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1 **The contributions of socio-environmental information maps in an**
2 **environmental mobilisation: the case of a fight against a highway**
3 **project in France**

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24 **The contributions of socio-environmental information maps in an**
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27 Large linear transport infrastructure projects, such as highways connecting large
28 metropolitan areas, are continuously under development in France. Although the
29 economic and social benefits of such projects are often disputed, their impacts on
30 the environment and local populations are multiple. These potential impacts almost
31 systematically result in conflicts between decision-makers and planners on one
32 side, and local actors with various profiles (e.g., farmers, residents, environmental
33 associations) mobilised against the projects on the other. In the context of a citizen
34 mobilisation against the A45 highway project in eastern France, this study aimed
35 to analyse the social contributions of maps in terms of information reception. The
36 study is based on the creation of maps representing combined spatial impacts (on
37 mobility, housing, land, landscapes, agriculture, and ecosystems). These maps,
38 created by researchers, were presented in the form of posters aimed at opening
39 discussions with non-experts. The maps created an original medium for discussing
40 and debating the impacts of a highway project through the participatory encounter.
41 Under the lens of spatial and environmental justice, this study questions the
42 discrepancies between who makes decisions on a project and who suffers its
43 impacts, and also raises questions about the position of scientific research in citizen
44 mobilisation.

45 Keywords: public participation; environmental mobilisation; spatial planning;
46 mapping; highway

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53 **Ethical considerations**

54 The procedures involving human participants in this research are in accordance with the French
55 GDPR (General Data Protection Regulation) and with European regulations relating to the
56 protection of individuals and their personal data and its circulation.

57 1. Introduction

58 New linear transport infrastructures, such as highways and high-speed railway lines,
59 change the landscape as well as the practices of people living nearby. Such
60 infrastructures, considered to be in the public interest, are imposed on all inhabitants and
61 all land uses: residential, industrial, agricultural, and natural (Angelsen and Kaimowitz
62 1999). Assessment of their potential impact must therefore consider all the economic,
63 social, and environmental factors involved (Zembri-Mary 2017; Hickman, Hall, and
64 Banister 2013; Banister 2008). Considering their multiple potential impacts, such projects
65 can be a source of conflict between planners, politicians, and inhabitants when the
66 different stakeholders' interests are divergent (Von Der Dunk et al. 2011). With such
67 linear projects (as opposed to areal projects), there may be multiple mobilisation centres
68 because of the successive routes envisaged and the diversity of landscape types crossed.
69 These multiple mobilisation centres can give rise to extension of the conflict, although
70 often in a dispersed way. Indeed, the linear pattern of a highway can lead to divergent
71 opinions between different territories and different ways of life. However, the problem is
72 not reducible to individual or collective interests of different actors in different territories,
73 but also depends on the decision-making processes and the way decision-makers perceive
74 the general and/or public interest. It therefore seems legitimate to question the
75 discrepancies between who makes the decisions and who suffers the impacts of an
76 infrastructure project. In this context, very few studies have focused on articulating the
77 different impacts to improve understanding of them with the aim of opening discussion
78 with non-expert inhabitants.

79 Studies on conflicts related to planning projects often show the relevance of mapping for
80 highlighting the areas of conflict (Brown and Raymond 2014). Such studies frequently

81 use approaches based on geographical information systems (GIS), which allow
82 quantification and visualisation of the project and its impacts. The mapping of changes in
83 natural and built landscapes can potentially encourage communication with local
84 decision-makers and stimulate the willingness of the public and stakeholders to support
85 or oppose a planning project (Pettit et al. 2011). Indeed, studies show that mapping and
86 GIS can make infrastructure projects more understandable for inhabitants and decision-
87 makers, particularly increasing the understanding of environmental impact studies
88 (Banerjee and Ghose 2016).

89 Reflections on the social, political, and epistemological implications of GIS and
90 associated technologies for representing people and places emerged in the 1990s from the
91 ‘GIS and society’ initiative, a research agenda linking critical social theory and GIS and
92 focusing on the social implications of GIS (e.g., Sheppard 1993; Pickles 1995). Then, the
93 construction of a form of critical GIS research questioned the contemporary practices of
94 GIS and associated technologies, as well as the postures and practices of alternative GIS,
95 such as participatory GIS (Pavlovskaya 2006; Wilson 2017). These works gradually
96 gained popularity from the 2000s (e.g., Crampton and Krygier 2005; Schuurman 2004;
97 Cope and Elwood 2009; Crampton 2010), combining the potential of cartography,
98 information technology, and advances in social critique to open up new possibilities as
99 tools for social transformation (Pavlovskaya 2018) and to challenge oppression and
100 inequality (Schwanen and Kwan 2009). This changed the practices and decision-making
101 processes in which GIS are used, as well as the intellectual position of GIS science as a
102 research methodology in geography (Elwood 2006). It also gradually challenged the
103 status quo of technology, social power, and the creation of spaces of possibility for people
104 (Pavlovskaya 2018).

105 The 'GIS and society' initiative led to the development of sub-domains including
106 participatory GIS. Participatory GIS is seen as a way of improving access to GIS and
107 digital geographical data, making GIS applications inclusive and allowing democratic
108 spatial decision-making (Craig, Harris, and Weiner 2002). The technological, social, and
109 political practices of participatory GIS emerged from the combined efforts of GIS
110 researchers and other more-neophyte user groups to access GIS and adapt it to their
111 knowledge and needs (Elwood 2006). These approaches, which focus on the context and
112 problems rather than on the technology, seek to emphasize the involvement of
113 communities or marginalized populations in the production and/or use of geographical
114 information (Dunn 2007). These approaches have since grown, largely because of their
115 potential to bridge between the technical world of expert-led spatial planning and bottom-
116 up and local knowledge from lived experience (Brown and Kytta 2014), and they offer a
117 means to increase dialogue between experts and non-experts (Stieb et al. 2019).

