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Dykes and 'nature'. Results of a survey on the perception of dykes and their evolution in 21st century France



Digues et "nature". Résultats d'une enquête sur la perception des digues et de leur évolution en France au 21^e siècle

Diques y "naturaleza". Resultados de una encuesta sobre la percepción de los diques y su evolución en Francia durante el siglo XXI

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Résumés

English Français Español

The traditional paradigm of dyke management focuses on water defense. This article analyzes the perception and representation of coastal and river dikes among a sample of 828 residents and users. Five scenarios for the evolution of dikes were proposed to the respondents. Among these scenarios, maintaining the dikes in their current state is the most desired, while vegetation is the least rejected. In contrast, the scenarios of reinforcement and opening/lowering the dikes encounter notable rejection. This surprising refusal of reinforcement could indicate a shift in the perception of dike management in France, while the rejection of their opening remains consistent with the limited development of soft coastal and river defenses. Furthermore, the respondents' choices are strongly influenced by their relationship with nature, even though they refer to a nature that is anthropized and tamed. These results are important for developing scenarios for the evolution of dikes in the face of climate change challenges and for better communicating with audiences that are often unresponsive to innovations.



Le paradigme classique de la gestion des digues est centré sur la défense contre les eaux. Cet article analyse la perception et représentation de digues maritimes et fluviales par un échantillon de 828 riverains et usagers. Cinq scénarios d'évolution des digues ont été proposés aux personnes

enquêtées. Parmi ces scénarios, le maintien des digues dans leur état actuel est le plus souhaité, tandis que la végétalisation est la moins rejetée. En revanche, les scénarios de renforcement et d'ouverture/abaissement des digues rencontrent un refus notable. Ce surprenant refus du renforcement pourrait indiquer un changement dans la perception de la gestion des digues en France, tandis que le rejet de leur ouverture demeure cohérent avec le faible développement de la défense douce littorale et fluviale. De plus, les choix des répondants sont fortement influencés par leur relation à la nature, bien qu'ils fassent référence à une nature anthropisée et apprivoisée. Ces résultats sont importants pour élaborer des scénarios d'évolution des digues face aux défis du changement climatique et pour mieux communiquer avec des publics peu réceptifs aux innovations.

El paradigma clásico de la gestión de diques se centra en la protección contra el agua. Este artículo analiza la percepción y representación de los diques marítimos y fluviales a partir de una muestra de 828 rivereños y usuarios. Se consulta a los encuestados sobre cinco posibles escenarios en la evolución de este tipo de infraestructura. Entre estos, mantener los diques en su estado actual es el más deseado, mientras que la revegetación es el que presentó menos rechazo. Por otro lado, los escenarios de refuerzo y apertura/descenso de los diques presentan un notable rechazo. La sorprendente negativa a reforzar podría indicar un cambio en la percepción de la gestión de los diques en Francia, mientras que el rechazo a su apertura sería coherente con el débil desarrollo de defensas costeras y fluviales. Sumado a lo anterior, las respuestas de los encuestados están fuertemente influenciadas por su relación con la naturaleza, aunque más bien desde un punto de vista antropizada y domesticada. Estos resultados son relevantes tanto en la propuesta de escenarios sobre la evolución de los diques frente a los desafíos del cambio climático como para propiciar una mejor comunicación con audiencias poco receptivas a las innovaciones.

Entrées d'index

Mots-clés : digues de protection, dépolderisation, nature, représentations sociales, scénarios

Keywords : depolderisation, protection dykes, nature, scenarios, social representations

Palabras claves : diques protectores, despolderización, naturaleza, representaciones sociales, escenarios

Texte intégral

We would like to thank the Bioterre Master at the Paris 1 Panthéon-Sorbonne University and Master's students Enora Soriano and Mathilde Ravoyard for collecting data at the respective sites of the Dives, the Marais Poitevin and the Baie d'Authie. This study has received financial support from the LabEx Dynamite (ANR-11-LABX-0046 - Investissements d'Avenir) and from the French National Research Agency (ANR-18-CE03-0008-01).

Introduction

- 1 In France, dykes extend over approximately 9,000 km. They are linear hydraulic structures standing a few meters higher than the surrounding natural terrain and the fresh or coastal waters they border. Although the first French river and coastal dykes date back to Roman and medieval times, most of them were built in a period from the 17th to the 19th century. The main objective of their construction has always been to defend adjacent, naturally floodable land areas against rising water levels (CIRIA et al., 2013), although dykes also make it easier to reclaim new land from the sea (Verger, 2009) or the riverbed (Dion, 1961; Morera, 2011). River dykes protect land from flooding during high-water events, while sea dykes protect land from coastal flooding, which can occur during storms and high tides. Flooding and submersion occur when water flows over the top of the dyke or when a breach forms in the dyke due to the pressure of the water. At present, French dykes and dyked areas are particularly vulnerable to climate change in that scientists predict with a high degree of confidence a continuation of sea level rise, an increase in marine erosion and submersion, and an increase in river flooding - except for Mediterranean France (<https://www.adaptation-changement-climatique.gouv.fr/dossiers-thematiques/impacts>). The defensive function



of the dykes can only be guaranteed if they are constantly maintained, or even reinforced or raised in the areas most at risk.

2 However, over the last fifteen years, the defensive role of dykes has been questioned (Guerrin & Bouleau, 2014; Pigeon, 2014; Serre et al., 2017; Verger, 2011) because of the risk they create by their presence, or because of the decline in risk culture they may induce. In light of the flood risk, a change in dyke management is thus necessary, something that the lawmakers have recently acknowledged in France with the introduction of the GEMAPI, or Management of Aquatic Environments and Flood Prevention competence in 2018. This competence is delegated to local authorities, placing them in a position of legal and political responsibility regarding the integrated governance of flood risk management and biodiversity recovery (de Godoy Leski, 2021). In particular, the local authorities will now have to create, manage and regularize protection works against flooding and against the sea by intervening directly on their dykes (<https://www.ecologie.gouv.fr/gestion-des-milieux-aquatiques-et-prevention-des-inondations-gemapi>). Moreover, looking beyond their defensive role and technical aspects, which are often the only angle from which they are studied (CIRIA et al., 2013; Igigabel, 2016), dykes can be associated with other societal issues, primarily related to their uses (Dèbre et al., 2022) and, more rarely, to nature or landscape (Forray and Clément, 2017). But, if there are studies on the links between flood risk perception and landscape (Quinn et al., 2019) or nature (van Heel & van den Born, 2020), very few exist on links between dykes and landscape/nature perceptions, in particular without the classic prism of risk perception.

3 Yet, European planners and managers are increasingly considering the idea of opening/lowering or setting back dykes, in the face of physical, ecological and socio-economic arguments (Bax et al., 2023), both in fluvial/estuarine (Valette et al., 2015; Tafel et al., 2012; Warner et al., 2012) and coastal environments (Bazin, 2022; de la Vega-Leinert et al., 2018; Esteves, 2013; Goeldner-Gianella, 2013; Roca & Villares, 2012). New management solutions, more innovative and less costly, have recently gained acceptance with more emphasis on the landscape, defensive and ecological restoration role of vegetation in the foreland of dykes or behind reopened dykes (Shepard et al., 2011; Weinstein & Kreeger, 2000; Wolters, 2006). Some researchers are also considering the management of vegetation present on the dykes, particularly trees (Venetier et al., 2015), or of vegetated coverings of dykes (Chapman & Underwood, 2011; Gueben- Venière, 2014; Scheres & Schüttrumpf, 2019; Schoonees et al., 2019; Van Loon-Steensma et al., 2019). Thus, in these uncertain times of climate change, decline in biodiversity, growing attention to local uses and landscape and to new management of defensive dykes by the local political level, it has become necessary to reflect on the future of French dykes: regarding their management, what are the issues involved, the financial means available, the possible options for the responsible municipalities?

