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## **Combining discourses and maps to grasp nature perceptions: Insights from a PPGIS case study in Martinique (Lesser Antilles)**

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### **► To cite this version:**

Romain Monassier, Marylise Cottet, H el ene Mathian, Anne Rivier e-Honegger, Quentin Hejda. Combining discourses and maps to grasp nature perceptions: Insights from a PPGIS case study in Martinique (Lesser Antilles). *Applied Geography*, 2023, 158, pp.103047. <10.1016/j.apgeog.2023.103047>. <halshs-04169232>

**HAL Id: halshs-04169232**

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Submitted on 1 Oct 2025

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Title: Combining discourses and maps to grasp nature perceptions: insights from a PPGIS case study in Martinique (Lesser Antilles)

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Aknowledgements: This work was supported by the Fondation de France. The funder had no involvement in the present study. We thank the anonymous referees for their very helpful comments. We are very grateful to Joanne Hughes who translated the article and to Peng Gao who proof read the text. We used data in open access for the creation of the maps and data analysis.

Declarations of interest: none.

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## 1 Abstract

2 Understanding human-nature relationships has become both a theoretical and an  
3 operational issue with the increasing adoption of participatory approaches in  
4 environmental management. PPGIS methods are widely used for their ability to  
5 demonstrate these relationships as spatial patterns on a map and to reach a large and  
6 spatially distributed audience. The resulting spatial data are generally decoupled from  
7 participants' discourses, even though the latter can provide original and nuanced  
8 insights into what lies underneath the map, therefore human-nature relationships. Here,  
9 we conducted a web-mapping survey in Martinique (Lesser Antilles) to understand  
10 inhabitants' perceptions of "rich nature". We proposed a quantitative method combining  
11 the spatial data sketched by inhabitants with their discourse data to investigate their  
12 perceptions of "rich nature". Our results indicated a strong relationship between the "rich  
13 nature" perception and its spatial representation. The validity of the method was  
14 strengthened by good participation levels (n=573) and geographical representativeness,  
15 although socio-demographic representativeness was not reached. This approach  
16 confirmed the added value of discourses in participatory mapping, hence supporting a  
17 PPGIS method that combines both mapping and participants' discourses.

18 Keywords: PPGIS; Human-nature relationship; Rich nature; Martinique; Internal and  
19 external validity.

## 20 1. Introduction

21 Humans build plural relationships with natural places that can be considered as either  
22 cognitive, affective, or conative (Jorgensen & Stedman, 2006). Environmental managers

23 are aware that they should integrate human-nature relationships in their decisions to  
24 design, reinforce, and legitimate their actions (Jankowski et al., 2021; Rivière-Honegger  
25 et al., 2015). Participatory approaches were conducted to address this operational issue  
26 (Reed, 2008).

27 PPGIS (Public Participation Geographic Information System) refers to the use of geo-  
28 technologies and other spatial tools to widen public implication in policymaking (McCall  
29 & Dunn, 2012; Sieber, 2006). They were broadly used to engage stakeholders in  
30 mapping their relationships with natural places (Brown & Kyttä, 2014; McLain et al.,  
31 2013). Despite differences in contexts, spatial scales, purposes, and research themes,  
32 PPGIS approaches share a methodological common ground (Brown et al., 2017; Brown  
33 & Kyttä, 2014; Fagerholm et al., 2021). The most frequent data collection method is to  
34 ask participants to map spatial attributes using web-mapping and self-administered  
35 surveys (or geo-questionnaire; Jankowski et al., 2016). PPGIS applications applied a  
36 variety of spatial attributes (Brown, 2012; Brown & Kyttä, 2014; Fagerholm et al., 2021),  
37 among which the landscape values typology (e.g. aesthetic, recreation, biological  
38 values) is the most popular (Brown et al., 2020). Once gathered, the spatial data are  
39 explored and analyzed with different quantitative methods (Fagerholm et al., 2021).  
40 Density estimations are extensively used to identify collectively designated areas,  
41 namely “hotspots” (Alessa et al., 2008).

42 PPGIS studies vary in the design of the mapping question (the spatial attribute to be  
43 mapped, the vocabulary), the design of the survey (hardcopy or digital map, base map),  
44 and the participants (expertise, acquaintance with the territory, mapping experience,  
45 socio-demographic characteristics), hence differences in data outcomes and quality

46 (Nahuelhual et al., 2016). We may refer to internal validity and external validity to  
47 estimate the validity of a participatory mapping research design (Campbell & Stanley,  
48 1963). Following Brown et al. (2017), internal validity refers to “the control of threats that  
49 provide alternative explanations” and external validity to “the degree of generalization to  
50 other places or persons” (p. 154). A PPGIS method shows external validity if it provides  
51 representative samples of the population, but also of the geographical area under study.  
52 External validity depends on the sampling strategy, size, and representativeness  
53 (Fagerholm et al., 2021; Lechner et al., 2014). PPGIS output presents internal validity if  
54 it “shows what it is believed to show” (Lechner et al., 2014, p. 1502), i.e., if PPGIS  
55 provides relevant, reliable and precise data to measure and interpret human-nature  
56 relationships.

57 The scientific literature provides information on the external and internal validity of  
58 PPGIS research designs. Regarding external validity, web-mapping surveys are likely to  
59 reach a large and spatially distributed audience (Jankowski et al., 2016), albeit  
60 embedded with potential response bias (Brown, 2012, 2017). In particular, it is assumed  
61 that participants locate places they know better, or are attached to, hence they are  
62 geographically close to, which could result in a sample of places that is  
63 unrepresentative of the study area (a bias called spatial discounting) (Brown et al.,  
64 2020). Regarding internal validity, predefined typologies are a replicable, standardized,  
65 and convenient method in PPGIS, and were applied to a variety of contexts (Brown et  
66 al., 2020). However, they have two main limitations. First, they predicate that “values  
67 always accord with typologies” (Stephenson, 2008, p. 128). In other words, the listed  
68 values are assumed to be understood and to faithfully account for participants’

69 relationships with natural places (Cervený et al., 2017). Yet, spatial attributes are not  
70 equally challenging from a cognitive standpoint (Brown, 2017), and there is concern that  
71 participants neglect the vaguer values in favor of the simpler ones. A recent literature  
72 review indicated that the recreation value was one of the most frequently mapped  
73 values (Brown et al., 2020). Biedenweg et al. (2019) demonstrated that the recreation  
74 value modified the mapped results when included within the typology, therefore  
75 overshadowing other, equally heuristic, values. Recreation is probably popular because  
76 it is more concrete or simpler to associate with a natural place than other values  
77 (Biedenweg et al., 2019; Cervený et al., 2017). A second assumption about predefined  
78 typologies is that they “encompass all values” (Stephenson, 2008, p. 128). From a  
79 content analysis, other studies (Cervený et al., 2017; Plieninger et al., 2018) unearthed  
80 different values from those typically proposed in PPGIS typologies. A predefined list of  
81 values may not detect these broader relationships and, as such, does not appear to be  
82 exhaustive. It was suggested to add a category “other” to the existing typologies (Brown  
83 et al., 2017), or even to create a context-specific list of local values based on a  
84 preliminary phase of interviews (e.g., Plieninger et al., 2018), to take this variability into  
85 account. However, these solutions alone do not address the limitations raised by  
86 predefined typologies in terms of internal validity, namely the collection of equivocal,  
87 biased and/or truncated data.

88 Discourses have been used as supplemental material in participatory mapping because  
89 they provide new insights into understanding participants’ maps, interpretations of the  
90 spatial query, and relationships with natural places (Bijker & Sijtsma, 2017; Cervený et  
91 al., 2017; Huck et al., 2014; Lowery & Morse, 2013; Nahuelhual et al., 2016; Plieninger

92 et al., 2018; Verbrugge et al., 2022). In this regard, discourses have the potential for  
93 enhancing the internal validity of participatory mapping approaches solely based on  
94 spatial data. Qualitative approaches, including semi-structured interviews or workshops  
95 (e.g., Cottet et al., 2023; Fagerholm et al., 2019; Klain & Chan, 2012; Lowery & Morse,  
96 2013) were conducted for this purpose, but generally lack external validity due to small  
97 sampling size. In quantitative approaches, discourses were collected using open-ended  
98 questions in web-mapping surveys but mostly analyzed qualitatively, e.g. by content  
99 analysis (e.g., Knaps et al., 2022; Plieninger et al., 2018; Verbrugge et al., 2022), with  
100 the notable exception of Huck et al. (2014) who used Natural Language Processing  
101 techniques to combine free-text data with PPGIS spatial data. By opting for either rather  
102 qualitative or quantitative approaches, participatory mapping research designs oscillate  
103 between internal and external validity (Brown et al., 2017). Mixed methods were  
104 advanced as a methodological conciliation, but they require important financial costs  
105 (Brown et al., 2017). In this regard, the tension between internal and external validity in  
106 PPGIS studies has yet to be solved. Textual data analysis (or text mining)  
107 encompasses a range of methods for corpora data processing (Lebart et al., 2019).  
108 Although robust on survey data, these methods have not yet been exploited in a PPGIS  
109 research design and deserve particular attention.

110 Based on these considerations, we hypothesize that the combined production of spatial  
111 data and discourse data within the framework of a web-mapping survey makes it  
112 possible to increase both the external and internal validity compared to the methods  
113 traditionally employed in participatory mapping, i.e., quantitative approaches involving  
114 predefined typologies, or qualitative approaches through semi-structured interviews. In

115 this perspective, this paper aims to propose a method based on textual data analysis  
116 that facilitates the joint analysis of open-ended and mapping questions in web-mapping  
117 surveys and to assess its contribution in terms of external and internal validity. For this  
118 purpose, we relied on a web-mapping survey conducted in Martinique (Lesser Antilles).  
119 Participants were asked to map “rich nature” using polygons and to explain their  
120 mapping in a free-text response. All the polygons sketched by the participants were  
121 aggregated to produce hotspots of “rich nature”, that we will hereafter call *collective*  
122 *maps of "rich nature"* in Martinique.

