is used as support) and by the participants' characteristics, such as their visual and manual abilities. Accuracy, on the other hand, could be defined (Brown, 2012, p. 290) as "how well the marker approaches the true spatial dimensions of the attribute being identified". This depends on the scale of the map used, the geographical entity to be mapped (e.g., attribute of interest, definitions and instructions provided), the mapping environment (characteristics of the base map), and respondents' characteristics (familiarity with the study area, map literacy). Despite the attention given to issues related to the usability of PPGIS (Poplin, 2015), much work is needed to come up with mapping approaches that employ user-friendly applications and guarantee the validity of the research method.

In principle, mapping projects such as OpenStreetMap (OSM), dealing with verifiable spatial features with well-defined boundaries, allow user-generated content to be benchmarked against authoritative geospatial data sets to assess the quality of the spatial data collected. However, there are other cases such as citizens' science projects (e.g., Brown et al., 2019) or PPGIS initiatives to aid decision-making (e.g., Brown & Reed, 2009) in which there is not a suitable reference data set to which the collected data could be compared. In these latter cases, the requests could be, for example, to identify on maps the locations of features which are mobile in nature (e.g., animals), or activities of which that only participants who have experienced them in person could have knowledge (e.g., recreational outdoor activities), or vague concepts (e.g., aesthetic value). Further challenges emerge when asking participants to use traditional spatial features to capture geographic entities that are hard to define spatially and about which people usually talk imprecisely (Carver et al., 2009; Montello, Goodchild, Gottsegen, & Fohl, 2003). Assuming that individuals are willing and can identify locations of the spatial attributes of interest on a map in definitive terms, at what point are the spatial data produced by non-experts of sufficient quality and fit for the purposes for which they are collected?

According to Soini (2001), mapping is a method that can offer a valuable contribution to landscape research exploring local people's view of the surrounding environment. However, in a context in which such knowledge is elicited by requesting non-expert users to read georeferenced base maps and interact with them to place spatial features, it is relevant to analyze whether there is a correspondence between the respondents' intended mapped place and the mapping outcome. Existing technologies enable the collection of large volumes of landscape data that can potentially complement and enhance traditional authoritative data sources. However, some caution is required when using them. In fact, as highlighted by Brown (2005, p. 32), "[w]hat does landscape value mapping really measure, how reliable is it, and how useful is it given its inherent limitations?".

The main objective of this article is to analyze the positional accuracy of collected data when asking local populations to participate in PPGIS applications by placing perceptual landscape attributes on a map. For this purpose, I will use the results from an anonymous map-based survey administered in the Friuli Venezia Giulia (FVG) region of Italy during 2018. In this research, the spatial information to be elicited was on sites perceived either as beautiful or degraded within the study area. In this contribution, I want to explore the quality of contributed spatial data by focusing especially on positional accuracy, defined as "the accuracy of the position of features (i.e., points, lines or areas) within a spatial reference system" (Fonte et al., 2017, p. 141). In particular, attention will be paid to data collected through online map-based surveys, as, when the spatial component is gathered alongside other non-spatial responses, mapping outcomes can be analyzed in relation to the participants' characteristics and other information provided through the survey. Given that the adopted map-based approach does not include quality control mechanisms during the acquisition phase, the hypothesis is that the spatial data collected vary in terms of positional accuracy. Jankowski, Czepkiewicz, Młodkowski, and Zwoliński (2016) listed a series of factors that might influence the positional accuracy, including the "nature of mapped entities and their attributes" (Jankowski et al., 2016, p. 918). In this application, the possibility of creating an external data set for data benchmarking makes it possible to identify which of the two PPGIS attributes considered in the analysis is mapped more accurately.

The remainder of this article is organized as follows. Section 2 provides some reflections on the participation of lay people in landscape matters. In addition, it reviews major implementation issues in participatory mapping and previous studies on data quality. The study area is introduced in Section 3, together with a description of the methodological approach employed. Section 4 provides the results of the study, presenting the demographic profile of respondents and basic information on their participation in the mapping activity. In addition, it assesses some aspects of data accuracy for the spatial data collected. Section 5 discusses the findings, pointing to the most important considerations for those contemplating future work of this nature. Section 6 provides the main conclusions and closing remarks.

2 | RELATED WORK

2.1 | Landscape, participation and perceptions

The implementation of consensual proposals that comply with local values is a widely acknowledged need in landscape planning and management (Santé et al., 2019). In the European context, the invitation, or better, the obligation to establish procedures for the participation of the general public comes from the European Landscape Convention, which is the first international treaty to be exclusively concerned with European landscape issues (for a review, see Déjeant-Pons, 2006). According to the Convention, people's perceptions play a key role in defining landscape, which is much more than the combination of visually distinctive features. In fact, the Convention defines landscape as “an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors” (COE, 2000, Art. 1) and requires signatory states to “recognize landscapes in law as an essential component of people's surroundings, an expression of the diversity of shared cultural and natural heritage, and a foundation of their identity” (COE, 2000, Art. 5). The Convention obliges signatory states to seek the views of all who have an interest in the definition and implementation of landscape policies in the decision-making process. As highlighted by Jones (2007), there is neither complete delegation of powers to local communities nor the substitution of traditional actors such as governments or local authorities. However, the fact of setting up a broad consultation with all interested individuals means that values and meanings attached by locals to their surrounding environment need to be formally considered. Another important issue, which is relevant for the theme of this paper, is that the Convention covers all types of landscape, not only natural ones, but also industrial corridors along motorways, suburbs and quarries, to give some examples, in other words those landscapes that can be considered as commonplace or degraded. This means that not only outstanding landscapes are taken into account, but also those that need enhancement rather than protection and preservation.

There is increasing awareness, highlighted by this key policy framework, that the inclusion of citizens' voices allows a better overview of the problems afflicting local communities, thus enabling identification of overlooked issues and appropriate solutions. In spite of this, relying on perceptions and participation is not without problems. As highlighted by Scott (2002), personal experiences of landscapes, and the attachment of values and meanings to these, influence, among other aspects, people's sense of wellbeing and their sense of place. As the public is constituted of individuals with varying and subjective views on current and future landscapes, the combination of perception with participation “brings into consideration issues of equity, accountability and democracy, and questions the way that the wider public interest is represented and implemented in landscape management terms” (Scott, 2002, pp. 272–273).

Among the major challenges encountered in public participation, also outside landscape matters, there is the fact that the contributions that local residents may offer are different from those of experts. As stressed by Golobič and Marušič (2007), while public knowledge is developed through everyday life, specialist knowledge is determined by educational and professional experience. In this light, there is no surprise if lay knowledge has only gradually passed from being seen by professionals as “inferior and irrelevant due to its apparently subjective, controversial and unstructured nature” (Golobič & Marušič, 2007, p. 994) to being considered a positive input to the planning process.

Beside the different informative value of public and expert knowledge, another well-known issue is the possible barriers to participation that lay people may face. In Zolkafli, Liu, and Brown (2017), interview data revealed public participants’ limited understanding of planning documents and terminology as a hurdle. Interestingly, other factors related to people's attitudes, culture, location and political ideology emerged as pitfalls to the implementation of participatory approaches. These findings suggest that lay people contribute according to personal stimulus, which might differ among social groups and geographic contexts.

2.2 | Implementation issues in participatory mapping

The involvement of the public in decision-making is often achieved through the use of participatory mapping techniques (Boschmann & Cubbon, 2014). Landscape research is one of the wide range of themes on which these techniques have been employed (Cerveny, Biedenweg, & McLain, 2017) and one possible application entails eliciting public perceptions regarding landscape (McClelland, 2019). When the collection of spatial data aims to capture meanings and values that people attach to places, there is the problem of dealing with the subjectivity of such data and the issues of quality and fitness for purpose (Mocnik et al., 2018). While the first aspect cannot be avoided, as it refers to the intrinsic property of perceptual data, the second could be partially handled by improving some aspects of data acquisition. In general, the collection of spatial information can be carried out using high-level technology, such as geographically referenced base maps embedded in online surveys or in digital web-mapping applications, low-level technology such as a simple paper-and-pencil approach in the context of participatory workshops or household mail-based surveys, or by using a mixed-method approach (e.g., Pánek, 2018; Poplin, 2017). It is evident that the internet presents some exciting opportunities for surveys, linked to the possibility of reaching spatially distant respondents, shortening the turnaround time, and reducing the time devoted to data entry, not to mention that it is more sustainable environmentally. Moreover, as regards the mapping component, in web-based PPGIS the precision of marker placement could increase given the possibility of accessing multiple map scales and switching between different base maps, along with the fact that marker size is no longer a constraint in the mapping exercise as it is in paper versions. Not least, the direct collection of data via online base maps eliminates the burdensome task of digitalizing the collected spatial responses. However, the internet is not exempt from drawbacks, especially regarding response rates (Brown, 2017), and ultimately, when compared with low-level technologies, it is not clear which approach is preferable. Pocewicz, Nielson-Pincus, Brown, and Schnitzer (2012) explored how participants' characteristics and mapping results varied when the same PPGIS survey was administered through the two different modes. With regard to spatial features, a relevant point of their research was that the survey mode did not influence where the participants placed the point markers on the map.