4 To help, locally, to bring possible evolution scenarios to fruition, particularly in the context of the new GEMAPI competence and by revealing blocking factors frequently of a social nature (Cortina-Segarra et al., 2021), we set up a social survey among residents and users of dykes. Our research objectives were to understand 1) their perception of dykes and 2) their opinion regarding various evolving scenarios for the coming decades (reinforcing dykes or, on the contrary, opening or lowering them up or setting them back, vegetating or equipping them further, or not changing them) with regard to a range of issues, sometimes contradictory: defense against water, uses, nature and landscape. These objectives arise from several scientific observations: if other water-related infrastructures have been studied from the angle of their perception – such as groynes (Barraud et al., 2013) or dams (Barraud & Germaine, 2017; Blanc & Bonin, 2006; Germaine & Lespez, 2023) –, this was not the case for dykes as infrastructure. Moreover, only the perception of innovative evolution scenarios (managed realignment in particular) has been studied, particularly in Europe (de la Vega-Leinert et al., 2018; Esteves, 2013; Goeldner-Gianella, 2013; Roca & Villares, 2012). Indeed, in these surveys, the entire range of dykes' evolution – from the most traditional to the most innovative ones (opening/lowering/setting back, vegetating) – has rarely been



simultaneously explored, as well as other issues than its use as defense. Finally, our survey aims to confirm the need to consider population's opinions regarding ecological restoration (Egan et al., 2011) – through opening/lowering/setting back dykes –, which is not yet sufficiently the case in Europe (Cortina- Segarra et al., 2021).

Part 1: A survey on the perception and future of coastal and river dykes in France

1. Study sites

- 5 Seven study sites were selected in the DIGUES research program to consider the evolution of dykes in France in the 21st century (Fig. 1). They either border major rivers (Seine, Loire, Sèvre Niortaise) or the Channel coastline. We considered river and coastal dykes simultaneously due to their identical role in protecting against water, in periods of river or coastal floodings – they are, in fact, studied together (as in CIRIA et al., 2013). Moreover, they are concerned today by the same legislative instruments: the PAPI (Programme d'Actions de Préventions des Inondations, or Flood Prevention Action Programme, covering floodings of all kinds) since 2002, the Flood Framework Directive since 2007, and the GEMAPI competence since 2018.
- 6 The studied dykes (Table 1) vary in length (from a few kilometers to several dozen kilometers), in construction period (from the Middle Ages to the 1920s), condition (from poor to good), function (generally defensive or agricultural), but also in the population density of the municipalities protected against the water, and in the surrounding landscape (from deeply rural to highly urbanized areas). These two last contextual elements mark the dykes in the bays of Authie (1) and Les Veys (2), Luthenay-Uxeloup (6) - simply named Luthenay in the text - and Marais Poitevin (7) as 'rural dykes', those of the Dives (3) and Jargeau (5) as 'urban dykes' and those along the banks of the Seine in SE Paris (Alfortville-Ivry - 4) as 'highly urban dykes' – or low walls ('murettes'). After interviews with local actors, we also chose dykes concerned by short-term local projects of opening, lowering or setting back, which are already in application or at the idea stage (Table 1).

Table 1: Characteristics of the study sites and their dykes

Study sites / Characteristics	Bay of Authie (1)	Bay of Les Veys (2)	Dives (3)	SE Paris (4)	Jargeau (5)	Luthenay (6)	Marais Poitevin (7)
Department	Somme, Pas-de-Calais	Manche, Calvados	Calvados	Val-de-Marne	Loiret	Nièvre	Vendée, Charente maritime
Length of the dyke(s)	approx. 10 km	approx. 10 km	approx. 10 km	a few kilometers of low walls	a few kilometers	a few kilometers	several dozen kilometers
Dyke width	5 to 10 m	5 to 10 m	5 to 10 m	low walls of a few cm, but several meters with the river bank	approx. 30 m	several meters	10 to 50 m



'Local' municipalities housing the "local residents" category of the survey	Groffliers, Waben, Conchil, Colline-Beaumont, Quend, Fort-Mahon-Plage	Carentan-les-marais, Géfosse-Fontenay, Sainte-Marie-du-Mont, Grandcamp-Maisy	Cabourg, Dives-s/Mer, Périers-en-Auge, Varaville	Vitry-sur-Seine, Alfortville	Sandillon, Darvoy, Jargeau, Férolles, Ouvrouerles-Champs, Sigloy, St Denis de l'Hôtel	Luthenay-Uxeloup, Fleury-s/Loire	Doix-les-Fontaines, St-Pierre-le-Vieux, Maillezais, Maillé, Vix, Courçon, St-Cyr-du-Doret, La Ronde, Taugon, St-Jean-de-Liversay
Average density of 'local' municipalities (inhabitants per km ²) in 2019	78	43	419	10196	134	14	58
Surrounding landscape	rural	rural	urban (Cabourg) to rural	highly urban	urban to rural (Jargeau - spillway)	rural	rural
Period when the dyke was built	18th, 19th centuries	19th, 20th centuries	18th, 19th centuries	after the 1924 flood	from the Middle Ages, and 1882 for the spillway	1755	17th century
Initial / current function of dyke	defence / defence	land gain / land gain	defence + land gain / defence + land gain	defence ('murettes') / defence	defence / defence	defence + navigation / (defence)	land gain / defence + separation of waters
Dyke's general condition	average	average	poor	good	average	good	average
Short-term local project (in application or at the idea stage)	breaches proposed by the Conservatoire du Littoral to better support coastline's evolution	the idea of a depoldering interests the Conservatoire du Littoral	moving the dyke back + attenuating their slope proposed by a local association	maintenance	lowering of the spillway (proposed by state technical services to prevent urban flooding risk)	breaches envisaged because the dyke which is neither functional in the face of floods is not classified	maintenance

7 It is important to present the landscape characteristics of the dykes studied, very vegetated in most cases (Fig. 1), relying in particular on the notion of naturalness. Guetté et al. (2018) explain that naturalness is not comparable to simple wild nature, but represents a three-faceted concept highlighting some gradients. Based on these facets, their own observations (Jolly et al., 2022; Hureau et al., submitted) and the more characteristic dyke's portions (Fig. 1), the program researchers determined the naturalness of the studied dykes, from a low (bay of Les Veys, SE Paris, Jargeau) to a medium degree (Bay of Authie, Dives, Marais poitevin), high in one case only (Luthenay).



Figure 1: The studied dykes in their most characteristic portion

2. Methodology

8 To analyse perceptions and representations of the dykes, a questionnaire-based survey was conducted in 2021, involving 828 users – both residents and non-residents – of the seven study sites. The distribution of responses per site is relatively balanced (16% in Baie d'Authie (132 surveyed people), 17% (141) in Baie des Veys, 20% in Dives (166), 10% in SE Paris (83), 20% in Jargeau (166), 4% in Luthenay (33) and 13% (108) in the Marais poitevin), with the exception of Luthenay where the dyke is isolated from the village and of SE Paris where the survey was conducted during the sanitary crisis.