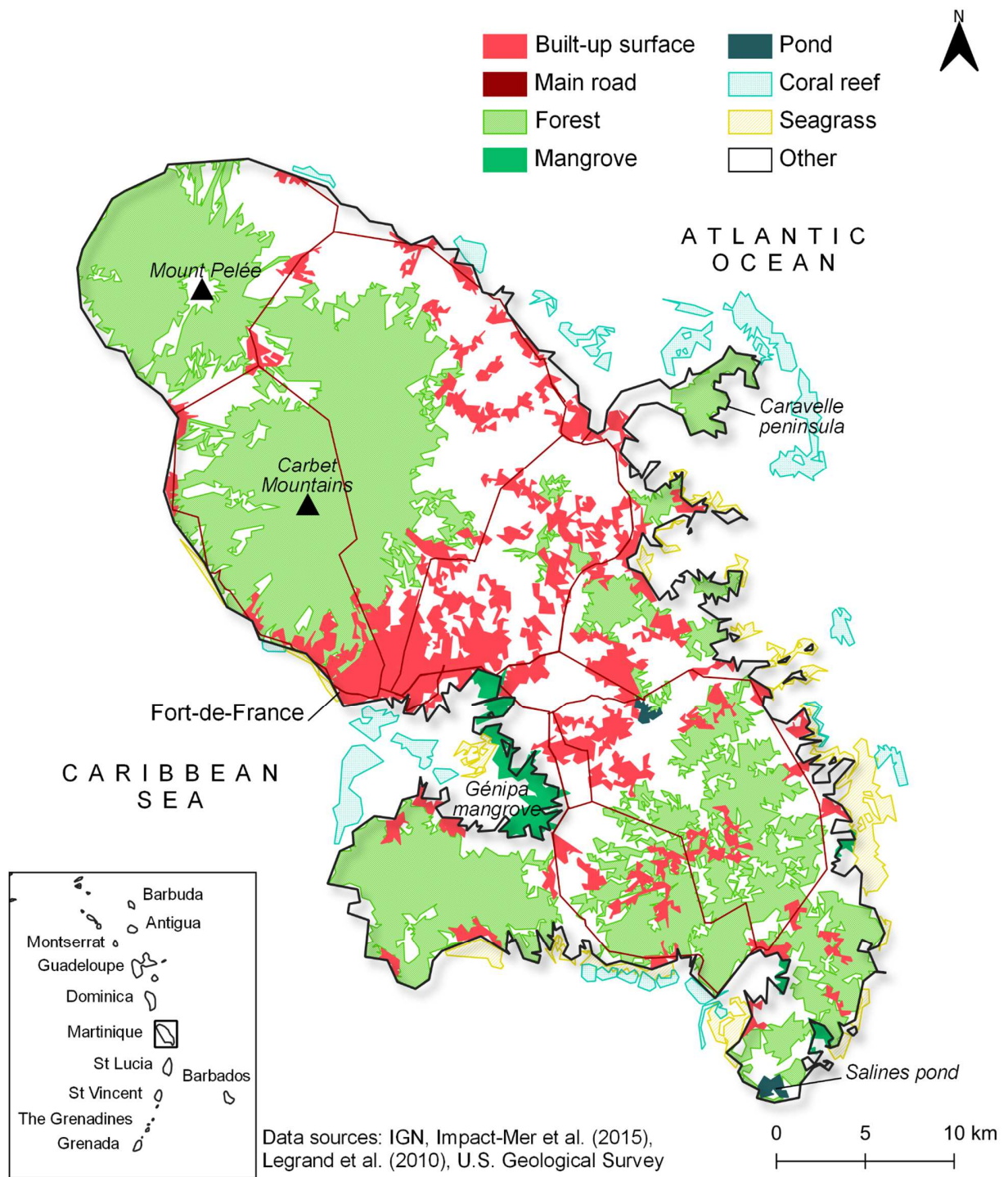
123 To demonstrate the internal validity of our method, we investigated how concurrent the  
124 collective maps of “rich nature” were with and without the integration of discourses. To  
125 do so, we first analyzed all the polygons and produced an overall collective map of “rich  
126 nature”. Second, we analyzed discourses using textual data analysis and identified the  
127 main types of collective perception of “rich nature”. Using these types, we subdivided  
128 the polygon dataset into several subsets, analyzed their spatial characteristics, and  
129 produced a collective map for each subset. Finally, the collective maps - the overall one  
130 vs those based on types - were compared by measuring their spatial accordancy. We  
131 assessed the external validity of our method in terms of sample size, and socio-  
132 demographic and geographical representativeness.

## 133 2. Materials and methods

### 134 2.1. Study area

135 Martinique is a 1,128 km<sup>2</sup> volcanic island in the Lesser Antilles of the Caribbean with a  
136 total population of 361,225 (2020). It has a wet, tropical climate characterized by two

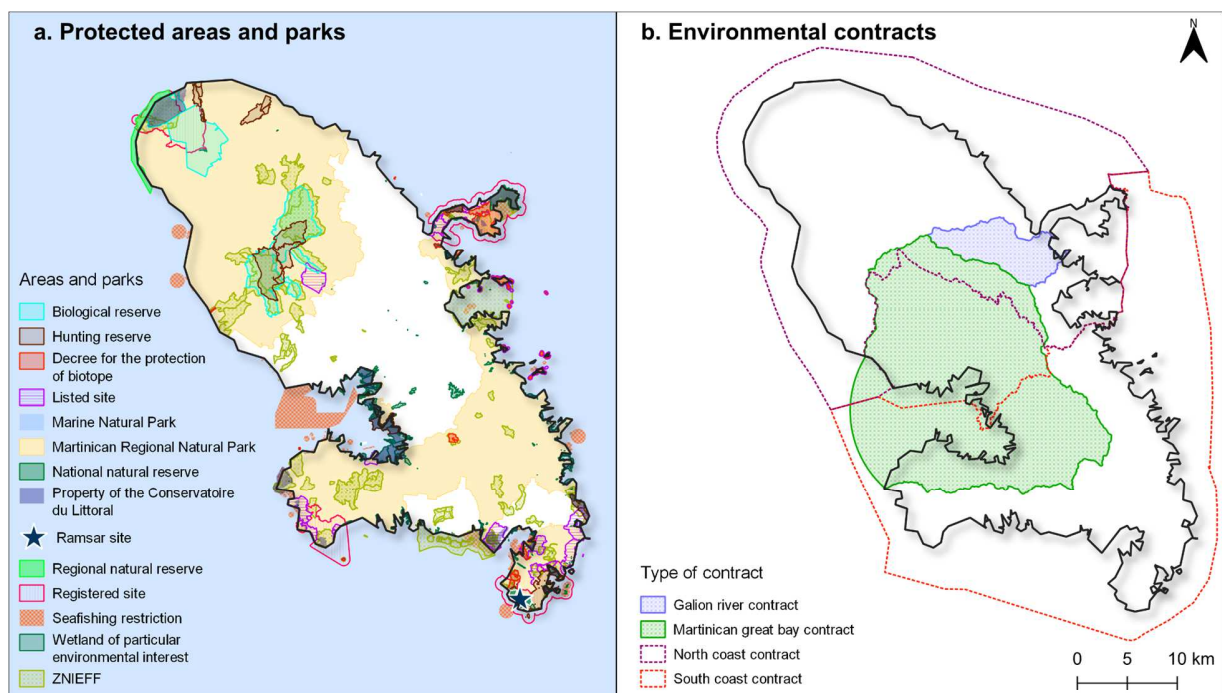
137 seasons: a dry season and an intermediate wet season. In Martinique, there are large  
138 forest areas, wetlands, and marine habitats that involve seagrass and coral reefs  
139 (Impact-Mer et al., 2015; Legrand et al., 2010) (Figure 1).



140

141 Figure 1: Geography of Martinique and its land-cover types.

142 Martinican ecosystems face numerous anthropogenic threats, including urbanization,  
 143 hyper sedimentation, and pollution from agricultural sources (Bouchon et al., 2002;  
 144 Della Rossa et al., 2017). These perturbations are intensified by the insular context  
 145 (Gros-Désormeaux, 2012) and have led to the degradation and destruction of the  
 146 island's wetlands (Impact-Mer et al., 2015). They partly contributed to loosening the ties  
 147 of the inhabitants to nature. Inhabitants nevertheless demand that authorities care about  
 148 and monitor ecosystems (Morandi et al., 2015, 2017). Environmental managers  
 149 deployed regulatory tools to conserve the island's ecosystems, such as protected areas  
 150 and parks (Figure 2a), along with environmental contracts (Figure 2b). The 2021  
 151 candidacy of the volcanoes and forests of Mount Pelée and the Northern Pitons to the  
 152 UNESCO World Heritage List goes in this direction (Louis-Régis et al., 2020).



153

Data sources: IGN, INPN, MNHN, DEAL Martinique, O.D.E. Martinique

154 Figure 2: Regulatory protection perimeters in Martinique: protected areas and parks (a)  
155 and environmental contracts (b).

156 Managers are inclined to implement participatory management. In this perspective, they  
157 report a need for information about human-nature relationships in Martinique and have  
158 initiated a partnership with social science researchers. This paper results from this  
159 collaboration.