118 In light of this, the general objective of our research was to question the contribution of
119 GIS and the production of mapping information representing the combined impacts of a
120 highway project in the context of a citizen mobilisation in which contrasting and
121 competing positions were expressed. By designing a participatory approach mediated by
122 maps, we sought to analyse how the design of maps and their presentation can be used to
123 open-up and feed the debate on the construction of a highway project, and how their use
124 could allow local inhabitants to achieve a better overall understanding of the project.

125 From this, we formulated three main hypotheses.

- 126 1. Maps create an original discussion medium for debating the impacts of a highway
127 project through participatory encounters, as highlighted by Rydin and Natarajan (2016).
- 128 2. Maps present an objectified vision of the space and the project, allowing citizens

129 to better-appropriate and differently-understand the risks and benefits of the project
130 (Dransch, Rotzoll, and Poser 2010).

131 3. Debate and discussions around the project are more effective if the reading of the
132 maps by the general public is guided by researchers focused on certain themes, who reveal
133 the processes behind their data and its representation.

134 We first look at the case study by presenting a literature review on the highway's
135 construction effects and the general context of the A45 highway project in France,
136 considering that each transport infrastructure project has its own local specificities.
137 Second, we present the mapping production processes used to highlight the potential
138 impacts of highway projects found in the literature and mentioned in the study area. Third,
139 we present several of the resulting maps and the associated feedback obtained from a
140 workshop on a day of mobilisation against the highway project. Finally, we discuss this
141 critical feedback and evaluate the relevance of the mapping produced in the context of
142 the planning conflict by asking the question: can we really propose neutral maps to fuel
143 a subjective debate?

144 **2. Case study**

145 Before producing the maps, preparatory methodological work aimed at identifying the
146 different themes was undertaken. This work focused on the thematic and contextual
147 dimensions of our case study with (2.1) a review of the scientific literature on the different
148 consequences of highway construction and (2.2) an analysis of the local context,
149 including the actors' arguments for and against the project.

150 **2.1. Scientific literature background on highway construction effects**

151 The construction of transportation infrastructure such as highways is generally supported
152 by political leaders who want to increase economic development within their territories

153 and improve accessibility to cities, thereby concentrating (always more) shops, jobs,
154 services, and associated activities. Local decision-makers worldwide often justify the
155 construction of such projects by arguing that better accessibility will lead to better
156 economic productivity. In some cases, improved accessibility (reducing commuting
157 times) contributes to the attractiveness of a region, with a correlated increase in the price
158 of housing (Levkovich, Rouwendal, and van Marwijk 2016) and/or improved access to
159 employment for rural populations (Paliska and Drobne 2020). A possible consequence of
160 this improved accessibility is a growth in the population (Ribeiro, Antunes, and Páez
161 2010). However, even if new transport infrastructure is deemed to be crucial for good
162 regional cohesion, it seems insufficient if it is not accompanied by other effective
163 economic and social policies (Ribeiro, Antunes, and Páez 2010).

164 Some studies have shown that such outcomes that are *a priori* rather favourable to the
165 construction of new infrastructure should be examined more closely. Indeed, an increase
166 in population near to highway interchanges may depend on newcomers who have a
167 particular education profile (Ribeiro, Antunes, and Páez 2010) and own a car (Paliska and
168 Drobne 2020). Several scientific studies showed that highway construction has an impact
169 on the price of land, with more attractive (and therefore more expensive) land being that
170 situated near to interchanges (Paliska and Drobne 2020; Levkovich, Rouwendal, and van
171 Marwijk 2016). Conversely, the price of land in the vicinity of the transport infrastructure
172 but at a distance from the interchanges decreases (Kilpatrick et al. 2007; Paliska and
173 Drobne 2020).

174 A highway project can therefore become a factor increasing socio-spatial inequalities at
175 local and regional scales (Ribeiro, Antunes, and Páez 2010), particularly by concentrating
176 economic activity in poles that are well-connected by the infrastructure (Holl 2007; Yu
177 et al. 2016). This is strengthened by the fact that when a new highway is built between

178 two cities of different sizes, the improvement in accessibility tends to benefit the bigger
179 of the two, as shown by studies performed in France (Puga 2002), Japan (Kim and Han
180 2016; Kakumoto 1999), South Korea (Jun and Kang 2007), and the United States
181 (Funderburg et al. 2010). As stated by Rokicki and Stępnia (2018), Zembri-Mary (2017)
182 and Bröcker and Rietveld (2009), it is therefore not possible to systematically
183 demonstrate theoretical predictions linking better accessibility with greater economic
184 dynamism. While certain economic actors and inhabitants may benefit from improved
185 accessibility to employment areas (Kim and Han 2016), others may suffer from the
186 infrastructure more than they benefit from it.