9 Following an initial exploratory survey, the questionnaires distributed at the seven sites were almost identical, with some necessary adjustments in vocabulary: for instance, the dykes are called 'levées' in Luthenay and in the Marais Poitevin, 'renclôtures' in the Baie d'Authie and 'murettes' (or low walls) along the Parisian Seine; meanwhile, the lowered dyke at Jargeau is in fact a 'déversoir' or spillway (footnote 1). The face-to-face questionnaire took between 15 minutes and one hour, most often on or near the dyke and sometimes at the residents' homes. Our sampling method was non-probabilistic - the only possible method when the reference population is unknown (e.g. the people who use and/or know the dykes of each study site): thus, the respondents were selected arbitrarily (e.g. convenience sample), after having verified that they knew or frequented the dyke. Data from non-probabilistic surveys present inevitable participation and selection biases, but this is the only possible way to obtain data on the perception and attendance of dykes. To prevent biases, the number of investigators was limited - one or two per site, including a doctoral student or researchers who designed the survey and trained the investigators to deploy an identical method and never induce answers.

10 There were 39 questions, both closed (single and multiple-choice) and open. After many questions on the perception of the dykes and associated issues, the last part asked respondents to consider 5 scenarios for the evolution of the dykes. The statistical processing of the results involved flat and cross tabulations (Fig. 2, 4, 5, 6), subject to the significance of the Chi-square test when applicable. In most cases, the relatively rare 'don't know' responses were excluded from the analysis, to highlight the respondents'



prevailing perceptions.

- 11 For each site, the researchers defined 5 dyke evolution scenarios, based on scientific literature (see Introduction), field exploration and discussions with local stakeholders around local projects already under discussion or in mind (Table 1) and around other potential scenarios. For each scenario, a detailed table was shown to the respondents, presenting its positive and negative effects according to the four issues addressed in the questionnaire. These effects are summarized in Table 2, which does not contain the local adaptations which were present in the tables presented locally to people. Thus, they could position themselves based on a global analysis, adapted however to each study site. After reading and understanding the table, respondents were asked 'whether they thought the scenario was desirable for the future'.

Table 2: Summary of the positive and negative effects of each scenario

Issues Scenarios	Defence	Uses	Nature	Landscape
SO: Not changing the dykes	Dykes won't protect the area against a major flood. In Jargeau, the spillway will no longer function in the event of a flood.	Activities are preserved.	Natural areas are maintained.	Dykes are part of the local heritage, and may permit observation of the landscape.
S1: Reinforcing the dykes	Protection is to be renewed and/or reinforced so that the dykes provide better protection, which involves a cost	Uses, particularly agricultural uses, on and around the dykes intensify.	Vegetation changes (dykes are less vegetated ; trees are replaced by grass in the Marais Poitevin).	Reinforced dykes become more visible.
S2: Opening/ lowering the dykes	Water may spread onto the land (so more frequent flooding). In Jargeau, the spillway may give way in case of a major flood.	Uses must adapt to the temporary presence of water (accessibility, agriculture).	Vegetation evolves naturally with the water.	Dykes become less present and visible.
S3: Vegetating the dykes further	The defensive function of the dykes is maintained at its current level. The spillway no longer functions at Jargeau. Vegetation can help to protect against water (e.g. salt marshes).	Uses are maintained, particularly on the dykes, unless the vegetation grows too much.	Vegetation would take several forms in the various sites*. Nature is to be managed to increase biodiversity or to prevent burrows which weaken dykes. The vegetation can create landscape continuity with the adjacent territory...	... but may partially block walkers' views.
S4: Equipping the dykes further	The level of protection does not change	Greater recreational uses on the dykes, with the risk of a loss of privacy and conflicts between	Vegetation may be degraded and animals disturbed.	More artificialization.



		new and traditional uses.		
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* Baie des Veys, Luthenay, Jargeau and in SE Paris: allowing vegetation, including small trees, to develop on the dyke. Dives: allowing vegetation on the attenuated dyke slopes along the river. Baie d'Authie: encouraging the development of salt marshes in front of the dykes, with no planting of trees. Marais Poitevin: encouraging the renewal and diversification of tree species on the dykes.

- 12 If the respondents did not answer all the questions, we nevertheless observed a low average rate of refusal to answer (for instance 3.8% of the 828 people questioned, concerning the single-choice questions in Figures 3 to 5).

3. Profile of respondents

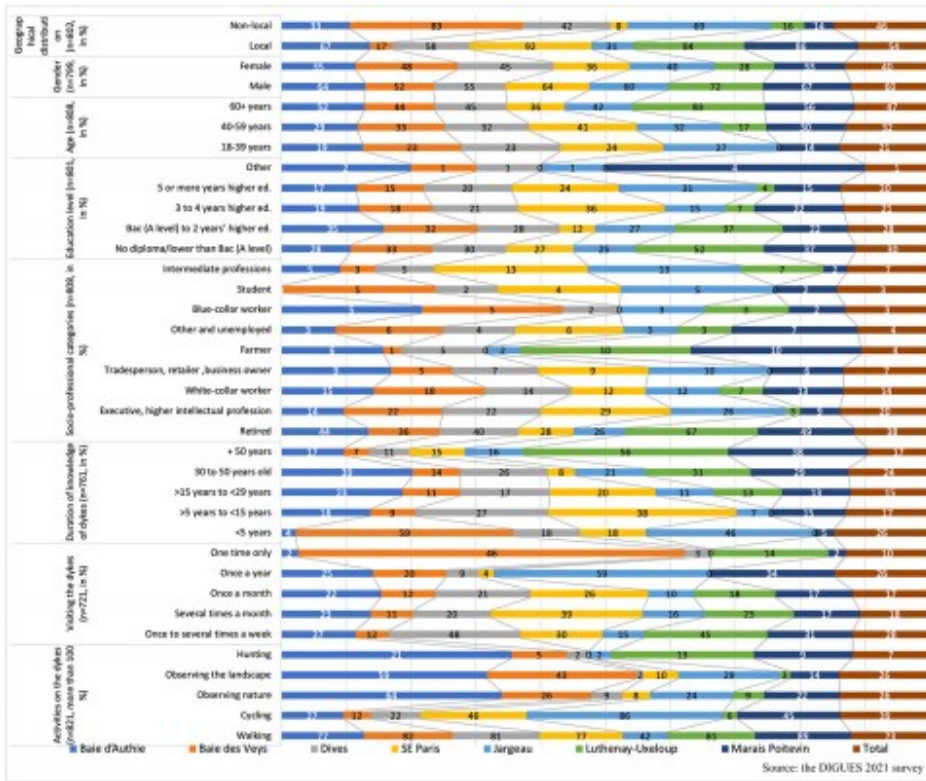
- 13 As shown in Figure 2, we were careful to ensure a balance between the number of respondents residing in the vicinity of the dyke system or the study area¹ (54% local residents) – the distance to the nearest dyke being a discriminating variable (Mol et al., 2020) – and non-local residing at various distances (46%). However, we were unable to avoid a certain imbalance between the proportion of men and women (60 and 40% respectively). The age groups are relatively well distributed either side of the 60-year mark (53% were under 60 and 47% over), which reflects a high number of retired people in the socio-professional categories (38%). However, our sample included more young people at the 'urbanized' sites (Jargeau and SE Paris), while older and retired people predominate around the rural ones (Luthenay and Marais Poitevin). There are more people having completed fewer than three years' higher education (58%), while the share of executives and higher-intellectual professionals only accounts for 20%. More specifically, there are fewer graduates and more farmers in rural areas (Luthenay and Marais Poitevin) and more graduates, intermediate professions, executives and independent professionals in urban ones (Jargeau and SE de Paris).