## 160 2.2. A web-mapping survey to collect spatial and textual data

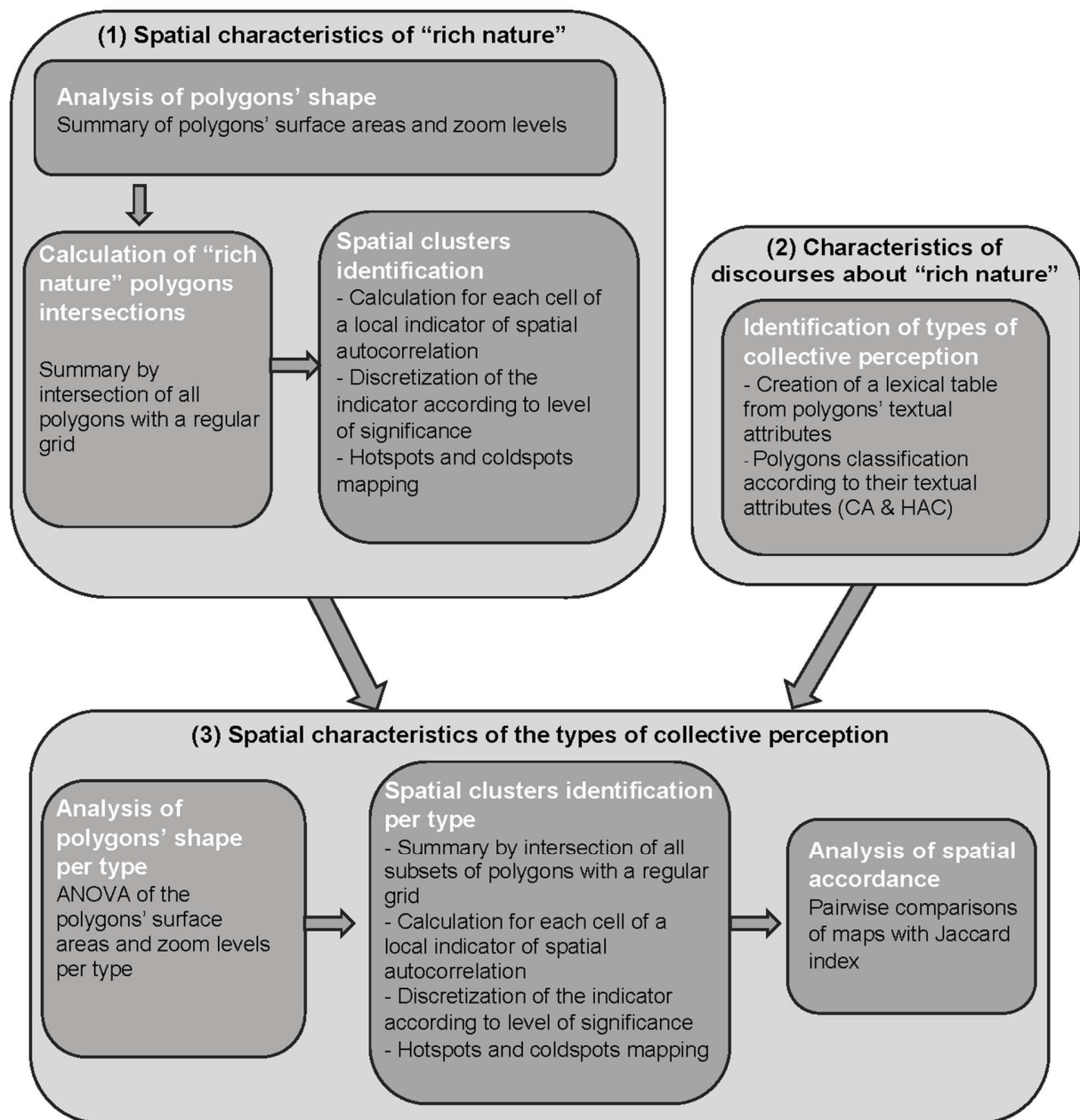
161 We developed a web-mapping survey using Maptionnaire (<https://maptionnaire.com/>) to  
162 ask Martinicans residents over 18 years old about their relationships with nature.  
163 Among other spatial and non-spatial questions, participants were asked to “*circle*  
164 (“entourer”) on a map at least two areas of Martinique, which host *rich nature* according  
165 to [them]”, and to explain their choice in a free-text response. The designation of “rich  
166 nature” was deliberately vague so as not to impose a fixed definition of nature: it  
167 circumvented the more restrictive term “biodiversity” (Ducarme & Pautard, 2021) and  
168 permitted a free interpretation. Participants were also asked to locate their dwelling with  
169 a point feature and, ultimately, to fill in socio-demographic information.

170 The survey was tested with about 20 partners of the study (environmental managers  
171 and researchers) and revised. It was officially launched from June 17th, 2020, to July  
172 31st, 2020. Satisfactory participation in web-mapping surveys is not always assured  
173 (Garcia et al., 2020), which is why we took particular care in its dissemination. We sent  
174 the survey to a contact base of 250 interlocutors (researchers, environmental  
175 managers, local organizations, sports clubs, firms, and local authorities) who were

176 asked to share the survey in their networks. We also promoted the survey on social  
177 (Facebook, WhatsApp) and local (radio, television, press) media and funded two  
178 advertising campaigns on Facebook, which greatly improved participation levels. The  
179 web-mapping survey could be filled in using a computer, tablet, or smartphone. The  
180 interface was a satellite image at the regional scale with toponymic information. The  
181 survey was provided with a video tutorial to guide users through the exercise.

182 2.3. A method to identify and map different types of collective perception of “rich nature”  
183 We collected both spatial (sketched polygons) and textual (free-text annotations)  
184 materials about “rich nature”, therefore we combined methods of spatial and textual  
185 analysis into a single framework (Figure 3).

186 We first analyzed the spatial characteristics of “rich nature” areas, in terms of location  
187 and shape, and produced, with individual polygons, an overall map of the perception of  
188 “rich nature” in Martinique (1). Then, we analyzed the free-text annotations thanks to  
189 textual data analysis. In particular, we aggregated participants’ annotations into different  
190 categories, hereafter called “types of collective perception” (2). Lastly, we produced a  
191 map for each type of collective perception and examined its spatial characteristics. We  
192 assessed the spatial accordance (or concurrence) between the maps of “rich nature”  
193 with a spatial metric (3).



194

195 Figure 3: Spatial and textual data processing flow chart.

196 2.3.1. Analysis of the spatial dimension of "rich nature" areas - Spatial analysis

197 **Analysis of polygons' shape**

198 By sketching polygons on a map, participants shaped their perceptions of "rich nature"  
199 at a certain scale. We analyzed these characteristics using two indicators: the polygons'  
200 surface areas and the zoom level at which they were digitized. The surface areas were  
201 calculated using GIS, and the zoom level was automatically stored after digitization. We  
202 identified surface area outliers and eliminated polygons larger than 300 km<sup>2</sup> (8.8% of  
203 them), which covered too large marine and/or continental areas to be considered in the  
204 same way as the other polygons. With the zoom level, we acknowledged that  
205 participants could choose a different zoom level (i.e., scale) depending on the  
206 information to be mapped (Hewitt et al., 2020).

207 **Analysis of polygons' spatial location**

208 Delineating hotspots from participatory mapping data is a way of identifying special  
209 places in the eyes of the participants (Alessa et al., 2008; Karimi et al., 2015). Spatial  
210 clusters were plotted with a local spatial statistic, in two steps (see Karimi et al., 2015):

- 211 i) First, we intersected all the polygons with a regular 500 m<sup>2</sup> grid. Each cell was  
212 assigned the total number of intersecting polygons, i.e., the number of times  
213 the cell has been included in a participant's "rich nature" sketch.
- 214 ii) Second, we calculated a local spatial autocorrelation index: Getis-Ord  $G_i^*$ .  
215 This index measured the local spatial autocorrelation of each grid's cell, which  
216 made it possible to identify zones where polygons' concentration was  
217 significantly high (hotspots) and low (coldspots).

218 Thus, hotspots designated places that were representative of “rich nature”, while  
219 coldspots indicated which places were significantly less targeted as “rich nature”. We  
220 identified five types of zones based on the values related to the significance of the  
221 concentration, in other words, on the value of the “rich nature” score. Any zone with a  
222 significance value exceeding 1.96 (resp. under -1.96) was considered a major hotspot  
223 of “rich nature” (resp. major coldspot), while any zone with a value between 1 and 1.96  
224 (resp. -1 and -1.96) was considered a minor hotspot of “rich nature” (resp. minor  
225 coldspot). When the significance value was between -1 and 1, the local concentration  
226 was considered nonsignificant. The Getis-Ord index was calculated with the R library  
227 “spdep”, and the hotspots mapped in QGIS 3.4 based on the above-mentioned  
228 thresholds.

### 229 2.3.2. Analysis of the discourses about “rich nature” areas - Textual analysis

230 We applied an exploratory method to uncover the main interpretations of the “rich  
231 nature” notion. We relied on textual data analysis methods (Lebart et al., 2019) to  
232 quantitatively analyze participants’ discourses. First, we turned the textual data into  
233 lexical data, (i.e., the presence-absence data concerning each of the corpus words).  
234 Then, we filtered the lexicon by removing tool-words and applying a frequency  
235 threshold. The resulting table is called a lexical table. Next, we computed each word’s  
236 frequency and analyzed the lexical table with a Correspondence Analysis (CA) followed  
237 by a Hierarchical Ascendant Classification (HAC). The combination of both methods  
238 enabled us to determine the structure of the corpus and to cluster participants’ answers  
239 according to their lexicon (Lebart et al., 2019), producing what we call *types of collective*  
240 *perception*. The textual analysis was performed with the R library “XplorText”.