Beside the means of interacting with the public, another key methodological issue that has to be addressed when soliciting the collection of spatial information concerns the spatial feature to be employed in the PPGIS. In fact, the precision and accuracy of the spatial attributes placed by the participants on the map partly determine the quality of data. The use of polygons can limit the usability of data as, for example, in the absence of further information a drawing extending over the entire study area is difficult to interpret. The placement of points is less ambiguous for users, but when dealing with spatial attributes concerning perceptions, the spatial extent of the geographic entity to be mapped is indeterminate. The creation of polygons through point density can be a way to address spatial inaccuracy of points (Brown, 2005; Brown & Reed, 2009).

Research that compares mapping outcomes when different geometric objects are employed is scarce. An exception is found in Brown and Pullar (2012), where a quasi-experiment was conducted through a mail-based paper PPGIS system to evaluate the trade-offs between point and polygon geometry. They demonstrated that the same PPGIS attributes identified by points and polygons produced the same mapping results provided there are enough observations in the study area to make meaningful inferences.

Besser et al. (2014) made a strong case for the use of multiple geometric objects, especially at the regional scale, as they provided participants with more flexibility. However, in PPGIS applications, polygons and lines are seldom used (exceptions are, for instance, Cui & Mahoney, 2015; Jankowski et al., 2016; Poplin, 2012). Surprisingly, this also occurs in cases where the entity on which the public has to express its opinion clearly has a line-shape (Wolf, Brown, & Wohlfart, 2018). Also, in Luz et al. (2019), where participants were asked to identify green spaces they most frequently visit, the preference was for points rather than polygons. However, there is no denying that using lines has its limits. For instance, in Bearman and Appleton (2012), the examination of line data disclosed waterborne activities taking place 400 m from the river, hardly understandable without further information.

Alongside the decision to allow the collection of one geometric object, or more than one, there is the possibility of introducing hypotheses on the meaning of the marked locations. As an example, Santé et al. (2019) implemented a PPGIS application aimed at creating the landscape inventory of Galicia where they addressed the limits of the point-based approach using two different methods. In the modules aimed at eliciting people's opinion on sites with high landscape value and degraded areas, they added a free-text box where users could add a description of the spatial delimitation of the geographical area associated with the point. In another module concerning landscape values, the spatial attribute of interest was represented symbolically with a point whose value was successively assigned to the entire pre-identified landscape unit in which respondents drew their spatial feature.

As just illustrated, approaches based on participants placing spatial features on the map have some weaknesses. Nonetheless, other procedures, in which participants express opinions on pre-identified areas marked with polygons, are not exempt from problems either. In the research developed by Plieninger et al. (2013), where the pre-identified polygons used in the PPGIS were derived from the official land-use map, it was shown that the placement of some ecosystem services was not associated with any particular landscape attribute, hinting at the fact that the procedure biased the results. Al-Kodmany (2001) provided an example of a web-based survey where the pre-identified areas to be evaluated by respondents were grids, identifying a square selection of the study area on the map. In order to evaluate the study area, respondents first had to choose a positive or negative feeling (e.g., like or dislike) and then select the grid that was characterized in their view by that attribute.

An alternative PPGIS application proposed to overcome the requirement for users to identify exact locations through geographic primitives makes use of an airbrush-style interface (Carver et al., 2009; Waters & Evans, 2003). In Huck, Whyatte, and Coulton (2014), users could identify vague entities (i.e., places without defined boundaries) by "spraying" on the map. By clicking on a location on the map, respondents did not identify a point, rather, they added a series of proximate dots in correspondence to the location on which they had clicked. In this application, the airbrush-style interface was complemented by a relational data structure where each geometry point created by the spraying activity was stored in a relational database together with other attributes of the dots and a free-text box provided for the participant to make comments relating to their spray pattern.

2.3 | Previous studies on data quality

Despite the proliferation of a wide range of methods and applications in PPGIS, and the attempts to outline key issues and priorities of participatory mapping (Brown & Kyttä, 2018) and PPGIS (Brown & Kyttä, 2014), only a few studies concentrate thoroughly on data quality, or more precisely, on one or more data quality measures and indicators (positional/thematic/temporal accuracy, completeness, logical consistency, to cite a few). An important consideration is that there is no agreed process that guides such assessments. The ISO 19157 standard for spatial data quality (ISO, 2013) is the framework that serves entities such as national mapping agencies for producing high-quality products. However, when crowdsourced data are under analysis, a different approach to quality assessment is needed (Fonte et al., 2017).

The positional accuracy of OSM data has been studied quite extensively within the geographic information science community and various measures have been adopted (Senaratne, Mobasheri, Ali, Capineri, & Haklay, 2017). Research focuses chiefly on data quality assessment based on extrinsic approaches, that is, where volunteered data are compared with another data set of higher accuracy (Yan et al., 2020). Among these studies, interest has primarily concentrated on the quality of linear features (OSM road network), whereas concern with data quality assessments of nonlinear features has been more sporadic and fragmented. The buffer-zone method has been used on several occasions to evaluate the positional accuracy of line objects (see, for example, Haklay, 2010). This approach is based on the application of a buffer of user-specified width around the benchmark linear features to determine whether and how much of the tested object falls within the buffer. Quality measures based on the average distance and the Hausdorff distance have also been proposed for linear features (e.g., Girres & Touya, 2010). The assessment of point-based data sets generally relies on the Euclidean distances between the volunteered point data and a comparison data set (Jackson et al., 2013). For the positional differences between polygons, investigations made use of different approaches ranging from the shape similarity between corresponding pairs of polygons (Mooney, Corcoran, & Winstanley, 2010) to the joint examination of several geometrical aspects (Kalantari & La, 2015). In summary, as observed by Antoniou and Skopeliti (2015), despite the great popularity of OSM, a solid framework for assessing data quality is not yet available.

Outside the context of OSM, Brown (2012) assessed the spatial accuracy of a mapping exercise with three different sampling groups. The attribute of interest was native vegetation, and the user-generated data were compared with the New Zealand Land Cover Database vegetation data. The quality assessment involved creating a buffer around each PPGIS point and then identifying the existence of a spatial error if the buffered area around the original point contained no native vegetation. A key finding was that the highest spatial error was associated with the group of randomly selected households, followed by on-site visitors and volunteer members of the public. Brown, Weber, Zanon, and de Bie (2012) used the mapping effort and data usability as metrics to evaluate the quality of the spatial responses given by a group of online opt-in panelists called to participate in a PPGIS on regional conservation in Australia. The first concept was defined as the physical or mental energy involved in performing the mapping exercise, and was operationalized by examining the total number of markers, the total time spent in the mapping activity, the mean time in placing a marker, and the zoom level when placing the marker. The second referred to markers that were placed within an area that was considered appropriate for the purpose of the PPGIS survey and its assessment was made by calculating the percentage of total markers inside the study area. In their study, the lower mapping effort was obtained by an online opt-in panel, compared to other sample groups. The research of Brown, Weber, and de Bie (2015), in the context of conservation planning in Australia, considered different types of landscape values and management preferences and studied the spatial accuracy and completeness of the data set collected. These assessments were made by benchmarking the collected data with an expert-derived spatial conservation model available for the study location. It is also worth briefly reviewing how Cui and Mahoney (2015) assessed data quality in their internet GIS survey administered in Florida, which, contrary to most of the applications reviewed, was highly customized to minimize data-entry barriers. As for precision, they analyzed the zoom level. In addition, they assessed the logical accuracy of on-water fishing spots and the positional accuracy of boat launch sites generated by boaters. For the first accuracy aspect, they overlaid the user-generated content with the land cover GIS layers in Florida, to check if the on-water fishing spots were marked (logically) on water or (illogically) on land. Using the Euclidean distance, they evaluated the positional accuracy. This was assessed for the spatial data generated by the respondents who could not find the launch site on a given list available in the survey, and so, in order to respond to the spatial question, had to select the location autonomously on the map.

Outside geographic journals, Dasgupta, Vaughan, Kramer, Sanchez, and Sullivan (2014) analyzed whether maps embedded in online surveys were a reliable and valid alternative to the collection of address-based data. In this study, respondents were asked to reply to spatial questions asking where they lived and the location of their last attended HIV care provider in two different ways. They had to enter the street address in a text field (for the residence) or select the care provider from a checkbox menu (or, if it was missing from the list, by writing in the name and address of their doctor). In addition, always for both spatial questions, they had to click these locations on maps. The analysis showed that the difference between the intended mapped location and the marker for most participants was under a mile. As for the consistency between their home and care provider location, the participants' error rate showed poor to fair reliability, even though results varied across recruiting methods.

As the studies reviewed above demonstrate, participatory mapping techniques can be applied in a wide range of fields and specific data quality issues might emerge in relation to the data acquisition context. This work builds on previous research on data quality assessment and contributes to it by exploring the use of sketch maps when perceptual landscape attributes are under consideration.

3 | STUDY AREA AND METHOD

3.1 | Study area

The Italian administrative region of FVG covers an area of about 7,900 km^2, with a population of about 1.2 million inhabitants. Geographically, it is situated in the northeastern part of Italy, bordering Austria to the north and Slovenia to the east and opening southwards onto the Adriatic Sea (Figure 1).