187 The landscape impacts of new transport infrastructure are rarely considered when a
188 project takes place (Mészáros and Antonson 2020), even though the transformation of
189 landscapes can give rise to land use impacts including visual changes, barrier effects on
190 cultivated land, and conflicts between infrastructure, recreational facilities, and cultivated
191 land (Mészáros, Gergely, and Illyés 2018). Unlike spatially-concentrated areal planning
192 projects (e.g., shopping zones, new urban developments), linear infrastructure such as
193 highways may cross various landscapes (rural, urban, or suburban areas), resulting in a
194 net loss of land and a fragmentation of land over several tens or hundreds of kilometres.
195 This implies direct and indirect environmental impacts on agricultural land (Bacior,
196 Dudzińska, and Prus 2018; Eremina 2018), air quality (Filigrana et al. 2020; Zhu et al.
197 2002), landscapes (Mészáros, Gergely, and Illyés 2018), and ecosystems (Wu et al. 2014;
198 Coffin 2007; Bennett 1991). One specific impact on ecosystems is the barrier effect of
199 roads, which disrupts wildlife movements across the landscape (Girardet, Foltête, and
200 Clauzel 2013; Fu et al. 2010; Cushman 2006; Forman and Alexander 1998). Such
201 movements are made difficult by the presence of fences and the volume and speed of
202 traffic (Holderegger and Di Giulio 2010; Fahrig and Rytwinski 2009; Marsh et al. 2008).

203 For these reasons, some authors have named the fragmentation of natural habitats by
204 transport infrastructure as the “single greatest threat to biodiversity” (Hess 1996; Noss
205 1991). Examples of studies illustrating these threats include that of Ghadiri
206 Khanaposhtani et al. (2019), which showed that bird diversity was impacted on a large
207 scale, particularly through changes in habitat structure and soundscapes, that of Koemle,
208 Zinngrebe, and Yu (2018), which showed that new highways can cause population
209 declines in terrestrial species, and that of Kušta et al. (2017), which showed an increase
210 in collisions affecting many wildlife species. Other studies also showed that
211 compensatory measures such as wildlife crossings are not always effective (Kaphegyi et
212 al. 2013).

213 **2.2. Context of the A45 highway project and its actors**

214 This study was carried out in parallel with a citizen mobilisation against the construction
215 of a new highway (named the A45) dedicated to interconnecting the cities of Lyon and
216 Saint-Étienne in eastern France (Figure 1).

217 Our analysis of the project history, the local context, and the actors’ arguments is based
218 on different sources. Newspaper articles first constituted an important element for tracing
219 the project history and identifying the arguments for and against the A45 project. A search
220 was made for all relevant articles published in the local newspaper (*Le Progrès*) between
221 2015 (year of the choice of highway concessionaire, thereby making the project real) and
222 2018 using the simple keyword “A45”, and this was supplemented with other regional
223 and national newspaper articles identified during this work. In parallel, one of the authors
224 participated in fifteen public or mobilisation meetings between 2016 and 2018 to further
225 their understanding of the arguments against the project. In addition, seven semi-
226 structured interviews were conducted with the inhabitants of the territory concerned by
227 the project. The questions asked in these interviews were aimed at identifying individual

228 (familial, professional, and residential) trajectories and understanding the project and its
229 mobilisation history, as well as the modalities and forms of potential engagement. Finally,
230 grey literature corresponding to academic works (Zosso and Fiol 2018; Zimmermann
231 2018; Girard 2018; Diaz 2018; Sanchez-Penas 2018) also served to support our analysis
232 of local issues related to the project. We here summarise the elements of this research.

233 The A45 highway project is intended to relieve another highway (A47) constructed in
234 1983, which is currently the fastest route between Lyon and Saint-Etienne (about one
235 hour, outside peak traffic hours). However, the travel time on this route is often longer
236 than it should be because of heavy local, regional, and international traffic, and the
237 resulting traffic jams, especially at crossing points and in the morning and evening.

238 Although an existing railway line allows the stations of both cities to be reached in
239 approximately 45 minutes, time constraints, its saturation, and the locations of the stations
240 in and between the two agglomerations do not allow enough people to change from car
241 to train. Furthermore, there is also a certain individual resistance to leaving the private
242 car (Buhler 2011). Since the 1990s¹, certain politicians and local stakeholders have
243 promoted the idea of building a new highway in addition to and in parallel with the
244 existing A47 highway. Supported by regional political authorities, the project for the
245 highway moved forward in 2015 with the choice of the highway concessionaire.

246 Since 2016, several local associations have formed a collective of opponents to

¹ As early as the 1970s, when the A47 highway project was not yet completed, there were already projections of a rapid saturation of this first highway, and the idea of a second highway was being discussed. Indeed, in the context of the “Trente Glorieuses” (the “Glorious Thirty”, the thirty years from 1942 to 1973), with oil still very inexpensive and an all-car population being considered the ideal, the French model was still very much oriented towards the development of heavy infrastructure to support the growth dynamic and compensate for the excessive centrality of Paris.

247 the A45 highway, organising several demonstrations and using different mobilisation
248 strategies. Our research project began at this time of strong mobilisation against the
249 project. The opposite positions of the “pro A45” and “anti A45” campaigns were asserted,
250 among both political and economic actors, as well as among inhabitants. Between
251 September 2017 and September 2018, we identified the arguments for and against the
252 project in the grey literature, newspaper articles, public meetings, and several individual
253 interviews of those engaged against the project.

254 For many of those in favour of the A45, the project aims to improve the
255 accessibility and economic attractiveness of Saint-Etienne (404 607 inhabitants in its
256 urban area in 2018), its exchanges with the urban area of Lyon (1 398 892 inhabitants in
257 2018), and road transit on a European scale. The political positions of local elected
258 representatives with regard to this project show contrasts (Figure 1). The majority of
259 municipalities near to Saint-Etienne (Loire department) are in favour of the highway
260 project, whereas near to Lyon (Rhône department) the majority of locally elected
261 representatives are against the project².