241 2.3.3. Analysis of the spatial dimension of the types of collective perception of “rich  
242 nature”

243 We used the types of collective perception of “rich nature” as polygons’ attributes and  
244 subsetted the polygons according to their type. We repeated the aforementioned spatial  
245 analysis to the total dataset and the polygon subsets.

246 i) Differences in surface areas and zoom levels between types of collective  
247 perception were tested using Kruskal-Wallis ANOVA with Dunn’s test as a post  
248 hoc test.

249 ii) Differences in locations between two collective maps (including the overall map)  
250 were quantified by comparing the degree of spatial accordance (overlap)  
251 between their hotspots (Brown et al., 2014). We used the Jaccard index, a  
252 similarity coefficient, to quantify the overlap percentage between the hotspots  
253 (minor and major) of two given maps (Karimi et al., 2015). A strong coefficient  
254 (close to 100%) indicated total overlap, while a weak coefficient (close to 0%)  
255 denoted an absence of overlap.

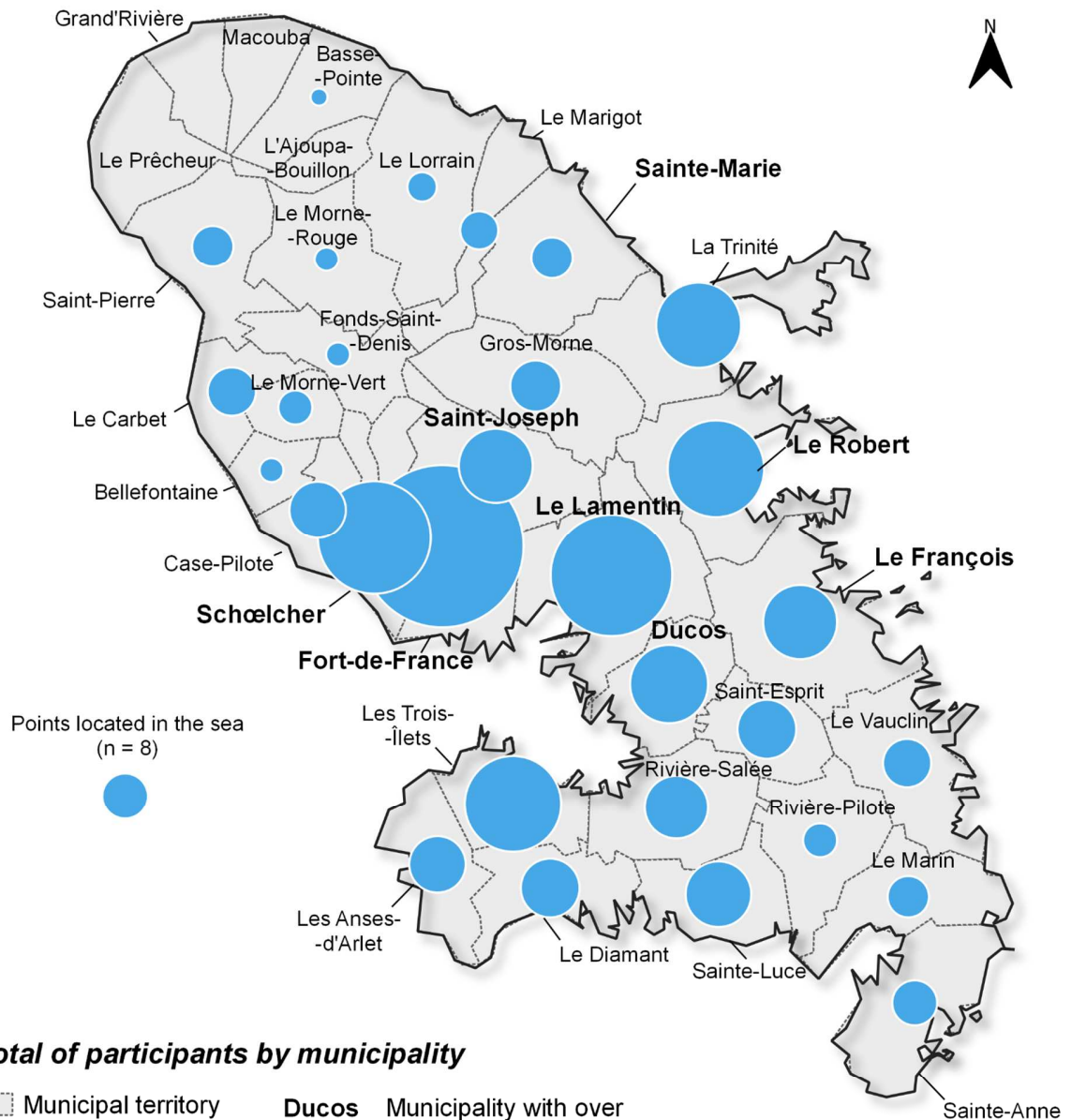
## 256 3. Results

### 257 3.1. Sample description

#### 258 3.1.1. Participants

259 The survey was partially completed by 1,138 inhabitants with 573 individuals answering  
260 the question “circle on a map at least two areas of Martinique, which host rich nature  
261 according to you”. Out of the 573 participants, 425 also filled in the socio-demographic  
262 variables, which were then used to compare with the 2018 census (the French Institut

263 national de la statistique et des études économiques [INSEE]) to estimate the survey's  
264 socio-demographic representativeness. We noted a slight overrepresentation of women  
265 (63.8% of participants, although they represent 54.0% of Martinicans), a large  
266 overrepresentation of executives and higher intellectual professions (49.3% instead of  
267 5.2%) as well as of craftspeople, merchants, and company managers (8.0% instead of  
268 3.9%) coupled with underrepresentation of workers (0.8% instead of 3.9%) and  
269 pensioners (5.8% instead of 25.2%). Regarding the demographic structure of the  
270 sample, we noted an overrepresentation of the 25- to 39-year individuals (35.1%  
271 instead of 18.0% of Martinicans), and underrepresentation of the over 65-year  
272 inhabitants (5.6% instead of 25.8%). 70.8% of participants were between 25 and 54  
273 years old. Among the 573 respondents, 490 digitized their place of residence, which we  
274 aggregated at a municipal scale (Figure 4).

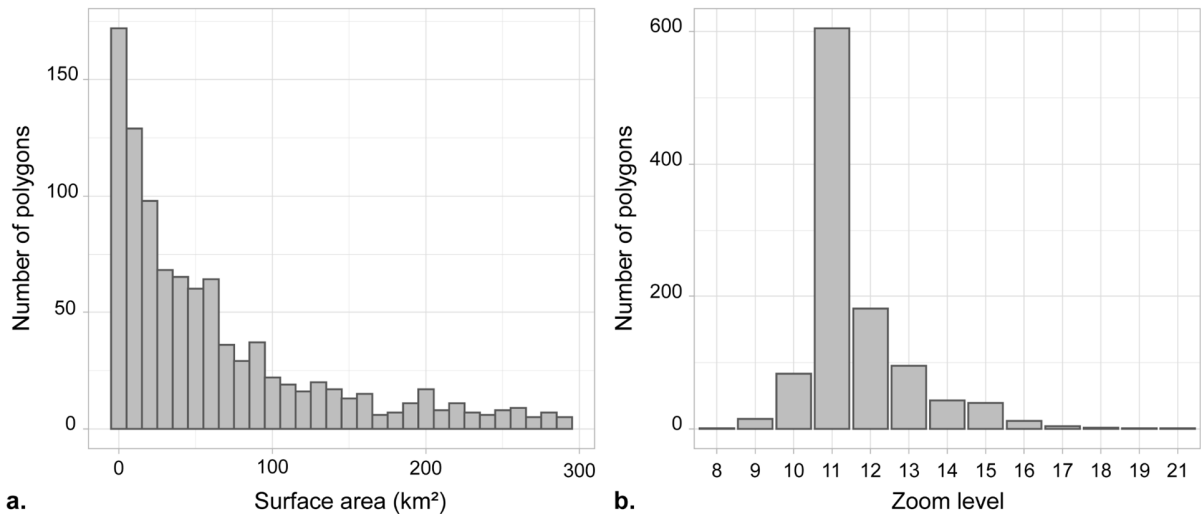


276 Figure 4: Municipal distribution of the participants who answered the question “circle on  
277 a map at least two areas of Martinique, which host rich nature according to you”  
278 (n=490).

279 Fort-de-France had the most participants (n=91), followed by the municipalities of its  
280 urban area (Le Lamentin, Schœlcher). We noticed weak participation in the northern  
281 half of the island. The municipal proportions of the participants were highly correlated  
282 with those of the population in Martinique ( $R=0.93$ ;  $p\text{-value} < 0.005$ ). Therefore, the  
283 surveyed sample represented the municipal distribution of the Martinican population.

### 284 3.1.2. Polygons

285 Overall, 1,082 polygons of “rich nature” were digitized. The number of polygons varied  
286 from one to seven depending on the participant. 22.0% of participants sketched only  
287 one polygon, and therefore, did not follow the instruction, 70.5% drew two polygons,  
288 and 7.5% more than two. Polygons’ surface areas varied from a few square meters to  
289 11,871.4 km<sup>2</sup>. Outliers excluded, the surface areas’ mean was 63.6 km<sup>2</sup>, the 1st quartile  
290 10.7 km<sup>2</sup>, the 3rd quartile 89.9 km<sup>2</sup>, and the median 40.0 km<sup>2</sup> (i.e., the surface area of a  
291 large Martinican municipality) (Figure 5a). Around 73.0% of the polygons were drawn at  
292 the scale of a city (zoom of 11 or 12) (Figure 5b).



293 **a.** **b.**

294 Figure 5: Surface areas (a) and zoom levels (b) of the polygons digitized by the  
 295 participants. Outliers were removed before plotting.