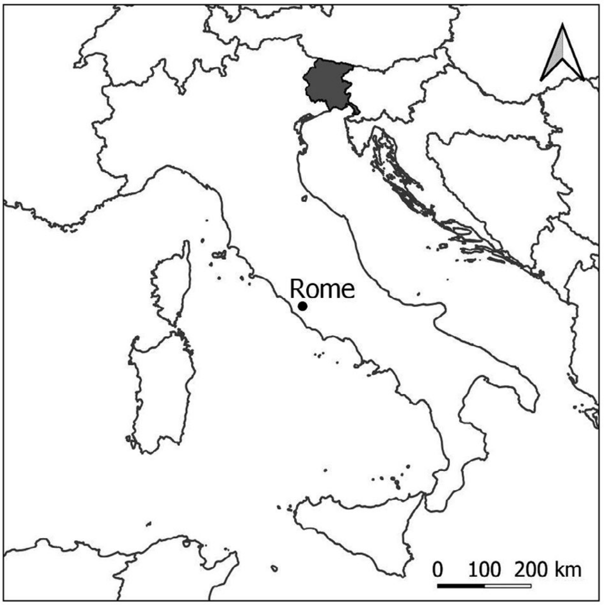

FIGURE 1 The geographic position of the Friuli Venezia Giulia region

Despite being a small region, FVG is characterized as having a strong south–north altitudinal gradient and a variety of climatic, geological and land-use conditions. As shown in Figure 2, more than a half of the territory consists of forest and semi-natural areas (51.9%), located especially in the north, followed by agricultural areas (37.9%), concentrated in the central and southern part, and artificial surfaces (7.9%). The remainder is constituted by water bodies (2%) and wetlands (0.3%). The artificial surfaces prevail in the hilly and plain areas of the region, and they are mainly made up of discontinuous urban fabric and of industrial and commercial units. Given the existence of territorial imbalances in the regional environmental landscape, it is unsurprising that economic disparities also occur. The region enjoys one of the highest levels of wellbeing in the country (according to OECD, n.d., the region is similar to Berlin and Catalonia), but there is a strong difference in the distribution of wealth between urban centers and rural and mountainous areas.

On the study location, it should also be said that the involvement of the local population in the characterization of regional landscapes is not a novelty in this region. Researchers at the University of Udine and regional authorities collaborated during 2015–2017 on a participatory process that entailed the organization of workshops and implementation of a web GIS to collect and share data on positive and negative aspects identified by local residents. This geographic information was subsequently used in the elaboration of the Regional Landscape Plan (Guaran & Michelutti, 2018; Guaran & Pascolini, 2019).

3.2 | Survey

The analysis carried out in this article relies on the spatial data collected through an online self-administered questionnaire on citizens' perceptions of risk and landscape degradation.[1] The survey examines the perceptions that locals have of the surrounding landscapes, from different perspectives. Specifically, the first part of the questionnaire comprises a set of questions aimed at investigating the perceived presence of different typologies of degradation, the perceived importance of a list of actions to prevent landscape degradation, and risk perceptions

FIGURE 2 Land cover in FVG, based on Corine Land Cover 2018 (Level 1)

relative to a series of risks.[2] A second section consists of a mapping exercise, where respondents were asked to identify sites in the study area perceived as of high landscape quality and of degradation. The survey ends with a group of questions related to demographics. All questions are formulated in Italian (see the Appendix for a non-literal English translation of the survey questions used).

The administration of this questionnaire is part of wider research on regional landscapes, specifically those considered as degraded, neglected, and derelict. The landscape is not only the place where one lives or works, but also a space that deeply preserves the traces and signs of the communities that have inhabited it. Therefore, the research was designed to bring out the immaterial aspect of the landscape, in its positive and negative aspects, intercepting the knowledge of the people who live in the geographic context under study and the values and meanings that they attribute to it (Amaduzzi, Bressan, Guaran, Pascolini, & Zaccomer, 2019; Bressan & Pascolini, 2019). By considering both the perceptions regarding situations of degradation and the risks interviewees are more concerned about, the survey seeks to identify the individuals' concern for the surrounding environment and for the events that can occur in it. In both domains, something of human value is at stake.

Turning to the section tailored to the collection of data with a geographical dimension, the survey included two non-compulsory spatial questions (Q5–Q6) asking respondents to indicate a maximum of three places in the FVG region that are of particular value to them as well as a maximum of three places in the same region that are in a particularly critical state. Respondents were free to give their own interpretation of sites perceived as of value or degraded, as no definition was provided in the survey. This approach of asking respondents to identify only two types of spatial attribute differs from most of the other PPGIS applications reviewed (an exception is Al-Kodmany, 2001), and derives from the fact that the presence of numerous spatial attributes can lead to error on the part of the respondent (Brown & Kyttä, 2014). The decision to allow respondents to identify only three sites per question is also quite uncommon in participatory mapping, but it was deemed necessary to induce the respondent to identify a meaningful set of locations.

Each spatial question was followed in the survey by two (non-compulsory) open-ended questions, enabling respondents, firstly, to introduce a textual description of the place previously reported and, secondly, to explain the reasons that motivated their selection. It is evident that, as the survey had asked respondents to express subjective judgments about the positive and negative characteristics of the regional landscape, the thematic accuracy of the mapped feature could not be assessed: no true or accepted reference map exists with which to compare user-generated content. However, the first free-text question revealed what people meant to map and, consequently, the existence of a correspondence between the intended map location (written in the text) and the drawing produced by contributors. Moreover, the presence of this open-text question, for those who were willing to collaborate but had some trouble with interactive maps, allowed respondents to make their report in a textual form only. It was in fact among the survey's objectives to maximize the number of positive and negative evaluations of the landscape, regardless of the contributor's mapping abilities (Bressan & Pascolini, 2019).

Moving on to the technical aspects of the spatial section of the questionnaire, the primary aspect to consider is that, for each of the six possible exercises, participants were first asked which geometric object they preferred to use for placing their opinions on the map. The options were points, lines and polygons. Then their task was to draw their spatial reply on the base maps embedded in the survey. In this map-based approach, the features sketched were not visible to other respondents. Detailed instructions on how to complete the reports were provided before each map. Users could pan, zoom in and out, and erase points. Participants interacted with spatially referenced materials, and, as such, the mapping approach employed in the research falls into the category of sketch maps (Boschmann & Cubbon, 2014). Specifically, they could switch between one of three base map layers, and an OSM layer was displayed by default.

The survey was developed using a third-party platform,[3] and there were limits to customizations. The main advantage of such a platform is that the survey can be completed using either a computer or smartphone, even if the second option is considerably more problematic for the user. Among the drawbacks, it is necessary to highlight that it was not possible to select the map extent, and, as a consequence, the base map was not centered on the study area. On the researcher's side, the use of these third-party services did not allow for the collection of statistics on the use of the zoom in/out function, total elapsed time in the mapping activity, or incomplete questionnaires, for instance.

3.3 | Study participants

To ensure the collection of spatial data is high quality, we relied on participants we supposed to be credible, that is, possessing "at least some degree of both trust and expertise in combination" (Flanagin & Metzger, 2008, p. 141). Initial invitations to fill in the survey were sent by email to a comprehensive set of environmental, cultural, and geographic associations and organizations based in the region and to a mailing list of individuals who had previously interacted with the research team during a past project. The invitation contained a link to the Enketo web form with the survey questions and the contact details of the research team. We encouraged the associations to forward it to their own associates, who we assumed would be knowledgeable on the topic and would have a pre-existing interest in the survey subject content, and thus an intrinsic motivation to participate. As pointed out by Brown, Kelly, and Whitall (2014), the mapping outcomes resulting from the contribution of volunteer participants could differ from those achievable with randomly sampled participants. Because of this, and the fact that the target population in this research was made up of persons with certain priorities and values seeking to safeguard the local environment and culture, the chosen sampling method could have introduced an ideological bias. This is not a major issue in this PPGIS as the mapping activity was not implemented within the context of a formal planning process. However, if the request was to collect spatial information concerning development preferences in a process with direct consequences for the involved community, it is necessary to warn that participants could take advantage of their role to impose their views in accordance with their vested interests (Zolkafli et al., 2017). Another characteristic of a self-selected public group that emerges in the literature is that it could put greater effort into mapping compared to other sample groups (Brown, 2012; Brown et al., 2012). Despite the various problems associated with volunteer participants, involving different associations and past research participants had the aim of maximizing the range of possible values attributed by locals to the local environment. In addition, the choice of using an online survey as a spatial collection method ensured that the mapping activity of each participant is, in principle, independent. Other data collection formats, such as workshops, may introduce additional sources of bias, as participants may feel influenced by other group members or by existing drawings on the maps (Cerveny et al., 2017).

Returning to the participants of this PPGIS, it was also assumed that the target population lived within the region or, at least, was very familiar with the study area.

The survey was available to respondents from June 2018 until November 2018. The invitation to participate was repeated by email in September 2018. The reminder to the mailing list members contained a link to the same questionnaire, while the email to the associations included a link to a different questionnaire where only point geometry was allowed.[4] No financial incentive was offered; however, participants were advised that they could receive updates on the research outcomes via the project's Twitter account, which was provided in the invitation letter.

Given that the mapping exercise included in the survey relied on volunteers providing geographic data using an internet-based tool, the online map-based approach intersects, in this respect, with the field of volunteered geographic information (Brown, Donovan, et al., 2014).

3.4 | Data analysis

The replies to the multiple-choice questions and open-ended questions were analyzed using Excel and SPSS statistical software. The analysis of georeferenced data followed a different process. A table containing the replies to the questions with maps, together with some basic information linked to such questions (participant ID, attribute of interest, textual description), was imported into GIS software in order to visualize the raw spatial data entered by respondents and assess some aspects of data quality.