- 14 Depending on the site, users do not have the same relationship with the dykes (Fig. 2). Knowledge of the dykes is very high overall, since three quarters of the respondents have known about them for 5 years or more and 41% for more than 30 years, particularly in rural areas (Baie d'Authie, Luthenay and Marais Poitevin). Most of those who were less familiar with them were interviewed in the Baie des Veys and in Jargeau, where few local residents actually responded. The respondents also visit the dykes a great deal²: 63% of the respondents frequent the dykes on a daily to monthly basis, whereas it is only annual in Jargeau or in the Baie des Veys. Among the activities practised on the dykes, walking ranks first (75%) – with the exception of Jargeau along the Loire, where cycling predominates –, followed by nature and/or landscape observation (32%), particularly in the Baie d'Authie but very little in Luthenay or along the Dives. Hunting (7% on average) is more frequent at the latter two sites (21% in Luthenay and 13% along the Dives respectively). In this analysis, the Baie des Veys stands out from the other sites for the higher number of non-local residents among the respondents, which explains why more of them have only recently become aware of the dykes, rarely visit them and mainly coming here to observe the landscape.

- 15 Although our approach is not probabilistic and there is no reference population for people using the dykes, we compared the local residents in the survey to the reference population of the surveyed municipalities (for the 2020 census). We note that with the exception of the Dives site, we interviewed more men and more people aged over 60 in the study sites than in the reference populations, men being visibly more inclined to talk to us about these infrastructures and the over 60s more present on the dykes. Nevertheless, what is important for us, more than an impossible representativeness, is the high level of knowledge and use of the studied dykes regarding the surveyed people.

Figure 2: Profile of respondents and relationship to dykes (in %)





Source: the DIGUES 2021 survey.

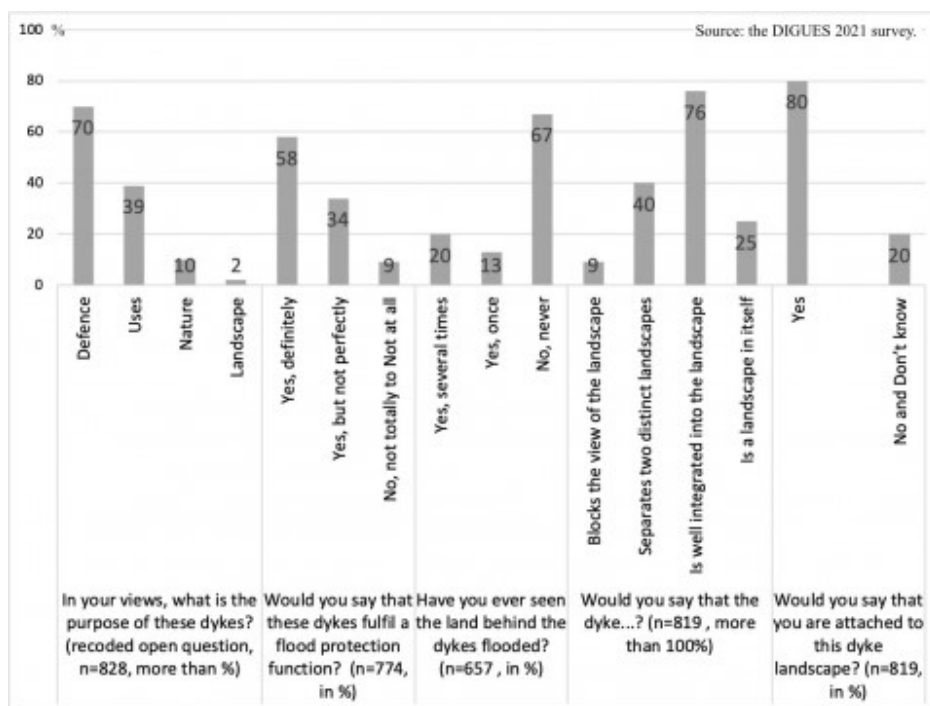
Part 2: Main results

1. Perception and knowledge of dykes in France

16 Our study into the perception of dykes (Fig. 3) shows that only their function in protecting against water is well recognized: 70% of the respondents acknowledge that the dykes have a defensive function, while only 39% mention other uses in connection with the dykes; fewer still mention links with nature or the landscape (10% and 2% respectively). In terms of water defense, an overwhelming majority (90%) believes that dykes have a function in flood protection (Fig. 3) (particularly in the Baie d'Authie, along the Seine in SE Paris and the Loire at Jargeau) although two thirds have never observed such a phenomenon (Fig. 3). This emphasis on defense shows that the primary function of dykes is generally well known to the population. This ranking of the issues associated with dykes is very similar to that provided by an analysis of social representations of river and sea dykes in France, carried out by studying articles on this topic in the national daily newspaper *Le Monde* (Goeldner-Gianella et al., 2021) from 1944 to 2020. 77% of the articles in a corpus mentioning dykes referred to their defensive function, whereas only 20% and 14% respectively referred to nature and landscape issues related to dykes.

Figure 3: Perception and knowledge of dykes in France





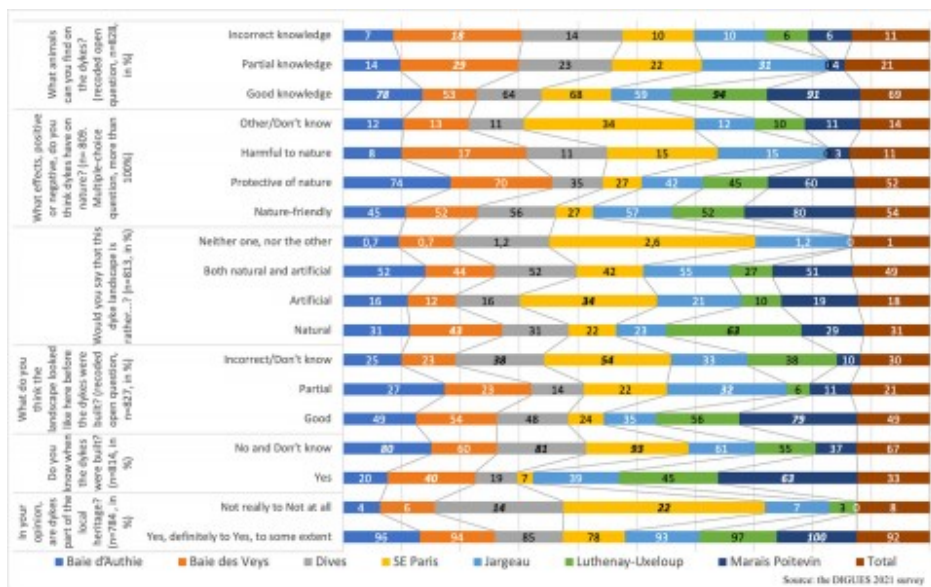
Source: the DIGUES 2021 survey.

17 The heritage dimension of the dykes is also widely recognized (92%) (Fig. 4), but the respondents do not know when they were built (67%) (Fig. 4). 75% of respondents perceive the dykes as 'well integrated into the landscape' and a quarter even consider that 'they are a landscape in themselves' (Fig. 3). Finally, half the respondents had sound knowledge³ of the general characteristics of the landscape before the dyke was built and a quarter had partial knowledge of this (e.g. tidal or river marsh, low natural bank, no break between water and land, etc., Fig. 4). The level of attachment to the dykes studied is very high (80% of all respondents, and at least 65% for the low walls in SE Paris).