296 3.1.3. Textual data

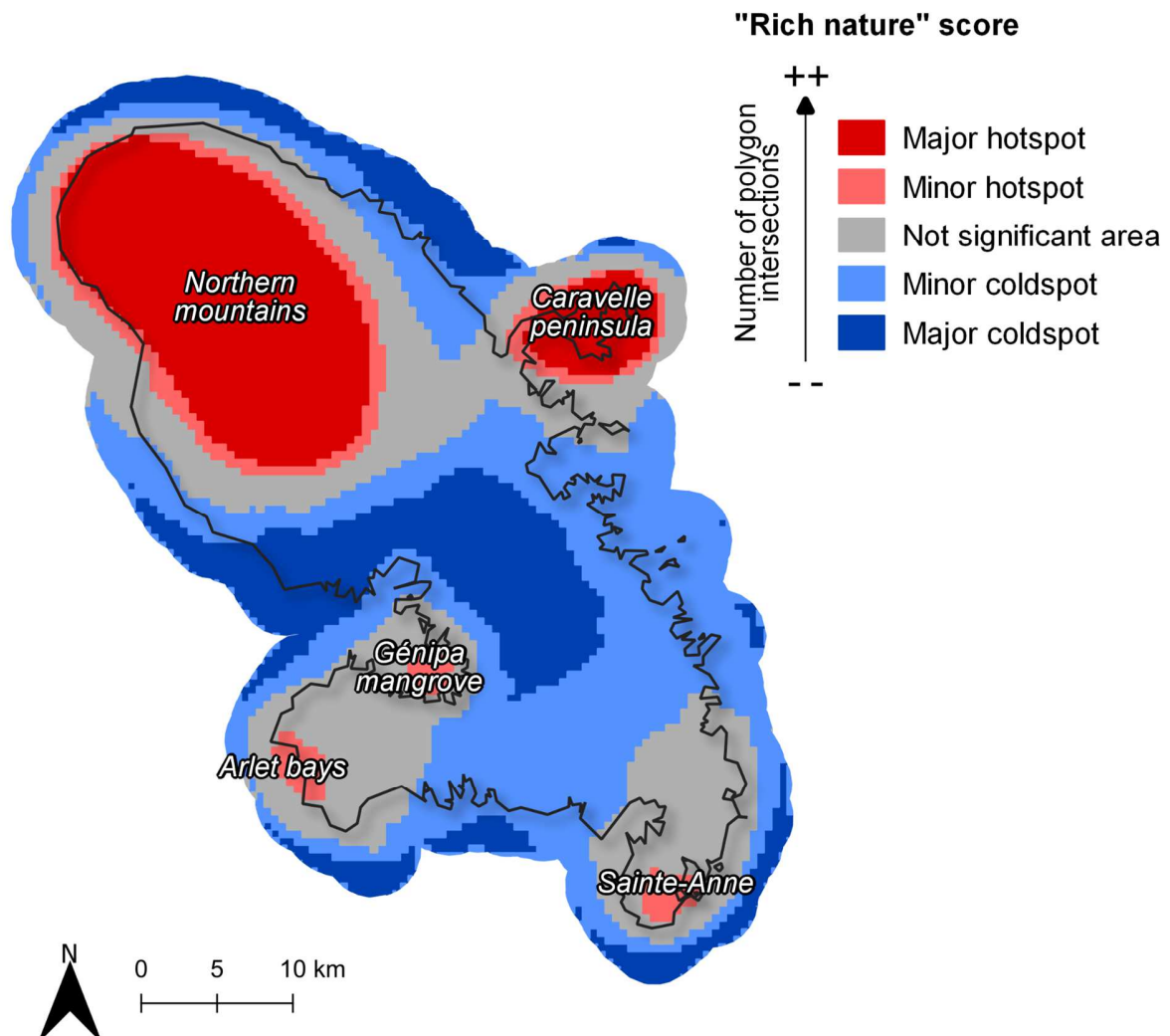
297 494 of the 573 respondents (86.2%) added textual information to their digitization of the  
 298 “rich nature” areas, which applied to 885 of the 1,082 polygons (81.8%). The textual  
 299 data samples contained 2 to 51 words, with an average of 10 words. The initial corpus  
 300 consisted of 1,331 different words.

301 3.2. “Rich nature” in Martinique

302 3.2.1. An overall map of “rich nature”

303 Analysis of the polygons’ spatial location indicated two major hotspots: the Northern  
 304 mountains and the Caravelle peninsula (Figure 6). The Northern mountains of  
 305 Martinique (including Mount Pelée and the Carbet Mountains) grow at an altitude of 0 to  
 306 1,395 m. They constitute a large mountainous mosaic of tropical seasonal evergreen,  
 307 ombrophilous, and dry forests, with a high rate of endemism of plant and animal

308 species. The Caravelle peninsula is a small peninsula with an alternation between  
309 coastal and inland habitats, ranging from mangroves, herbaceous savannas, and  
310 thickets, to sylvatic formations. It was traditionally devoted to agricultural purposes, of  
311 which the ruins of the old plantation complex Château Dubuc are a relic. Both hotspots  
312 are emblematic Martinican areas, low urbanized (Figure 1), and subjected to plural  
313 regulations (e.g., National Natural Reserve of the Caravelle Peninsula) (Figure 2). Minor  
314 hotspots included the largest mangrove of the island, the Génipa mangrove, located in  
315 front of the capital, Fort-de-France; the Arlet bays and sandy beaches on the Caribbean  
316 coast; the Sainte-Anne site combining different natural features, i.e., a savannah, a  
317 large wetland (Salines Pond) and a mangrove, all of them being bordered by a hiking  
318 trail. Meanwhile, the largest Martinican agglomeration, Fort-de-France, and the  
319 Southern lowland and agricultural areas were coldspots of “rich nature”.



320

321 Figure 6: Location of hotspots and coldspots of "rich nature" areas based on the total  
 322 dataset.

### 323 3.2.2. "Rich nature" discourses

324 We built a lexicon with the 86 words appearing at least 12 times and selected the 829  
 325 answers having at least two of these words. The analysis was conducted on the French  
 326 answers, but the words were finally translated from French to English for the  
 327 convenience of reading this paper. Literal French answers are indicated between

328 brackets. The most frequently used words were “area” (“zone” in French) (used in 185  
 329 answers), “rich” (“riche”) (n=109), “fauna” (“faune”) (n=89), “mangrove” (“mangrove”)  
 330 (n=87), “species” (“espèces”) (n=85), “biodiversity” (“biodiversité”) (n=83), and “flora”  
 331 (“flore”) (n=71). A HAC was carried out on the nine first dimensions (19.1% of the  
 332 inertia) of the CA performed on the lexical table. The HAC distinguished seven types.  
 333 Table 1 characterizes each of these types by its number of answers (polygons) and its  
 334 number of participants, by its characteristic words (with |test value| > 2 and p-value <  
 335 0.05), and by its paragon individuals’ literal answers (i.e., individuals closest to the  
 336 center of a type).

337 Table 1: Characteristics of the seven types of collective perception of “rich nature”.

Type	Name	Number of answers (n=829)	Number of participants	Characteristic words ( <i>initial French version</i> )	Paragons’ literal answers ( <i>initial French version</i> )
T1	Coastal areas	248 (29.9%)	195	species (“espèces”), a lot (“ <i>beaucoup</i> ”), mangrove (“ <i>mangrove</i> ”), fish (“ <i>poisson</i> ”), space (“ <i>espace</i> ”), turtles (“ <i>tortues</i> ”), protected (“ <i>protégé</i> ”), numerous (“ <i>nombreuses</i> ”), reproduction (“ <i>reproduction</i> ”), animal (“ <i>animales</i> ”), birds (“ <i>oiseaux</i> ”), bay (“ <i>baie</i> ”), crabs (“ <i>crabes</i> ”), to observe (“ <i>observer</i> ”), large (“ <i>grande</i> ”), to preserve (“ <i>préserver</i> ”), marine (“ <i>marines</i> ”)	- “Area with some mangrove, rich in marine species and birds” (“ <i>Zone ayant une partie de mangrove, riche en espèces marines et oiseaux</i> ”) - “Earth/sea interface that must be protected, reproduction area for numerous marine and terrestrial species; protection of land/cyclonic swells” (“ <i>Interface terre/mer qui doit être protégée, zone de reproduction de nombreuses espèces marines et terrestres ; protection des terres/houles cycloniques</i> ”) - “The mangrove is an incredible place of biodiversity for the fish, the birds” (“ <i>La mangrove est un espace de biodiversité incroyable pour les poissons, oiseaux</i> ”)
T2	Wild and non-urban nature	49 (5.9%)	40	few/little (“ <i>peu</i> ”), urbanized (“ <i>urbanisée</i> ”), wild (“ <i>sauvage</i> ”)	- “Area with few dwellings and no road” (“ <i>Zone où il y a peu d’habitations et pas de route</i> ”) - “It is preserved because it is not very accessible” (“ <i>Elle est préservée car peu accessible</i> ”) - “Rich and wild nature, little urbanized” (“ <i>Nature riche et sauvage, peu urbanisée</i> ”)