262 Our interviews revealed that the ‘anti-A45’ campaign saw several problems with
263 the project, such as the cost of construction (48-km length, 4 tunnels, and 11 viaducts),
264 financing through local, regional, and national taxes, the cost of the future toll (11€ for a
265 round-trip), the poor access for inhabitants located between the two agglomerations,
266 exposure to pollution, and the cutting off of areas of high agricultural (organic farming,
267 short-distance production, vineyards, and orchards) or environmental value (such as

² These decision-making processes and support for the infrastructure project are part of partisan political orientations. Thus, the lower administrative levels largely conform to the political leaders (the President of the region is for it, as is the mayor of Saint-Etienne, from the same (right-wing) political party, while the mayor of Lyon (socialist party), from the opposite party, finally spoke out against the project in order to distinguish himself from his competitor in an election for the leadership of the city.

268 wetlands, forests, and open areas). However, the decision-making process at state and
269 local level (reservation of zones in urban plans, budget voted by the communities,
270 approved regulatory texts) moved fast, making the opponents fear (in 2016) that
271 construction of the highway could start as early as 2019. The uncertainties linked to the
272 project, its realisation, and its timetable, thus contribute to keeping the inhabitants in a
273 situation of both expectation and uncertainty in terms of land, residential, and quality of
274 life prospects.

275 **Figure 1.** Study area with municipalities for and against the A45 highway project.

276

277 **3. Mapping production**

278

279 Our methodology is mainly based on the cartographic visibility of social-
280 environmental impacts as a medium for discussion between researchers and citizens. Our
281 aim was to interact with a diverse and significant number of stakeholders and citizens
282 affected by the project, and an opportunity for this was presented in the form of the
283 planning of a day of citizen mobilisation against the A45 on 22nd September 2018. Based
284 on the principle that our maps should be addressed to a large audience during this event,
285 the main challenge consisted of working on many topics in order to discuss the project
286 with everybody, according to their interest. Therefore, another challenge was to collect
287 the diverse data and to represent it in map form, always with the target of creating and
288 exhibiting valuable documents in terms of quality of data and presentation. Another target
289 was to propose a scientifically robust design that would potentially be useful to any actors
290 (Burkhard et al. 2014), so that we could diffuse our work, tools, and methods to
291 demonstrate the utility of graphic representation and modelling. We were also careful to
292 provide details and landmarks that were considered valuable in previous studies, such as

293 major cities, roads, and waterways (Stieb et al. 2019). As mentioned by several authors
294 (Jacobs et al. 2015; Wood, Fels, and Krygier 2010; Pavlovskaya 2006; Monmonier 1991),
295 we believe that our maps must be subject to assumed choices of representation so that
296 they are not abused by either the ‘pro-A45’ or ‘anti-A45’ lobbies.

297 **3.1. Traffic and mobility**

298 The issue of road traffic and mobility is central to this project, as construction of the A45
299 highway is aimed at limiting the saturation of the region’s roads, thereby improving
300 regional cohesion by strengthening mobility between Lyon and Saint-Étienne on a local
301 scale, and between several French and European cities on a more global scale. However,
302 the literature review pointed to several traffic and mobility-related problems: an
303 inadequacy if not accompanied by other effective economic and social policies, a possible
304 increase in spatial inequalities, an increase in car use by rural populations with related
305 pollution, the advantage of the larger city over the other on either side of the
306 infrastructure.

307 To represent the theme of traffic and mobility on a map, we chose to represent information
308 on the actual situation and according to the projections proposed in several transport and
309 mobility plans (number of vehicles per day/per road and number of trains per day on the
310 railways). The idea was to demonstrate the importance of road traffic in a large area
311 around the highway project, with the area concerning a large proportion of the participants
312 active in the mobilisation.

313 **3.2. Land availability and housing**

314 The construction of a new highway has a direct impact on the availability and price of
315 land and some municipalities crossed by the highway project need to reserve areas for
316 several years to allow the building of the infrastructure. This blocking of urbanisable areas

317 can greatly limit the economic development of these municipalities. The municipalities
318 in our study area are predominantly rural, and the increase in population is more related
319 to the building of new dwellings in urbanisation areas rather than to urban renewal.

320 Debate with the participants on the issues of land availability and housing was
321 necessary, because construction of the highway is supposed to be in response to the
322 growing demand for new dwellings and the expected increase in population in the whole
323 study area. In France, Local Urban Plans (*Plans Locaux d'Urbanisme*, PLU) reserve areas
324 for urban development and give objectives for the evolution of the population and the
325 number of dwellings in the municipalities. From the compilation of these PLUs in the
326 study area (*i.e.* for the municipalities crossed by the highway project) we represented
327 three variables:

- 328 (1) the share of single-family housing planned by municipality between 2018 and
329 2030 according to extrapolations of the territorial coherence frameworks
330 (SCOTs);
- 331 (2) the number of dwellings planned in 2030 by municipality;
- 332 (3) the increase in population planned for 2030 in comparison with 2017 according
333 to municipality.

334 These three variables are generally neither linked nor mapped in planning
335 documents. If they are, they are more often represented for only the few municipalities
336 directly concerned by the planning document, rarely for such a large study area. The
337 mapping of the housing expected in the area crossed by the A45 is therefore an
338 unpublished map. These maps were designed with the aim of opening up debate on the
339 terms and conditions of peri-urbanisation and the resulting urban sprawl.