18 Another finding is that the dyke landscape⁴ is perceived more as both 'natural and artificial' (49%) or even as strictly 'natural' (31%), rather than as purely 'artificial' (Fig. 4). Respondents were asked to give the 'three words that come to mind when they look at the dyke landscape': the first words cited relate mainly to nature in general (22%), and to components of nature: vegetation (12%) and water (11%), but also to beauty (16%), peace and quiet (12%), walking (7.5%) and the notion of maintenance (7%). None of the words mentioned describe the dykes as an artificial landscape. In terms of nature, we can also see that the dykes are considered to be 'nature-friendly' (54%) and even 'protective of nature' (52%), while only 11% of respondents consider them to be 'harmful to nature' (Fig. 4). Unsurprisingly then, 90% mentioned the animals (wild and domestic) observed on the dykes (Fig. 4), with 69% recognizing at least two local species or one local species and one group of species. Many of the responses obtained thus emphasize a kind of 'naturalness' of the dykes.

Figure 4: Perception and knowledge of dykes in 7 study sites





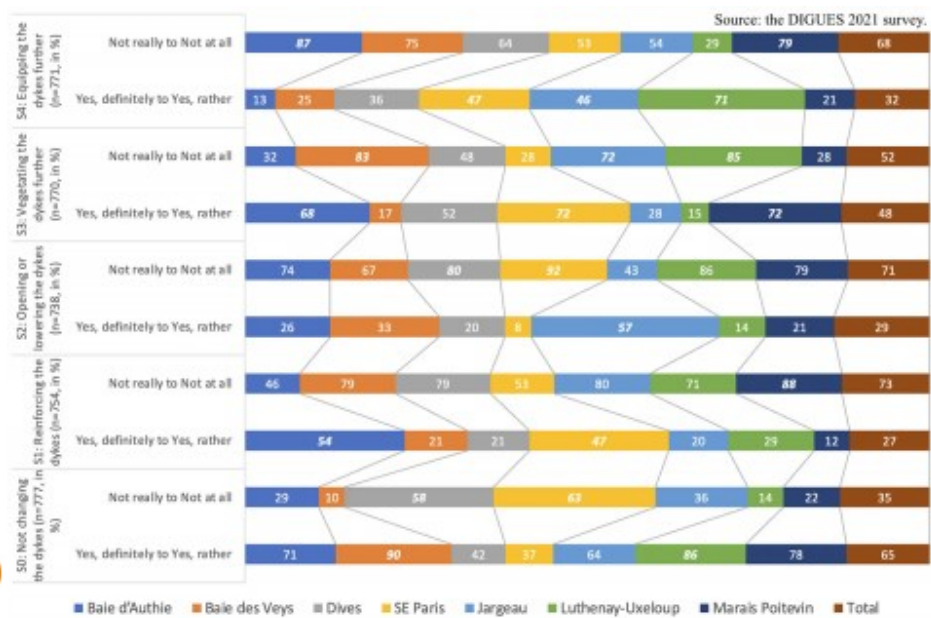
All the relationships are highly significant. Chi-square test was not applicable for the multiple-choice question concerning effects of the dykes on nature. Values in bold and italics are significantly over-represented (at the 5% risk threshold).

Source: the DIGUES 2021 survey.

2. Scenarios for evolution of the dykes mainly rejected

19 Of the 5 scenarios for dyke evolution presented to the respondents (Fig. 5), the scenario that involves no change to the current state of the dykes was the most popular (65%), except in the Dives and SE Paris. The 'further vegetate' and 'equip' dykes' scenarios are also fairly popular (48% and 32% respectively), with the 'open/lower' and 'reinforce' scenarios ranking lower. It is logical that the scenarios proposing the most significant changes are heavily rejected: reinforcing the dykes (73%, in particular in Marais poitevin), opening or lowering them (71%, in particular in Dives and SE Paris) and equipping them (68%). Only the scenario proposing to vegetate dykes further has a lower rejection rate (52%). In fact, this scenario is the most appreciated (48%) after the 'no-change' scenario, in particular in the Authie Bay and the Marais poitevin. It is even the first selected scenario in the Dives and SE Paris.

Figure 5: Degree of acceptability of dyke evolution scenarios according to study sites (in %)



Legend: All the relationships are highly significant. Values in bold and italics are significantly over-represented (at the 5% risk threshold).

Source: the DIGUES 2021 survey.

3. Scenario choices in relation to the respondents' profile and their perception of the dykes

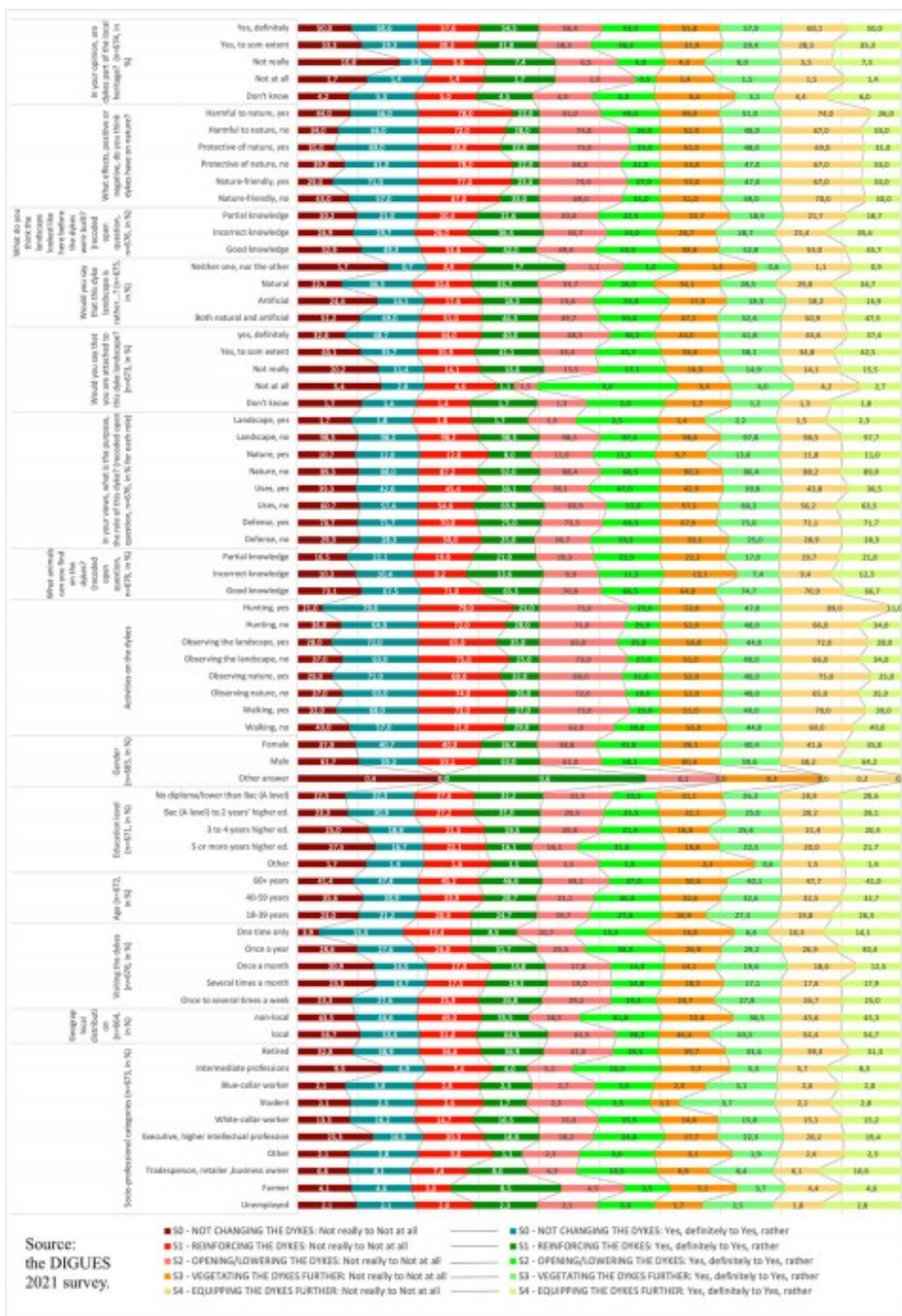
20 Focusing on the profile of individuals, the analysis shows that some groups express stronger positions in favour of one scenario or another (Fig.6). For example, farmers are more in favour of reinforcing dykes. Local residents are more in favour of reinforcement and less keen to vegetate the dykes further or to change their current state; they are also less keen to open/lower them. In contrast, non-residents express a preference for opening/lowering dykes. The more often the dykes are frequented, the more people want not to change them, to vegetate them further (for those who visit every month) and not to open/lower them. Finally, nature-related activities are also very divisive (Fig. 6, 7): people are more opposed to the opening/lowering of dykes when they walk along dykes; they are more opposed to equipping dykes when they hunt, observe nature or walk on them; and finally, they prefer not to change anything when they hunt, observe the landscape or walk along dykes. People with low qualification levels are more likely to refuse to open/lower the dykes or to desire not changing anything, while people with higher levels of education or executives are more likely to refuse the no-change scenario. Retired people are more likely to reject the opening/lowering of the dykes and over-60s rejected the vegetation of the dykes.