T3	Tropical forests	90 (10.9%)	87	forest ("forêt"), luxuriant ("luxuriante"), river ("rivière"), vegetation ("végétation"), tropical ("tropicale"), nature ("nature"), dense ("dense"), mountain ("montagne"), wet ("humide"), magnificent ("magnifique")	- "Rich and dense forest" ("Forêt riche et dense") - "Green nature! A relatively preserved area, without too much pollution on the paths. The forest is so dense there!" ("Verte nature ! Une zone plutôt préservée, sans trop de pollution sur les sentiers. La forêt y est si dense !") - "Tropical forest area with numerous rivers" ("Zone de forêt tropicale dense avec de nombreuses rivières")
T4	Biodiversity	247 (29.8%)	206	fauna ("faune"), flora ("flore"), biodiversity ("biodiversité"), rich ("riche"), marine ("marine"), very ("très"), richness ("richesse"), aquatic ("aquatique"), area ("zone"), life ("vie"), protected ("protégée"), coastline ("littoral")	- "It is an area that is very rich in flora and wild fauna. The walk there is magnificent, the landscapes varied. It is an area rich in history with the Château Dubuc" ("C'est une zone très riche en flore et en faune sauvage. La promenade est magnifique, les paysages sont variés. C'est une zone riche en histoire avec le Château Dubuc") - "Place that is very rich in flora" ("Lieu très riche en flore") - "Very rich biodiversity area with endangered species. To be protected by all means" ("Zone de biodiversité très riche avec des espèces en voie de disparition. À protéger absolument")
T5	Emblematic areas	82 (9.9%)	75	more ("plus"), less ("moins"), Martinique ("Martinique"), wild ("sauvage"), island ("île"), still ("encore"), coast ("côte"), natural ("naturel"), water ("eau")	- "Most well-known area" ("Zone la plus connue") - "1st emerged area of Martinique" ("1ère zone émergée de la Martinique") - "Virgin area of Martinique with almost no dwellings" ("Zone vierge de la Martinique presque sans habitation")
T6	Reserves	59 (7.1%)	48	natural ("naturelle"), reserve ("réserve"), protected ("protégée"), magnificent ("magnifique"), bay ("baie")	- "Natural reserve, protected and rich" ("Réserve naturelle, protégée, et riche") - "Preserved natural reserve including a mangrove and rare species" ("Réserve naturelle préservée incluant une mangrove et des espèces rares") - "Because it is a natural reserve" ("Car c'est une réserve naturelle")
T7	Marine areas	54 (6.5%)	47	seabeds ("fonds"), marine ("marins"), beauty ("beauté"), mangroves ("mangroves"), beaches ("plages")	- "The seabeds still possess incalculable value and rarity... may this last" ("Les fonds marins sont encore d'une valeur et rareté inestimable... que cela dure") - "Rich area in terms of biodiversity and seabeds" ("Zone riche en termes de biodiversité des fonds marins") - "Very rich seabeds" ("Fonds marins très riches")

338 The textual answers revealed different perceptions of what “rich nature” is in Martinique.  
339 Nearly half of the “rich nature” areas were associated with a specific ecosystem,  
340 whether it was coastal (T1; n=248 polygons; 29.9%), marine (T7; n=54; 6.5%), or  
341 tropical forest (T3; n=90; 10.9%). Conversely, for about one-third of the polygons (T4;  
342 n=247; 29.8%), “rich nature” corresponded to areas with high biodiversity, irrespective  
343 of a specific ecosystem. In a smaller proportion, some respondents perceived “rich  
344 nature” in Martinique as opposed to human-made landscapes or, on the contrary, as a  
345 hybrid co-construction with human: on the one hand, “rich nature” areas were  
346 associated with wild and non-urban areas (T2; n=49; 5.9%); on the other hand, to  
347 emblematic areas for Martinican society in view of its history (T5; n=82; 9.9%), or  
348 intentionally protected areas (T6; n=59; 7.1%).

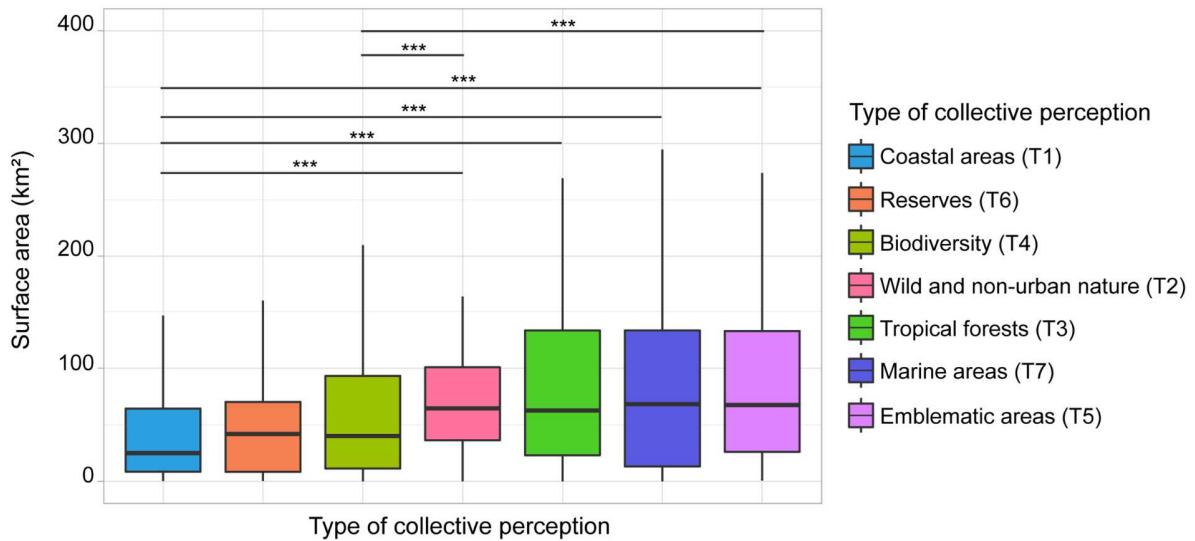
349 Paragons highlighted that “rich nature” in Martinique elicited a diversity of intertwined  
350 values, whatever the perception respondents had of “rich nature”. For example, “marine  
351 areas” (T7), as well as “reserves” (T6), were valued as much for their biological value as  
352 for their aesthetic value (e.g., "beauty", "magnificent").

353 Thus, from an analytical point of view, the cognitive construction of “rich nature” was  
354 done primarily through the lens of ecosystems, within which a plurality of values was  
355 juxtaposed.

### 356 3.2.3. Spatial dimensions of the different types of perception of “rich nature”

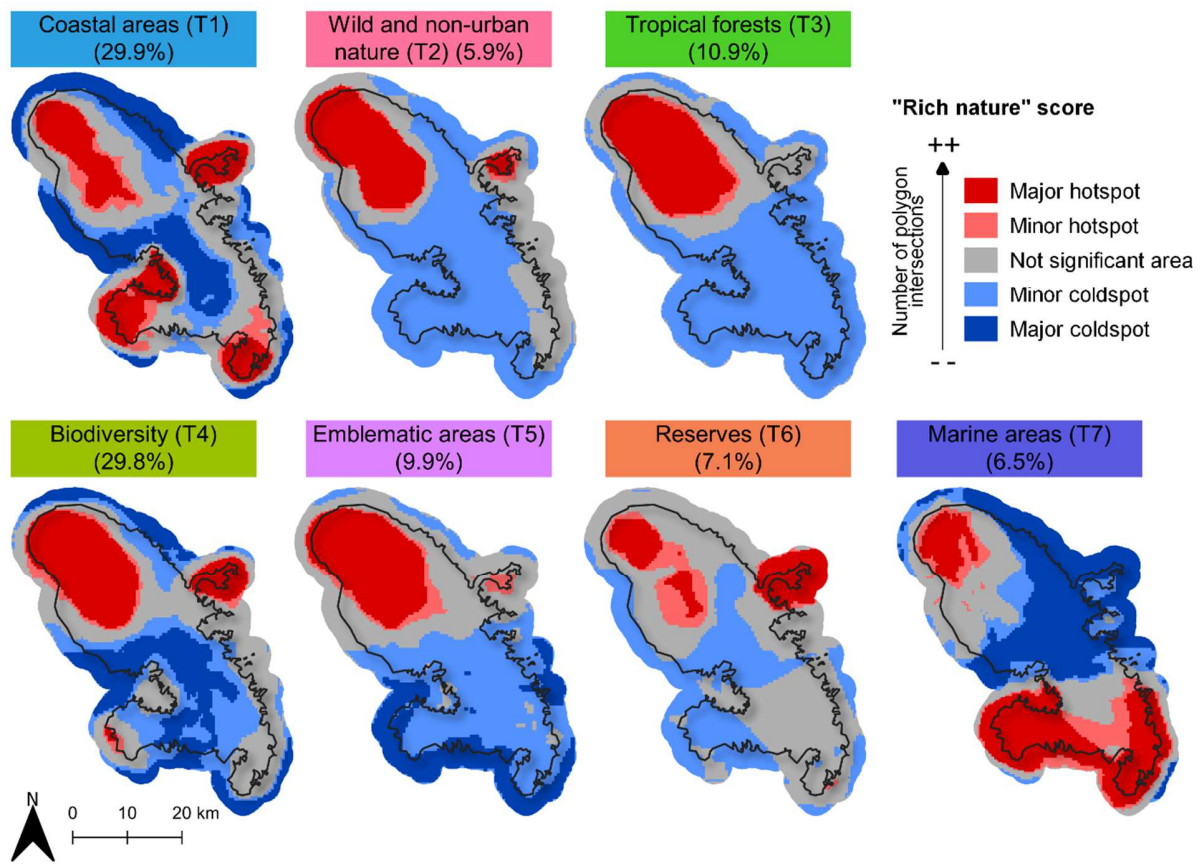
357 The surface areas of the “rich nature” polygons varied significantly according to the type  
358 of collective perception (Kruskal-Wallis test,  $\chi^2 = 37.6$ , p-value < 0,001) (Figure 7).  
359 Polygons relating to the “coastal areas” perception type (T1) had the lowest mean

360 surface area value (mean = 51.0 km<sup>2</sup>) and the “emblematic areas” (T5) had the highest  
 361 (mean = 90.5 km<sup>2</sup>). There was no significant relationship between the zoom levels and  
 362 the types of collective perception (Kruskal-Wallis,  $\chi^2 = 8,1$ , p-value = 0.23).