340 **3.3. Landscapes and agriculture**

341 By crossing agricultural areas, transport infrastructure causes the loss of arable land, first
342 through the net loss caused by the project's right-of-way itself, but also through the
343 cutting up of plots of land making them unusable by farmers because of the difficulties
344 faced in crossing the infrastructure. The crossing of an area by transport infrastructure
345 can thus have major consequences for the local agricultural economy. It is difficult to
346 summarise all these issues with a few maps; therefore, to address agricultural issues and
347 more general land use conflicts, we created a land cover map into seven main land cover
348 categories (water surfaces and rivers, wetlands, forests, urban areas, vineyards and
349 orchards, crops, grasslands and meadows), adding the proposed highway route. In this
350 way, we believe that the participants would be able to identify the land cover types
351 (including agricultural areas) crossed, and engage in discussion on the relevant issues.

352 **3.4. Impacts on species habitats and ecological connectivity**

353 To initiate the debate on biodiversity loss, we chose to start by presenting a
354 topographical map of part of the territory crossed by the highway project (5 km around
355 the mobilisation site). The first objective of this map was to show the landscape
356 configuration of the territory with the support of the topographic background (with
357 forests, buildings, contour lines, and place names) and integration of the highway route
358 within the landscape. We also represented on this map some remarkable bird species
359 whose habitat was identified as threatened by experts from a nature-based non-
360 governmental organization (NGO; the Ligue de Protection des Oiseaux). The locations
361 of these points of presence, which were not exhaustive, were intended to raise public
362 awareness of the potential impacts of land transport infrastructure on the loss of species'
363 habitat. In our opinion, this map allowed to launch the debate, but did not effectively
364 spatialize the ecological impacts of the highway project, as the location of species near to

365 the highway route does not show the impacts of the project on their movements. Existing
366 work carried out by local volunteer naturalists allowed us to highlight some remarkable
367 heritage species whose habitat would be threatened by the new highway. However, as
368 with the first map presented in this section, the potential habitat losses did not in any way
369 consider the impacts of the highway project on ecological connectivity.

370 To assess the potential ecological impacts of the highway project, we focused some maps
371 on the notion of ecological connectivity defined as the degree to which the landscape
372 facilitates or impedes movement among resource patches (Taylor et al. 1993). The loss
373 in ecological connectivity caused by a new highway can lead to a significant loss in
374 biodiversity and ecosystem change at a wider scale (Forman et al. 2003).

375 We therefore presented several maps demonstrating the local impacts of the highway
376 project on ecological connectivity for fifteen species groups, classified according to their
377 habitat preference and dispersal distance (see Bourgeois and Sahraoui (2020) for details).
378 From these results, three maps were designed for presentation to the public during the
379 day of mobilisation. Two of these maps represented the potential loss of connectivity that
380 would be caused by the A45 highway in respect to two groups of species (birds of open
381 environments and amphibians), whereas the other map represented the most important
382 loss of connectivity for each pixel of the study area, as computed from the fifteen selected
383 species groups. It therefore showed the worst-case scenario in terms of the potential
384 impacts of the A45 on ecological connectivity.

385 **3.5. Analysis of debates following the presentation of the maps**

386 The maps were presented in the form of workshops during the mobilisation day.
387 During the workshops, we took note of the main remarks and recorded the debates to
388 document the main feedback from the observers. We also performed ex-post exchanges
389 with members of the collective on the reception of the process. The debates around the

390 maps were not planned and emerged spontaneously from the participants on the day of
391 mobilisation.

392 **4. Results**

393 Our maps were intended to be a transcription of the data collected and the analyses
394 performed. They were presented during workshops as part of the mobilisation against the
395 A45 highway project. The resulting thirteen maps were printed on seven A0 size posters
396 and were hung in the exhibition. The posters were printed in duplicate so that they could
397 also be placed onto tables, allowing the possibility for participants to annotate them and
398 add new elements. This participatory dimension to the maps should help to stimulate
399 participants' imaginations (Rinner 2007). The first poster related the project's history and
400 showed a map of the municipalities in favour or against the new highway (Figure 1). The
401 other six posters, each with two maps, dealt with various previously mentioned themes
402 related to the project, and detailed in Table 1.

403

404 **Table 1:** List of the maps and posters presented on 22 September 2018 in La
405 Talaudière during the day of mobilisation against the A45 highway. The full posters, as
406 they were presented on the day of the mobilisation, are presented in the Appendices
407 section. They have been translated into English from the original French for presentation
408 in this article.

409

410 Only a few representative maps of those discussed and used as support during the
411 mobilisation are presented here. These maps are the same as those presented, except that
412 they have been translated from French into English for this paper. The maps were
413 extracted from their original posters, except for Poster 4, which is presented in its full

414 version (without all the landmarks, to facilitate better readability). For each map, we
415 therefore also present here the feedback from the workshop participants.

416 **4.1 Mapping of urbanisable areas in urban planning documents**

417 **Figure 2** shows the planned urbanisation areas according to the urban planning
418 documents. From the data collected, we calculated that 1127 hectares of land were open
419 to urbanisation in the PLU, 82% of which was for residential use. The current rate of
420 urbanisation was 29.7% of the assessed area, and the total surface area open to
421 urbanisation represented 2.5% of the currently built-up area. The spatialisation of these
422 areas (in red on **Figure 2**) enabled us to show the process of peri-urbanisation currently
423 underway in the living areas of the participants, supported and guided by the urban
424 planning documents, and therefore by the local authorities. The main feedback from the
425 participants allowed us to highlight their lack of knowledge, both on the path of the
426 proposed highway and the municipalities crossed, and the areas open to urbanisation.
427 Indeed, the inhabitants of the rural municipalities concerned were not necessarily aware
428 of the extent of the phenomenon of peri-urbanisation within their living area. In particular,
429 it can be noted that no municipality was against all residential growth. In concrete terms,
430 the dialogue with inhabitants over this map showed that many of them understood that
431 peri-urbanisation was already in process, and was not solely related to the highway
432 project. Therefore, if some of them wanted to fight against the consequences of urban and
433 metropolitan pressure, fighting against the highway alone was not enough. However,
434 from the perspective of spatial justice, preserving spaces and prohibiting the arrival of
435 new people can contribute to forms of social isolation, while at the same time the central
436 spaces in Lyon are becoming increasingly unaffordable for many people.