21 Regarding the perception of dykes (Fig. 6), people who prefer to open/lower the dykes believe that dykes are harmful to nature. At the same time, the wish not to change the dykes is mainly expressed by the respondents who believe that the dykes are nature-friendly and even protective of nature and who have some knowledge of the animals on the dykes. Finally, those who want to vegetate them further have sound knowledge of the animals present and believe that the dyke plays a role with respect to nature. Moreover, concerning rejection of scenarios (Fig. 6), those who reject reinforcement see the dykes as nature-friendly or as playing a role with respect to nature, while those who reject the opening/lowering scenario consider them to be un harmful to nature and even protective of it. Finally, those who reject the vegetation scenario have only partial or incorrect knowledge of the animals present on the dykes. It is noteworthy that the links identified between the acceptance or the rejection of scenarios and the perception of dykes often concern 'nature' (effects of the dykes on nature, knowledge of the animals present, role of the dykes with respect to nature), to a much greater extent than the defense, landscape or use thematics.

22 However, as well as this link to nature, we can see that attachment to the dykes is also an important factor in positioning: the respondents who said that they were very attached to the dykes did not want to change them or to open/lower them, unlike those who were not attached to them (more of these respondents wanted to change or open them). Meanwhile, the fact that the dykes were considered to be a heritage feature had little influence on the responses, leading only to a wish not to change them and not to further equip them.

Figure 6: Relationship to dykes, perception of dykes and profile of respondents according to the degree of acceptability of dyke evolution scenarios





Legend: Only significant statistical relationships are commented on in the text. Source: the DIGUES 2021 survey.

Part 3: Discussion

23 How should we understand the main results of the survey, which show 1) that people refuse to see the dykes change, even when it comes to the opposing scenarios of reinforcement or opening/lowering, and 2) that many of the responses emphasize a kind of 'naturalness' of the dykes?

1. Future changes to the dykes are rejected

24 The majority of respondents opted for the scenario that involved 'no change' to the dykes (65%). This result can be interpreted in light of their attachment to the dykes, which is extremely high: 80% on average. Moreover, many of these dykes are already vegetated and well integrated into the landscape (Fig. 1) which, along with their average to good condition overall (Table 1), could justify leaving them unchanged. Finally, their

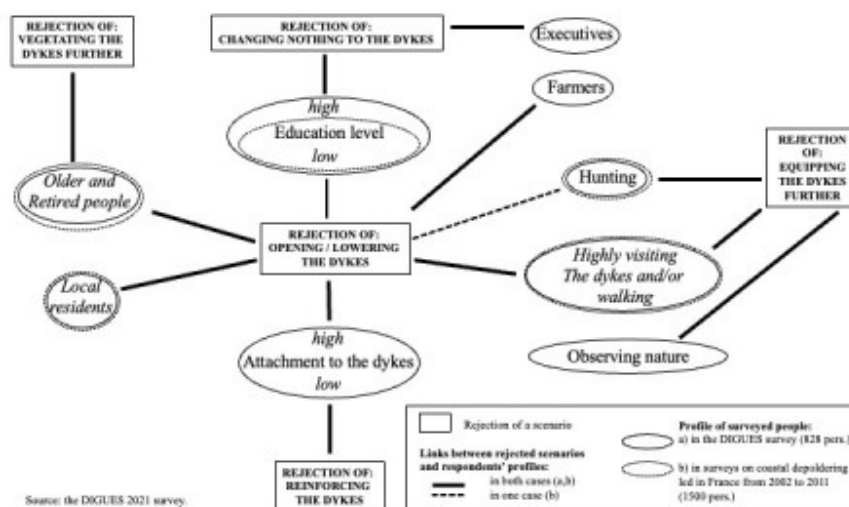


high level of use is undoubtedly to be taken into consideration (3/4 of the surveyed people walk along these dykes). The analysis also shows that those who refuse to change the dykes (Fig. 6) are mainly hunters, walkers and landscape observers.

25 In addition to their wish to leave things as they are, the respondents naturally express their rejection of other scenarios. It is not surprising that they rejected the opening/lowering of dykes (71%). This result has been observed regularly over the last two decades by a comparison of 5 surveys on coastal depoldering in France, conducted between 2002 and 2011 and involving approximately 1500 people (Goeldner-Gianella and Bertrand, 2013): the majority of respondents in Arcachon Bay and on the coast of Picardy were against depoldering. In Germany, Spain or UK, local population (de la Vega-Leinert et al., 2018) and local stakeholders can express a similar opposition to the opening of dykes (Esteves & Thomas, 2014; Roca & Villares, 2012), even if administrative decision-makers present more favorable opinions - although with various concerns - regarding dyke relocation (Tafel et al., 2021). In the French mentioned surveys, the profile of these opponents shows strong similarities with the results of the DIGUES survey (Fig. 7): age, education level, level of frequentation, activities on and around the dykes, and place of residence are variables that help to explain the refusal to open/lower the dykes.

26 It is more difficult to comment on the high level of rejection for the dyke reinforcement scenario, as this is an unusual response given the previous findings. For example, a continuation of hard defense solutions was chosen as a priority in previous surveys, in the Arcachon Bay and on the Picardy coast (Goeldner-Gianella, 2013; Goeldner-Gianella et al., 2015). And elsewhere in Europe, local population or stakeholders continue to favor hard defense and therefore the maintenance of dykes (de la Vega-Leinert et al., 2018; Roca & Villares, 2012). The different wording of the questions in the successive French surveys⁵ can partly explain this shift from acceptance of dyke reinforcement to its rejection. Or the newly observed reluctance to reinforce dykes could also be a sign of a change in mentalities, 10 or 20 years after the first surveys on this subject. Similarly, a survey by de Groot (2012) showed that in river environments, at the start of the 2010s, dyke reinforcement was no longer viewed positively in France, Germany and the Netherlands. Further research is needed to confirm this hypothesis. The change may also be linked to a decline in risk culture which lessens the importance of the dykes' defensive function, and/or to a strong attachment to dykes as a heritage or landscape feature.