The analysis of the position of the collected data with respect to the study area and the computation of the spatial extent of reports made through lines and polygons offer some insights into the characteristics of the raw data gathered through the map-based approach. The first aspect was scrutinized by overlapping the layer of the region with those of the raw data collected, one for each geometric object, and assessing whether the perceptual landscape attributes were within the source layer. The second aspect was analyzed by computing the surface area (for polygons) and length (for lines) of the reports.

Next, the locational accuracy of landscape features pertaining to the study area was analyzed. The existence of an open-ended question associated with the georeferenced data permits determination of the consistency between the mapped feature and the intended map location and, consequently, the fitness of the raw data for the purpose of the research (i.e., studying landscape perceptions for the FVG region). The text description consisted in most cases of a clear place name that allowed the identification of known landscape features to which the respondent was referring. The assumption is that the textual information is correct, and thus it constitutes the basis for determining the quality of the corresponding spatial data. In this project, the OSM layer was used in spring 2019 as a reference to find the location of the intended map features. As noted previously, research on positional accuracy of volunteered geographic data has been primarily conducted in the context of OSM (see Section 2.3). In the absence of a solid framework, the extension of these approaches to other typologies of contributed data such as the case of vague landscape entities should be carefully assessed. Succinctly, OSM data concern physical features which exist on the ground. They are contributed by people who are aware their efforts are aimed at creating a user-generated map that is free to use under an open license. On the other hand, in mapping initiatives such as those discussed in this paper, where vague landscape entities are collected, the spatial extent of the contributed data, regardless of their accuracy, depends on participants' hands-on experience with and opinion on the feature to be mapped. It follows that these spatial data might not correspond to verifiable geographic entities. The other important consideration is that contributors to the project are primarily offering their personal knowledge of the local context, which is not already available somewhere else. These characteristics have at least two implications in the conduction of quality assessment. The first is that "well-defined" benchmark features might not exist. The second is that, in default of specific requests provided by the organizers, mappers do not assume that data quality is a goal. This could be, on the other hand, more explicit in the OSM context, where contributed data are mainly valued for their cartographic contents.

To return to the data quality assessment, the first phase consisted of excluding inadmissible locations (outside the regional borders, as a result of the analysis of the textual information) and vague spatial replies (where the spatial feature was not described by any text or where both the description and mapped feature were unclear). Then the centroids of the mapping outcome collected through the polygon and line geometric objects were calculated.[5] As previously observed, the existence of an open-ended question makes it possible to understand what the participant intended to map and thus to identify such entities in other georeferenced base maps. The points falling within the area described by the textual reply were considered as "of quality." The following phase involved creating a new layer containing the possible "right" position of the mislocated mapped features, one for each original geometric object. The identification of such reference points for the mislocated reports made use of two sources of information. The first is the textual information in the open-ended question. The second source is the participant's drawing. Both sources were considered reliable, even if the second may be not correct, due to the fact the participant could have difficulty using online maps. The geographic knowledge that each mapper entered had been employed by selecting a reference point which was close to the participant's drawing. The decision to create three point-based data sets for the quality assessment stems mainly from the fact that, when dealing with perceptual data, the true extent of the benchmark geometry to which a certain response relates cannot be determined objectively. In addition, the visual inspections of spatial data revealed that the spatial extent of reports made with polygons and lines were far from accurate (see Section 4.2). It is possible to assume that, as data quality was not explicitly mentioned in the text of the invitation to collaborate in this PPGIS, the importance of entering precise drawings was not considered by study participants.

A measurement of data quality was introduced by computing the distance[6] between a possibly correct map location and the mislocated point. These computations were made both when the original geometric object was a point, and when the volunteered data were represented by the centroid of the sketched polygon or line. The length of the lines computed can be interpreted as the error that the participant made in the mapping exercise of each report. Other possible approaches to data quality were considered (Antoniou & Skopeliti, 2015; Senaratne et al., 2017), but not implemented.

The output of these procedures was afterwards exported from the GIS software for analysis in SPSS. The analysis distinguished the results for the places perceived positively from those perceived negatively in order to highlight the possible existence of a different pattern of data accuracy according to the attribute of interest in question.

4 | RESULTS

4.1 | Survey participation

Altogether, 212 respondents expressed their opinion on the condition of the regional landscape in the FVG region by submitting the online form. Of these, 148 were completed by associates of the contacted associations and organizations; the remaining 64 were from people who had previously collaborated with the research group. Just 37 new map-based surveys were gathered through the second invitation to the associations, which allowed only for the collection of mapping using point geometries. There was a nearly equal distribution between male and female participants (52.8% were males). As for the other demographic characteristics, most of the respondents were adults (64.2% were over 40 years old), highly educated (56.7% held a University degree), and a large majority lived within the study area (96.2%).

As already observed, the mapping exercise was included in a wider questionnaire, aimed at studying respondents' opinions on their surrounding environment. The first part included two questions exploring whether respondents perceive the presence of any degraded and/or compromised areas, either where they live or work in the FVG region (Q1), and in the rest of the region (Q2). To the first question, which referred to the most familiar places, the large majority of respondents (90.1%) replied "yes," and the same opinion emerged for the second question (61.8%). A confirmation of the relevance of the problem in question is given by the fact that in response to Q3, the vast majority signaled that the public authorities should take action against landscape degradation. In fact, according to 202 respondents (95.3%), public authorities should prioritize prevention of degradation to landscapes in the territory.

Moving on to the spatial questions of the survey (Q5–Q6), 171 respondents (80.7%) gave their contribution using the mapping component, while the rest (41; 19.3%) skipped that part. Interestingly, despite there being more male study participants than female in the survey, slightly more female participants did not provide any reports (58.5%). Also, in terms of education level, there is a change with respect to general profile of respondents, as overall, those who did not complete the spatial section held a high school diploma or lower level (53.7%). No variations are present in term of residence, as those who did not contribute to the spatial section were still predominantly from the study area (95.1%). Curiously, the highest frequency of people who did not complete the spatial section is associated with the 20–24 age group (12 out of 41), all of whom were students.

The fact of the mapping exercise being embedded in a wider survey makes it possible to analyze the coherence of participants' replies. To this end, it is interesting to notice that most of those who ignored the spatial component answered "yes" (36 out of 41, 87.8%) to a multiple-choice question relating to the presence of degraded and/or compromised areas where they lived (Q1). In the following question (Q2), 48.8% (20 respondents) again answered affirmatively, signaling an incoherence between their opinion and the fact that they did not identify any of these sites in the mapping component.

4.2 | Raw spatial data

Overall, the survey yielded a total of 664 reports. If only the volunteers who completed the mapping component are considered, there are 3.9 reports per questionnaire. Points were the preferred geometric object and were used for 260 reports; 78 reports were made with lines; 162 with polygons; and 164 in text form.[7] In other words, about a quarter of the reports received were not produced by the interaction of the participants with the online maps. The fact that more points were used compared to other spatial features is in line with the idea that the use of this geometric object is more intuitive. However, in this specific case it could also be a consequence of having included a survey that allowed only the points-based approach, along with the text form, in the reminder to participate sent to the associations.

Besides scrutinizing the number of replies in the spatial component, it is worth analyzing how respondents behaved. Thirty-eight respondents availed themselves of the possibility of using only the text form in the survey and 15 volunteers used both geometries and the text option to complete the reports. It is interesting that 13 of those who used the text form decided to identify the maximum number of locations (i.e., six), signaling their strong willingness to contribute regardless of the barriers created by the presence of interactive maps. Of the 118 respondents who used only the spatial features, 42 provided the maximum number of reports permitted, while the other 76 contributed to a lesser degree to the data collection. The 55 top contributors, that is, those who made six reports, were predominantly male (60%), adult (63.7% are over 40), and held a University degree (69%). In addition, all resided within the region.

TABLE 1 Absolute frequency (and percentage) of reports within the source layer, by geometric object and attribute of interest

Geometric object	Sites perceived as of beauty	Sites perceived as degraded	Total
Point	130 (92.9%)	119 (99.2%)	249 (95.8%)
Line	38 (74.5%)	21 (77.8%)	59 (75.6%)
Polygon	65 (65.0%)	50 (83.3%)	115 (71.9%)

Source: Own calculations.

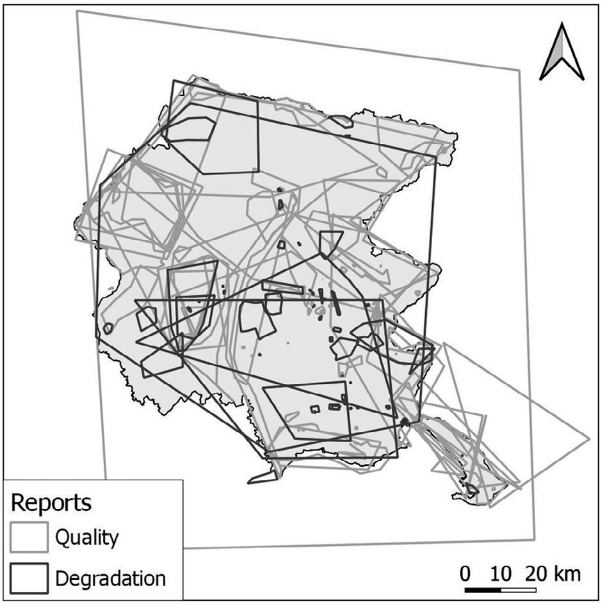

FIGURE 3 Reports completed with the polygon geometry (close-up on the study area)

People preferred to map high-quality sites (a total of 384 reports, 58%) rather than those of degradation. This preference is constant among all four different types of response.