437 On learning about the new urbanisation zones near the planned highway route,
438 some participants pointed to the need to find new solutions for mobility, even though
439 most of them remained opposed to the highway project.

440 **Figure 2:** Urbanisable areas in local urban plans (residential, industrial, and
441 commercial). To simplify the reading of this paper, some details have been removed
442 from the poster presented during the day of mobilisation (names of all municipalities
443 and secondary road network). We have kept only the two main towns (Lyon and Saint-
444 Étienne) and the site of the mobilisation day (La Talaudière). One municipality crossed
445 by the highway project is not represented on our maps because the local urban plan was
446 not available.

447 **4.2 Maps of planned changes in the housing stock**

448 The maps shown in **Figure 3** correspond to **Poster 4**. The municipalities with the
449 highest rates of single-family homes are the most rural in the study area, located between
450 the conurbations of Lyon and Saint-Étienne. This map shows the process of urban sprawl
451 in this region, with a low expected share of multi-family housing. The second map
452 represents two variables: the number of dwellings planned per municipality and the
453 population increase planned for 2030 in comparison with the population of these
454 municipalities in 2017. The first variable is generally correlated with the number of
455 inhabitants of each municipality, with the most populated municipalities being those for
456 which the greatest number of new dwellings is expected. However, there are a few
457 exceptions, and some municipalities (e.g., L'Horme, La Grand Croix, Lorette) are
458 expected to receive a large number of new dwellings by 2030, and to increase their
459 population by 25% to 50%. Other municipalities expected to show substantial
460 development of their housing stock are located in the suburbs of Saint-Etienne and Lyon.

461 The main feedback from participants about these maps also noted a lack of
462 information on planned housing, especially on the number of multiple dwellings

463 developments planned in most of the municipalities crossed by the highway route, which
464 are predominantly rural. Most participants also observed that the planning documents
465 predicted drastic increases in the number of dwellings in some municipalities (sometimes
466 more than a 50% increase), and judged that they were not sufficiently informed about
467 these projected medium-term trends. It appears that even though the single-family home
468 model seems to be common, the development choices (with a growth in mainly individual
469 houses) of each municipality are not questioned at this scale. The maps show the
470 cumulative effects of the development policies of each municipality in combination with
471 neighbouring municipalities. It is accompanied by a disconnection between municipal
472 power and the devolution of power to local councils and agglomerations, which
473 contributes to the blurring of decision-making methods. Thus, many discussions focused
474 on the gradual distancing of inhabitants from decisions made concerning their daily lives.

475 In discussions over the second map, it was pointed out that if sparsely populated
476 municipalities doubled their population, the impact on mobility would be low, whereas if
477 the municipalities that were already densely populated doubled, the impact would be
478 greater. For all the participants, these maps tended to show that new solutions must be
479 envisaged in terms of short-term mobility, as more journeys would be conducted by the
480 increased population if no changes in current daily practices occurred and the dissociation
481 between place of residence and place of work continued.

482 Finally, the discussions around **Poster 4** deviated almost exclusively to the issue
483 of housing policies, with very little mention of the highway project. Although the
484 highway route is centrally represented on the two poster maps, the use of bright colours
485 and large black proportional circles may have influenced the participants to discuss the
486 housing issue, which is not necessarily directly related to the highway project.

487

488 **Figure 3:** Rate of increase of single-family homes planned by each municipality
489 between 2018 and 2030 and the number of dwellings (by municipality) and population
490 increases planned for 2017–2030. To simplify the reading of this paper, some details
491 have been removed from the poster presented on the day of mobilisation (the names of
492 all municipalities and the secondary road network) (see full details in Appendix 4). We
493 have kept only the two main towns (Lyon and Saint-Étienne) and the site of the
494 mobilisation day (La Talaudière).

495 **4.3 Mapping of potential connectivity losses that would be induced by the** 496 **new highway**

497 The map in **Figure 4** and taken from **Poster 7** shows the potential loss of
498 connectivity that would be induced by the A45 highway. We show this loss for a group
499 of species including amphibians linked to wetlands and aquatic environments. The
500 majority of the impacts are located close to the highway. The species studied do not move
501 more than a few hundred metres between habitat patches. The potential impacts observed,
502 sometimes up to more than 5 kilometres from the infrastructure, therefore highlight the
503 potential impact of the highway on ecological connectivity, not only on species' habitats.
504 On the basis of this map and the others presented, the participants noticed that impacts
505 could occur far from the highway. Indeed, for other species, impacts can be observed as
506 far as the Pilat massif to the south of the zone. However, participants specialised in
507 environmental issues (e.g., naturalist NGOs) questioned the design of the maps due to
508 their misunderstanding of ecological connectivity modelling, which constitutes a 'black
509 box' effect, i.e., the fact that the input data of the model are known and the output results
510 are understood but without knowing what is going on the model.