Figure 7: Significant links between the respondents' profile and their rejection of the five scenarios



Source: the DIGUES 2021 survey; Goeldner-Gianella & Bertrand, 2013.

27 Finally, site by site, scenario preferences arise for varied reasons (see Table 1). In the Dives, where four scenarios are (more or less) rejected although certain sections are in poor condition, the one proposed by an association and consisting in revegetating the

southern dykes with a slight attenuation of the dyke's slope turned out to be the most (weakly) accepted. It responds to the risk of marine submersion for the urbanized northern part and the desire to preserve the traditional activities practiced behind the dykes in the rural southern part (Rich et al., 2022). Opinions are of the same order in the bays of Authie and Veys, where rural coastal dykes should preferentially remain as they are, either unequipped or not open – although certain public actors would be favorable to this last idea. The only difference: the desire for reinforcement in the Bay of Authie – already hit by storms – and for additional revegetation, unlike the Bay of Veys where the dykes, already considered “natural”, should remain as they are (Douillard et al., 2021). In the rural Marais Poitevin (Pernet, 2023), three scenarios are also refused (reinforcement - undoubtedly in the face of a little-known risk -, opening and equipment). For the population who is very attached to the vegetal character of the embankments and their accessibility, the dykes must remain unchanged and above all natural (e.g. the vegetating scenario). Conversely, in Luthenay-Uxeloup where density is not an issue and the dyke is in good condition, people refuse to reinforce as much as to open or vegetate further (the dykes are already considered “natural”), but wish either not to change anything, or equip them more, for walking purposes. In Jargeau, in a more urban atmosphere where the dykes are maintained and already used, three scenarios are refused (reinforcement, revegetation and equipment): people prefer to maintain them as they are or to lower the spillway (an idea also considered by the public authorities) in the face of the risk of flooding. Finally, in the SE of Paris, where the density exceeds 10,000 inhabitants/km², preferences are for refusing to open the low walls, in the face of a risk of flooding already experienced, and for the revegetation of these very “artificial” walls. Thus, in certain cases, beyond the profile of the people interviewed, the local context (Table 1) is also at the origin of the preferences observed (state of the dyke, risk, density, landscape, activities, attendance, etc.).

2. Dykes as ‘hybrid objects’ and ‘natural artifacts’?

28 Other results worthy of discussion are the apparent ‘naturalness’ of dykes in the respondents’ view, the links concerning nature between the acceptance or the rejection of scenarios and the perception of dykes, and the fact that the ‘vegetating’ scenario is the most appreciated after the ‘no-change’ one. These results are quite paradoxical given the fact that dykes are built infrastructures that extend over former natural marshes.

29 One first explanation for such a regular reference to nature is that some dykes, which are highly vegetated (Fig. 1), are appealing in their current form – 80% of respondents are attached to them, after all – and revegetating them could, in a way, be equated with not changing anything – the option preferred by the respondents. Moreover, the general public’s vision of dykes is undoubtedly limited to a superficial landscape, which they perceive and consider in its continuity – as experienced when walking on it –, whereas the scientific and land-use planning visions assimilate the dyke more with a complete volume (the surface and its bedrock) separating the land from the water, and therefore with a form of ecological and landscape rupture. Hence, a superficial and continuous vision of the dykes would make it easier for the public to associate them with a natural landscape. As for the navigation groynes built in the bed of the Armorican Loire in the early 20th century (Davodeau et al., 2013; Barraud et al., 2013), associating dykes with nature comes closer to the ‘*experienced view*’ than to the ‘*scientific model*’ that automatically excludes these man-made infrastructures from nature. Although artificial, these groynes are now perceived as natural, due to their appearance and because they are ‘*immersed in the banks*’ – just as some of our dykes are immersed in vegetation – to the point that they are ‘*one of the components of the “Loire, wild river” model*’ (Davodeau et al., 2013).

A third explanation for such a regular reference to nature is related to the specific social representations of nature⁶ in France. Concerning social representations of nature



in France, many authors, from all disciplines, highlight the close interconnections between society and nature in a France that American historian Michael Bess describes as a *'light green society'* (2011). De Groot (2012) shows that while the French considerations of *'pure nature'* are very similar to those of the Germans or Dutch, much more French people than Germans, and around the same number as the Dutch, also consider *'managed nature'* to be natural. A CGDD survey conducted among 4000 French people on social representations of nature clarifies this observation (Ducarme & Pautard, 2020). It indicates that *'spaces and species'* remain the entry point for the perception of nature, but, after that, the concept of nature appropriated by human activities ranks relatively highly, particularly in relation to rurality. The social representations of nature *'also refer [...] to an idea of interdependence between people and their environment'* for a small proportion of the respondents. Conversely, *'nature is not fundamentally "wild", and is on the contrary hospitable, and on occasion maintained or gardened; it is a setting [...] in which humankind appears to have its rightful place'* (Ducarme & Pautard, 2020). A survey carried out thirty years earlier (1991) already gave similar results (Collomb & Guérin-Pace, 1998): *'anthropized nature'* was considered to be one of the social representations of nature in France. Finally, geographer E. Reclus defended the same idea as early as 1866: *'The nature that the French understand best and like to contemplate most is the countryside [...]', 'nature shaped by work (which) has become anthropized'. This 'obviously very French vision of a hospitable and tamed nature'* (Ducarme & Pautard, 2020) or a *'lack of love'* for wild nature (Chansigaud, 2017) can probably be explained by the very long history of anthropization of French territory, which over the centuries has taken the form of a careful and almost complete domestication of the land (Frémont, in Nora, 1997; Dagognet, 1988). Hence, it is not all that paradoxical that the French people see dykes not as a man-made element but as a purely natural or semi-natural one, associate their landscape with nature, consider them beneficial for nature, and prefer them more vegetated in the future. They are undoubtedly referring to a deeply anthropized and tamed nature, and not to a wilderness that could not be assimilated with dykes.




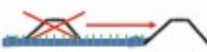

31 Based on this desire for anthropized nature, could we imagine dykes evolving into infrastructures that would be better integrated into nature and landscape and more truly in accordance with the vision or the expectations of the general public? This idea is being considered more and more, if not yet implemented. Thus, if engineers generally prohibit trees due to the impact of tree rooting in dykes and the risks of internal erosion and degradation of their facings (Vennetier et al., 2015), they estimate that they could be tolerated in the case of wide dykes with controlled and selected vegetation, or dykes made of draining materials or otherwise reinforced (Zanetti, pers. comm., 2021). German and Dutch researchers are also proposing to move towards greener coastal infrastructures and *'nature-based design considerations'* by designing for sea dykes - currently preceded by mudflats and covered with riprap at their base and then a short grassy area - to develop ecosystems and/or nature-based structures in the foreshore, to adapt seeding mixtures towards more ecologically valuable vegetation and to move towards vegetated revetments and vegetated fortified dyke paths (Schoonees et al., 2019). The German engineers Scheres & Schüttrumpf (2019), who also seek to enhance the ecological value of sea dykes, mention the progress of reflections concerning the foreland of dykes (salt marshes and artificial structures), but underline the uncertainties still relating to the ecological enhancements of the dyke structure itself (vegetated coverings, types of vegetation). The movement of engineers, ecologists and landscapers towards natural infrastructures is, however, underway in the reclaimed European countries faced with the need to preserve most dykes and adapt them to climate change. These various proposals appear to be in full agreement with the revegetation scenarios that the public favored locally in our survey (respectively revegetation included trees on the dykes of SE Paris and the renewal of trees on the dykes of the Marais Poitevin; softened and vegetated slopes along the Dives or the development of saltmarshes in the Bay of Authie).