A preliminary assessment of data quality is offered when the layer with the polygon of the FVG region is overlaid with the layers containing the collected spatial data, one for each geometric object.[8] Such comparison permits exploration of whether the mapped features are within the study area or not. Table 1 summarizes these results. The majority of the reports were within the source layer feature, and of the three geometric objects employed, the point features are considerably more accurate than the others. Other interesting insights emerging from the consideration of this data quality criterion are that the placement of degraded sites is more accurate than those concerning beauty spots, and the difference between the two PPGIS attributes is larger when the polygon is used. Lines are more frequently placed within the study area than polygons, but the contributions concerning degraded sites made with polygons have a higher quality compared to lines.

Figure 3 shows the sketched polygons collected with the map-based survey. The visual inspection of such data highlights the problems inherent in the absence of error-free tools during the collection stage, as for some contributions the surface area is mostly outside.

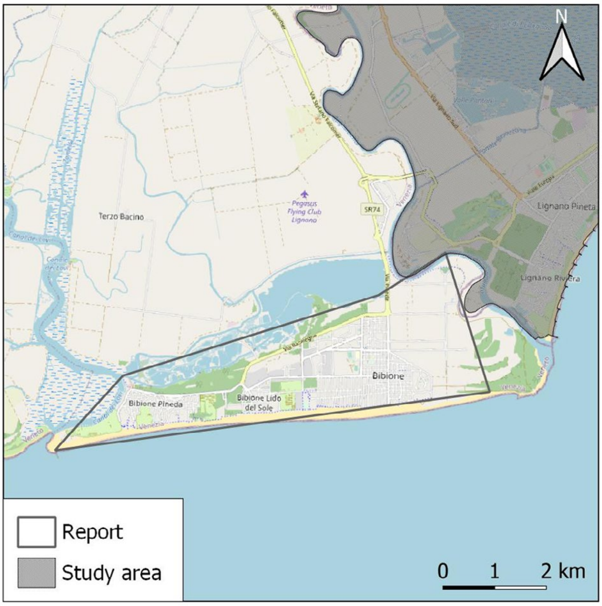

FIGURE 4 Example of polygon geometry placed outside the study area: inadmissible report (© OpenStreetMap contributors)

Figure 4 provides an example of inadmissible location (i.e., not in accordance with the purpose of the research, because it refers to a location outside the study area). The overlay of the spatial reports (for which a description in words of the mapped feature exists) with a base map containing toponyms permits verification of the coherence between the geometry and the intended map location. In this example, the participant's contribution is placed outside the study area, over the nearby seaside town of Bibione (Veneto region). The related open-ended question contains as text "Bibione seafront," confirming the choice of the participant to map a feature outside the study area.

The visual analysis of the raw data for lines shows that some users were evidently not able to control the tool and use the erase button, as there are lines flowing out illogically from the study area (Figure 5).

The number of points outside the study area is very limited (Figure 6). However, some of them are far away from FVG (e.g., Croatia, Ukraine, North America), signaling the difficulty for some participants in using the interactive cartography.

An interesting case is that of a participant who mapped a feature in nearby Slovenia, despite the reference to a cross-border entity in the text (Figure 7). In the open-ended question the participant writes his intended map location, Transalpina Square (Piazza della Transalpina), which is a square divided between the towns of Gorizia (Italy), and Nova Gorica (Slovenia). However, the point is over the railway station of Nova Gorica which is located at the eastern end of the square, on the Slovenian side. Formally, the point geometry is outside the regional boundary, but the intention was to map an entity which rightfully belongs in the study area. Contrary to the case presented in Figure 4, here the report is retained in the analysis to respect the participant's willingness expressed in the open-ended question.

These results reveal that more investigation is needed to understand whether participants' replies are anomalous because they are not in accordance with the purpose of the PPGIS (i.e., they are outside the study area) or because they are a consequence of contributors' difficulties in using mapping tools and/or lack of geographic awareness.

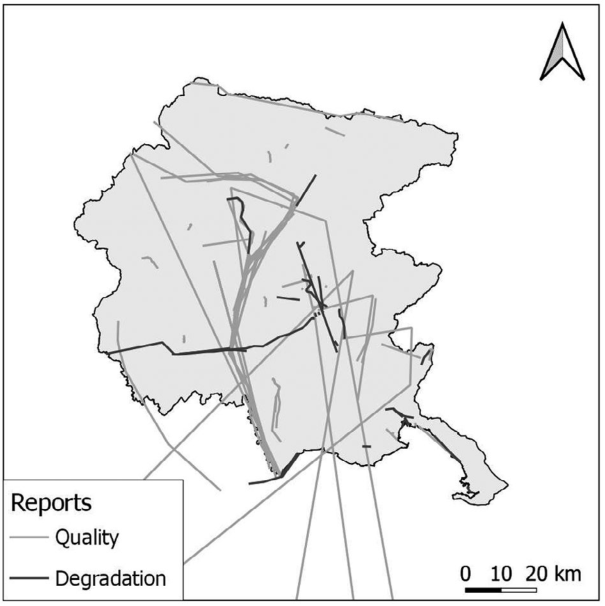

FIGURE 5 Reports completed with the line geometry (close-up on the study area)

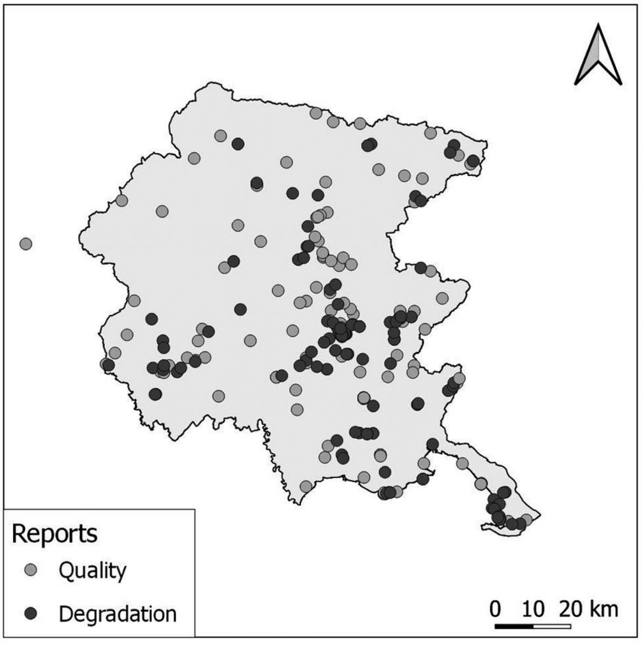

FIGURE 6 Reports completed with the point geometry (close-up on the study area)

With reference to the spatial data collected through lines and polygons, it is possible to comment on their spatial extent. This is done by calculating the length (for lines) and surface area (for polygons). Lines ranged from 2.3 m to 888 km in length, with a median of 7.88 km. For polygons, the dimensions ranged from 0.4 m^2 to more than 17,000 km^2; the median in this case was 3.07 km^2. Despite the fact that the number of lines and polygons is

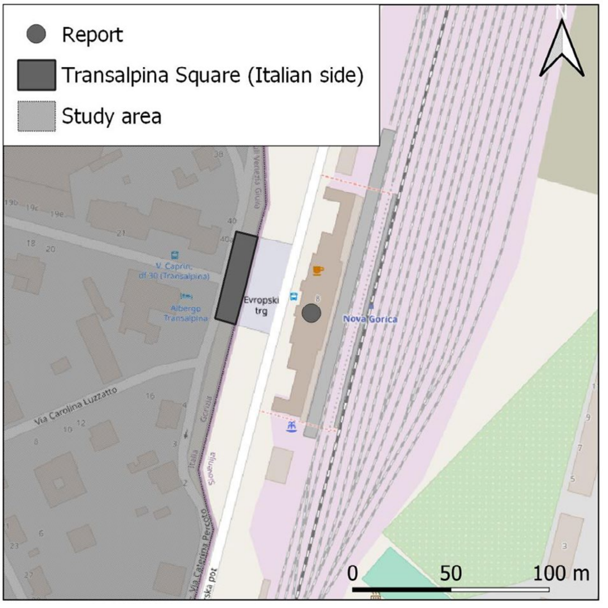

FIGURE 7 Example of point geometry placed outside the study area: admissible report (© OpenStreetMap contributors)

different (Table 1), it is worth observing that participants used smaller geometric objects to map sites perceived as degraded. For lines, the median was 5.92 km (compared to 12.52 km for positively perceived sites); for polygons, the median was 1.73 km^2 (compared to 6.45 km^2 for positively perceived sites). Oversized polygons are probably the most interesting to analyze, as a comparison with the study area's surface provides some insights into the adequacy of the sketched polygons for the purpose of the research. The biggest polygon (high-quality site) is more than twice the size of FVG and has no associated text. The second biggest feature (degraded site), which was approximately the size of the entire region, concerned a vague feature – in the text description there was reference to "FVG city planning". For the third biggest polygon (3,242 km^2), which refers to "Friulian mountains and foothills", there could be, in principle, a correspondence between the dimension of the mapped feature and the "true" geometric entity. Of the three examples, only the last one has some meaningful informative value which can truly contribute to the analysis of the regional landscapes.