511 Although these maps required more explanation of the complex methods used to produce
512 them, the participants noted that the bright colours (from yellow to dark red) helped to
513 emphasise the wider ecological impacts of the highway. Although they were really *only*

514 about the potential impacts on ecological connectivity, the maps were perceived by some
515 participants as maps of ecological impact, or even of immediate biodiversity loss, which
516 allowed them to scientifically justify their fight against the highway project.

517 **Figure 4:** Loss of potential ecological connectivity due to the A45 highway (effects on
518 amphibians). Brown shading represents a loss of potential connectivity close to 100%,
519 while white represents no impact on ecological connectivity. For this map, we assessed
520 the ecological connectivity effects on several amphibians that inhabit wetlands (e.g., the
521 palmate newt and marsh frog). Computations were made with Graphab software
522 (Foltête, Clauzel, and Vuidel 2012; Foltête et al. 2021).

523 **5. Discussion**

524 The use of a GIS to produce maps for consultation by the general public is a fairly
525 standard method of communication in geographical studies. The method is of particular
526 interest for communicating information about natural hazards (Liu et al. 2017; Dransch,
527 Rotzoll, and Poser 2010; Rinner et al. 2010), environmental exposure or health risks
528 (Stieb et al. 2019) such as the global pandemic related to COVID-19 (Mooney and Juhász
529 2020). Studies have shown the value of maps for effectively communicating information
530 about large-scale development projects such as the design of new urban development
531 areas (Rydin and Natarajan 2016), wind power projects (Simão, Densham, and Haklay
532 2009), and the construction of expressways in mountainous areas (Banerjee and Ghose
533 2016). However, certain conditions are required to achieve the optimum public support.
534 People need to be able to identify where they live on the maps (Dransch, Rotzoll, and
535 Poser 2010), and also need to be able to take ownership of the materials to participate.
536 The value of participatory mapping has been shown in several studies (e.g., Brown and
537 Eckold 2020; Kahila-Tani, Kytta, and Geertman 2019; Rinner et al. 2010; Simão,
538 Densham, and Haklay 2009). Although the participants did not contribute to the initial
539 production of the maps, they directly modified their contents, appropriated them, and

540 expressed their opinions and their own experiences of the areas, leading to the feeling that
541 they could act and make their voices heard.

542 However, participatory mapping seems to be more effective if a true participatory
543 encounter is put in place (Rydin and Natarajan 2016). To encourage people to adhere to
544 our debate, we offered them the possibility of annotating the maps, correcting them, and
545 indicating the places they visited in the course of their daily lives (occupation, houses,
546 leisure activities, visiting family; Figure 5). In the situation described in this study, our
547 maps based on existing spatial and statistical data could not be explicitly created through
548 a participatory approach, but the work could nevertheless be enriched by counter-
549 mapping actions (Collective, Dalton, and Mason-Deese 2012) contributing to the
550 definition of other possible scenarios for the transformation of the territory and other
551 indicators of the impacts. Therefore, we created an environment for participatory
552 encounters by proposing informal discussions with participants standing around several
553 tables where they could come-and-go freely (Figure 5). This informality to the
554 discussions was a real challenge, as it was not possible for us to be physically present at
555 each table at the same time. However, an advantage of the approach was that people had
556 time to read the documents before engaging in discussions with us. We found this format
557 to be an effective way of communicating because our maps were not real scientific
558 posters.

559 The review by Stieb et al. (2019) presents three levels of use of maps by people:
560 reading (e.g., to search, identify, measure), analysis (e.g., to recognize, rearrange,
561 compare, discriminate), and interpretation to make inferences about spatial relationships.
562 Our experience showed that the participants used the maps at these three levels, to which
563 we add the further possibility that the maps could shift the debate on the way in which

564 the project could impact the daily lives of inhabitants and farmers, i.e., a more indirect
565 use of the maps.

566 Discussion between the researchers and participants was necessary for a good
567 understanding of the documents and to start debates around the presented themes. The
568 different maps all aroused the interest of the participants, but it was around the
569 connectivity maps that the discussions reached their richest level, probably because these
570 maps needed the deepest explanation of the modelling process. Our connectivity maps,
571 which used complex methods, were simplified as much as possible to ease the general
572 public's understanding of them. Although the understanding of these documents was
573 generally good, we were well aware that we could not represent the impacts of the
574 highway on biodiversity from a non-subjective point of view. In the case of research work
575 based on a quantitative methodological arsenal, this underlines the importance of setting
576 up companion methods integrating non-scientists at the start of the research process, as
577 performed by Sahraoui et al. (2021) when they considered the impacts of planning
578 scenarios on landscape connectivity. Indeed, a shared vision from the start of a research
579 protocol can clarify the terms as well as the objectives. Decisions on what colours (dark
580 red for a significant loss of connectivity) and thresholds (at what threshold is the loss
581 considered significant enough to be in red?) are applied are not neutral.

582 Using qualitative interviews, Severtson and Vatovec (2012) showed that the use
583 of red reinforced the interpretation of danger when communicating risk maps. Malavasi
584 (2020) made the same observation, showing that it is not possible to have a neutral
585 representation of nature, and that it is necessarily influenced by our personal
586 constructions, our dominant cultures, and our scientific blindness. As Monmonier (1991)
587 points out, "the power of maps can get out of control".

588

589

590 **Figure 5:** Debates with participants in our workshop (September 22nd, 2018, in
591 La Talaudière). Photographs: Marie Detemple.