These newly conceived natural infrastructures have, as in the case of the Loire



groynes, 'an undefined and unstable status somewhere between nature and culture' (Davodeau et al., 2013). Dykes or dyked areas can be qualified as a *hybrid object or environment* (Lespez & Dufour, 2021), but to what extent? Are they hybrids as artificialized natural areas or as renatured artificial areas? In the case of dykes and their evolution, the answers are plural (Table 3).

Table 3: Dykes and dyked areas are “hybrid objects or environments”...

Dykes and dyked areas...	... as artificialized natural areas	... and as renatured artificial areas
	After land reclamation, nature is artificialized to the point of disappearing...	
		... but not completely (e.g. nature living behind the dyke)
 © L. Goeldner-Gianella		Nature is currently present on the artificial dyke: both inert (in the earth constituting numerous dykes) and having developed spontaneously (a riparian forest climbing on a dyke...) or planted and managed (the trees of some levees; the mowed grass on the dyke...)
		Nature has been restored by the accidental or artificial reopening of a dyke and is progressively able to evolve spontaneously
 © L. Goeldner-Gianella		The nature that could be deployed further on the dykes (in order to maintain them in the face of climate change while increasing their ecological value)

33 It is obvious that on and around the dykes and in the reclaimed areas, nature and artifice are in constant interaction, both spatial and temporal (Table 3), provided we admit that there are several conceptions of 'nature' or degrees of naturalness (Larrère & Larrère, 2015). In the context of the innovative evolutions mentioned above, a dyke and the dyked area even constitute a good example of a *natural artifact*, that is *an intentionally created entity capable of being part of the natural processes' continuity and having the potential for autonomy* (Waller, 2016). This qualification undoubtedly applies better to the natural area restored by opening a dyke, but it could also concern, to a certain extent due to the floristic management they require, some dykes already heavily vegetated or in the process of becoming densely vegetated in the future. A new survey precisely focusing on dykes and nature would make it possible to better understand which sort of nature is locally desired - in front of, on, or behind the closed or reopened dykes - by exploring with the respondents the diverse facets of these hybrid objects' naturalness (Guetté et al., 2018).

Conclusion

34 The results of this first survey on French river and coastal dykes should help stakeholders to build future local scenarios and design development projects. To help them further, beyond the survey results, the program researchers also constructed generic scenarios of dyke evolution (De Godoy-Leski et al., submitted), from our 7 study sites, taking into consideration 17 different environmental and social variables, including the variable “perception of dykes and evolution scenarios” resulting from this survey. This “perception” variable is particularly decisive in two of those generic scenarios: perception is the criterion which, among technical management, governance, environmental and territorial dynamics, most encourages the maintenance of the dykes and pushes the least when opening/lowering them. The results of the DIGUES survey thus constitute a important factor to be taken into consideration by dyke managers and



ected officials, when reflecting to the dykes' future or to the profile of the opponents to some scenarios.

35 We arrive at the final idea that to help local stakeholders, it would be useful to combine evolution scenarios and their cumulative positive impacts, instead of designing them separately. In particular, it could be interesting in the face of climate change to combine the increasingly considered scenario of opening/lowering dykes (see Introduction) with the approved scenario of increased vegetation, around and on dykes; or this vegetation scenario with the maintaining or reinforcing scenarios, when those remain necessary in inhabited territories. For the moment, combining opening/lowering dykes and increased vegetation does not seem to attract populations: indeed, when several scenarios are simultaneously chosen, the desire for vegetating the dykes further still goes hand in hand with traditional scenarios of changing nothing (Baie d'Authie, Marais Poitevin) or reinforcing dykes (Baie d'Authie, and to a lesser extent SE Paris) (Fig. 5). Therefore, to develop nature-based solutions, it is towards this type of combination - associating a still feared scenario (opening/lowering dykes) with a frequently appreciated one (vegetating dykes further) - that we should turn to raise awareness among local people.

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Notes

1 'Local' municipalities are listed in Table 1. 'Non-local' encompasses both nearby non-locals and distant non-locals.

2 This question was rarely asked along the low walls of SE Paris, and was also missing from some of the Luthenay and Jargeau questionnaires.

3 The open answers of the respondents were recoded according to their degree of knowledge of the coastal and river landscapes before the dykes' construction and by accepting the use of a non-scientific vocabulary.



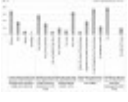


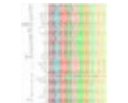


4 The respondents implicitly understand the notion of "dyke landscape", without wondering if the scale of observation of a dyke is not too narrow to speak of a "landscape". Even if researchers would speak more of a "landscape element", they have approved this familiar expression.

5 In Arcachon Bay (2010), respondents were asked about 'in 30 years' time', while in Picardy (2011), they were asked about 'future protection' of the sites; in the DIGUES survey (2020-21), the question was: 'Do you think this scenario is desirable for the future?'

6 Because of the diversity of 'nature's meanings, at this stage we shall retain 2 of the 4 definitions proposed by F. Ducarme after a study of its meaning in European languages: 'all of the material reality that does not result from human will (as opposed to artifice, intention and culture)' and 'the force behind life and change' (<https://www.encyclopedie-environnement.org/vivant/quest-ce-que-la-nature>).

Table des illustrations



	Titre	Figure 1: The studied dykes in their most characteristic portion
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-1.jpg
	Fichier	image/jpeg, 636k
	Titre	Figure 2: Profile of respondents and relationship to dykes (in %)
	Crédits	Source: the DIGUES 2021 survey.
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-2.jpg
	Fichier	image/jpeg, 456k
	Titre	Figure 3: Perception and knowledge of dykes in France
	Crédits	Source: the DIGUES 2021 survey.
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-3.jpg
	Fichier	image/jpeg, 172k
	Titre	Figure 4: Perception and knowledge of dykes in 7 study sites
	Légende	All the relationships are highly significant. Chi-square test was not applicable for the multiple-choice question concerning effects of the dykes on nature. Values in bold and italics are significantly over-represented (at the 5% risk threshold).
	Crédits	Source: the DIGUES 2021 survey.
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-4.jpg
	Fichier	image/jpeg, 288k
	Titre	Figure 5: Degree of acceptability of dyke evolution scenarios according to study sites (in %)
	Légende	Legend: All the relationships are highly significant. Values in bold and italics are significantly over-represented (at the 5% risk threshold).
	Crédits	Source: the DIGUES 2021 survey.
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-5.jpg
	Fichier	image/jpeg, 224k
	Titre	Figure 6: Relationship to dykes, perception of dykes and profile of respondents according to the degree of acceptability of dyke evolution scenarios
	Légende	Legend: Only significant statistical relationships are commented on in the text. Source: the DIGUES 2021 survey.
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-6.jpg
	Fichier	image/jpeg, 868k
	Titre	Figure 7: Significant links between the respondents' profile and their rejection of the five scenarios
	Crédits	Source: the DIGUES 2021 survey; Goeldner-Gianella & Bertrand, 2013.
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-7.jpg
	Fichier	image/jpeg, 64k
	Titre	Table 3: Dykes and dyked areas are "hybrid objects or environments"...
	URL	http://journals.openedition.org/cybergeogeo/docannexe/image/41212/img-8.jpg
	Fichier	image/jpeg, 259k

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Référence électronique

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Article 530

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Article 525

Paru dans *Cybergeogeo: European Journal of Geography*, Environnement, Nature, Paysage

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Article 1062

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