4.3 | Positional accuracy of the landscape attributes pertaining to the study area

The analysis presented above highlights the possibility that some mapping results were mislocated, too generic for the purpose of the analysis, or inadmissible (i.e., referring to sites outside the study area). However, the greatest contribution of the textual information is that for admissible reports it allows benchmarking of the mislocated points with a reference data set and provision of a measure of data quality. Figure 8 shows a report which was made with the point spatial feature wrongly placed. The text associated with this report contained the expression "The ironworks of Trieste," but the spatial feature falls over a logistics hub. A possible correct location for the description provided in the textual description (intended map feature) is about 1 km away from the original.

Other examples of inaccurate mapping outcomes are provided in Figure 9. The reports shown all refer in the textual description to the Tagliamento River (FVG's longest river, about 180 km in length). In three out of four cases, the lines' centroids do not intersect with the river and so the participant's contribution is considered

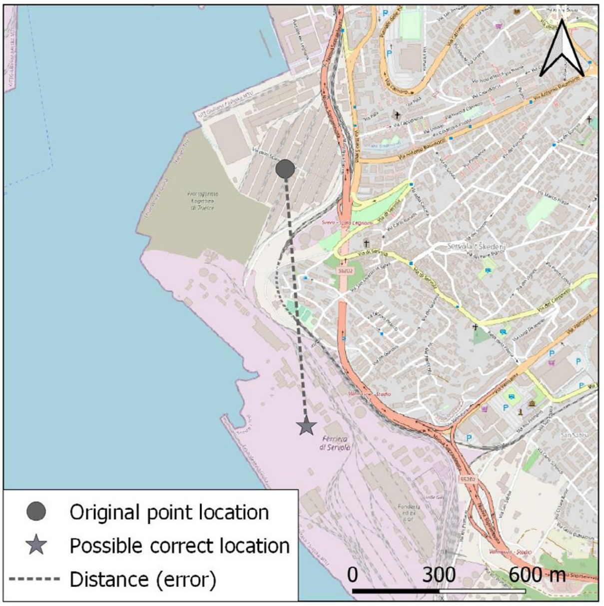

FIGURE 8 Example of locational inaccuracy when the point geometry is used: ironworks in Servola, Trieste, Italy (© OpenStreetMap contributors)

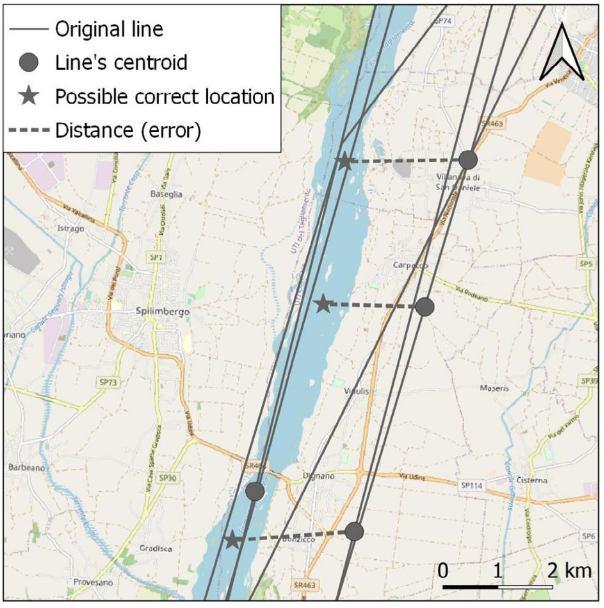

FIGURE 9 Examples of locational inaccuracy when line geometry is used: Tagliamento River (© OpenStreetMap contributors)

mislocated. In these cases, some possibly accurate locations are identified and the distance from the centroid and such reference data calculated. The centroid falling within the river is considered accurate, even though along the entire tract of river the geometric object might not always correspond with the course of the river.

TABLE 2 Errors associated with mislocated reports, by geometric object and attribute of interest

Geometric object	Sites perceived as of beauty	Sites perceived as degraded	Total
Point			
N	31	20	51
Min.	20.80 m	46.92 m	20.80 m
Max.	2,691,564.51 m	3,992.36 m	2,691,564.51 m
1st quartile	192.02 m	281.98 m	258.51 m
2nd quartile	1,522.55 m	648.63 m	892.64 m
3rd quartile	4,227.44 m	1,117.62 m	2,764.98 m
Line			
N	31	18	49
Min.	4.50 m	7.90 m	4.50 m
Max.	193,453.57 m	2,547.10 m	193,453.57 m
1st quartile	102.17 m	24.82 m	68.04 m
2nd quartile	797.20 m	102,23 m	366.79 m
3rd quartile	2,249.21 m	452.01 m	2,064.50 m
Polygon			
N	20	17	37
Min.	97.11 m	39.08 m	39.08 m
Max.	22,363.35 m	3,208.04 m	22,363.35 m
1st quartile	1,513.03 m	196.26 m	323.53 m
2nd quartile	3,615.57 m	347.04 m	928.41 m
3rd quartile	5,173.25 m	655.68 m	4,120.57 m

Source: Own calculations.

Mapping results without associated textual information, overly generic reports (e.g., the two largest polygons described previously) and inadmissible locations were not considered in the following quality assessment. The exclusion rate was around 4% (specifically, 3.8% for points, 2.6% for lines, 4.4% for polygons), and concerned predominantly high-quality sites. Almost 70% of the reports were placed within the area described by the textual information and thus were considered correct. The percentage of mismatched reports is around 27%, for both degraded and beauty spots. Table 2 presents the absolute number of mislocated reports and the distances between the mislocated mapped features and the possible correct locations. The joint analysis of the collected spatial data with the place name written in the open-text questions showed that a spatial mismatch occurred in 51 reports completed with the point feature (19.6% of the total point features collected), in 49 centroids derived from lines (62.8%) and 37 derived from the centroids of polygons (23.1%). The comparison of the sites perceived as of beauty with those seen as degraded offers interesting insights. In fact, the value of the error is markedly lower in the case of degraded sites (i.e., the median value is lower than the corresponding one for quality sites), regardless of the original geometric object used. In addition, when considering the values of the median and the first and third quartile, it also emerges that the positional error is always lower in the case of lines compared to the values obtained for points and polygons.

5 | DISCUSSION AND RESEARCH PERSPECTIVES

5.1 | Quality assessment

The results reveal that the sites perceived as degraded, despite being less numerous than those considered to be beautiful, are located more accurately by respondents, according to the criteria adopted in the analysis. For all three geometric objects, the percentage of degraded sites within the source layer is higher than the corresponding percentage for the other attribute of interest. The other interesting finding is that when a mismatch occurred between the georeferenced data and the intended mapped location, the positional errors are lower when degraded sites were considered. The latter are also mapped through smaller lines and polygons compared to sites which are positively perceived.

In this PPGIS, the information from locals on the condition of regional landscapes was partially elicited through polygons and lines, in addition to "traditional" point features. Lines were both used less frequently and also more often wrongly placed, compared to points and polygons. However, when computing the distance between a location incorrectly identified by a respondent and a possible correct point, the value of the error is lower for the line geometry. A possible explanation is that the identification of a line on a base map requires a large map scale, that is, to zoom in on the base map until visualizing the line to be mapped. This task requires the respondent to exercise greater precision compared to cases in which the entity to be mapped has a large surface area and so is visible with a small map scale.

A problem that emerged in the FVG case study concerned the existence of spatial features placed outside the study area. Such results could reflect respondents understanding regional boundaries in different ways and could have been the consequence of having collected spatial data without including any quality control mechanism during the acquisition phase. A possible solution, which was not adopted in this application, could be to mark the boundaries of the region on the map and centering the display on it. An alternative to such an approach is to allow respondents to choose from pre-identified geographical features and enable them to alter the shape or move the position of such entities on the map if they wish. This is similar to the approach adopted by Cui and Mahoney (2015). Another possible option is to pre-identify a set of geographic entities to be examined and allow respondents to "vote" on them by assigning one of the available PPGIS attributes. Despite simplifying data entry for the user, these solutions might still have some drawbacks. In the first case, there could be a tendency for respondents to "make do" with existing, pre-identified locations, thus reducing the possibility of exploiting local and "new" knowledge through PPGIS. In the second case, the pre-identified geographic entities might not be identified as having only one specific characteristic, as the same individual could assign multiple characteristics to them.

An additional observation is that the collection of georeferenced data does not guarantee that meaningful local knowledge is obtained. In this PPGIS, the analysis of the textual description associated with the spatial data assists in distinguishing inadmissible landscape features (i.e., not pertaining to the study area and thus useless) from those "simply" mislocated outside the regional borders.

The added value of allowing respondents to use lines and polygons derives from the fact that the evaluation of perceptual aspects means that the same landscape feature, if examined from different observation points, can be considered both of value and degraded. For example, an alpine path can be considered well kept for most of its length, but replete with waste such as metal cans and sunscreen packaging around some of its rest areas. Moreover, in this application, the collection of landscape features through multiple geometric objects offers the possibility of distinguishing localized situations of degradation from large areas where a more widespread problem is perceived to exist. However, the inspections of the spatial extent of lines and polygon showed that some spatial features did not appear suitable for the purpose of the research. The question is whether it is acceptable to express a judgment on a person's perception, by excluding from the analysis contributions that are disproportionately large compared to the study area.