592

593 On some maps, we tried to show the importance of road traffic in the area and the
594 very high demographic forecasts, to explain why this highway project was envisaged.
595 However, the presentation of the maps on ecological connectivity was a strong argument
596 against the highway project. We knew that on a day of mobilisation against the highway,
597 we would not find many people in favour of the project. Indeed, the participants used
598 these connectivity maps to justify their commitment against the highway project. As
599 shown by Sebastien (2017), we confirmed the fact that mobilisations against major
600 development projects seem to develop new territorial attachments that involve a
601 rediscovery of the environmental and heritage values of the territory. Our maps also
602 provided information on the modalities of development in the context of space waiting
603 for the highway. For example, an elected official from a municipality was able to show
604 us the difficulties they faced in granting building permits. In the end, there was no
605 response from the municipality, department, region, or state, and only a private
606 concessionaire validated the project. This raises questions about the capacity of public
607 authorities to act in this context, and points to the questioning of official governance and
608 the resulting arrangements, particularly in regard to public action.

609

610 In terms of perspectives, our work helps to show the implications of the interplay
611 of scales and the articulation between the practices and policies that aim to organize them.
612 In doing so, it is the notion of (spatial) justice that helps to assess the links between modes
613 of decision-making and the types of development and their impacts, whether social,

614 economic, and/or ecological. On our side, we tried to proffer alternative solutions to the
615 highway project, while the participants generally identified solutions directly from the
616 maps. For example, to solve the issue of road traffic on the existing highway, two
617 solutions were regularly mentioned: (1) widening the existing highway to ease traffic and
618 building a new bridge in a critical area, and (2) increasing the frequency of trains to
619 improve mobility between Lyon and Saint-Étienne. Boyle, Litzgus, and Lesbarrères
620 (2020) showed that from an ecological point of view, the widening of existing roads is
621 the most favourable option for limiting impacts on mammal movements. However, this
622 solution is not necessarily the most relevant from a more global ecological point of view,
623 as improving the usability of a road traditionally leads to an increase in traffic and only
624 solves congestion problems in the short term. Moreover, it does not call into question the
625 system that calls for ever greater mobility and the dissociation of functions across
626 different places. On the other hand, facilitating the use of a railway axis may solve these
627 problems, but may risk reducing the economic development of the smaller city (here
628 Saint-Étienne) in favour of the larger one (here Lyon) (Kim and Han 2016; Puga 2002;
629 Kakumoto 1999). Another proposed approach, which is more complex to implement in
630 practice, is to encourage the relocation of economic activities so that they are as close as
631 possible to the inhabitants, in order to limit travel as much as possible.

632 Finally, it should be noted that our approach is only based on static maps. Another
633 approach used in planning, risk, and environmental management is to use dynamic,
634 interactive, or web-based maps, with such media being likely to improve participation
635 (Nuojuua 2010; Kingston 2007), communication of information, and the collection of data
636 for a spatially-located discussion (Schwarz and Bräuer 2021). For example, studies on
637 risk communication showed the advantages of playing with extent and scale and selecting
638 alternative scenarios (Stephens, DeLorme, and Hagen 2017) and the utility of split-screen

639 capabilities for comparing maps (Cinnamon et al. 2009). Such possibilities would have
640 been relevant in our case, allowing spatial comparisons of the highway's impacts and
641 observation of the predicted effects of alternative scenarios to construction of the
642 highway. However, the substantial spatial analysis work needed for the communication
643 of our results did not allow us to easily automate the results to allow evaluation of the
644 predicted effects of alternative scenarios. Furthermore, in the context of this project, no
645 other alternative highway route has been considered by local planners, which makes it
646 difficult to create other scenarios. The logistics on the ground during the day of
647 mobilisation may also have constrained the participatory possibilities for many people.
648 However, an interactive spatial comparison of the maps would have been relevant to the
649 collective debate on the impacts. A prerequisite for the adoption of such technology by
650 the participants would be their admission of its advantages compared with other media,
651 and that it is consistent with their needs and experiences (Caley, Shiode, and Shelton
652 2008). One should also be careful to ensure that the interaction between each participant
653 and the maps does not replace the map-based interactions between participants.

654 **6. Conclusion**

655 Our work consisted of producing maps for the general public to feed the debate
656 on the A45 highway project connecting the French cities of Lyon and Saint-Étienne.
657 These maps were presented during a day of mobilisation against the project on 22
658 September 2018. We found that the participatory encounter was a very effective concept
659 for engaging in discussion around the maps. The topics addressed by the maps were
660 related to different themes: mobility, housing, land, landscapes, agriculture, and ecology,
661 but they always had a spatial component. The maps presented were not scientific posters
662 and were deliberately intended to be factual and succinct. This representation choice
663 opened up the debate with the participants, who were eager to know more about the

664 conception and representation objectives of the maps. We were not able to set up a real
665 participatory mapping project as the theme did not necessarily lend itself to such a format.

666 The meeting allowed us to present our research to the general public and to
667 demonstrate how they can engage with scientific research (Dietrich and Grim 2019).
668 Indeed, even if we believe that our maps showed a certain scientificity, we could see that
669 this was not totally the case, since the choice of maps guided the participants in their
670 reflections. Most of the time our maps served the participants purposes, as the participants
671 were mostly against the highway project. This controversial highway project was finally
672 abandoned in July 2020, but we do not assert the presence of a causal relationship between
673 provision of the maps and the decision to abandon the project, because several local
674 associations campaigned against this project for almost thirty years. Nevertheless, the
675 relationships constructed between research and mobilisation actions during this work
676 showed that scientific research in geography, which is often used to help planning
677 decisions, can also constitute a way towards evidence-based mobilisations.

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