363  
 364 Figure 7: Surface areas of the polygons according to the types of collective perception  
 365 they refer to. Kruskal-Wallis test with accompanying Dunn’s post hoc analyses was  
 366 performed. \*\*\*: p-value < 0.005.

367 The analysis of locations highlighted that the Northern mountains were a common  
 368 hotspot to the seven types of collective perception and that the southern Caribbean  
 369 coastline was peculiar to the “coastal areas” (T1) and “marine areas” (T7) perception  
 370 types (Figure 8).



371

372 Figure 8: Location of hotspots and coldspots of "rich nature" by type of collective  
 373 perception.

374 Table 2 shows hotspots overlap percentages between pairs of "rich nature" maps. The  
 375 overall map showed weak accordance with the "marine areas" (T7) (18.1%) and  
 376 "coastal areas" types (T1) (42.4%), strong accordance with the "wild and non-urban  
 377 nature" (T2) (73.5%), "emblematic areas" (T5) (73.5%), and "biodiversity" types (T4)  
 378 (84.1%). As for the types of collective perception, the "marine areas" (T7) type coincided  
 379 the least with the other types (from 11.9% to 41.8% at maximum), indicating a strong  
 380 spatial specialization. Conversely, certain perception types were more spatially

381 concurrent because they shared a common hotspot, which was the Northern mountains  
 382 (T2, T3, T4, T5), and/or the Caravelle peninsula (T1, T4, T6).

383 Table 2: Hotspots' overlapping matrix. Read: the surface area of the intersection of the  
 384 "coastal areas" (T1) and "tropical forests" (T3) hotspots represents 28.3% of the total  
 385 surface area of the union of both types' hotspots.

Hotspots by type of collective perception	Hotspots' surface area (km <sup>2</sup> )	Spatial accordance with...							
		Overall	Coastal areas (T1)	Wild and non-urban nature (T2)	Tropical forests (T3)	Biodiversity (T4)	Emblemati c areas (T5)	Reserves (T6)	Marine areas (T7)
Overall	422.2	X	42.4%	73.5%	67.7%	84.1%	73.5%	53.1%	18.1%
Coastal areas (T1)	548.8	42.4%	X	34.7%	28.3%	40.8%	30.7%	41.0%	41.8%
Wild and non-urban nature (T2)	349.0	73.5%	34.7%	X	63.3%	73.7%	75.6%	51.8%	16.0%
Tropical forests (T3)	377.0	67.7%	28.3%	63.3%	X	61.8%	79.9%	39.3%	15.2%
Biodiversity (T4)	428.3	84.1%	40.8%	73.7%	61.8%	X	71.7%	57.7%	16.7%
Emblemati c areas (T5)	400.3	73.5%	30.7%	75.6%	79.9%	71.7%	X	42.9%	15.3%
Reserves (T6)	329.5	53.1%	41.0%	51.8%	39.3%	57.7%	42.9%	X	11.9%
Marine areas (T7)	637.3	18.1%	41.8%	16.0%	15.2%	16.7%	15.3%	11.9%	X

386 Thus, the overall map and the collective maps produced with perception types were  
387 generally concurrent regarding the “rich nature” areas, which were limited to the  
388 following: the Northern mountains, the Caravelle peninsula, the Génipa mangrove, and  
389 the Southern Caribbean coastline. Among these places, the Northern mountains were  
390 the only place consistently designated as a “rich nature” area, regardless of collective  
391 perception types. Meanwhile, the others were to a varying degree targeted as “rich  
392 nature” areas, depending on the collective perception type. In particular, the Southern  
393 Caribbean coastline did not appear on the overall map and was specifically sketched by  
394 the participants who associated “rich nature” with coastal (T1) and marine (T7) areas.

#### 395 4. Discussion

396 In this paper, we proposed a research design to investigate Martinicans’ “rich nature”  
397 perceptions from maps and discourses collected with a web-mapping survey. We  
398 analyzed spatial data in light of discourses, using both textual data analysis and spatial  
399 analysis, and assessed the contributions of our method in terms of internal and external  
400 validity. Following Brown et al. (2017), we understood internal validity as “the control of  
401 threats that provide alternative explanations”, and external validity as “the degree of  
402 generalization to other places or persons” (p. 154). Discourses provided original and  
403 nuanced insights into the perceptions of the “rich nature” notion, while polygons  
404 informed us about their location, shape, and scale, i.e., their spatial representation. Our  
405 web-mapping survey reached a large and spatially distributed audience in a  
406 representative manner, albeit not socio-demographically representative.

## 407 4.1. The added value of our participatory mapping method

### 408 4.1.1. Internal validity

409 Within PPGIS studies, human-nature relationships have been investigated as spatial  
410 patterns and mainly captured by predefined typologies of landscape values (Brown et  
411 al., 2020). However, discourses could enhance participatory mapping internal validity,  
412 by providing a more accurate account of the mapped attribute, hence human-nature  
413 relationships (Cervený et al., 2017; Huck et al., 2014; Lowery & Morse, 2013; Plieninger  
414 et al., 2018). Free-text annotations provided us with qualitative yet numerous data  
415 regarding the reasons to identify a place as “rich nature”. Thanks to textual data  
416 analysis, we uncovered seven main perception types of “rich nature” in Martinique.  
417 Three of them associated “rich nature” with natural ecosystems (mangroves for coastal  
418 ecosystems, tropical forests for terrestrial ecosystems, and coral reefs and seabeds for  
419 marine ecosystems). Thus, participants were able to map perceived valuable habitats,  
420 despite the cognitive challenge this represents (Nahuelhual et al., 2016; Plieninger et  
421 al., 2018), certainly because of the comfort they had with the notion of “rich nature”.  
422 Bernardo et al. (2021) also underlined that laypersons do not always know or  
423 understand the term biodiversity, although they can identify places with high  
424 biodiversity. Talking about “rich nature” was therefore a more effective way of capturing  
425 the naturalistic value inhabitants assign to certain places than an expert notion. The  
426 notion of “rich nature” places was thus primarily thought of in terms of ecosystem type  
427 (mangrove, tropical forest and coral reefs) and not in terms of value orientation (e.g.  
428 aesthetic, recreational, biological value). Besides, as already highlighted by Cervený et  
429 al. (2017), several value orientations often overlapped in the same place: for example,

430 respondents declared they value marine ecosystems for both their aesthetic and  
431 biological values. It makes it then difficult to think analytically about places according to  
432 independent values as it was traditionally done in previous web-mapping studies  
433 investigating human-nature relationships (Brown et al., 2020). These results underline  
434 that entering through predefined typologies of values is not necessarily the best way to  
435 transcribe how the relationship with nature is constructed. Instead, our method grasped  
436 this relationship by referring to the description inhabitants gave of it, i.e., the free-text  
437 annotations, therefore gaining in precision.

438 When mapped, “rich nature” perception types showed significant differences in both  
439 shape and location. We observed significant differences in surface areas, with coastal  
440 areas having the lowest mean value and emblematic areas the highest, indicating that  
441 participants did not attribute the same extent to the “rich nature” notion when mapping it.  
442 However, the zoom level did not differ between the types of collective perception,  
443 although participants could choose a different zoom level depending on the information  
444 to be mapped (Hewitt et al., 2020). While it is recognized that PPGIS outcomes are  
445 affected by the spatial scale (de Vries et al., 2013; Ives et al., 2018), it seems that the  
446 multiple perceptions of “rich nature” were on average mapped at similar scales.  
447 Concerning the location of hotspots of “rich nature”, the degree of accordance between  
448 the maps representing the different perception types of “rich nature” and the overall map  
449 varied from 18.1% to 84.1%. We observed strong accordance because a limited set of  
450 places (Mount Pelée, Caravelle peninsula, to cite a few) were consensually designated  
451 as “rich nature” areas, but for different reasons. Meanwhile, some perception types  
452 showed a high degree of spatial specialization. Two of the "rich nature" maps (marine

453 and coastal areas) were less than 50% concurrent with the overall map, and one  
454 (reserves) was around 50% concurrent. Particularly, participants who interpreted “rich  
455 nature” as coastal or marine areas significantly designated the southern coastline of  
456 Martinique as rich, while most respondents rather targeted the Northern mountains and  
457 the Caravelle peninsula. The entire Southern coastline did not appear, at first glance, on  
458 the map of “rich nature” areas produced by the spatial data only.

459 Even though reduced to free-text annotations in our survey, discourses therefore  
460 provided original and nuanced insights into what lied underneath the map, i.e., the  
461 relationships Martinicans build with natural places. Our open-ended question yielded  
462 information about the participants’ perceptions of the “rich nature” notion, while the  
463 mapping elicited its location, shape, and scale. In the end, combining discourses with  
464 maps allowed for a deeper understanding of participants’ perceptions than spatial  
465 information alone (Huck et al., 2014). Above all, the high consistency between the  
466 discourses and the polygons highlighted a strong relationship between the meaning  
467 given to the “rich nature” and its spatial representation, hence the rationale for  
468 comparing a participatory mapping outcome with the discourse underlying it.  
469 Accordingly, discourses can enhance the internal validity of participatory mapping and  
470 should be integrated into the research design, for instance using free-text boxes and  
471 textual data analysis.