The choice of employing multiple geometric objects brings up the question of how to assess whether lines and polygons are well positioned. In this paper a data quality measure based on centroids was presented. The main advantage of such an approach is that the same measure is applied to each of the three original geometric objects, and so a comparison can be made. Future investigation is needed to evaluate whether other approaches not based on the point feature are possible. Contrary to other contexts where verifiable facts about the world are under consideration (e.g., OSM), the use of polygon geometry as a benchmark is quite challenging in the case of perceptual data. If the decision is to consider the entire extent of the polygon or linear feature in the quality assessment, a hypothesis could be that, for each sketched polygon or line, the point at the beginning of each drawing is more accurate geometrically and thematically than the others. As described in Section 3.2, the map was not centered in the study area, so the first point is the result of the participant zooming into the base map where the intended map location is placed and starting the drawing. Further work is therefore needed to investigate whether the accuracy of each vertex placement decreases as the drawing becomes more complex (i.e., the number of vertices entered by the study participant increases). Another consideration that impacts on the choice of the data quality approach, always in the case of linear data, is that there might not be a correspondence between the participant's drawing and the "normal" geometry of the intended map location. For example, a possible representation of a river could be, in the case of perceptual data, a perpendicular line to the river bed. In fact, people might cross the river either via a bridge or by fording it, and thus their perception is limited to that stretch and they do not consider the entire waterway axis.

In addition, it should be recognized in this discussion that there are other quality measures, which are not based on the comparison with external data sets (Mocnik et al., 2018). For example, intrinsic assessments also have serious limitations in this context, due to the perceptual character of the landscape and, consequently, the possibility that different participants may express contrasting views on the same geographic feature.

5.2 | Survey interface and design

The third-party service used for developing the survey did not allow for customization of the mapping component, and as such some limitations emerged both for users and researchers. Among the factors that might influence positional accuracy, Jankowski et al. (2016) also identified the quality of the mapping environment. In this PPGIS, the absence of information on the zoom level and time elapsing during the mapping activity does not enable exploration of a participant's behavior in the mapping activity. Another aspect which would be relevant to analyze is whether there was the tendency for people to place their drawings over place name labels (Boschmann & Cubbon, 2014). Unfortunately, it is not possible to carry out such an analysis, as information on the participants' interaction with base maps is not available. The introduction of error-proof tools would be desirable to improve the quality of mapping. Possible examples include denying the placement of spatial features outside the study area and allowing drawings of the spatial features only when a certain scale map is reached. A customized base map was not provided and, given that the information available on this could affect participants (Besser et al., 2014), this aspect also needs to be explored. A usability survey analyzing the efficacy of the layout and clarity of the instructions might shed light on some aspects of data quality.

The number of dropouts from the survey prompted by the mapping component is unknown. It would be interesting to investigate whether potential participants did not complete the questionnaire because they thought the mapping task too demanding. Together with this aspect, a deeper understanding of why some participants who correctly submitted the form did not carry out the mapping exercise is also desirable. In this survey respondents could also answer spatial questions by using exclusively the text form, as the main challenge of the project was to elicit local knowledge on the current condition of the landscape by gathering as many opinions as possible. It was a successful strategy, as highlighted by the fact that almost a third of those who answered the spatial section used the text only option at least once. Is the reason for using solely the open-ended question to be found in scarce map-reading skills, or were participants frustrated by using the map and so preferred to speed up the process by just using text? People might, in fact, choose places which they can confidently identify on maps, and avoid mapping the others. Further investigation is needed in this domain to determine if reports vary when a verbal rather than a map-based approach is used (Linden & Sheehy, 2004).

In this PPGIS, those who did not complete the spatial component had a low educational level. Further research is needed to understand if they were unable to use the tools available to draw, if they did not realize that it was possible to report by using the text form, or if they considered the survey too lengthy. It does not seem plausible that they could not give any response to the spatial questions, as in another part of the survey (Q1–Q2) most thought there were degraded sites in their surroundings.

5.3 | Participation

In this research, the decision to invite members of regional associations and individuals who had previously collaborated in research to complete the survey seeks to harness the knowledge of people who could probably provide meaningful information on their surrounding environment. Despite respondents' interest in the topic, marked by the fact that they participated in the initiative voluntarily, it is not possible to establish, except in broad terms, the thematic accuracy of collected data. However, given that some features of the spatial component of the survey were not user friendly, it is possible to consider the mapping activity as having high barriers to entry, and therefore those who mapped were very determined to share their knowledge and expertise for the research.

Ensuring the public's input will translate into tangible changes could be an incentive for participation, but it was not the case in this project as the PPGIS was not sponsored by any local public authority. The decision in this PPGIS application was to provide potential participants with a link to the project's Twitter account to enhance visibility and accountability. However, the initiative did not obtain the expected outcome.

Despite the case study being set in a rather populous area, participation was somewhat low. Difficulty in accessing the internet and computer hardware, a lack of interest in the project, a high cognitive demand linked to the mapping activity, or the lack of satisfaction to be gained from participating in the project as a "simple" respondent may be explanations for the limited participation. In addition, the request to fill in the survey may not have reached every associate, as the invitation was sent to the associations, which may have declined the request to forward our email to their members.

Together with uncovering the reasons for the limited participation, a better insight into who answered the survey is also extremely important, as it would contribute to interpreting the mapping outcomes in relation to their author (Jankowski et al., 2016). Some demographic characteristics have already been included in the survey and considered in this paper. Others have not been considered in the survey (e.g., GIS skills, geographic literacy) or were not adequately explored in this analysis (e.g., municipality of residence).

In this case study, participants preferred to identify places perceived positively rather than degraded sites. In the study location, are there objectively more sites of high landscape value? Did the structure of the survey favor the identification of sites of high landscape quality, as the question appeared before that on degradation? Did respondents prefer to identify positive over negative features? Did the survey's emphasis on degradation motivate respondents to invest more effort when mapping degraded sites? What came to light in this PPGIS application is that mappers, when asked to reflect on situations in which deterioration, decay or impoverishment occurs, refer to them in more accurate terms than when reflecting on positive situations. The involvement of people with different sensitivities and interest in landscape enhancement would probably lead to different results. This should be explored by collecting the same landscape attributes in other similar contexts.

6 | CONCLUSIONS

The involvement of the local population in the study of local landscapes can have enormous benefits for individuals and the local community per se. It is in fact an opportunity, among other things, to create awareness of the state of their surroundings, increase their sense of civic duty and contribute to thinking and planning possible improvements in today's landscapes. Additionally, when maps are included in public participation processes, the request to map how locals perceive their surroundings is a way to collect original spatial data that do not already figure in authoritative data sets. One of the problems that undermines the acceptance of such methods is the quality of the spatial data collected. The contribution of this article is in presenting an approach for assessing the positional accuracy of vague landscape features and in illustrating its potential to other researchers and practitioners interested in carrying out similar analyses. The data collection process was not error-proof, but a quality assessment is carried out in this article to explore whether the spatial features collected are improperly located by study participants. Specifically, the existence of an open-ended question requiring a description of the locations being identified in the mapping exercise enables verification of the correspondence between the spatial data and the place named in the text. The application of the proposed method for quality assessment on an empirical basis revealed that the pattern of data accuracy varied according to the PPGIS attribute. Despite this interesting result, there is still much to uncover on the influence of other factors on positional accuracy, such as the mapping environment and the participants' characteristics. In addition, many issues concerning the validity of PPGIS applications and the information value of the mapping results are not discussed here. It is to be hoped that the experience gained and illustrated in this article might help other researchers who, as in this PPGIS, are collecting explicitly contributed data in absence of strong top-down coordination.

In a data-scarce context such as the one under analysis, crowdsourced geospatial data could play an important role. However, in order to improve confidence in these data, efforts should be made both to establish posterior quality assessments and to enhance quality during the collection phase.

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHOR CONTRIBUTIONS

This contribution is the result of the work carried out for the departmental project PARIDE "The Landscapes of Risk and Degradation: from perception, to representation and to territorialisation. Interdisciplinary knowledge and awareness in support of local government policies", conducted at the University of Udine, Italy. The other members of the research group, which I thank here, are Mauro Pascolini, Salvatore Amaduzzi, Andrea Guaran and Gian Pietro Zaccomer. I am grateful to the volunteers who shared their time for this map-based survey. Some preliminary results from this research were presented at the seminar "Dalla mappa al GIS 2019", Università Roma Tre, Rome, 17–18 April 2019. I am deeply grateful to the anonymous reviewers for their detailed suggestions and comments on the drafts of this article.

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ENDNOTES

1 A detailed account of the survey, a description of the participants' profile and some preliminary results are available in a conference paper authored by Bressan and Amaduzzi (2020).

2 For completeness, here it is worth mentioning the definition of risk perception that guided this specific section of the survey. Aven and Renn (2009) defined it as the judgment that a person has about a risk, and specified that it "could be influenced by the facts (for example, showing observed correlations between smoking and lung cancer), scientific risk

assessments, the individual's own calculations and assessments, as well as perceptional factors such as dread or personality factors such as a personal preference for risk-averse behavior" (Aven & Renn, 2009, p. 8). Information on risk perception can be acquired through sketch maps (Brandt et al., 2020; Klonner, Usón, Marx, Mocnik, & Höfle, 2018).

