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

Marc Bourgeois^{a*}, Yohan Sahraoui^b, and Judicaelle Dietrich^a

*^aEnvironnement, Ville, Société, UMR 5600 CNRS, University Lyon 3 Jean Moulin,
Lyon, France; ^bThéMA, UMR 6049 CNRS, University of Franche-Comté, Besançon,
France*

*Marc Bourgeois

marc.bourgeois@univ-lyon3.fr

Environnement, Ville, Société, UMR 5600 CNRS

University Lyon 3 Jean Moulin,

1C, avenue des Frères Lumière - CS 78242 - 69372 LYON CEDEX 08

Yohan Sahraoui

yohan.sahraoui@univ-fcomte.fr

32 rue Mégevand, 25000 Besançon, France

^b ThéMA, UMR 6049 CNRS, Université de Franche-Comté

Judicaelle Dietrich

judicaelle.dietrich@univ-lyon3.fr

Environnement, Ville, Société, UMR 5600 CNRS

University Lyon 3 Jean Moulin,

1C, avenue des Frères Lumière - CS 78242 - 69372 LYON CEDEX 08

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

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

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

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Ethical considerations

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

1. Introduction

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

Studies on conflicts related to planning projects often show the relevance of mapping for 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).

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

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

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

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

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

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

2. Case study

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

2.1. Scientific literature background on highway construction effects

The construction of transportation infrastructure such as highways is generally supported 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

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

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

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

2.2. Context of the A45 highway project and its actors

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

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

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

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

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

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.

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

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

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

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

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

3. Mapping production

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

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

3.1. Traffic and mobility

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

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

3.2. Land availability and housing

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

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

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

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

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

3.3. Landscapes and agriculture

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

3.4. Impacts on species habitats and ecological connectivity

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

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

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

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

3.5. Analysis of debates following the presentation of the maps

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

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

4. Results

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

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

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

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

4.1 Mapping of urbanisable areas in urban planning documents

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

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

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

4.2 Maps of planned changes in the housing stock

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

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

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

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

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

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

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

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

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

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

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

5. Discussion

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

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

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

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

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

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

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

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

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

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

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

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

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

6. Conclusion

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

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

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

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998