472 The design of PPGIS surveys requires a certain amount of customization. We have  
473 mainly discussed the implications of the spatial attribute and left out other factors critical  
474 to the internal validity of participatory mapping data, such as the spatial primitive, or the  
475 base map (Lechner et al., 2014; Nahuelhual et al., 2016). The polygon seemed more

476 faithful than the point to spatially translate an individual perception of “rich nature”  
477 because the polygon informs about its shape and extent (Lowery & Morse, 2013), but  
478 the question of the best-suited spatial primitive remains a matter of concern (Brown &  
479 Pullar, 2012; Ramírez Aranda et al., 2021). The interactive map was more appropriate  
480 than a paper map for studying human-nature relationships in Martinique at the regional  
481 scale. Also, interactive maps theoretically benefit spatial data accuracy because of the  
482 zoom and navigation tools. But, when comparing dwellings’ locations with textual  
483 attributes (address name), we noticed that 12.9% of the dwellings were misplaced (we  
484 relocated them whenever the textual information allowed it). Recognizing that  
485 participatory mapping can provide uncertain data (Lechner et al., 2014), it seems  
486 prudent to collect metadata as well.

#### 487 4.1.2. External validity

488 Our web-mapping survey provided numerous spatial and textual data, compared to  
489 qualitative approaches, based on semi-structured interviews (e.g., respectively 47, 28  
490 and 30 participants; Blake et al., 2017; Cottet et al., 2023; Klain & Chan, 2012) or  
491 workshops (e.g., 122 participants; Lowery & Morse, 2013). Counter-examples exist but  
492 require substantial financial and human resources (Fagerholm et al., 2019; Kafas et al.,  
493 2017). Self-administered and online surveys enhance participation levels, although  
494 weak participation rates were also noted with similar web-mapping surveys (Garcia et  
495 al., 2020). Our participation level may result from effective dissemination strategies  
496 (contact base, promotion on social networks and local media), but also from  
497 Martinicans’ interest in environmental issues (Brown, 2012). According to Haywood  
498 (2014), place attachment is an influencing factor in determining inhabitants’ motivation

499 and involvement in participatory programs. Other surveys conducted in insular contexts  
500 (Blake et al., 2017; Plieninger et al., 2018) also resulted in high participation rates. The  
501 reasons for greater adherence to participatory approaches in insular contexts may be  
502 related to place attachment, and need further investigation.

503 Despite good participation levels, our survey's socio-demographic composition was not  
504 representative of the Martinican population. Women, younger and middle-aged, and  
505 higher educated people were overrepresented. The same demographic composition  
506 was observed elsewhere and attributed to a digital divide (Garcia et al., 2020). As digital  
507 surveys, web-mapping surveys raise a usability question, especially for the elderly  
508 groups (Gottwald et al., 2016; Rzeszewski & Kotus, 2019). Indeed, web-mapping  
509 surveys are more likely to be completed by higher educated and younger participants  
510 than paper surveys (Pocewicz et al., 2012).

511 Aside from the online nature of the survey, using polygons may discourage some  
512 participants from responding (Brown & Pullar, 2012; Klain & Chan, 2012; Levine &  
513 Feinholz, 2015), while the point is considered to be simpler to manipulate. Accordingly,  
514 the polygon has generally been collected in administered (e.g., Cottet et al., 2023;  
515 Kafas et al., 2017; Klain & Chan, 2012; Levine & Feinholz, 2015; Lowery & Morse,  
516 2013) rather than self-administered surveys (e.g., Ernoul et al., 2018). In our study,  
517 22.0% of participants recorded fewer polygons than the two minimums required,  
518 whereas only 8.6% mapped less than two points in response to another survey question  
519 that required two answers. Therefore, our web-mapping survey may have posed  
520 technical difficulties for some people, notably the older ones, despite the video tutorial.  
521 The absence of feedback made it difficult to test this hypothesis.

522 Although non-representative from a socio-demographic standpoint, our survey's  
523 distribution statistically represented the municipal distribution of the population, and  
524 covered the whole island, except some Northern rural villages. This result confirms that  
525 web-mapping surveys may reach a large distribution (Jankowski et al., 2016), in  
526 developed countries at least (Loc et al., 2021; Weyer et al., 2019). Furthermore, our  
527 data do not show a spatial discounting effect (Brown et al., 2020), certainly because of  
528 the Martinican spatial-wide audience of our survey, and of the particular relationships  
529 the inhabitants have with their island (Plieninger et al., 2018).

530 In short, even if web-mapping surveys do not always make it possible to collect  
531 representative data on a socio-demographic level, ours was an effective way of  
532 covering the island and collecting a large amount of spatially representative data. Web-  
533 mapping surveys may reach a different public from the one participating in workshops,  
534 for instance (Brown et al., 2014; Kahila-Tani et al., 2016), meaning that both methods  
535 can be used in complementarity to reach a large audience with a varied profile.

#### 536 4.2. Future directions

537 Participatory mapping has reached high methodological maturity (Fagerholm et al.,  
538 2021), but both internal and external validities remain challenging. To improve the  
539 internal validity of PPGIS research designs, research concerning participants'  
540 experience with interactive maps and different geographical primitives should continue  
541 (Garcia et al., 2020; Rzeszewski & Kotus, 2019). Given the inner limitations of points  
542 and polygons, it should be noted that PPGIS researchers tested other spatial primitives:  
543 spray (Huck et al., 2014) or marker (Ramírez Aranda et al., 2021), both producing a  
544 blurry boundary effect. What remains critical is to formalize a perception on a map,

545 especially with a digital tool. Although convenient, GIS may not be the ideal tool to cope  
546 with the spatially vague nature of perceptions (imprecise position, ambiguous  
547 boundaries, and multiple scales) (Huck et al., 2014). Overall, twisting human-nature  
548 relationships into vectorized geographical data remains a simplification of its complexity  
549 and richness, just like the reduction of discourses to free-text annotations and filtered  
550 lexicon. We still lack computer systems offering greater freedom to represent a mental  
551 perception on a map, which encourages experimentation in this field.

552 Furthermore, future research should seek new insights into the type of public that web-  
553 mapping surveys reach, and into their motivations, to boost PPGIS research designs'  
554 external validity (Brown & Kyttä, 2014; Garcia et al., 2020). Evidence suggests a biased  
555 composition of PPGIS participants (Brown, 2012, 2017). In our case, we are uncertain if  
556 socio-demographic representational issues only originated from survey design, or if  
557 inhabitants' different regards about nature were also a possible cause. We noticed that  
558 inhabitants made use of environmental management vocabulary (e.g., "biodiversity",  
559 "reserve"). We knew that some inhabitants had good knowledge of current regulations  
560 (Morandi et al., 2015, 2017), and expected that they used it to answer our survey.  
561 Inhabitants' discourses may converge with those of "experts" because these inhabitants  
562 are themselves, experts. Indeed, the perceived areas of "rich nature" for inhabitants  
563 were highly consistent with those of environmental managers (e.g., regional and  
564 national natural reserves). The prominence of Mount Pelée and the Carbet Mountains,  
565 submitted for inscription on the UNESCO World Heritage List in 2021, was an example  
566 of such converging views. It remains to be ascertained whether this knowledge is  
567 professional, or vernacular. Our dissemination method was based on a contact

568 database including environmental management agencies and may have caused the  
569 overrepresentation of environmental professionals. Either way, we may be missing  
570 residents who have little or no environmental knowledge, or at least little interest in  
571 environmental issues. A real sampling effort is required to reach this audience. As  
572 stated by Brown (2017), “Who participates?” and “Whose voice counts?” are critical  
573 questions in PPGIS. From a participatory perspective, we need to ensure that  
574 environmental management is not just a matter for experts and that their voices do not  
575 outweigh those of marginalized or underrepresented inhabitants (Larrère & Larrère,  
576 1997).

## 577 5. Conclusion

578 To date, participatory approaches have not yet reconciled the simultaneous needs for  
579 internal and external validity. While web-mapping surveys have a high potential for  
580 external validity, the focus was on the collection of spatial data using predefined  
581 categories of spatial attributes, to the detriment of additional information that could  
582 increase their internal validity, e.g., discourses. Here, we demonstrated the added value  
583 of discourses in PPGIS while advocating a method to include them in the research  
584 design. To do so, we relied on a web-mapping survey conducted in Martinique, in which  
585 the inhabitants had to map “rich nature” on the island and explain their choices in a free-  
586 text answer. The internal validity of our method was assessed with a comparison of the  
587 spatial results obtained with and without the integration of free-text answers; the  
588 external validity in terms of sample size, and socio-demographic and geographical  
589 representativeness. The participants' annotations allowed us to distinguish several  
590 perceptions of “rich nature”. From a spatial standpoint, these perceptions differed from

591 one another and, to a certain extent, with the results obtained merely with spatial data.  
592 We argue these differences originated from a strong relationship between the meaning  
593 given to the “rich nature” and its mapping. Our results were strengthened by satisfying  
594 participatory levels and geographical representativeness, although socio-demographic  
595 representativeness was not reached. Accordingly, survey-based studies of human-  
596 nature relationships should not dissociate mapping data from related discourses. The  
597 latter provides information on the deeper meaning of these relationships, while the map  
598 informs us about their location, shape, and scale. Web-mapping surveys remain  
599 effective options to reach a large and distributed audience, although embedded with  
600 potential response bias.

601 The method we propose is based on these remarks and can contribute to the  
602 implementation of participatory mapping. However, methodological developments are  
603 insufficient to guarantee the public’s participation. This study is the result of a request  
604 from environmental managers in Martinique who are aware of the issues related to  
605 participation. The decision to enhance its results remains theirs. Managers are used to  
606 manipulating maps, as an object of dialogue or as a decision-making document, and our  
607 maps could serve the same purpose. However, managers may find it hard to reuse  
608 maps of nature perceptions and give prominence to experts’ rationalities. Following this,  
609 the appropriation of participatory mapping in environmental management deserves  
610 particular attention. This feedback will be essential for PPGIS approaches to fulfill their  
611 participatory role.

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