[3] The survey was developed in May 2018 on the Enketo platform at https://ona.io/home/, and was then made available to the respondents during the administration period. The descriptions provided in this paper might not reflect the service now available on the platform due to possible changes in its functionalities and in the base maps. The issue of reproducible research when computer techniques are involved is well known in the literature and difficult to solve, especially when third-party services are involved (Bearman & Appleton, 2012; Cui & Mahoney, 2015).

[4] The decision to simplify the mapping component of the survey was taken because some potential participants highlighted their difficulty in mapping polygons. In this survey, the drawing of the polygon was not complete until the "close polygon" button was clicked. If this action was not completed when submitting the questionnaire, a data error appeared and the data input was not transmitted to the platform. The association members who reacted to the reminder have, de facto, responded to a different survey. It should be noted that they differ from the first-round respondents because they had also probably disregarded the first invitation email delivered in the months before, probably signaling a lack of interest in the project.

[5] These points have no special characteristics from the participants' perspective, as they were not aware that the centroids of their drawings would be employed in a quality assessment. If on the one hand this choice simplifies the analysis from the researchers' point of view, on the other hand it does not make the best use of participants' mapping efforts, as the spatial extent of polygons and lines they drew are no longer considered. This solution should not be considered a novelty in PPGIS research. For example, in a map-based approach aiming to elicit residents' preferences about land use in an urban context, Jankowski et al. (2016) also evaluated the positional accuracy of the sketched polygons using centroids.

[6] Distances were calculated using the "XY to Line" function in ArcGIS 10.2.1. The geodesic line type was considered. The spatial reference was ETRS89/UTM zone 33N (N-E).

[7] The reports completed in text form cannot be directly represented in the cartography and are not considered in this analysis. The Batchgeo geocoding service was utilized to transform the text into georeferenced points. These reports also contributed to the construction of the overall geospatial inventory (Bressan & Pascolini, 2019). Another point to note is that two reports made using the polygon geometry were not considered in the analysis, owing to their having an invalid shape.

[8] Operatively this assessment was carried out using the spatial selection method "are within the source layer feature" in ArcGIS 10.2.1.

[9] The survey was translated from Italian into English for the purpose of publication.

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APPENDIX 1

SURVEY QUESTIONS[9]

LANDSCAPE DEGRADATION

Question	Question type
1. Do you think that in the territory where you live or work in FVG there are any degraded and/or compromised areas and landscapes?	Multiple-choice

1.1. Referring to the categories below: if they are present in the area where you live and work in FVG, what is their level of degradation, in your opinion? (If you answer "no" to Question 1, go straight to Question 2)

Categories	Question type
1.1.1. Traditional manufacturing business areas and/or industrial areas in a state of partial or total abandonment	Likert scale
1.1.2. Commercial areas in a state of partial or total abandonment	Likert scale

Categories	Question type
1.1.3. Landfill areas	Likert scale
1.1.4. Quarries or former quarries	Likert scale
1.1.5. Disused military areas	Likert scale
1.1.6. Power lines, antennas	Likert scale
1.1.7. Non-urban road infrastructure	Likert scale
1.1.8. Solar parks	Likert scale
1.1.9. Urban neighborhoods, suburbs, and parcels of land	Likert scale
1.1.10. Other category (specify)	Open-ended
1.1.10.1. Assessment of "Other category"	Likert scale

Question	Question type
2. Excluding the territories already considered in the questions in the previous section, do you believe that in the FVG region there are any degraded and/or compromised areas and landscapes?	Multiple-choice

2.1. Referring to the categories below: how degraded are they, in your opinion? (If you answer "no" or "I don't know" to Question 2, go straight to Question 3)

Categories	Question type
2.1.1. Traditional manufacturing business areas and/or industrial areas in a state of partial or total abandonment	Likert scale
2.1.2. Commercial areas in a state of partial or total abandonment	Likert scale
2.1.3. Landfill areas	Likert scale
2.1.4. Quarries or former quarries	Likert scale
2.1.5. Disused military areas	Likert scale
2.1.6. Power lines, antennas	Likert scale
2.1.7. Non-urban road infrastructure	Likert scale
2.1.8. Solar parks	Likert scale
2.1.9. Urban neighborhoods, suburbs, and parcels of land	Likert scale
2.1.10. Other category (specify)	Open-ended
2.1.10.1. Assessment of "Other category"	Likert scale

Question	Question type
3 Do you think that possible conditions of degradation existing in the territory should be a priority for the public authorities?	Multiple-choice

3.1. In your opinion, how important are the following actions to prevent environmental and/or landscape degradation? (If you answer "no" or "I don't know" to Question 3, go straight to Question 4)

Actions	Question type
3.1.1. Report any form of degradation to the relevant authorities	Likert scale
3.1.2. Intervene with individual behavior that could limit the different forms of degradation	Likert scale
3.1.3. Take part in public debate on the theme of landscape quality	Likert scale
3.1.4. Encourage, including collectively, actions of public awareness and public protests	Likert scale

Actions	Question type
3.1.5. Encourage, including collectively, formal complaints to the competent authorities	Likert scale
3.1.6. Other action (specify)	Open-ended
3.1.6.1. Assessment of "Other action"	Likert scale

PERCEPTION OF RISKS

4. With reference to the categories listed below, what is your perception of risk within FVG as a whole?

Categories	Question type
4.1. Industrial accidents and consequent leaks of harmful substances	Likert scale
4.2. Seismic events	Likert scale
4.3. Floods and sea storms	Likert scale
4.4. Hydrogeological instability, landslides, and avalanches	Likert scale
4.5. Extreme weather events	Likert scale
4.6. Air pollution from fossil fuels	Likert scale
4.7. Crime	Likert scale
4.8. Effect of the economic crisis	Likert scale
4.9. Terrorism	Likert scale
4.10. Landscape degradation	Likert scale
4.11. Immigration	Likert scale
4.12. Abandonment of buildings and warehouses used for industrial, commercial or military purposes	Likert scale
4.13. Construction/land consumption	Likert scale
4.14. Road accidents	Likert scale
4.15. Electromagnetic pollution	Likert scale
4.16. Noise pollution	Likert scale
4.17. Other category (specify)	Open-ended
4.17.1. Assessment of "Other category"	Likert scale

5. Identify (no more than) three places in/aspects of the FVG region that are of particular value/quality to you.

Questions	Question type
5.1. As a first aspect, do you want to identify a point, a line or a polygon?	Multiple-choice
5.1.1. Mark on the map a first place perceived as of quality in FVG.	Map
5.2. Specify the place/aspect identified.	Open-ended
5.3. Why is it of value/quality to you?	Open-ended
5.4. As a second aspect, do you want to identify a point, a line or a polygon?	Multiple-choice
5.4.1. Mark on the map a second place perceived as of quality in FVG.	Map
5.5. Specify the place/aspect identified.	Open-ended
5.6. Why is it of value/quality to you?	Open-ended
5.7. As a third aspect, do you want to identify a point, a line or a polygon?	Multiple-choice
5.7.1. Mark on the map a third place perceived as of quality in FVG.	Map
5.8. Specify the place/aspect identified.	Open-ended
5.9. Why is it of value/quality to you?	Open-ended

6. Identify (no more than) three places in/aspects of the FVG region that you think are in a particularly critical/degraded state.

Questions	Question type
6.1. As a first aspect, do you want to identify a point, a line or a polygon?	Multiple-choice
6.1.1 Mark on the map a first place perceived as degraded in FVG.	Map
6.2. Specify the place/aspect identified.	Open-ended
6.3. Why is it critical/degraded to you?	Open-ended
6.4. As a second aspect, do you want to identify a point, a line or a polygon?	Multiple-choice
6.4.1. Mark on the map a second place perceived as degraded in FVG.	Map
6.5. Specify the place/aspect identified.	Open-ended
6.6. Why is it critical/degraded to you?	Open-ended
6.7. As a third aspect, do you want to identify a point, a line or a polygon?	Multiple-choice
6.7.1. Mark on the map a third place perceived as degraded in FVG.	Map
6.8. Specify the place/aspect identified.	Open-ended
6.9. Why is it critical/degraded to you?	Open-ended

PERSONAL DATA

Questions	Question type
7. Sex	Multiple-choice
8. Age group	Multiple-choice
9. Professional status	Multiple-choice
9.1. Other status	Open-ended
10. Qualification	Multiple-choice
11. State your place of residence. If you live in FVG, select the municipality.	Multiple-choice

For those who live in Italy but not in FVG (If you answer "other Italian region" go to Questions 11.1–11.3. If you answer "abroad" to Question 11, go to Questions 11.4–11.6)

Questions	Question type
11.1. State your region of residence.	Multiple-choice
11.2. What is your reason for being in FVG? (main reason)?	Multiple-choice
11.2.1. Other reason (specify).	Open-ended
11.3. State the municipality frequented in FVG.	Multiple-choice

For those who does not live in Italy (conditional on Q11= “abroad”)

Questions	Question type
11.4. State your country of residence.	Multiple-choice
11.5. What is your reason for being in FVG?	Multiple-choice
11.5.1. Other reason (specify).	Open-ended
11.6. State the municipality frequented in FVG.	Multiple-choice